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Increasing re-use of construction and demolition materials and products

Measures for prevention of waste at Swedish recycling centres

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In cooperation with HMXW, Renova AB,
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Preface

The study is a part of Vinnova's and project partners funded project "*Resursbank: increased reuse of construction and demolition waste from households renovation*" (2019-02447). The project was performed in 2019-2020 involving the Swedish Construction Federation (Byggföretagen), Stockholm Vatten och Avfall AB, Renova AB (two municipal waste management companies), an architect's company HMXW and the Swedish Environmental Research Institute (IVL). The focus on reusable construction materials with the purpose to facilitate a more effective matchmaking between the suppliers and the potential users.

The aim of this feasibility study is to map and systematize the regulatory, technical and economic aspects that are important for the re-use of construction and demolition waste. The study focuses primarily on materials available at the recycling centres both before and after they come to recycling centres (mainly from households' renovation projects).

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Malmö, 2020-06-08

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Summary

The purpose of this feasibility study was to map and systematize regulatory, technical and economic aspects that are important for the re-use of construction and demolition waste. The study focuses primarily on *materials available at the recycling centres both before and after they come to recycling centres (mainly from households' renovation projects)*. Information for the study was collected mainly through surveys, interviews, secondary literature review and in-situ observations at recycling centres.

Many C&D products and materials stemming from renovation projects have a potential to be reused. The left-over new building materials (e.g. isolation, tiles), as well as used doors, windows, bathroom porcelain, such as toilet chairs and tubs and electrical appliances are usually accepted at recycling centres and usually in demand on the second-hand markets. The reuse potential varies among different products groups depending on their quality and ultimately end-value. Reusable items from households' renovations are usually available in smaller quantities and usually of varying and lower quality, but this might not be the case for items from larger industrial construction and demolition projects. Antique or rare products usually have a greater value and are in greater demand.

Some of the main actors for the reuse of C&D materials are private households, small construction and renovation companies, municipal waste management companies and various actors in the second-hand chain. The reuse could happen both before materials/products come to the recycling centres (prevention) and after the materials/products come to the recycling centres (reuse, including preparation for reuse).

Generally, low interest and the lack of habit among the potential clients is one of the most important challenges for reuse at a larger scale. Reuse is also often inhibited by limitations such as quantity, quality and higher costs. Costs of reusables can be high due to disassembly, preparation for reuse and transports. Limitations such as high costs of storage, improper handling during storage and the potential risks of undesirable or hazardous substances entering the reuse stream are also inhibiting reuse. There is also a considerable lack of information on regulations regarding the reverse logistics and handling of reusable C&D flows. The challenges to leave the materials for others to reuse at recycling centres are similar to those challenging the reuse before it comes to recycling centres, but economic reasons are more dominant here.

According to municipalities responsible for the management of this kind of waste, the most preferable option would be a reuse before materials come to recycling centres, which would alleviate some difficulties with the space and personnel. The existing municipal initiatives of second-hand activities have usually high operational costs and require significant investment. Furthermore, lack of information, knowledge and awareness throughout the value chain were also often named as one of the main barriers by both municipal and second-hand organizations.

Our study presents examples and cases which are seemingly addressing several of the above-mentioned challenges. The presented selection of case examples detail how municipalities could build or facilitate cooperation across the C&D value chain. For instance, some simple screening tools, such as the "Material Atlas" for quality and risk assessment of different C&D products, could improve the information regarding material safety and several environment issues of reusable materials. The "re-purposing" concept might be useful to overcome challenges related product and material diversity. Initiatives exploiting this concept usually offer an ample selection of reuse ideas



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which often bridge reuse applications in construction, renovation or different artistic applications. Information platforms, such as “Digital marketplace” and “Digital products database”, can reduce the transaction costs in reverse logistic chains.

Sammanfattning

Den här genomförbarhetsstudien har syftet att kartlägga och systematisera föreskriftande tekniska- och ekonomiska aspekter som är viktiga för återanvändning av bygg- och rivningsavfall. Studien fokuserar främst på material som finns tillgängliga på återvinningscentraler (före och efter det kommer till återvinningscentraler) huvudsakligen från hushållens renovering. Information för studien insamlades främst genom undersökningar, intervjuer, litteratur och observationer på plats vid återvinningscentraler.

Bygg- och rivningsprodukter och material som kommer från renoveringsprojekt har en återanvändningspotential. De kvarvarande nya byggnadsmaterialen (exempelvis isolering, gipsskivor), liksom begagnade varor som dörrar, fönster, badrumsporslin (toalettstolar och badkar) och elektriska varor accepteras vanligtvis på återvinningscenter och efterfrågas vanligtvis på begagnatmarknaden. Återanvändningspotentialen varierar mellan olika produktgrupper beroende på deras kvalitet och värde. Antika produkter eller produkter som användas för designändamål har vanligtvis ett större värde och högre efterfrågan. Återanvändbara produkter/material från hushållens renoveringar finns i mindre volymer och vanligtvis i sämre och mer varierande kvalitet. Detta är förmodligen inte fallet för produkter/material som kommer från större industriella konstruktions- eller rivningsprojekt.

De huvudsakliga aktörerna för återanvändning av bygg- och rivningsmaterial är privatpersoner, små renoverings- och byggföretag samt kommunala avfallsbolag och secondhand aktörer.

Återanvändningen kan ske både innan material/produkter kommer till återvinningscentralerna (förebyggande) och efter (återanvändning, inklusive förberedelse för återanvändning). Lågt intresse bland potentiella kunder är en av de viktigaste utmaningarna för återanvändning i större skala. Detta beror delvis på volym- och kvalitetsbegränsningar och högre kostnader (enligt företagen), både när det gäller demontering och förberedelse för återanvändning samt transporter. Andra frågor avser begränsningar och kostnader för lagringsutrymme, korrekt hantering under lagring och de potentiella riskerna för oönskade/farliga ämnen finns i återanvändningsströmmen. Dessutom finns det betydande brist på information om föreskrifter om omvänd logistik och hantering av återanvändbara bygg- och rivningsmaterialflöden. Utmaningar kopplade till att lämna material för återanvändning på återvinningscentraler skiljer sig inte från utmaningarna kopplade till återanvändning som sker *innan* materialet når återvinningscentraler med undantaget att ekonomiska faktorer dominerar i det senare fallet.

Enligt kommunala avfallsbolag skulle det mest föredragna alternativet vara en återanvändning innan material kommer till återvinningscentraler, vilket skulle underlätta utmaningarna med utrymme och personal. De befintliga kommunala secondhandinitiativen har oftast höga driftskostnader och kräver betydande investeringar. Dessutom nämns ofta brist på information, kunskap och medvetenhet i hela värdekedjan av både kommunala och återbruksorganisationer som ett av de största hindren.

I studien presenterar vi också goda exempel och fallstudier som försöker adressera flera av de ovannämnda utmaningarna. Ett screeningverktyg, som "Materialatlas" för kvalitet och riskbedömning av olika bygg- och rivningsprodukter, kan potentiellt förbättra informationen om materialsäkerhet och risker för miljö vid återanvändning av material.

Konceptet "re-purposing" kan också vara användbart för att övervinna utmaningar relaterade till produkt- och materialdiversitet. Initiativ som utnyttjar detta koncept erbjuder vanligtvis ett gott



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urval av återanvändningsidéer som ofta är tillämpbara återanvändningsapplikationer i konstruktion, renovering eller olika konstnärliga tillämpningar.

Informationsplattformar som till exempel "Digital marknadsplats" och "Digitalproduktdatabas" är utformade för att minska transaktionskostnaderna för omvända logistikkedjor för återanvändbara tillgångar.

Studien presenterar ett urval av exempel från andra länder som beskriver hur kommuner kan bygga eller underlätta samarbete över hela värdekedjan för bygg- och rivnings material.

1. Background and methodology

Background

In Sweden, around twelve million tons of waste are generated annually from the construction sector in Sweden (Naturvårdsverket, 2020). Due to its large amount and the existing opportunities to recycle or reuse this waste is among prioritised waste streams in the national waste prevention program and waste plan. Construction and demolition (C&D) waste can originate from commercial operations as well as household projects and be collected and handled at municipal waste facilities. Today about half of C&D waste is used as backfill or landfill coverage material (Almasi, Miliute-Plepiene, & Fråne, 2018), which does not align well with the state's vision for a circular economy.

Reuse is at the top of the waste management hierarchy as it is a way to prevent waste, prolong product's life and an effective measure for resource conservation and climate change mitigation. Unfortunately, the reuse rate of C&D materials is still low, especially as a replacement of new construction products and building materials. A report from the Swedish Waste Association showed that at present only at a few dozen tonnes of C&D waste are reused at recycling centres in Sweden (Avfall Sverige, 2019). At the same time there are considerable volumes of reusable products and materials collected at municipal recycling centres, which potentially constitute a significant untapped resource for waste prevention (Hultén, Youhanan, Sandkvist, & Belleza, 2018).

The purpose of this feasibility study is to map and systematize regulatory, technical and economic aspects that are important for the re-use of construction and demolition waste. The study primarily focuses on materials available at *the recycling centres (before and after it comes to recycling centres)*, mainly from households' renovation. Initially, the project aimed to explore challenges and possibilities of the reuse of two selected pilot products (windows and doors). However, during the study we discovered that possibilities and systematic challenges are common for most of product groups. For this reason, our discussion refers largely to common challenges for all post-demolition or unused building materials, unless specific examples refer to issues prevalent to specific products or materials (windows and doors).

The feasibility study also provides a framework to structure information and the main aspects concerning different actors in the C&D value chain. We also discuss opportunities for a Vinnova's stage 2 development project. The main preliminary idea for such a project is to explore whether it would be feasible to establish a new material database or to update an existing materials' database that would better support a more efficient marketplace for C&D products and materials available at the recycling centres.

The study is a part of the Vinnova funded project "*Resursbank: increased reuse of construction and demolition waste from households renovation*" and was performed in 2019-2020 by the Swedish Construction Federation (Byggförretagen), two municipal waste management companies (Stockholm Vatten och Avfall AB and Renova AB) and an architect's company HMXW Swedish Stockholm and Swedish Environmental Research Institute (IVL Svenska Miljöinstitutet). The purpose of the project is to facilitate a more effective matchmaking between the supply side and the potential users of reusable construction materials.

Methodology

In order to allow for a combination of numerical measurement and in-depth exploration, we used both quantitative and qualitative methods for data collection in the study, including survey, interviews and in-situ observations.

Survey for household renovation professionals (SMEs and craftsmen). We have developed and tested a questionnaire (Appendix 5) during two online workshops with our project partners: the Swedish Construction Federation (Byggföretagen), two municipal waste management companies (Stockholm Vatten och Avfall AB and Renova AB) and an architect's company HMXW. The survey was distributed on the basis of Apsis platform, a professional website for marketing surveys. The information about the questionnaire and invitation to participate has been distributed through IVLs newsletter and MyNewsdesk (platform for journalists), targeting mass media writing about the construction sector in order to disseminate the information about the survey. In addition, the Swedish Construction Federation (Byggföretagen) distributed the survey among its members (around 3,700) as well as exploiting own channels, including e.g. newly released articles together with the information about the survey (e.g. Byggtjänst.se, Hållbartbyggande.com, Fplus.se).¹ Further, the paper version of the questionnaire has been available at a health care centrum in Malmö in the period of Oct-Nov 2019, where the target group (SMEs and craftsmen) is among the dominant patients.

The questionnaire was available on-line in the period from 2019-10-01 to 2020-03-31. In total 51 accesses have been made during this period, however, in total only 11 relevant persons completed the survey. The low response rate could probably be explained by that part of accessed persons were outside our focus group and visited the questionnaire just from their own curiosity (e.g. students, municipalities etc). It also could be possible that our questionnaire was too complex (too long) indicated by five responders who did not complete the questionnaire). Responders were widely distributed in Sweden (Stockholm (6), Malmö (1), Helsingborg/Lund (1), Jönköping (1), Goteborg (1) and Örebro (1).

In-depth interviews (households' renovation professionals and municipalities). Besides the questionnaire, in the period 2019-09 to 2020-03 we also made around 19 in-depth interviews with:

- Five small construction and renovation companies that are working with renovation/construction projects for households,
- Municipal organisations including waste management companies, that have collection points for re-use or sharing places for reuse at their companies (6 interviews), and second-hand municipal companies selling construction materials for re-use (8 interviews).

The interview questions are presented in the Appendix 6-Appendix 8.

¹ <https://omvarldsbevakning.byggtjanst.se/artiklar/2019/november/hushallens-byggavfall-ska-ateranvandas/>

<https://www.fplus.se/nu-ska-ateranvandningen-av-rivningsavfall-forbattas/a/MRX8gR>

<https://hallbartbyggande.com/ateranvandningen-av-hushallens-rivningsavfall-ska-forbattas/>

<https://www.ivl.se/toppmeny/pressrum/nyheter/nyheter---arkiv/2019-11-08-resursbank-ska-oka-ateranvandningen-av-bygg--och-rivningsavfall-fran-hushall.html>



Short interviews (households' renovation professionals and private citizens). In addition to the online survey and the in-depth interviews, we conducted around 20 short interviews. Interviews were carried out amongst visitors at Malmö Återbyggdepå (ÅBD). ÅBD is a storage selling re-used building materials (doors, windows) among others. Visitors (respondents) included both private citizens and professionals (SMEs (bricklayer/ carpenter companies) and individual craftsmen (carpenters, bricklayers).

The aim of these short interviews was to investigate barriers and potentials for re-use amongst both private citizens and professionals working with re-use from construction and demolition waste and uses the reused material in their daily work.

Answers from these short interviews may be biased as visitors are already expected to have a positive attitude towards re-use.

Observations. Observations were carried out on two recycling centers and included a visit to Bunkeflo Recycling Center in Malmö and Gastelyckan Recycling Center in Lund. Both recycling centers hold separate collection points for building materials and products with a re-use potential.

The aim of these observations was to investigate the current re-use practice at different recycling stations. barriers and potentials for more re-use amongst both private citizens and professionals working with re-use from construction and demolition waste.

Observation was carried out at the re-use collection points and on the re-use site, including containers on site (wood, small flammable, metal). The latter to observe whether building and construction waste with a re-use potential was being prematurely recycled or incinerated.

Observations were followed up by short interviews with site workers.

Workshops An online workshop has been held in 2nd of April to map the interest in digital tools among stakeholders interested re-use and communicate the results of the project along the value chain. In total 22 actors have registered for the workshop and 18 attended.

Another online workshop has also been held on 12th of Maj to communicate project results, plan for the Stage 2 and engage stakeholder to participate in the projects Stage 2.

2. Current practices

This section gives a background for our study. It describes the main materials' and products' flows and introduces actors and legislation relevant for C&D products and materials. Our focus is on materials available (or potentially available) at municipal recycling centres. The study also provides a summary of municipal responsibilities and current practices for the re-use of C&D flows from recycling centres.

2.1. Material/product flows

Theoretically, the main material – or product flows with potential for re-use from household's renovation projects are:

- New left-over building materials (e.g. in unopened packaging)
- Bricks
- Concrete & stone slabs
- Roof and ridge tiles
- Beams (steel or wooden)
- Doors
- Windows
- Wood materials (planks, boards, etc.)
- Bathroom materials (toilets, sinks, bathtubs etc.)
- Kitchen fittings
- Pallets
- Electrical appliances

According to our survey and interviews (2.1) a range of new left-over building materials (e.g. isolation materials), used doors, windows, bathrooms porcelain (toilet chairs and tubs), electrical appliances and post-demolition bricks are the highly demanded by the second-hand market. These materials are also often left at the recycling centres for reuse. According to our interviews with construction and demolition companies, almost all of the above-named materials could be reused, as long as the materials comply with the quality requirements and technical standards. There are, however, big variations among different products groups. For instance, according to an interview with a craftsman working with reuse of kitchen materials for 20 years, there is a trend that products made before 1960s are much easier to re-use/renovate. The main reason is typically higher quality, design and the use of materials that are more suitable for reuse, such as e.g. natural timber trees wood instead of wood chip boards (L. Persson, 2020).

According to our results, reusing or leaving materials for reuse is not common practices for small construction/renovation companies. Only about one-third of the responders indicated that they usually or sometimes practise it. This complies with the data from other studies, which indicate that a considerable part of potentially reusable materials is managed in other ways than re-use, i.e. landfilled, incinerated or recycled at best. For example, a study of two recycling centres in Sweden showed that up to 24 % of C&D waste products collected for incineration or recycling can potentially have some commercial value in reuse (Hultén et al., 2018).

Construction/renovation companies can reuse either those materials/products that occur within their *own activities*, or those *outside* their activities, i.e. buying/possessing from other companies, second-hand actors or recycling centres. According to our survey and interviews, the reuse practice within the same companies is much more common than reuse of external materials.

We used two products - windows and doors - as pilot materials to explore common practise - in this business. During the study we discovered possibilities as well as systematic challenges that are common for most of product groups. For this reason, most of our discussion refers to common challenges for post-demolition or unused building materials, unless specific examples refer to special issues prevalent to specific products or materials.

2.2. Legal requirements in Sweden

Proposal of revision of current legislation in connection of the revision of the EU directive on waste

Recently the Swedish government has published a *new proposal* for changes in current national waste legislation to facilitate the implementation the EU's revised waste directives steering towards the circular economy, including strategies for reuse. The proposals include following changes in the Swedish Environmental Code and other legislation:

- The definition “*municipal waste*” replaces the term “*household waste*” in line with the new EU definition and the waste directive: “*Municipal waste must be household waste and such waste from other sources that, by their nature and composition, resemble household waste.*” The new term “*municipal waste*” does not include household waste, such as sludge and construction and demolition (C&D) waste. Clarification of waste definitions and which materials belong to different waste categories helps the municipalities to scope, plan and fulfil their responsibilities.
- The municipalities' responsibility for C&D waste is clarified. The new Swedish proposal makes a clear division of responsibilities (while there was some room for interpretations before): professionals who produces C&D waste shall be responsible for its management. Municipalities are responsible for the C&D waste produced in non-professional activities.
- Requirements for source-sorting of C&D waste in a number of (specified) fractions.
- Control plans in the Planning and Building Act (2010: 900) are supplemented so that they must include information on all C&D waste and construction products that can be reused.
- Prohibition of incineration or landfilling of fractions collected separately for preparation for reuse or material recycling.
- The Swedish Environmental Code introduced provisions for waste when its ceases to be defined as “waste”; who is responsible for meeting the regulatory requirements for such materials and products are also defined.
- Anyone who collects or processes waste will be required to disclose information on the possession of waste that can be prepared for reuse, but which is not intended to be treated in that way and offer it to anyone who intends to professionally prepare it for reuse.
- Suppliers of goods shall provide information on the presence of particularly dangerous substances in goods to the European Chemicals Agency. The information should be available to waste management actors and consumers.

These amendments are proposed to enter into force on the 1st of August 2020.

Guidelines for recycling and reuse for the construction sector

Among the important guidelines for recycling and reuse of C&D waste are the guidelines for resource and waste management of C&D. They serve as the industry standard for waste management in the construction and real estate sector and aim to improve resource management in the sector (Byggföretagen, 2019).

The guidelines are a tool for fulfilling the general requirements of the Swedish Environmental Code and the EU Waste Management Hierarchy. These are designed to contribute to Sweden's environmental objectives and meeting the general expectations of circular solutions in the society regarding industry's material and waste management. In some cases, the Swedish guidelines exceed the requirements of the EU legislation.

The guidelines were updated in 2019 and contain normative provisions for the industry, such as, the construction industry's agreement regarding resource and waste management during construction and demolition. These for instance include:

- Material inventory prior to demolition, together with procurement of inventory;



- Waste management prioritising waste sorting and reuse at source, including the procurement of adequate contractors for the works;
- Adequate design practices that would facilitate future waste sorting at source and circular waste management, including the procurement of adequate construction contractors;

The normative industry texts have appendices which contain descriptions of how C&D waste should be managed in practice, industry-wide designations for a number of waste fractions and signs and colours for waste collection systems.

The Swedish Construction Federation takes responsibility for keeping the guidelines updated. This entails changes due to legislation and supplements on waste prevention (Byggföretagen, 2019).

Regulation for the use of reuse construction materials

There are no separate regulation specifically governing the reuse of construction materials. The same rules apply for new and reused building products and materials regulated by the National Building Code (BBR) and several specific requirements for different product groups. For instance, a door (any) used in a building need to fulfil specific safety, structural, acoustic, thermal and fire resistance requirements.

2.3. Actors and responsibilities

The five major activities of the relevant actors from the value chain and their roles are outlined in the table below.

Table 1. Relevant actors and their responsibilities for construction and demolition materials/waste

Value chain	Role
Private households	<p>Initiate reuse/renovation practices, accept costs/designs, decide on the fate of potentially recoverable materials (if specified in a contract with demolition/renovation businesses).</p> <p>They might also to some extent renovate themselves and thus decide on the fate of the potentially recoverable materials.</p>
Service providers (small renovation companies (craftsman))	<p>Carry out renovation, building or demolition services (it could be up to the contractor to decide how to dispose of the potentially reusable materials).</p> <p>Collect, store and/or transport the potentially reusable product or materials either</p> <p>Reuse generated within or outside own activities/organisation.</p> <p>Dismantle and leave the materials/products for reuse for second-hand actors (other companies or private households).</p>
Municipalities (municipal waste companies or other)	<p>Facilitate reuse practices before the materials/products come to recycling centres or after it. They can also put forth requirements to</p>

municipal entities responsible for household waste recycling)	<p>relevant actors to reuse products/materials in works on public buildings.</p> <p>Responsible for management of construction/demolition waste that comes from households to recycling centres.</p>
Second-hand actors (private or municipal)	Collect/accept, store, market and resell second-hand construction/demolition products and materials.
Other actors	<p>Digital marketplaces or private initiatives that provide/facilitate the reuse among small companies and private households, such as, e.g.:</p> <p>Blocket - is a digital marketplace for used goods. Some C&D products under section “building and garden” could be sold (such as old doors and windows, old kitchen). The user usually should pay a fee of 50 SEK for placing an advertisement.</p> <p>Facebook groups – usually locally-based household-initiated social groups where members can donate, sell or buy some used materials, including C&D waste and materials.</p>

The role of municipalities

There is great variation of C&D waste management practices among Swedish municipalities for waste stemming from household’s renovation projects. The main issues have been unclear definitions in the Swedish law on responsibilities. The current regulations do not indicate to what extent C&D waste is included in the term of “household waste” and is thus covered by the municipal responsibilities. The Swedish EPA provided some guidance for the definition of household C&D waste, where responsibilities and status were defined as follows (EPA, 16/01/2008):

- Minor maintenance work and repairs in a home should be counted as one normal part of accommodation. Waste from such works (for example, used paint, wallpaper, floor waste and replacement of worn details) is therefore a household waste.
- If a construction work is extensive (major repair, renovation, remodelling, demolition, etc.) the waste is mainly due to construction activities and therefore not generated by households. Waste from such extensive works cannot be considered as coming from households, not can the waste be considered comparable to such origin(s). Whether a work is extensive or not, is ought to be assessed in each individual case.

As a result, municipalities have made different interpretations of such provisions. This resulted in a range of models on how and where small companies and craftsmen can leave their C&D waste to the responsibility of municipalities.

According to the new proposal within the revision of the new EU directive, municipalities will be responsible for the management of C&D waste that comes from households. The waste that arises from professional activities is a responsibility of relevant professional (business) actors. These may choose to dispose/manage of the waste in a manner other than submitting it to the municipalities. The municipal recycling centres are to be the main waste management option for the materials that

come from household's renovations.² The Swedish municipalities have varying resources (both human and financial) and varying waste management practices, including varying reuse practice.

Some municipalities cooperate and build joint waste management companies on a larger scale and some manage these on their own. The possibilities of different municipalities to form joint recycling centres and cooperate with other municipalities or private actors differ. Eventually, regardless of their capabilities, most of municipalities have no reuse practices for C&D materials, but their interest in doing so is increasing. The existing forms of reuse practices for construction and demolition waste among municipalities in Sweden are, according to the latest report by Miliute-Plepiene, Almasi, and Hwargård (2020) of three categories: sales-based reuse in separate facilities outside recycling centres, sales-based reuse as part of recycling centres or re-use parks and finally non-sales-based reuse: SWAP places.

1. **Sales-based reuse in separate facilities outside recycling centres** (e.g. Återbyggdepå in Malmö, Halmstad's Byggåtervinning).

Malmö and Halmstad are examples of municipality-owned second-hand facilities focusing primarily on social goals such as employing long-term unemployed persons. These often cooperate with waste management companies/recycling centers, where they have collection points where almost exclusively C&D materials are collected, which facilitates high collection (and potentially reuse) volumes. Typically, large premises of up to 16,000 m² are used. The collection is up to 99% from companies, i.e. construction and demolition actors that want to get rid of materials that can be reused/resold. Reuse operators are actively looking for cooperation with C&D companies or other suppliers and then collect the products with their own transport. Transport services are a significant source of income. E.g. Återbyggdepå in Malmö receives almost half of its revenue from transport services for customers. The bulk of the annual operating costs comprise employment and rental expenses. The latter are to a large degree covered by municipal programs for social support and other authorities such as the Employment Service offering employment for long-term unemployed persons. The customers are both private households and companies.



Figure 1. Malmö Återbyggdepå – sales based reuse. Ref: IVL

² In many recycling centres, households can leave their waste free of charge, while small C&D companies or craftsmen should pay a fee. However, it is difficult to control whether it is the household or company leaving their waste. To prevent professional free-riders, many municipalities introduce some limitations for free-of-charge times to accept C&D waste.

2. Sales-based reuse as part of recycling centres or re-use parks (e.g. Alelyckan in Gothenburg, ReTuna, Halmstad's Byggåtervining (2007–2009))

The goal of re-use supports both environmental and social objectives, but the reuse of C&D waste is only part of the re-use parks. Usually, less space/premises are designated for the delivery, storage and sales compared to reuse outside recycling centres (see above). To a large extent, the collection is through recycling centres and the assortment of collected products and materials is much more diverse. Customers are mostly private individuals. The staff is looking less actively for contacts with construction and demolition companies to encourage their deliveries. Own transports are used to a much lesser extent than in facilities outside the recycling centres.



Figure 2. Kretsloppsparken Alelyckan. Ref: www.higab.se

3. Non-sales-based reuse: SWAP places (e.g. Byggboden in Jönköping, Benjamin's Reuse)

In these examples the main objective is environmental. The collection sites dedicated to reuse are quite small and the reuse rate is low in comparison to the operations described above. The operations do not offer any transport – neither for collection nor to customers, but the operating costs are much lower compared to the sales-based reuse examples. In SWAP places staff need to spend less time on re-use than, for example, the staff at recycling centres with sales-based reuse (for example, to check that the products do not disappear or are sorted properly). Moreover, the number of visitors and the number of satisfied customers has been increasing after the introduction of these non-sales-based reuse collection models. The municipalities also experience the test period as a success.



Figure 3. Reuse place SWAP: "Byggboden" at the recycling center in Jönköping. Ref: June&Avfall

3. Challenges and possibilities to increase the re-use

The chapter is based on the results from surveys, interviews and observations sampled at recycling centres. Challenges identified through surveys were further cross-checked using in-depth interviews and complemented by literature studies. In the section on possibilities we identify some practical examples and case studies of how to overcome some of the challenges. We focus on possibilities that are most relevant to facilitate knowledge and information exchange along the value chain of C&D as well as matchmaking between relevant actors.

3.1. Survey and interviews results

Figure 4 presents an overview of main challenges for reuse of building/demolition products and materials seen from the perspective of professionals. Results are based on survey and interviews with construction -and renovation companies. Results are indicative, as we used slightly different questions for the two methods (survey and interviews). Interviews at Återbyggdepå are different from others as we meet companies that were already interested in reuse.

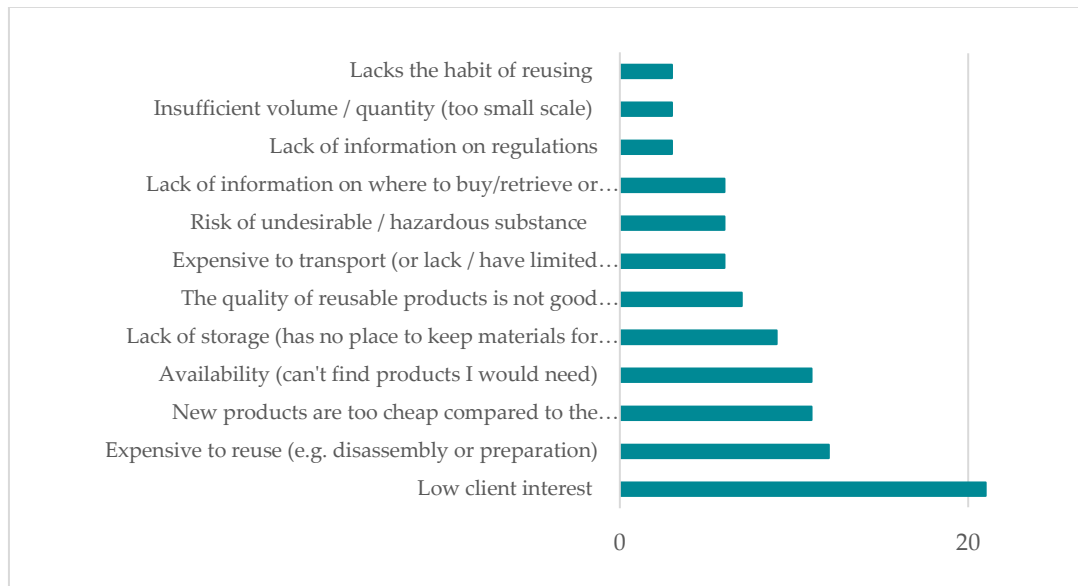


Figure 4. Overview of the main challenges for reuse. Based on survey&interviews with renovation/building companies.

Results on challenges indicated by the survey and interviews with companies and craftsmen are presented in Figure 4. In the survey we asked respondents to indicate main challenges for three different options/ways of reuse for materials that are generated: (i) within own organisation, (ii) from other organisations, and (iii) challenges related to leave the materials for reuse.

Data show that there is not a big difference between the first two options. In both cases, main indicators challenging reuse are lack of the interest from the customers, different economic aspects, risks and quality. However, in regard to main challenges for reusing materials generated from others, slightly more respondents indicated the lack of storage as the main challenge. In deeper face-to-face- interviews, lack of storage was often revealed as a central barrier to reusing materials generated in own project.

Different aspects were named as challenging for leaving the materials/products/waste for reuse (at recycling centres, for other companies or for the second-hand markets) compared to barriers related to reusing within own organisation. Economic -and related aspects linked to lack of time to manage these material flows, insufficient volumes, lack of information and general availability of materials/products were indicated as most challenging (Figure 5).

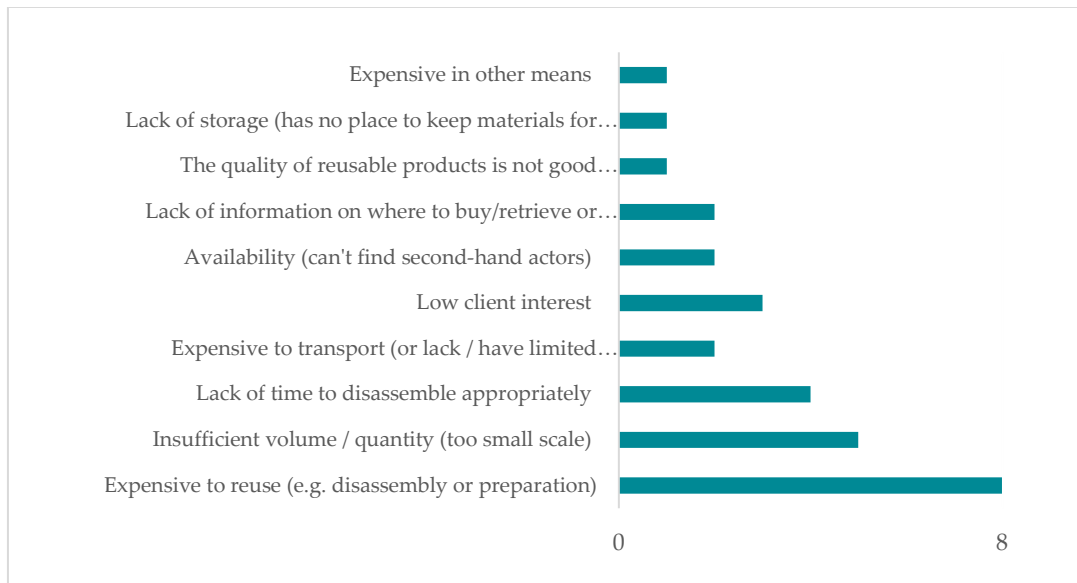


Figure 5. Main challenges for companies/craftsmen donating materials for reuse (survey)

At Återbyggdepå both companies and private households were interviewed in regard to reuse (Appendix 2). The most challenging issues for private households seem to be similar to those of the companies. However, due to a rather low number of responses (during the interviews at Återbyggdepå) we cannot withdraw any general conclusions regarding any significant differences between the two groups.

Appendix 2 lists the main challenges indicated during all interviews. An overview of all challenges throughout value chain are presented in Table 2. Based on the results, challenges are systemized into four groups: lack of information and awareness, technical aspects, economic aspects and regulatory requirements. However, many challenges are interrelated, e.g. the interest in reuse by craftsmen depends on demand from households which again relates to the economic feasibility to perform reuse. A discussion on the main challenges and possibilities is presented in the following chapters.

Table 2. Main challenges for reuse throughout the value chain – summary based on interviews, surveys and observations

Type of challenge	Ways of reuse	Private households *	Companies/craftsmen perspective	Municipalities (ÅVC) perspective	Second-hand organizations (e.g. Återbyggdepå, Allelykan)
Information and awareness	To reuse before ÅVC	<p>Lack of information on where to buy/retrieve products/materials for reuse, which SMEs or individuals that want/can reuse.</p> <p>Lack of information how to reuse.</p> <p>Lack of habit/norm to reuse.</p>	<p>Low client (households) interest.</p> <p>Lack of information on where to buy/retrieve products/materials for reuse.</p> <p>Lack of habit to reuse.</p> <p>Lack of information on regulations.</p>	Lack of information, knowledge and awareness throughout the reuse chain	Not relevant
	To leave for reuse	Lack of information on where to leave for reuse	<p>Lack of information on where to leave the materials for reuse</p> <p>Low client (households) interest</p>	<p>Lack of information, knowledge and awareness throughout the reuse chain.</p> <p>Lack of reliable statistics on reuse rates among almost all reuse forms.</p> <p>Lacking awareness among both private people and companies regarding possibilities of/for re-use.</p> <p>Existing secondhand markets do not advertise enough that they can collect reusable items from costumers.</p>	<p>Low interest from building companies to leave materials for reuse.</p> <p>Lack of reliable statistics on reuse rates are lacking among almost all reuse forms at the municipalities.</p> <p>Lack of information, knowledge and awareness throughout the reuse chain</p>
Technical aspects/regulatory	To reuse before ÅVC	Inconvenience: poor infrastructure, few second-hand actors or unknown SMEs that would renovate or build with reused materials.	<p>Availability (can't find products I would need)</p> <p>Insufficient volume / quantity (too small scale)</p>		Not relevant



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Type of challenge	Ways of reuse	Private households *	Companies/craftsmen perspective	Municipalities (ÅVC) perspective	Second-hand organizations (e.g. Återbyggdepå, Allelykan)
		Material availability: difficult to find and source products and materials at desired quality and of sufficient quantities.	Lack of own storage The quality of reusable products is not good enough or the quality is uneven. Risk of undesirable / hazardous substances.		
	To leave for reuse		Availability (can't find second-hand actors). The quality of reusable products is not good enough or of an uneven quality. Lack of storage (has no place to keep materials for reuse). Insufficient volume / quantity (too small scale).	Lack of space and personnel at the recycling centres for reuse. Risks for contamination, no guaranties could be provided.	The variety of products from recycling centres is very large and the quality is usually worse than the quality from larger recycling projects. (Alexis, 2019; Karlsson, 2019; M. Persson, 2019; Sundstedt, 2019)
Economic	To reuse before ÅVC	Time-consuming to find specific products New products are cheap compared to the reusable ones	Expensive to reuse (e.g. disassembly or preparation). New products are too cheap compared to the reusable ones. Expensive to transport (or lack of or have limited transport options).	Market price for new products is too low compared to re-used ones.	Not relevant



Report C 547 – Increasing re-use of construction and demolition materials and products – Measures for prevention of waste at Swedish recycling centres

Type of challenge	Ways of reuse	Private households *	Companies/craftsmen perspective	Municipalities (ÅVC) perspective	Second-hand organizations (e.g. Återbyggdepå, Allelykan)
	To leave for reuse		<p>Expensive to reuse (e.g. disassembly or preparation).</p> <p>Lack of time to disassemble appropriately.</p> <p>Expensive to transport (or lack of or have limited transport options).</p> <p>Expensive in other means.</p>	<p>It is not so difficult to increase collection, but it is difficult to sell/realise it. The diversity of products is very high.</p> <p>Reuse operations induce additional costs – largely due to more space and more staff required.</p>	<p>It is more expensive/time consuming to sort out materials at the recycling centres (if these are unmanned) than to collect it from bigger projects.</p> <p>Operational costs for the sales-based reuse are quite high; the largest costs are personnel costs and the rest of premises.</p> <p>Recyclable products that are left at recycling centres are not of the highest economic value compared to those provided by companies.</p>

* The results should be seen only as indicative due to a low sample (7 interviews at Återbyggdepå). However, we also include issues from household's perspective named by other actors.

3.1.1. Information and awareness

Households interest in reuse (from craftsmen perspective)

Many respondents in the survey and the interviews emphasised that there is no or not enough interest from the private households to re-use their construction/renovation products or to pay more for the time that would require to spend in looking for re-used products ().

According to interviews with a craftsman (Interviewee No 2, 2019) only one third of his clients were more or less interested in keeping old products or using reused products. Commonly, customers are interested either in getting a cheaper service or either in keeping, renovating and reusing products that have antique value. The main driving forces were not environmental, but economic. This has been emphasized in a majority of other interviews as well.

Another craftsman (Interviewee No 2, 2019) emphasised that he often suggests renovation services for old windows and that costumers are usually interested, but only at lower prices than new windows. Other interviewee (Interviewee No 3, 2019) observed a trend among some older generations on the country side and residents living in villas to have a habit of keeping demolished or other products and materials as a reserve for their houses (e.g. roof tiles), which makes renovations easier and cheaper. However, the majority of private households do not want to keep old products but rather want to replace them with fresh, modern, new products.

A craftsman with 20 year experience in Stockholm who works specifically with re-use projects pointed *out that* at the moment the interest in reuse among households is increasing for environmental reasons compared to previous years (L. Persson, 2020). The interviewee also emphasised that his clients usually share experiences with other conventional renovation companies or craftsmen. It seems that the most common attitude among conventional renovation companies is – “it is not possible” or “it is better/easier/cheaper to replace it with a new one” (L. Persson, 2020). There is also an indication that the conventional renovation and construction sector lacks knowledge or habits to perform reuse projects.

Households’ interest in re-use could probably be increased by raising their environmental awareness (e.g. lifting climate benefits of reuse), communicating costs savings, making it more cost effective, changing the prevailing costumers’ tastes and promoting/making the reuse/renovation process as a norm.

Construction and renovation companies’ interest from the perspective of second-hand organizations

Lack of interest form construction/renovation companies to leave materials for reuse was also mentioned by second-hand actors and recycling centres. It seems that households rather than construction/renovation companies who tend to be more interested in leaving materials for reuse. The main reason for the lack of interest is that companies want to spend as little efforts (time) for preparing and leaving the materials for recycling/reuse as possible and thus save extra expenses.

Lack of information

Lack of information about where to leave, buy or retrieve materials for reuse has been often mentioned in our interviews with the construction companies and craftsmen near Malmö and Gothenburg where large major second hands actors Malmö Återbyggdepå and Allelyckan of

Gothenburg are located. Around 80 % of the interviewed companies did not signal awareness about second-hand markets available nearby. Interviews at Malmö Återbyggdepå also indicated that some companies knowing about the existence of the reuse markets have no knowledge about products available at the Återbyggdepå.

From the interview it has also become apparent that municipal second hand companies do not actively advertise their activities owing to a lack of human or economic resources or restrictions to compete with private actors (Miliute-Plepiene et al., 2020). Some interviewed companies and private households at Malmö's Återbyggdepå emphasised that they cannot always find what they are looking for and it takes a lot of time to find specific second-hand products, which affects their interest in post-use building products and materials. The general lack of information, knowledge and awareness throughout the whole reuse chain in Sweden has also been named in other studies (Miliute-Plepiene et al., 2020).

3.1.2. Technical and regulatory aspects

Risk of undesirable / hazardous substances

One of the barriers to reuse is that some products may contain undesirable/hazardous substances. Such materials should be treated by other means especially if classified as hazardous waste. For instance, windows manufactured in Sweden between 1956 and 1973 may contain PCB-based sealants and in imported windows, PCBs were used even until 1980 (Avfall Sverige, 2008). Such products cannot be re-used as they are to be phased out and managed as special (usually hazardous) waste. Likewise, old paints and some other kits in windows or doors can contain lead and asbestos (Figure 6). This should be considered when reusing and/or renovating old products, and safety measures must be used. These should be treated as hazardous waste at recycling centres.

It is common that recycling centres taking reusable or second hand products have informal unwritten experience sharing largely based on personnel's experience, e.g. checking the production year and eliminating the products that potentially contain unwanted or hazardous substances (Miliute-Plepiene et al., 2020). For recycling centres wanting to start up a new reuse activity the potential lack of knowledge might become an issue. Guidelines, manuals and information tools are needed to alleviate such limitations. For example, in Denmark, a tool called the Material Atlas has been developed to facilitate the identification of hazardous or unwanted substances in reusable or recycling materials (see chapter 2.1).

Compliance with requirements of building regulations

Building codes and requirements are also a potential limitation for the reuse of renovation and demolition products and materials. For instance, for the reuse of windows and outer doors in houses with high energy efficiency requirements the use of older products might not be possible due to their incompliance. All new windows and outer doors sold within the EU are subject to the harmonizing product standard EN 14351-1 and must be CE marked. This means that the essential features such as thermal resistance should be reported in a performance declaration to allow a customer to compare different manufacturers' windows and assess whether a product meets national requirements. The CE marking does not impose requirements on the value / class of reported performance, but only requirements on how properties are to be determined and reported. For instance, if air tightness is to be reported in the CE marking for a window, the air



leakage according to another EU standard EN 12207³ may not exceed 50 m³ air throughput per hour per 1m² window area. If a window lacks a set value / class for a property, the manufacturer may choose to report an NPD which is an abbreviation for "No performance determined".

Energy labelling requires a window to be CE marked and comply with the requirements of the CE marking for the values / class of selected properties. The requirement for an energy-labelled window in energy class A is that the air leakage must not exceed 1 m³, i.e. only 50% of the lowest class in the CE marking.⁴

Therefore, reusing older products such as outer doors or windows might not be possible in renovation projects where high energy efficiency is required. However, such products could be used in other less energy requiring buildings (e.g. storage rooms, summer houses) or repurposing to another applications (see chapter 3.2).

Another aspect to consider is that when an architect or technical consultant designs a new building, they must demonstrate that the building lives up to the laws and regulations. Using performance-declared products reduces the risk of inaccuracies. If it turns out that laws and regulations are not complied with, the consultant can be liable for damages and this might be considered another barrier for using reused products.

³ <https://www.sis.se/api/document/preview/8024284/>

⁴ <https://www.energifonster.nu/sv/tips-rad/skillnaden-mellan-olika-fonster.aspx>



Figure 6. The armoire frame from the 50's containing lead. The product should be treated as hazardous. Ref: IVL



Figure 7. An example of sanitation work at a kinder garden in Lund. Window frames from the 50's containing PCB materials and cannot be reused. Ref: IVL

Lack of space and personnel at the recycling centers for reuse

Enough of personnel at the recycling centers to facilitate collection for reuse plays a crucial role when informing the building/renovation companies and households to collect materials for reuse. Such staff can advise whether a material could be reused instead of thrown away, to which households and companies often change their behavior in favor of reuse/recycling (Interviewee No 5, 2020; Interviewee No 8, 2020). To the same degree a dedicated, convenient and well-located place for collection is required in order to increase the reuse (especially bulky such as construction and demolition waste) throughout the recycling centers (Interviewee No 7, 2020).

However, many recycling centers in Sweden have no or limited possibilities to dedicate a space or enough of staff to facilitate reuse or even recycling (e.g. locate more containers for separate waste

fractions) (Almasi et al., 2018; Miliute-Plepiene et al., 2020). Sometimes, the lack of space can be partly solved with some simple reuse actions, such as e.g. a small dedicated place for non-sales-based reuse, like those practiced by Byggboden in Jönköping (Figure 3). These operations are cost-effective, although their capacities are low in comparison to the sales-based reuse (Miliute-Plepiene et al., 2020).

3.1.3. Economic aspects

Costs for construction and renovation companies

Our interviews and the survey have clearly indicated that reuse/renovation processes are expensive (Figure 4), which is due to:

- Time needed to look after/find reusable products;
- New products and materials are often cheaper;
- the actual recycling process, e.g. disassembly or preparation, are usually very expensive;
- High costs of transport (or lack/ have limited transportation options) for both internal reuse and for leaving of reuse.

The excessive time needed to locate reusable products is often related to small and sparse market for reusables (Interviewee No 1, 2019; Interviewee No 4, 2019). The economic reason for not reusing materials were often related to households' interest to receive as cheap as possible services and many of companies or craftsmen emphasized that is not possible to provide such services when time is spent on searching for reusables.

High costs were also mentioned in relation to time spent for leaving products and materials for reuse by others. Some interviewees suggested that they would be more active in reuse if they would be paid for leaving the materials or have a free pick-up service (Interviewee No 4, 2019). In several interviews it was emphasised that new products are too cheap compared to reusable products. If the market is not yet well developed it's not possible to achieve economies off scales which also contributes to higher costs of reusable materials.

On the other hand, some interviews and literature contradict the prevailing opinion that reuse projects cost much more than regular projects. For instance, it was experienced in business-to-business construction projects (Miliute-Plepiene et al., 2020). Some professional property owners who ran pilot reuse projects pointed that higher costs are not always the case. In their experience of buying reused items outside own organization the total costs of a project with elements of reuse are comparable to a conventional project. Used materials are usually 50-70% cheaper than the new ones, but a reuse project usually requires more architect hours. These, however, might decrease when architects get used to work with reuse projects (Miliute-Plepiene et al., 2020) or have some access to digital support tools such as Material Atlas (see section 2.5.1)

Similarly, according to one of our most experienced reuse entrepreneurs, the total renovation costs with reuse for private households can likely be not much higher as conventional work. For instance, in a reuse-based kitchen renovation project a household can save by not purchasing an entirely new kitchen set, although it might take more time to find suitable or desired products and materials. If a household can find the required materials, the total renovation price might be similar or even cheaper than purchasing and building a new kitchen (L. Persson, 2020).

Costs for the municipalities

Collection for reuse activities at the recycling centres or as separate municipal activities can imply additional costs for municipalities - both in terms of investments and operational costs, which are not always feasible to cover with the revenues from sold materials⁵. Miliute-Plepiene et al. (2020) present some examples of costs for different forms of reuse activities in municipal recycling centres or second-hand sale facilities. Sales-based activities usually imply high annual costs (space and personnel), which might contain up to 80 % of all operational costs (e.g. Malmö Återbyggdepå). However, high costs could partly be reduced throughout (Miliute-Plepiene et al., 2020):

- Collaboration around the reuse practise with social services through trainees (then costs are paid by other public service entities);
- additional transportation services that generate additional revenues;
- some of costs could be partly covered by the waste tax, as it could be tracked as “preparation for reuse”;
- optimal involvement of private actors could offer opportunities to reduce operational costs;
- operational costs for the sales-based reuse are quite high; the largest costs are personnel costs and the rest are costs of premises.

Some simple activities, like the above described SWAP schemes are much less costly even though their total reuse capacity is limited in comparison to the sale-based reuse (mainly due to limited spaces).

3.2. Possibilities and relevant case studies

3.2.1. Material Atlas: an online tool assessing the resource potential in building material

One of the most important issues for the reuse is the quality of reusable materials and products. Some simple, user-friendly tools for quality evaluation can help to assign quality labels and identify potential risks from C&D material reuse for both professionals in construction/renovation companies and other second-hand users.

In Denmark, researchers have developed an online tool named “Material Atlas” (Butera, Oberender, Stylsvig Madsen, Beim, & Kjær Frederiksen, 2016) a results of a 2-year InnoBYG project named "Use and management of waste and resources in construction". The project was a collaboration between two knowledge institutes; Technological Institute (TI) and CINARK - Center for Industrial Architecture at the Academy of Fine Arts' School of Architecture and included close dialogue with selected actors from the construction industry. The Material atlas of building materials' re-use and recycling potentials is primarily developed by TI in collaboration with relevant business partners.

⁵ Additional costs for municipal waste management companies usually implies higher waste fees for citizens and/or private companies.



The Material Atlas is designed as an overview of environmental opportunities and barriers associated with a wide range of building materials. It can serve as a reference book where relevant actors can, find information about the environmental problems associated with a specific building material from a given period. This allows the atlas to function as part of the preliminary studies in the development of new design strategies for the re-use and recycling of building materials (Butera et al., 2016).



The purpose of the Material Atlas was not to present an exhaustive list of building materials, but rather to point at material flows with great potential for reuse / recycling. As a supplement to using the on-line tool, there is a back-ground document, introducing the on-line tool, including how the material atlas was constructed and a reading guide.

The on-line tool offers:

- an overall assessment of the possibility to re-use or recycle the specific product or product group;
- evaluation of effects from the substances on work environment, external environment and indoor climate in connection with re-use or recycling of the materials;
- identifying possible problematic substances based on production time (the probability of occurrence of the problematic substances are shown for five time periods).

Table 3 provides an overview of information and reading guide on how to interpret the results in the online tool.

Table 3. Overview of information available for each specific product group in the Material Atlas (on-line tool) (Butera et al., 2016)

Overall assessment of the resource potential ⁶		Evaluation in relation to:			Time period	Hazardous material
Possibility of Re-use	Possibility of recycling	Indoor climate (during the operational phase)	External Environment (Potential challenges handling / disposal)	Work environment (Potential challenges by demolition, renovation, reprocessing)		
<p>The resource potential of the building materials has been assessed by indicating whether they can be recycled and / or reused.</p> <p>  </p> <p>Red: It is not legal to re-use / recycle the material or it is not possible to reuse / recycle it as there is a high probability of occurrence of problematic substances, regardless of the time period.</p> <p>Green: There is no knowledge of the use of the problematic substances (which are covered by the material atlas) in the building material concerned. It is estimated, that the material can be recycled / reused.</p> <p>Yellow: There may or may be a high probability for the occurrence of problematic substances in individual time periods. The material may be recycled / reused, however, provided it is legal, and that no banned substances have been used in material. It will require a closer examination and assessment of the materials content of problem substances.</p> <p>Red circle with a red cross: It is not technical possible / does not make sense to reuse and / or recycle the material: it may be paint or grout, for example which cannot be re-used / recycled per se</p>		<p>Effect of the problematic substances in relation to the categories indoor climate, external environment and working environment:</p> <p>  </p> <p>Red: The substance is a problem in relation to the chosen category e.g. it is regulated</p> <p>Green: The substance does not pose a problem in relation to re-use or recycling</p> <p>Yellow: The substance may be a problem in relation to the chosen category and one must therefore pay attention</p> <p>it (e.g. ensure that the materials have been examined for the substance concerned and / or that substance, to the extent that is technically possible / legal, is removed before re-use or recycling of the materials).</p>			<p>The probability of occurrence of the problematic substances are shown for five time periods. The time periods are selected from the date of application of the substances in Denmark.</p>	<p>The presence of problematic substances: The charts show the probability of occurrence of problematic substances in each time period</p>

⁶ The resource potential of the building materials has been assessed by indicating whether they can be recycled and / or reused. Waste legislation, both Danish (the Waste Order) and European (Waste Framework Directive), includes a clear definition of the various concepts, which is used in relation to waste re-use and recycling.

As an example, if a user is interested in knowing more about re-use or recycling potential of a specific product, in this case “old” windows. A table appears for the specific product group and gives the user information regarding an overall assessment of the possibility to reuse or recycle this product, an evaluation of the product in relation to indoor climate, external environment and work environment and finally different time periods of the product followed by the presence of problematic substances, if any (Table 4).

If windows are of the type “double glazed window”. The overall assessment of the possibility to re-use or recycle this product is Yellow meaning that the user should be aware that “there is or may be a high probability for the occurrence of problematic substances in individual time periods”. In this example, windows from the **1950-1977** contain PCB. Material may be recycled / reused, however, provided it is legal, and that no banned substances have been used in material. However, it requires a closer examination and assessment of the materials content of problem substances.

In the case of “single glazed windows”, the overall assessment of the possibility to re-use or recycle this product is Green meaning that “There is no knowledge of the use of the problematic substances (which are covered by the material atlas) in the building material concerned. It is estimated, that the material can be recycled / reused. However, if the window frame is painted. The overall assessment of the possibility to re-use or recycle this product is Yellow meaning that the user should be aware that “There is or may be a high probability for the occurrence of problematic substances in individual time periods”. In this example, window paint from all time periods contain a range of hazardous materials including PPb, PCB and others. The material may be re-used or recycled; however, it will require a closer examination and assessment of the materials content of problem substances.

The atlas is designed as an overview of the environmental opportunities and barriers associated with a wide range of building materials. It can serve as a reference book where relevant actors can, quickly and easily, find information about the environmental problems associated with a specific building material from a given period. This allows the atlas to function as part of the preliminary studies in the development of new design strategies the re-use and recycling of building materials (Butera et.al., 2016).

Table 4. Exemplified search on the Material Atlas online tool: opportunities and barriers for reusing or recycling windows” from different time periods (based on Butera et.al., 2016)

Product type	Overall assessment		Evaluation in relation to:			Time period (year)	Hazardous material
	Possibility of re-use	Possibility of recycling	indoor climate (during the operational phase)	External Environment (Potential challenges handling / disposal)	Work environment (Potential challenges by demolition, renovation, reprocessing)		
Double glazed						0-1949	
						1950-1977	PCB
						1978-2020	
Single glazed						0-2020	
Painted windows and door frames						0-1949	Pb , Cd, Cr, Cu, Ni, Zn, As, Hg, Kulbrinter
						1950-1977	Pb, PCB , Cd, Cr, Cu, Ni, Zn, As, Hg, Kulbrinter, Chlorparafiner
						1978-2020	Pb , Cd, Cr, Cu, Ni, Zn, As, Hg, Kulbrinter, Chlorparafiner

3.2.2. Re-purposing – expand the reuse

One of the very often mentioned challenges identified when talking with sellers of re-used product is that materials from recycling centres come in small amounts and vary a lot. This makes application at industrial scale difficult. One option to increase the reuse of diverse low quantity materials is “re-purposing” - a concept of finding new application areas for products and materials initially intended for something else. Re-purposing is an inspirational concept, originating from USA, to stimulate innovation and creativity through examples. There is an extensive database of re-purposing examples with creative applications of leftover products and materials.

For instance, old doors may serve over 20 other purposes - from table to beds or trellis for garden (Figure 8 - Figure 14). Old windows can be turned into e.g. coffee tables, cabinets, gardening frames, chalkboard calendars, coffee tables and so on (Figure 15-Figure 18). However, most of our consumer goods are not yet intelligently designed for re-purposing, and it is not always possible to re-purpose an existing product. Moreover, effects on lifespan of re-purposing in comparison of original purpose is not yet explored. In any case, re-purposing suppose can expand re-use and be a better option from the environmental perspective than disposal.



Figure 8. Repurposing old doors into a bookshelf, a chair with suspension hooks and kitchen shelf with slate board (Source: Newsner)⁷

⁷ <https://www.newsner.com/knep/19-anledning-till-att-aldrig-slanga-din-gamla-dorr/>



Figure 9. Repurposing old doors into different tables (Source: Newsner)



Figure 10. Repurposing old doors into tables photo frame (Source: Newsner)



Figure 11. Repurposing old doors into headboard, childbed and couch (Source: Newsner)



Figure 12. Repurposing old doors into kitchen shelf with hanging possibilities, a unique bar or corner shelf (Source: Newsner)

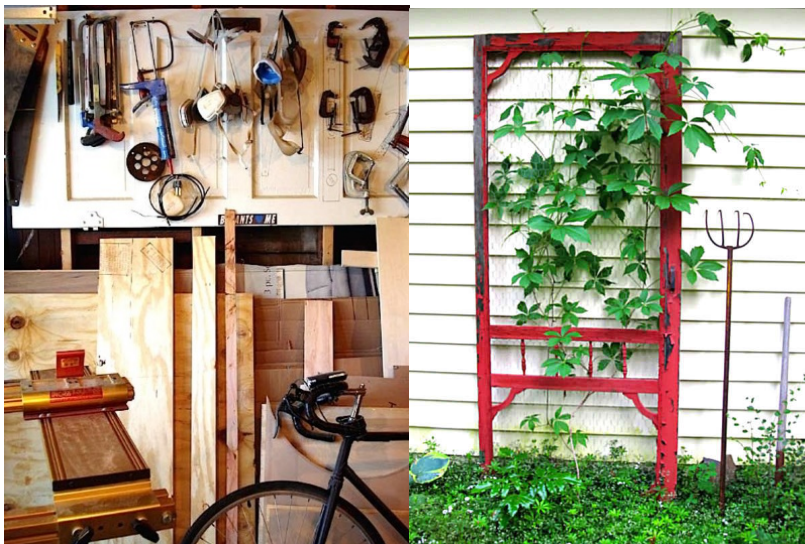


Figure 13. Repurposing old doors into storage of tools or trolley of the garden (Source: Newsner)

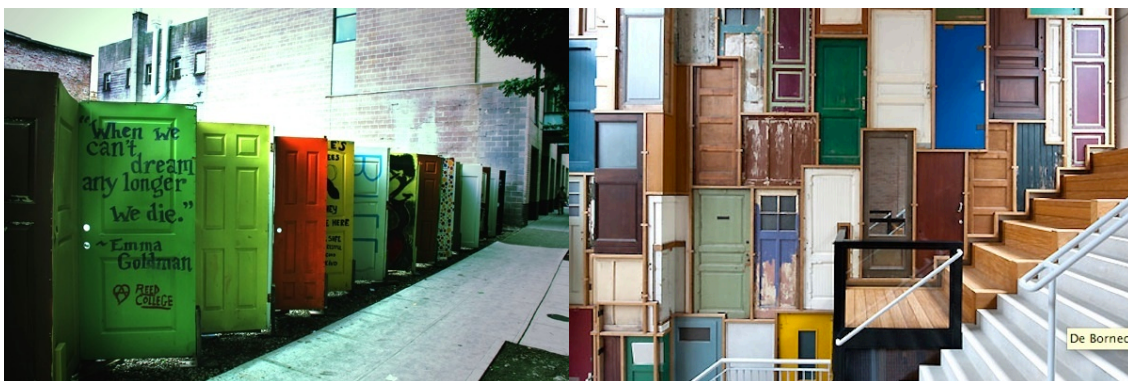




Figure 14. Repurposing old doors for spacious places: a fence and decoration of wall (Source: Newsner)



Figure 15. Repurposing old windows into cabinets (Source: diysweden.se; simonton.com; frkelton.blogspot.com/)⁸⁹¹⁰



Figure 16. Repurposing old windows into antique headboards or a cold frame for garden (Source: pinterest.se & simonton.com)

⁸ <https://www.diysweden.se/diy/inredning/bygga-skap-med-gammalt-fonster/>

⁹ <https://www.simonton.com/blog/repurpose-old-windows/>

¹⁰ <http://frk-elton.blogspot.com/2013/09/gamle-vinduer-blir-til-glasskap.html?m=1>



Figure 17. Repurposing old windows into decoration elements in gardens or homes (Source: [pinterest.se](https://www.pinterest.se) & [simonton.com](https://www.simonton.com))



Figure 18. Repurposing old windows into menu boards, chalkboard calendar or coffee tables (Source: [pinterest.se](https://www.pinterest.se) & [simonton.com](https://www.simonton.com))

Such an idea can be further developed, for example by:

The idea of Re-purposing has attracted a significant interest among large artisan- and do-it-yourself communities in the U.S. and other countries. Usually it works best if facilitated by a convenient platform to find required materials or sharing ideas. Steps to facilitate information sharing and exchange of ideas could, for instance, include:

- a knowledge sharing platform where innovative individuals or organizations share their ideas though pictures, detailed drawings and descriptions; an example of such initiative could be current blogs, such as "Do-It-Yourself" magazine in Sweden;
- linking material reuse to climate issues by showing the amount of greenhouse gas savings due to re-purposing different products and materials; given a considerable climate awareness in Sweden this could be an effective measure to promote reuse ideas.

As an established example on how companies can inspire costumers to increase reuse, including repurposing, is the Danish reuse company "Genbyg" which runs a reuse market for building products (see also section 2.5.5.2). Apart from sale of reuse building material, Genbyg.dk has a blog

where costumers share and find inspiration in other customers “do-it-yourself” projects. As an example: if a customer has made a project from reused products or materials bought from Genbyg they can share the project with others by e-mailing Genbyg, include pictures –and a short description of the project, including how the material has been used. The story is then shared on the blog as inspiration to others. As an incentive for more people to share ideas, Genbyg honour all contributors with a bottle of organic red wine. Examples from the blog can be found in figure Figure 19 and Figure 20.



Figure 19 Repurposed building material: Orangery made from reused building material (genbyg.blog.dk)



Figure 20 Repurposed windows: Shattered windows function both as doors and partition windows in a restaurant (genbyg.blog.dk)

3.2.3. Value chain perspective as a tool to initiate re-use

One of the main challenges for reuse of C&D materials are their (geographical) availability and insufficient volumes of reusable materials. However, on the other hand, according to our interviews with municipal waste management companies and second-hand actors, there is also low demand for some of the collected materials. A more active search for relevant local business interested in reuse including matchmaking services for materials available at recycling centers can facilitate the reuse. An example, how to increase the reuse of C&D waste from the recycling center

was done by the Danish waste management company Affald Plus, which conducted an experiment on preparation for re-use.

The aim of the experiment was to investigate potentials for making a business case on local re-use of waste (resources) from the reuse site from a value-chain perspective. This included an investigation where the aim was to identify one or more fractions from the re-use site, which could fit directly into the production of one of the local businesses, and thus make a business case. The experiment involved mapping potential local actors (business) and their needs. Secondly, meeting with potential actors, discussing potentials and constraints for a future cooperation.

As a result, Affald Plus identified three *potential* local value chains for specific product groups; waste wood, glass- and e-waste (Niras, 2017). It was particularly desirable to establish a local value chain around waste wood because it was, by weight, the largest waste fraction within the focus materials handled by them and also one of the fractions which the waste company has greatest difficulties getting disposed of (Niras, 2017). In the waste wood value chain, two potential local partners could come into play: a local Furniture - and Design Company named “Smedehytten” and a local company named “Egen Vinding & Datter” who could act as supplier of elements of reused wood for Construction -and Interior Design Companies by providing them with e.g. panels, bar counter, furniture etc. The company “Smedehytten” design and produce furniture on small scale. It is therefore expected that they will only buy smaller amounts of wood for their production (Niras, 2017, Moalem et.al, 2020). Figure 1 illustrate the potential partners involved in the value chain with the municipal waste management company as a main supplier of waste wood.



Figure 21. Potential local wood value chain. A cooperation between the municipal waste management company Affald Plus and two local companies (Moalem et.al, 2020 based on Niras, 2017)

Key learnings from the experiments was that conducting local market screening is a central element but mapping -and reaching out for new potential local partners is costly and time consuming. Further, a change in mindset e.g. think in *value chains* and how local companies can be weaved into those chains is a central element of value chain thinking (Moalem, Remmen, & Hirsbak, 2020; Niras, 2017). Overall, the experiment was successful and very positively accepted

by local businesses, however, one of the main issues was securing a certain volume and supply of specific products/fractions, thus the new system should include a storage. A solution for the municipal waste company was therefore to invest in and build a storage place to keep the selected materials (see section 3.4).

3.2.4. Warehouses for re-use building materials

Lack of storage space was mentioned as an important issue during our interviews. The space is lacking to both keep the materials for other renovation projects and to leave for reuse of other second-hand actors. In 2019, a Danish municipal waste management company Affald Plus opened both storage and a physical marketplace “Warehouse for re-used building materials” (PlusByg). This as an attempt to increase the reuse at the municipal recycling center. At PlusByg the local waste management company sells building materials (e.g. doors, windows, insulation, tiles), tools, larger furniture, house - and garden items (see figure 22)



Figure 22. The municipal waste management company AffaldPlus run a second-hand reuse market named “PlusByg”. Ref:www.affaldplus.dk

Items sold in the warehouse stem from several sources, e.g. citizens hand in items for reuse at the re-use site (adequate to recycling centers in Sweden). In addition, employees at the re-use site collect things out of the waste containers which are “too good to be thrown out” and finally, items stem from local businesses. In order to create an incentive for local businesses to sort out and hand in reusable material to be sold in the warehouse, the waste company cooperate with private businesses who are willing to deliver reusable products and materials directly to the site of the warehouse, free of charge and thus save the waste fee. In Denmark there is a debate concerning legal issues of municipal waste management companies preparing waste for re-use. The debate mainly consists of two criticisms: (1) it is a task for private sector to manage and sell re-used goods

as it *undermines* business and industry and (2) goods for re-use, should be handled by and for charity. The “Warehouse Model” is an attempt to test the legal “grey-zone” and thus see how to navigate in the current waste management legislation (Moalem, et.al, 2020).

In addition to the Warehouse, the municipal waste management company runs a range of second-hand shops on the premises of the re-use sites. Since the opening of the Warehouse, the waste company has increased the re-use rate. Apart from the sales area, the warehouse also holds a repair space where products are prepared for re-use e.g. bicycles and white goods (Moalem et al., 2020).



Figure 23. The Reuse Market “PlusByg” also function as a storage, securing a certain volume and supply on specific products/waste fractions (www.affaldplus.dk)

In addition of being a “warehouse”, the building functions as a storage where building materials and products can be kept until a customer demands it. This was a key learning from the experiment around value chain “thinking” (see section 3.3).

The waste company also uses the “warehouse” to store and sell secondhand furniture. Previously, the waste company experienced a great challenge with furniture in the waste companies’ secondhand shops because items occupies a lot of space and well-functioning furniture were therefore prematurely recycled or incinerated. Now, the waste company can bring unsold furniture to the “warehouse” where they can be displayed and wait for a buyer.

3.2.5. Digital tools

The development of digital tools and marketplaces could increase cooperation, information exchange, awareness along the value chain and decrease the costs of C&D waste management.

3.2.5.1. CCBUILD digital tools (Sweden)

In Sweden, a platform named “*Centrum för cirkulärt byggande*” (The Center for Circular Construction) has the aim to facilitate a more resource efficient construction through collaboration, dissemination of knowledge and developing a more accessible market for circular products and services. The platform is operated by IVL Swedish Environmental Institute and other parties within the Vinnova-funded research project “Circular product flows in the construction sector -

recycling of building materials on an industrial scale”. The platform is mainly designed for business-to-business cooperation, mainly large facility owners and C&D companies. Among the outcomes of the project were support tools developed to inventory and evaluate the existing products in C&D projects. Digitalised information about the available C&D resources increased their reuse potential and made products more available to new users. The tools also include support for quality assessment and evaluation of the reuse potential in terms of possible savings of resources / waste, reduced greenhouse gas emissions and the economic value of reuse.

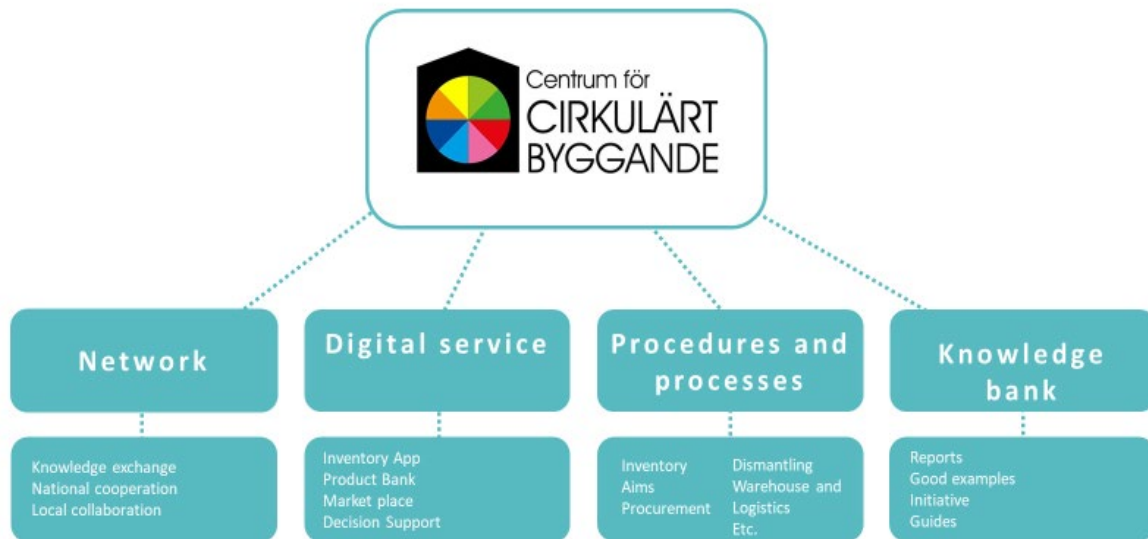


Figure 24. The main topics included in CCBUILD project and website (www.ccbild.se)

The digital tool consists of a product database with, at current state, three applications: an inventory app, a product bank and a digital marketplace. The tools were developed to support reuse in C&D projects within and between organisations. Users of the tools are property owners, architects, entrepreneurs and consultants. Their main focus is to support circular material flows. The tools has been used in more than 200 projects so far, however, they are still under development and not commercially introduced.

1. Inventory app (in operation). The app allows to predefine product parameters and quality criteria to simplify a uniform assessment of their suitability for reuse. The tool can be used before placing materials onto a digital marketing place or to a product bank for organisation’s internal or external use. It is synchronized with both CCBUILD’s product bank and its marketplace, which means that it can be used for retrieving statistics, reports and key figures regarding climate impact.

2. Product bank (in operation but under development). It is a database and a foundation of the CCBUILD project’s services. It can be used as base for inventorying and managing reusable products within an organization (e.g. built-in materials or those in storage). Decision support information regarding CO₂ equivalents intensities of products and materials, their weight (in kg), and some quality criteria (e.g. condition, function, product information) could be included manually in the app. The tool enables a specification of a range of product-specific parameters and different quality criteria that enable versatile filtering, sorting and different statistical support, including product/material value assessment in Swedish kronor and saving of CO₂ equivalents from reuse. The user interface and some other functionalities are still under development, but a prototype version is in operation and can be used by project partners.

3. Market place (in operation but under development). The marketplace tool is designed to cover both reusable building products and services. The goal is to facilitate the reuse of products and materials that are inbuilt or already dismantled. So far, no trading is done through this marketplace – the trading is done by the different actors respectively – at the moment this is only a platform for making stakeholders visible and displaying the available assortment of reusable products and make it easier to compile product of the same type from different suppliers. The tool could be used both as an internal-organizational marketplace or as entirely public marketplace. The marketplace in operation, although some interface features are still under development.

3.2.5.2. Market place in practice (both digital and physical): GenByg (Denmark)

The Danish company “Genbyg.dk” has created a business around re-use with the establishment of a reuse market, including a digital platform from where they sell re-use building and construction materials. Genbyg.dk is Denmark's largest online construction market with used building materials. The vision of Genbyg.dk is that sustainability pays off economically, socially and not least for the sake of the environment. “Genbyg” has existed since 1998 and specialize in the purchase and resale of used building materials. Used doors, windows, lamps, floors, door handles, timber and much more come to life when it is gently taken down and transported to the construction market in Amager. All materials are registered in Genbyg's photo studio and placed on the web in the webshop, so that both private customers and professionals can find old craftsmanship, solid building materials and fun, inspiring unique items. According to Genbyg.dk, the company has over 1 million visitors annually in their web shop and with customers from all over the world. At present, Genbyg.dk has more than 127.000 products for sale on the webshop (www.genbyg.dk 22.04.2020).

Genbyg buy used materials from private customers. If costumers have an item or material they would like to sell, customers can contact Genbyg by e-mail. In order for Genbyg to assess it, it is important that costumers e-mail as much information as possible to Genbyg, including pictures of the items so that Genbyg can get a clear idea of appearance, condition etc. and a good description of the item to the best of its ability and include any number and age of the material. One of the employees who handles purchases will then respond to the e-mail.



Figure 25 “Genbyg” has existed since 1998 and specializes in the purchase and resale of used building materials. Customers are both private and professionals. In addition to the physical shop, the company went “online” a few years ago and now runs the largest web shop for reused building materials in Denmark (www.genbyg.dk)

3.2.5.3. The Give-away scheme and digital portal (Sweden)

The Swedish municipal waste management company Stockholm Vatten and Avfall has introduced a *Give-away* scheme in their mobile recycling centre. The mobile recycling centre has a dedicated room/give away shop where customers can collect items or materials free of charge. This scheme is different from conventional SWAP schemes (see section 2.3) in the way that here the staff pre-sort the reusable items into two fractions. One consists of items of a higher economic value, easily acceptable by the second-hand actors (that Stockholm Vatten and Avfall has contracts with). The second fraction consists of items with a lower economic value, that are not sought after by the reuse actors, but still suitable for reuse, the so-called *Give-away* items. The latter could be taken by other households that still see the possibility for items to be re-used.

Uniquely from “conventional” SWAP activities at other municipalities, Stockholm Vatten and Avfall is also developing and going to test a digital portal that facilitates the transfer of Give-away items. The tool will be tested to see if items that are now recycled can have a longer life for the right user. Reusable items will be photographed for the portal and customers will be able to book reusable products before physically coming to recycling centre. Construction and demolition materials will be listed alongside with other product groups, such as e.g. used books, toys, office materials, furniture and other small household utensils.

Such digital platform is thought to overcome the many shortcomings present in “conventional” SWAP schemes. Digitalisation reduces the on-site load by the visitors, since only the pre-booked items can be collected and only off rush-hours. It also helps avoiding potential conflicts between visitors when several interested parties want to possess the same item. The system also spares unnecessary transports and reduces environmental impacts.



Figure 26. The Give-away scheme and digital portal in Stockholm (Source: Karin Sundin, Stockholm Vatten och Avfall).

4. Conclusions

C&D products and materials stemming from renovation projects have a considerable reuse potential. The left-over new building materials (e.g. isolation), as well as used doors, windows, bathroom porcelain (toilet chairs and tubs), electrical appliances are usually accepted at recycling centres and are usually demanded on the second-hand market. The reuse potential varies among different products groups pending their quality and ultimately end-value. Antique or rare products usually have a greater value and are in greater demand. Reusable products/materials from households' renovations are usually available in smaller quantities and usually of varying and lower quality. This might not be the case for those coming from larger industrial construction/demolition projects.

Some of the main actors for C&D material reuse are private households, small renovation and construction companies as well as municipal waste management companies and second-hand actors.

The reuse could happen both before materials/products come to the recycling centres (prevention) and after the materials/products come to the recycling centres (reuse, including preparation for reuse). However, generally low interest and the lack of habit of reusing among the potential clients is one of the most important challenges for reuse on a higher scale. This is largely due to volume and quality limitations and higher costs – both in terms of disassembly & preparation for reuse as well as transports. Other issues relate to limitations and the costs of storage space, proper handling during storage and the potential risks of undesirable /hazardous substances entering the reuse stream. Furthermore, there is a considerable lack of information on regulations regarding the reverse logistics and handling of reusable C&D flows. The challenges to leave the materials for others to reuse were similar to those challenging the reuse before it comes to recycling centres, but the economic reasons being dominated here.

According to municipalities responsible for the management of this kind of waste, the most preferable option would be a reuse before materials come to recycling centres, which would



alleviate the challenges of lacking space and personnel. The existing municipal initiatives of second-hand activities have usually high operational costs and require significant investment. Furthermore, lack of information, knowledge and awareness throughout the value chain were also often named by both municipal and second-hand organizations.

The study was based on both qualitative interviews and survey with limited response rate. This implies that results should be interpreted with caution as it gives rather a limited picture.

Our study also presents examples and case studies that seemingly address several of the above-named challenges. Some simple screening tools, such as the “Material Atlas” for quality and risk assessment of different C&D products, seemingly could improve the information regarding material safety and several environmental issues of reusable materials.

The “re-purposing” concept might also be useful to overcome challenges related to product and material diversity. Initiatives exploiting this concept usually offer an ample selection of reuse ideas which often bridge reuse applications in construction, renovation or different artistic applications.

Information platforms, such as “Digital marketplace” and “Digital products database” are designed to reduce the transaction costs of reverse logistic chains for re-usable assets. The study presented a selection of case examples from different countries detailing how municipalities could build or facilitate cooperation across the C&D value chain.

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5. Appendices

Appendix 1. Most important challenges for reuse based on survey of C&D companies.

For materials from OWN organisation	For material from OTHER organisations	Challenges to leave materials for re-use organisations
Low interest among the potential clients (8)	Low interest among the potential clients (6)	Expensive to reuse (e.g. disassembly, preparation) (8)
Risk of reusable products may contain undesirable substances (6)	Lack of storage (a company has no place to keep materials for reuse) (4)	Insufficient volume (quantity too small scale) (5)
Expensive to reuse (recycling processes, e.g. disassembly or preparation) (3)	The quality of reusable products is not good enough or of uneven quality (4)	Lack of time to disassemble appropriately (4)
New products are too cheap compared to reusable (3)	Availability (hard to find required products) (3)	Expensive to transport or lack of/ transport options (2)
Lack of information on regulations (3)	New products are too cheap compared to reusable (3)	Low client interest (3)
Expensive to transport (or lack / limited transport options) (2)	Lack of information on where to buy/retrieve or leave for reuse (2)	Availability (hard to find second-hand actors) (2)
Insufficient volume (2)	Lack of information on where to buy/retrieve or leave for reuse (2)	Lack of information on where to buy/retrieve or leave for reuse (2)
The quality of reusable products is not good enough or uneven quality (1)	Expensive to transport (or lack / have limited transport options) (2)	The quality of reusable products is not good enough or uneven quality (1)
Lack of storage to keep reusable materials (1)	Expensive to reuse (e.g. disassembly or preparation) (1)	Lack of storage to keep reusable materials (1)
Availability (hard to find required products) (1)	Lacks the habit of reusing (1)	Expensive in other means (1)
	Insufficient volume / quantity (too small scale) (1)	



Appendix 2. Most important challenges for reuse based on interviews with private households and companies at ÅBD.

Private households	Companies
Lack of information on where to buy/retrieve or leave for reuse (2)	Expensive to reuse (e.g. time consuming to find products) (4)
Availability (can't find products I would need) (2)	Availability (can't find products I would need) (4)
Time-consuming to find specific products (1)	Low client interest, e.g. wants to have cheap (3)
New products are too cheap compared to the reusable ones (1)	Reusable products are too expensive compared to the new ones (2)
Lack of habit/norm to reuse (1)	The quality of reusable products is not good enough or uneven quality (2)
Lack of information how to reuse (1)	Expensive to transport (or lack / have limited transport options) (2)
Cannot identify any issues (1)	Cannot identify any issues (1)
<hr/>	
Don't know/doesn't want to answer (7)	
Missed to interview (Återbyggdepå clients who passed by but were not possible to interview) (7)	
<hr/>	

Appendix 3. Most important challenges for the companies and craftsmen based on phone interviews.

Companies
Low client interest (4)
Expensive to reuse (the actual reuse process, e.g. disassembly or preparation) (4)
Lack of storage (I/company have no place to keep materials for reuse) (4)
New products are too cheap compared to the reusable ones (3)
Lack of information on where to buy/retrieve or leave for reuse (4)
Lacks the habit of reusing (2)
Availability (can't find products I would need) (3)
<hr/>

Appendix 4. Most important challenges based on literature (Miliute-Plepiene et al., 2020) and interviews with municipal waste management companies/reuse companies

Second hand actors	Municipal waste management companies (recycling centres that accept materials for recycling)
Low interest from building companies to leave materials for reuse	Lack of personnel at recycling centres to instruct/guide craftsmen/companies or private to leave for reuse (5)
Variety of products from recycling centres are very high and the quality is usually worse than the quality from bigger recycling projects	Lack of place at the recycling centres for reuse Shortage of awareness of both private and companies to re-use (3)
It is more expensive/time consuming to sort out materials at the recycling centres (if it is unmanned recycling centres) than to collect it from bigger projects	Private households usually leave more than companies. Many products could be reused; sometimes up to 50% of products are not reused (2)
Reliable statistics on reuse rates are lacking among almost all reuse forms at the municipalities	Market price for new products is lower compared to re-used ones (2) It is not so difficult to increase collection, but it is difficult to sell. Variety of products is very high (2).
Lack of information, knowledge and awareness throughout the reuse chain	Time requirements and sorting inconvenience deter costumers from contributing to reuse (2)
Costs for the sales-based reuse are quite high and for the most part they consist of personnel costs and local rent.	Risks for contamination (e.g. older window frames & doors can contain led or PCB that should be separated as hazardous materials (cannot be reused/recycled) (2)
Recyclable products that are left at recycling centers are not of the highest economic value compared to those provided by companies.	ÅBD do not advertise enough their ability to collect reusables.

Appendix 5. Survey questionnaire (in Swedish).

Renoverar du (ditt företag) hus (kök, badrum, utomhusmiljö) åt privatpersoner? Nu har du möjlighet att komma med inspel på vad som behövs för att underlätta återanvändning eller vilka hinder du möter för att göra det idag. Fyll i enkäten nedan och gör skillnad! (det tar 5–10 min).

Enkäten hittar du här. Enkäten är en del av projektet "Resursbank: Öka återanvändningen av bygg- och rivningsavfall från hushåll", finansierat av Vinnova. Projektet genomförs av IVL, Sveriges Byggindustrier, Stockholm VA, RENOVA och HMXW arkitekter. Syftet med projektet är att underlätta ett mer effektivt kunskapsflöde mellan olika aktörer i värdekedjan för att minska avfallet och öka återanvändningen.

Renoverar/inreder ni hus (t ex kök, badrum, utomhusmiljö) på uppdrag åt privatpersoner?

- Ja -> vidare till undersökning
- Delvis -> vidare till undersökning

- c. Nej → tack för deltagandet, enkäten riktar sig mot renoveringsverksamheter
2. Verksamheten finns i och/eller i närheten av (30 km):
 - a. Malmö
 - b. Göteborg
 - c. Eskilstuna
 - d. Stockholm
 - e. Halmstad
 - f. Borås
 - g. Lund
 - h. Simrishamn
 - i. Ystad
 - j. Staffanstorps
 - k. Svedala
 - l. Skurup
 - m. Annat (specificera ...)
 3. Återanvänder ni byggmaterial / byggprodukter / byggkomponenter:
 - a. Ja → gå vidare fråga 4
 - b. Nej, men jag lämnar bort till andra aktörer för återanvändning → gå vidare till fråga 4
 - c. Nej, jag överlämnar till beställaren att ta hand om avfallet/överbliven material → gå vidare till fråga 6
 - d. Nej, jag överlämnar till ÅVC:er eller avfallsbolag att ta hand om avfallet/överbliven material på → gå vidare till fråga 6
 - e. Vet ej → gå vidare till fråga 6
 4. Hur mycket återanvänder ni (av det som genereras totalt):
 - a. Återanvänder själva material som uppstår i egen verksamhet (uppskatta gärna andel (%) av det som totalt genereras)
 - b. Återanvänder själva material som uppstår i andras verksamheter (köper eller får gratis från andra återbruksaktörer) (uppskatta gärna andel (%) av det som totalt genereras)
 - c. Återanvänder ej, men lämnar till återbruk hos andra återbruksaktörer (uppskatta gärna andel (%) av det som totalt genereras)



5. Vilket sorts material/produkter återbrukar eller lämnar ni oftast bort till återbruk (fler kan markeras):

	Återanvänder själv från <u>egen</u> verksamhet	Återanvänder själv från <u>andra</u> återbruksaktörer	Återanvänder ej, men <u>lämnar</u> bort till andra för återanvändning
Överblivet nytt material (t ex isolering, gipsskivor och dyl.)			
Äldre produkter från rivning/reovering:			
Tegel			
Betong& stenplattor			
Tak/nockpannor			
Balkar			
Dörrar			
Fönster			
Trämateriäl (skivor, virke, reglar och dyl.)			
Badrum (toalettstolar/badkar och dyl.)			
Köksinredning			
Byggpallar			
Annat (specificera...)			

6. Vilka är de största hindren för att **återanvända eller lämna bort** mermaterial/produkter? Välj och gradera de 3 viktigaste hindren bland de exempel som listas nedan. Svara i cellerna på en skala från 1 till 3:
 1 = det **viktigaste** hindret,
 3 = det **tredje viktigaste** hindret,

	Återanvända själv från <u>egen</u> verksamhet	Återanvända själv från <u>andra</u> återbruksaktörer	Ej återanvända, men <u>lämna</u> bort till andra
Lågt intresse hos beställaren			
Risk att återanvändbara produkter kan innehålla oönskade ämne/farliga kemikalier			
Dyrt att återbruka (själva återbruksprocessen, t ex demontera eller förbereda för återanvändningen)			
Dyrt att transportera (eller saknar/har begränsade transportmöjligheter)			
Nya produkter är för billiga i jämförelse med de återanvändbara			
Dyrt pga annat (specificera) t.ex. regelkrångel, administration, skatter, kunskap, osv) (.....)			
Lagerbrist (har ingen plats att behålla material för återanvändningen)			
Tidsbrist att demontera på ett lämpligt sätt			
Tidsbrist för att leta efter återanvändbara produkter			
Informationsbrist om hur man kan återanvända			



Informationsbrist om vart man kan köpa/ta emot återanvändbara produkter eller lämna för återanvändningen			
Informationsbrist om miljönyttan			
Informationsbrist om regelverk			
Kvaliteten av återanvändbara produkter är inte tillräckligt bra eller ojämn kvalitet			
Saknar vanan att återbruka			
Tillgänglighet (hittar inte produkter som jag skulle behöva)			
Otillräcklig volym/kvantitet (för liten skala)			
Annat (specificera....)			

7. Hur många anställda har ditt företag?

- a. < 10 anställda
- b. 10-50 anställda
- c. > 50 anställda
- d. vill inte svara

Tack för medverkan!

Appendix 6. Questions to the construction contractor / craftsman and private households who leaves materials at recycling centres or buys materials at Malmö Återbyggedepå (in Swedish)

Frågor till byggentreprenör/hantverkare och privata hushåll som lämnar på ÅVC:er

Vi skulle vilja ställa 3 frågor. Det kommer att ta max 2-3 min.

- Är ni från ett företag? Sysslar ni med renovering för privatpersoner?
- Vilka är de 3 viktigaste sakerna som hindrar en större återanvändning?
- Vilka är de 3 viktigaste sakerna som skulle främja en större återanvändning?

Appendix 7. Questions to the private household's renovation companies (producers, users and potential buyer of reused materials).

Intervjufrågor till producenter/användare/köpare av återbruksmaterial från renovering av hushållen

1. Hur **mycket** och **vilken sort** av byggprodukter återanvänder ni? Andel (%) av totalt återanvänder ni själva av material/produkter som uppstår från egen verksamhet, andel (%) återanvänder ni själva av material/produkter som uppstår från andra återbruks aktörer, andel (%) som ej återbrukas, men lämnas till återanvändningen hos andra återbruksaktörer (återbruksbutiker, ÅVC:er osv.)? Om inget återanvändas, varför? Vilka bygg- och rivningsavfallsfraktioner har den högsta potentialen för återanvändning (t.ex. ekonomisk och teknisk)?
2. Vet ni var kan man köpa/ta emot återanvändbara byggprodukter i närheten?
3. Andel (%) av kunder/beställare som är intresserade av återbruk?
4. Vilka **hinder** ser ni för ett ökat återbruk idag (generellt)? För att öka återanvändningen av **dörrar, fönster** eller **byggpallar**?
5. Vilka rutiner har ni kring önskade **ämnen** i äldre produkter för återbruk?
6. Av vilken **anledning** använder ni återbruksprodukter i er verksamhet? Av vilken **anledning lämnar** ni återbruksprodukter till återbruk på secondhand butiker eller ÅVC:er?
7. Vad behövs det för att ni skulle använda återbruksmaterial ännu mer? Hur kan återbruket öka i framtiden?
8. Vilka konsekvenser skulle ett ökat återbruk få för er verksamhet?
9. Hur stort företag är ni (t ex antal arbetare)? Vilken sorts verksamhet tillhör ni (är det bara renovering, nybyggnation etc.) Var ligger/pågår er verksamhet?

Appendix 8. Questions to the municipalities (recycling centers) that are collecting for reuse (in Swedish)

1. Vilka material som idag lämnas på ÅVC skulle lätt kunna lämnas för återanvändning istället?? Varför?
2. Vilken andel (%) av material (dörrar, fönster) som lämnas på ÅVC skulle kunna återanvändas istället på en Återbyggedepå? Varifrån kommer dessa produkter? Från företag? Privata aktörer?
3. Vilka insamlingsinstruktioner eller andra informationskällor är tillgängliga för kunder (t.ex. på skyltar)?
4. Behandlas/sorteras avfallet/produkterna på något sätt innan det skickas till återanvändning?
5. Vilka material är mest populära för second hand att ta hand om?
6. Vilka är de viktigaste utmaningarna för att samla in mer byggmaterial för återanvändning till återanvändning (t.ex. relaterat till insamling, information, juridiska problem)? Hur kan man lösa dessa utmaningar?
7. Har ni några förslag eller erfarenheter som skulle kunna hjälpa till att **öka** återanvändningen?

Appendix 9. Synthesis of the results and ideas for Stage 2

This appendix synthesises the results gathered from the study with the focus on aspects relevant for matchmaking between the actors throughout value chain and information and knowledge exchange throughout the C&D value chain.



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Table 5. A framework for implementation and synthesizes of results.

Challenges	Possibilities (incl. tools examples)	Benefits	Target group	Existing infrastructure	Implementation/comments	Relevant for STAGE 2
Material quality	Materials Atlas	Easy screening for reusability and quality	SMEs and households, secondhand actors and recycling centres working with reuse	Danish example; no similar tool (website or studies) in Sweden	A pre-study is required; it might be integrated later into a digital tool (on website such as e.g. CCBUILD or other).	Yes
Low availability Diversity of products	Digital marketplace (for households and SMEs)	Decrease transition costs	Private households and SMEs Consumers-to-consumers and consumers-to-businesses	Selling through Blocket and FB groups is the main practice today among private households and (partly) professionals Digital marketplace by Stockholm Vatten och Avfall (still under development)	Municipalities can initiate or facilitate social media sites/platforms (e.g. s FB group) to increase reuse among households and small companies	Scale up SVOA tool for municipalities
	A “digital marketplace” for professionals (incl. e.g. an inventory tool and a product bank)	Increase availability	Municipalities and companies Business-to-business	The digital marketplace CCBUILD targets only the business-to-business segment (large property owners and C&D companies). The tool still is a prototype in development and to be tested and implemented (further developed in stage 3 of CCBUILD)	A potential exists to include municipalities into marketing, especially where second-hand market is not present. This requires warehouses for collected materials and additional resources for inventory and operation of the marketplace.	Applied for funding CCBUILD; 1 for stage 3.
	Re-purposing	Inspiration and new application areas for reuse	Private households and SMEs	No	Integrated in a CCBUILD or other webpage (e.g. second hand actors, municipalities), as part of an existing digital marketplace or a separate knowledge-sharing platform. Could be related to climate benefits	Yes



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Challenges	Possibilities (incl. tools examples)	Benefits	Target group	Existing infrastructure	Implementation/comments	Relevant for STAGE 2
Low interest for private households	Informational campaigns	Increased awareness	Private households and SMEs	n/a	Throughout listing the climate or other environmental benefits of re-use (a report, where the climate benefits of concrete products are listed) – as a part of digital marketplace or a separately presented in a knowledge sharing platform or as part of CCBUILD	Yes
	Lists of existing second-hand actors or SMEs working with re-use (e.g. digital maps)	Increased informational flows	Private households and SMEs		A separate knowledge-sharing platform or part of an existing scheme/initiative (e.g. CCBUILD)	Yes
Lack of business interest and actors	List of good dismantling practices for how to work with specific products for reuse (dismantling, transport etc.)		Private households and SMEs	Some instructions are present at CCBUILDs websites	Develop further existing examples in CCBUILD	Yes
Lack of information on regulations	Descriptions of regulation, requirements for specific products for reuse	Active facilitation of matchmaking	SMEs and municipalities	No existing examples in Sweden	A separate knowledge-sharing platform or part of an existing scheme/initiative (e.g. CCBUILD).	Yes
Availability (both actors and materials)	Active search, mapping and connecting business required reusable materials with those	Active facilitation of matchmaking	Municipalities and SMEs	No existing examples in Sweden	Requires storage for collected materials at recycling centres	



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Challenges	Possibilities (incl. tools examples)	Benefits	Target group	Existing infrastructure	Implementation/comments	Relevant for STAGE 2
	available at recycling centres					



Appendix 10. Plan for the Vinnova's Stage 2

The preliminary plan for the Stage 2 might include either:

- development of a new knowledge sharing platform specific for materials that come from households' renovation, or
- integration of required information/knowledge into existing platforms/data bases (e.g. CCBUILD).

The information/knowledge might include:

1. Swedish version of Material Atlas;
2. Development/adaptation of products' database & digital marketplace for municipalities;
3. Development digital marketplace for households and small companies;
4. Tool(s) based on the concept of Re-purposing;
5. Informational campaigns/awareness raising (households and/or SMEs) through existing or new platforms;
6. Other information/networks:
 - a. Existing second-hand actors;
 - b. SMEs working with reuse projects on households' level;
 - c. Regulation, requirements for specific products for reuse;
 - d. Instructions/descriptions on good dismantling practices how to work with specific products for reuse (how to dismantle, transport etc.);
7. Mapping local business that might require materials available at recycling centres.



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