Reuse, recycling and recovery of construction and demolition waste in the Nordic countries

AN INVENTORY OF FACILITIES AND TECHNIQUES IN THE NORDICS INCLUDING AN OUTLOOK ON OTHER EUROPEAN COUNTRIES.

Nordic Council of Ministers

Contents

This publication is also available online in a web-accessible version at: https://pub.norden.org/temanord2023-544

Executive summary

Construction and demolition waste (CDW) accounts for more than a third of all waste generated in the EU. The EU Waste Framework Directive (*2008/98/EC*) states that by 2020, the preparing for re-use, recycling and other material recovery is to be increased to a minimum of 70 % by weight for CDW. Studies show that the Nordic countries are not yet reaching this target.

At the same time, one of the three strategic priorities in the vision of the Nordic Councils of ministers "A green Nordic region" is promoting green transition and working towards carbon neutrality and a sustainable circular and bio-based economy. The main goal of this study is to support the circular economy domain while also contributing to the achievement of the goal of "Resource-efficient and non-toxic cycles". To support the goal, the study aimed to identify and present relevant techniques and facilities regarding reuse and recycling of construction and demolition waste in the Nordic market. It also included an inventory of the construction and demolition waste streams that currently are difficult to reuse or recover and finding ways forward to improve the situation.

EU legislation and targets serve as the foundation for how waste should be handled in the respective countries. Additionally, there are country-specific legislations applied nationally concerning CDW, with some countries, such as Denmark and Finland, having more extensive and stricter legislation than what the EU regulations entail.

The primary methods for treating CDW in the Nordics involve low-value recovery, such as energy recovery and backfilling. Some of the key challenges associated with recycling and reusing CDW include treatment and transportation costs, as well as the lack of on-site sorting. In Denmark, which boasts the highest recycling rates in the Nordics, recycling is generally less expensive than other treatments, largely owing to short distances and high landfill costs. Conversely, the widespread availability of waste incineration capacity and inexpensive raw materials, such as wood and aggregates, across most of the Nordics hinders the growth of recycling.

Both on-site sorting and pre-demolition audits were acknowledged as important factors for attaining high recycling rates and obtaining high-quality materials from CDW recycling. On-site sorting for both construction and demolition waste aids in producing high-quality materials for recycling. The pre-demolition audit helps identify and separate materials containing harmful substances used in previous decades, serving as an essential tool to identify reusable construction elements.

CDW fractions such as gypsum waste, mineral wool waste and reject from mechanical treatment of mixed CDW have been considered problematic to recycle in certain Nordic countries. These waste fractions have higher recycling rates in other countries where good treatment examples and demolition practices could be identified in this study. For example, in Denmark the reject from mechanical sorting of CDW is not considered as an issue, as CDW is separated more efficiently on-site.

The lack of detailed statistical information has been identified as an obstacle for conducting thorough analyses on which waste material streams are not currently recycled. For instance, numerous waste fractions are commonly consolidated under a single waste category (e.g., mineral waste). "You can't manage what you can't measure" applies here and to better identify and encourage the recyclability and reuse of specific material categories, significant potential lies in improving the sorting, documentation, and reporting of CDW. Among the Nordics, Denmark currently possesses the most comprehensive CDW statistics available. Denmark also reports significantly more CDW per capita, which could be due to, e.g., more detailed and comprehensive data, higher rate of stone buildings that weigh more than wood buildings, and that due to short distances, more waste is recorded instead of direct backfilling or recycling of mineral materials on-site. Also, the statistics can vary a lot from year to year.

Table 1: *Summary of the main CDW treatment methods for different fractions in Nordics.*

	Reuse	Recycling	Material recovery	Energy recovery	Disposal
Mineral (concrete, tiles, etc.)			DA, FI, IS, NO, SE		
Metal		DA, FI, IS, NO, SE			
Glass		DA, FI, NO, SE	IS		
Wood		DA		FI, IS, NO, SE	
Plastic				DA, FI, IS, NO, SE	
Plaster		DA, NO, SE			FI, IS
Mineral insulation wool		DA			FI, IS, NO, SE
Reject from mechanical CDW separation					FI, IS, NO

In the study, initiatives, and methods of CDW recycling and reuse in other European countries with high recycling rates are briefly described. Case examples highlight various successful business opportunities and techniques recycling practices and reuse of materials, as well as concludes with a policy overview of high-performing countries, such as reuse of bricks or other materials using techniques adapted to local market, sorting using AI and examples of recycling materials that are difficult to recycle in other countries. High-performing countries share common features such as effective legislation promoting a circular economy, the presence of suitable businesses and facilities, and innovative projects often in public-private partnerships.

The drivers influencing CDW recycling and reuse can be categorized into legislative and political, economic, technical, social, and cultural factors. This study emphasizes recommendations that underscore the significance of unified approaches within the Nordic countries and the EU. These recommendations include implementing end-of-waste regulations, extended producer responsibility, climate and resource targets, providing waste tax incentives, creating market value, establishing investment funds, improving on-site sorting, and developing standardized guidelines.

This study concludes that:

- The barriers for increased reuse and recycling of CDW are not technical. Techniques for recycling and reuse are available, but the upscaling of these are met with different legislative, economic and social barriers in all countries.
- The biggest barriers are economical and for some regions especially, long distances and small volumes. Also, attitudes and norms play a role.
- There is a lack of economic incentives both to recycle CDW and to use recycled materials.
- Data gathering and reporting is difficult.
- Better on-site sorting would enable more high-quality reuse and recycling.
- Pre-demolition audits are key in sorting out reusable and hazardous materials.
- There are regional differences in treatment and materials difficult to recycle in some countries, such as gypsum demolition waste, mineral wool demolition waste and reject from mechanical treatment of mixed CDW have higher recycling rates in other countries.
- There are many good innovations and many start-ups and projects, but as upscaling into a main business model is challenging, these examples are harder to find.
- Waste prevention by reusing, but especially by preventing demolition, should be the first step.

There is a need to establish unified approaches to enhance cooperation and opportunities within the Nordics and the EU, particularly concerning data development and policies.

An important step that remains underutilized in the prevention of CDW is promoting reuse, as well as implementing measures to prevent buildings from being demolished, for example by renovating and refurbishing. For new constructions, incorporating design for disassembly, adaptability, and material passports will aid in waste prevention and promote reuse and recycling in the future.

Sammanfattning

Bygg- och rivningsavfall (BRA) står för mer än en tredjedel av allt avfall som genereras i EU. EU:s avfallsramdirektiv (2008/98/EC) fastställer att fram till 2020 ska förberedelse för återanvändning, återvinning och annan materialåtervinning uppgå till minst 70 viktprocent för BRA. Studier visar dock på att de nordiska länderna inte uppnår detta mål.

Samtidigt är en av de tre strategiska prioriteringarna i Nordiska ministerrådets vision för Norden "En grön nordisk region" att främja en grön omställning och arbeta mot koldioxidneutralitet samt en hållbar cirkulär och bio-baserad ekonomi. Huvudmålet med denna studie är således att främja en cirkulär ekonomi samt bidra till uppnåendet av målet "Resurseffektiva och giftfria kretslopp". För att stöda detta mål strävade studien efter att identifiera och presentera relevanta tekniker och anläggningar för återanvändning och återvinning av bygg- och rivningsavfall på den nordiska marknaden. Den inkluderade också en inventering av bygg- och rivningsavfallsströmmar som för närvarande är svåra att återanvända eller återvinna samt att hitta sätt att förbättra situationen.

EU:s lagstiftning och mål utgör grunden för hur avfall ska hanteras i alla de nordiska regionerna. Dessutom tillämpas landspecifik lagstiftning om BRA, där vissa länder, som Danmark och Finland, har mer omfattande och strängare lagstiftning än vad EU-reglerna innebär.

De vanligaste metoderna för att behandla BRA i Norden är lågvärdig återvinning, såsom energiåtervinning och återfyllning. Några av de främsta utmaningarna med återvinning och återanvändning av BRA är behandlings- och transportkostnader samt brist på sortering på plats där avfallet uppkommer. I Danmark, där de högsta återvinningsgraderna uppnås, är sortering och återvinning ofta billigare än annan behandling, främst på grund av korta avstånd och höga deponikostnader. Samtidigt hämmar kapaciteten för avfallsförbränning och billiga råvaror som trä och mineralaggregat en ökad återvinning i de flesta av de nordiska länderna.

Både sortering på plats där avfallet uppkommer och materialinventering före rivning är viktiga faktorer för att uppnå höga återvinningsnivåer och erhålla högkvalitativa material från återvinning av BRA. Sortering på plats för både bygg- och rivningsavfall hjälper till att producera material av god kvalitet för återvinning. Materialinventering före rivning hjälper till att känna igen och separera material som innehåller skadliga ämnen som bör sorteras ut, samt är ett viktigt verktyg för att identifiera återanvändbara byggelement.

Vissa BRA-fraktioner, som gipsavfall, mineralullavfall och avfall från mekanisk behandling av blandat BRA har ansetts problematiska i vissa nordiska länder, särskilt i Finland. Dessa avfallsfraktioner har högre återvinningsgrader i andra länder där goda exempel på behandling och rivningsmetoder kunde identifieras i denna studie. Till exempel betraktas avfall från mekanisk sortering av BRA inte som ett problem i Danmark, eftersom avfallet separeras mer effektivt på plats där avfallet uppkommer.

Bristen på detaljerad statistik har identifierats som ett hinder för en mer detaljerad analys av vilka avfallsströmmar som för närvarande inte återvinns. Till exempel slås många olika avfallsfraktioner vanligtvis samman under en avfallskategori, som mineralavfall. Det finns stor potential att hämta genom bättre dokumentation och rapportering av bygg- och rivningsavfall (BRA). Men bättre data kunde nya möjligheter lättare identifieras för att öka återvinnings- och återanvändningsgraden. Danmark är det land av de nordiska länderna som för närvarande har den mest detaljerade BRA-statistiken tillgänglig. Danmark rapporterar också betydligt mer bygg- och rivningsavfall per capita, vilket kan bero på exempelvis mer detaljerad och omfattande data, en högre andel byggnader av sten som väger mer än trä, samt att på grund av kortare avstånd registreras mer avfall i stället för att hanteras via direkt återfyllning eller -användning av mineralmaterial på plats. Statistiken kan också variera märkbart beroende på jämförelseåret.

Tabell 1. *Sammanfattning av de huvudsakliga behandlingsmetoderna för BRA i Norden.*

	Åter-användning	Åter-vinning	Annan åter-vinning	Energi-återvinning	Deponering
Mineralavfall (betong, tegel, osv.)			DA, FI, IS, NO, SE		
Metall		DA, FI, IS, NO, SE			
Glas		DA, FI, NO, SE	IS		
Träavfall		DA		FI, IS, NO, SE	
Plast				DA, FI, IS, NO, SE	
Gips		DA, NO, SE			FI, IS
Mineralull		DA			FI, IS, NO, SE
Avfall från mekanisk behandling av blandat BRA					FI, IS, NO

I rapporten beskrivs kortfattat initiativ och metoder för återvinning och återanvändning av BRA i andra europeiska länder med hög återvinningsgrad. I rapporten lyfts några exempel på företag som antagit framgångsrika affärsidéer och tekniker för återvinningspraxis och återanvändning av material. Till exempel nämns återanvändning av tegelstenar eller andra material med tekniker anpassade till den lokala marknaden, sortering med AI och exempel på återvinningsmaterial som är svåra att återvinna i andra länder. En kort översikt över policys från länder med hög återvinningsgrad för BRA presenteras. Länder med hög andel återvinning har flera gemensamma nämnare som effektiv lagstiftning som främjar en cirkulär ekonomi, närvaro av lämpliga företag och anläggningar samt innovativa projekt.

Drivkrafterna för återvinning och återanvändning av BRA kan delas in i lagstiftande, politiska, ekonomiska, tekniska samt sociala och kulturella faktorer. Rapporten listar rekommendationer som understryker vikten av enhetliga tillvägagångssätt i de nordiska länderna och EU och inkluderar end-of-waste-kriterier, producentansvar, klimat- och resursmål, avfallsskatteincitament, marknadsvärdeskapande, investeringsfonder, sortering på plats och standardiserade riktlinjer.

Den här rapportens slutsatser är:

- Hindren för ökad återanvändning och återvinning av CDW är inte tekniska. Tekniker för återvinning och återanvändning finns, men uppskalningen möts av olika lagstiftnings-, ekonomiska och sociala hinder i alla länder.
- De största hindren är ekonomiska och för vissa regioner utgör långa avstånd och små volymer de största hindren. Även attityder och normer spelar en roll.
- Det saknas ekonomiska incitament både för att återvinna BRA och för att använda återvunna material.
- Tillgänglighet av avfallsdata och rapportering är ett hinder.
- Bättre sorteringsmöjligheter på plats skulle möjliggöra mer högkvalitativ återanvändning och återvinning.
- Materialinventeringar före rivning är nyckeln för att sortera ut återanvändbara och farliga material.
- Det finns regionala skillnader i behandling och material som är svåra att återvinna i vissa länder, som gipsrivningsavfall, mineralullrivningsavfall och avfall från mekanisk behandling av blandat BRA har högre återvinningsgrader i vissa länder.
- Det finns många goda innovationer och många start-ups och projekt, men eftersom uppskalning till en huvudaffärsmodell är utmanande är dessa exempel svårare att hitta.
- Avfallsförebyggande genom återanvändning, men särskilt genom att förhindra rivning, bör vara det första steget.

Det finns ett behov av att hitta enhetliga arbetssätt för att öka samarbetet och möjligheterna inom Norden och EU, till exempel när det gäller avfallsdata och policy. Ett viktigt steg i förebyggandet av BRA kvarstår, nämligen främjande av återanvändning, men framför allt genom att främja åtgärder för att förhindra att byggnader rivs, som exempelvis reparation och renovering. För nya byggnader kommer design för demontering och anpassningsbarhet samt materialpass att hjälpa till att minska uppkomsten av avfall och dessutom att främja återanvändning och återvinning i framtiden.

Definitions

This section introduces important terminologies used when discussing reuse of construction products. The definitions follow the EU Waste Framework Directive (WFD) 2008/98/EC and the Commission Decision 2011/753/EU.

Backfilling means a recovery operation where suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping and where the waste is a substitute for non-waste materials.

Construction and demolition waste (CDW) means waste generated by construction and demolition activities. It includes all the waste produced in the construction and demolition of buildings and infrastructure, as well as road planning and maintenance. In this study, land masses and excavated material, has been excluded.

Disposal means any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy.

Energy recovery refers to the conversion of waste materials into heat, electricity, or fuel through a variety of processes, such as incineration.

Glass waste from construction and demolition is mainly plate glass and window. Glass packaging is not included.

Gypsum waste primarily consists of waste from **plasterboards**, which are wall or ceiling panels made of a gypsum core between paper lining, but can also consist of plaster. Gypsum waste from new construction activities is typically a clean waste, and primarily consists of off-cuts or surplus of plasterboard. Demolition gypsum waste may contain contamination, which can be in the form of nails, screws, wood, insulation or wall coverings.

Landfill is the deposit of waste into or onto land. It includes specially engineered landfill sites and temporary storage of over one year on permanent sites.

Material recovery is restoration of materials found in the waste stream to a beneficial use which may be for purposes other than the original use. It includes e.g. backfilling.

Mineral waste from construction and demolition includes concrete, bricks, gypsum and plaster waste from construction and demolition, as well as mineral insulation materials and asphalt. These can be mixed or sorted separately per material.

Plastics in construction is used in a wide range of products such as pipes, cables, coverings, panels and linings. Plastics used in construction includes e.g., acrylic, composites, Expanded polystyrene, ETFE, Polycarbonate, Polyethylene, Polypropylene, Polyvinyl chloride (PVC), PTFE. Plastic packaging is not included in this study.

Preparing for re-use means checking and cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.

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

Recycling and material recovery rate for construction and demolition waste is in this study calculated as the sum of the preparing for reuse, recycling and other material recovery, including backfilling operations but excluding energy recovery, divided by all the construction and demolition waste generated excluding naturally occurring excavated material.

Recovery means any operation of which the principal result is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Recovery is divided into three sub-categories: preparing for re-use, recycling, and other recovery.

Re-use means any operation by which products or components that are not waste are used again for the same purpose for which they were conceived.

Waste prevention means measures taken before a substance, material or product has become waste, that reduce a) the quantity of waste, including through the re-use of products or the extension of the life span of products; b) the adverse impacts of the generated waste on the environment and human health; or c) the content of harmful substances in materials and products.

Wood waste from construction and demolition mainly consists of auxiliary materials, such as packages, mould boarding, and various losses. It may contain damages due to moisture and mechanical contaminants, such as metal parts, and concrete residue, or be treated with paint and other chemicals.

Abbreviations

AGEC law	The French law on Anti-waste and Circular Economy
AI	Artificial intelligence
As	Arsenic
BAMB	Buildings as Materials Banks
Cd	Cadmium
CDW	Construction and demolition waste
CEO	Chief executive officer
CEN	The European Committee for Standardization (French: Comitté Européen de Normalisation)
Cr	Chromium
Cu	Copper
CWR	Community wood recycling
DOC	Dissolved organic carbon
EPR	Extended producer responsibility
EoW	End of waste
EOL	End of Life
EP	Ethylene propylene
EPE	Expanded polyethylene
EPP	Expanded polypropylene
EPS	Expanded polystyrene
ETA	European technical assessment

EU	European Union
EWC-code	European Waste Catalogue code
FSC	Forest Stewardship Council
HFC	Hydrofluorocarbon (gas)
Hg	Mercury
L/S	Liquid-solid ratio
Ni	Nickel
PAH	Polyaromatic hydrocarbons
Pb	Lead
PBL	Swedish planning and building act
PC	Polycarbonate
PCB	Polychlorinated biphenyl
PE	Polyethylene
PE-HD	High-density polyethylene
PE-LD	Low-density polyethylene
PI	Polyimide
PIR	Post-industrial recycled plastic
POP	Persistent organic pollutants
PP	Polypropylene
PU, PUR	Polyurethane
PVC	Polyvinyl chloride
RBA	Road-based aggregate

Sb	Antimony
SME	Small- and medium-sized enterprises
TEK	Norwegian building requlation
TPE	Thermoplastic elastomeres
UK	United Kingdom
VANG	Van Afval Naar Grondstof
WFD	EU Waste framework Directive, EU Waste directive
XPE	Cross-linked polyethylene
XPS	Extruded polystyrene
Zn	Zinc

1. Introduction

1.1 Background

Construction and demolition waste (CDW) accounts for more than a third of all waste generated in the EU. The generated waste consists of many different materials such as minerals, glass, metal, wood, plastic and plaster. Several of these materials originates from virgin materials, which raw material extraction causes a big impact on nature and potentially finite resources. In many cases, they still end up on landfills or on the lower steps of the waste hierarchy after one use. The Nordic countries, as well as the EU, face the same problems as a large part of the construction and demolition waste is not reused or recycled. All the Nordic countries are not reaching the recycling targets of 70 % in 2025 set out in the EU waste directive.

Given the significant volume of waste generated by this sector, a transition in the construction industry towards more circular thinking is imperative to diminish global environmental degradation and reducing resource consumption. Reusing construction products facilitates the prevention of all impacts associated with producing and transporting new products, as well as construction and demolition waste.

Nevertheless, numerous initiatives are underway in this field, ranging from inventions and business ideas to legal requirements in the Nordic countries. By highlighting these good examples and by observing practices in the Nordics or in the EU, there are ways and methods to move forward to increase the amount of reused and recycled construction materials. That can effectively shift this sector towards a more circular approach.

1.2 Purpose of the study

The Nordic cooperation led by the Nordic Council of ministers works towards the vision that the Nordic region will become the most sustainable and integrated region in the world in 2030. To meet the goals of the Nordic vision, three priorities are pursued: a green Nordic region, a competitive Nordic region and a socially sustainable Nordic region. The strategic priority "A green Nordic region" focuses on promoting green transition and working towards carbon neutrality and a sustainable circular and bio-based economy. This study is supporting the work towards a green Nordic region by contributing to the achievement of the goal "Resource-efficient and non-toxic cycles" and the Nordic vision program "Nordic Sustainable Construction" and "Nordic Network for Circular Construction".

The study aimed to identify and present relevant techniques and facilities regarding reuse and recycling of construction and demolition waste in the Nordic market. It also included an inventory of the construction and demolition waste streams that currently are difficult to reuse or recover and finding ways forward to improve the situation. The objective of this study was to:

- Map technologies and facilities in the Nordic countries regarding reuse, recovery and recycling of construction and demolition waste.
- Highlight good examples in this field.
- Identify the main challenges that prevent the Nordics to achieve the targets as well as the opportunities.
- Demonstrate ways forward to increase the amount of reused, recovered, and recycled construction and demolition waste.

In the study the CDW fractions with currently limited recycling or reusing options and explore the primary obstacles and underlying reasons for this situation were assessed. By analysing the waste statistics, CDW fractions has the best potential to increase the recycling rate was identified, and the examples from the field highlight promising ways to do this. In addition, the differences in the CDW treatment methods between different Nordic countries were evaluated.

1.3 Methods

The study was conducted using various methods further described below and in Figure 1. The key method throughout the study was desktop research including open sources for information and data gathering in the countries covered in the report, but also network outreach and the use of internal experts. These contacts have consisted of colleagues at AFRY in the different Nordic countries as well as other European countries, officials at national authorities, representatives from different companies focusing on reusing and recycling materials from the construction and demolition sector.

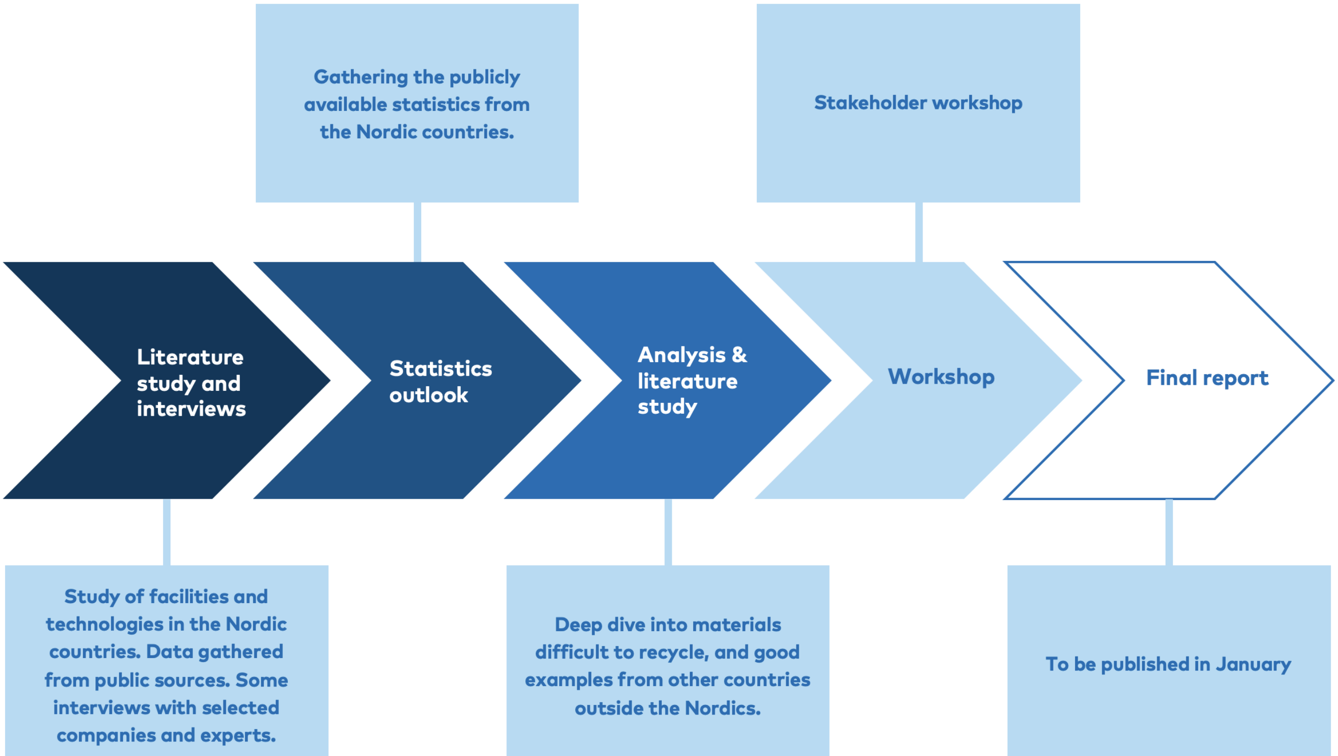

Figure 1. *Process diagram of the study. The work was done in 5 steps, from initial literature and case study review, gathering waste statistics, analysis and literature review of good examples, a stakeholder workshop and finally writing of the report.*

Data regarding waste streams and treatment methods has been collected from various open data sources in the countries. Additional efforts were necessary, involving contacting responsible officers for raw data, in order to acquire more detailed information or clarifications. Data of CDW treatment facilities were gathered through sector expert organisations, environmental permits and authorities. Facilities mechanically sorting mixed CDW as well as incineration plants were not included in the scope of this study. Reuse facilities proved difficult to find with this methodology, since the materials and products for reuse is not included in the waste statistics or environmental permits for waste treatment facilities.

A stakeholder workshop was also held with the aim to gather key people, create discussions and to get valuable insights from the stakeholders. The invitees were representatives from innovative companies in the field as well as representatives from authorities, construction companies and researchers.

Finally, the gathered information and data was analysed. This involved identifying key impact drivers that influence the potential for reusing or recycling a larger portion of the waste. Utilizing these impact drivers, comparisons were made among the countries to uncover similarities, differences, as well as obstacles and opportunities.

This study was carried out on behalf of the Nordic Council of Ministers by AFRY Management Consulting.

1.4 Scope and limitations

The study covered the five Nordic countries including the regions Åland, Faroe Islands and Greenland. It focuses on waste from the construction and demolition sector in terms of the following groups of materials: glass, metal, mineral, plaster, plastic, and wood. In this study, land masses and excavated material, have been excluded.

Regarding good examples in the field, case studies of actors from all the countries have been chosen. These are companies focusing on reusing materials as well as companies focusing on recycling materials. The case examples also aim to represent a variation of the materials covered in the study. There are more examples in the field that could be highlighted but, in this study, it is limited to only 2 to 3 examples chosen and described from each country.

Since the study used data from open sources, the quantity and quality of the data differ between the countries due to the countries' own reporting and data collection systems. Thus, the data and information from the countries covered in this study varies and it was not always possible to make relevant comparisons.

To describe available techniques and typical CDW management, the study also looked into regulations and policy, since it is a main driver in explaining the reasons behind potential differences between countries.

2. The current situation in the Nordics

The EU Waste Framework Directive[1] (*2008/98/EC*) states that by 2020, the preparing for re-use, recycling and other material recovery is to be increased to a minimum of 70 % by weight for CDW. This will include backfilling operations where waste is used to substitute other materials but excludes natural occurring excavated material and energy recovery operations.

Generally, the Nordic countries follow the EU legislation and targets on CDW treatment, even though Norway and Iceland are not member countries of the European union. The countries therefore should follow the goal defined in the Waste Framework Directive of having 70 % of CDW recycled/material recovered by 2020. The degree of preparation for reuse, recovery or recycling of non-hazardous construction and demolition waste has in previous studies varied, and according to this study was approximately only 43 % for Sweden, 44 % for Norway and 55 % for Finland, which is far from the recycling and recovery targets defined in the waste directive. Iceland reports 82 % recovery rate, most of which is backfilled mixed mineral waste, and Denmark results show a material recovery rate of 92 %. The statistics are gathered from national open-source statistics and include some level of uncertainty.

In this study, the current situation in the Nordic countries was analysed further, beginning with an overview of the national laws and regulations in relation to treatment of CDW and how the amounts of treated CDW and the waste streams look like in each country. Secondly, the study covered the general treatment process for CDW in the Nordic countries, as well as included an overview and analysis of the CDW materials that are currently difficult to reuse, recycle or recover today.

2.1 Overview on waste legislation and CDW waste streams in the Nordics

As stated above, the Nordic countries follow EU legislation and targets on CDW treatment, although Norway and Iceland are not member countries of the European union. The countries follow the waste hierarchy defined in the Waste Framework Directive (*2008/98/EC*) by the European Union where it is stated that waste prevention should be the priority, preparation for reuse should be the second

1. European Commission. Waste Framework Directive web page. Available: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

priority, recycling the third, other recovery the fourth, and the last step should be disposal. The waste hierarchy defined in the EU WFD is visualised in Figure 2.

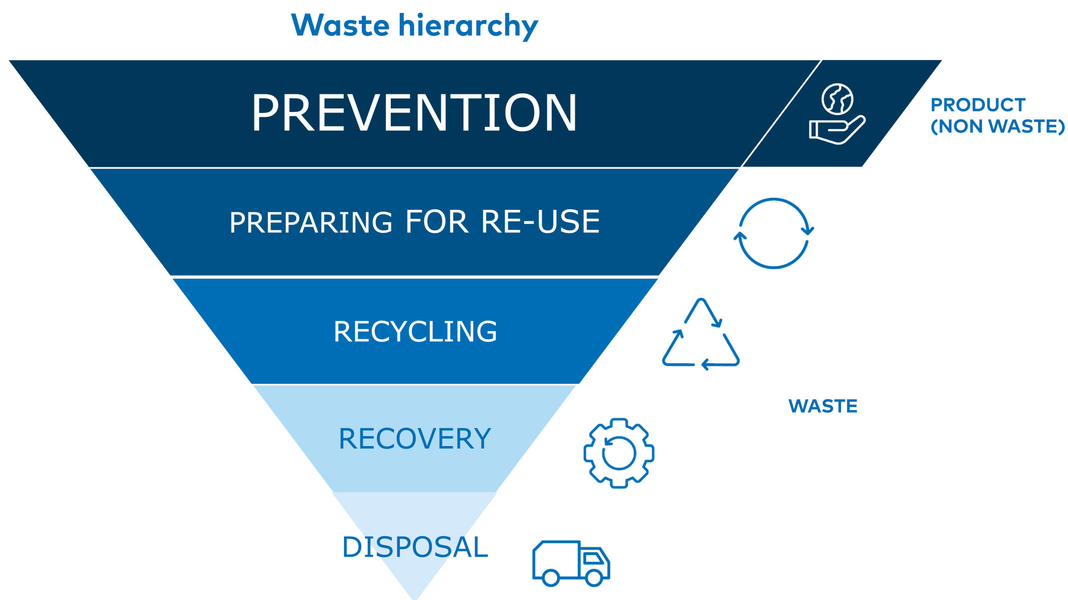

Figure 2: *The Waste Hierarchy as described in the EU Waste Framework directive.*[2]

EU legislations and targets act as a basis on how waste should be handled in the respective countries. Additional to the EU WFD, there are several EU directives and regulations that aim to drive the developments of the Circular Economy in the EU. The EU Green deal[3] includes several policy initiatives that combined has the overarching aim of having the EU Climate Neutral in 2050 and acts as an agenda for sustainable growth in the EU. The EU Circular Economy Action plan[4] is an example of one of the building blocks of the EU Green Deal, but the Action plan aims to prevent waste and maximize the utilization of resources within the EU economy for as long as possible.
In addition of following those legislations, there are certain country-specific specialties applied in the national legislation concerning CDW with some countries having more extensive and detailed legislation than what the EU regulations entails. Figure 3 shows a comparison on how the legislative framework in the Nordic countries details the minimum sorting requirements of CDW.

2. *European Commission. Waste Framework Directive web page. Available: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en*
3. European Commissions. The European Green Deal web page. Available: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
4. European Commission. Circular Economy Action Plan web page. Available: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

The comparison reveals that Denmark, Finland, and the Åland Islands have the most detailed sorting requirements for CDW as stipulated in their respective national waste frameworks, while legislation in the other countries only provides a more generalized level of specification. However, the waste legislation is accompanied by guidelines and building codes and other legislation and e.g., EPR schemes, and as a result, it does not describe all the fractions sorted in the countries. Therefore, the comparison below does not determine the actual differences in what is sorted and what is not. The requirements listed in the legislation is not necessary reflected in sorting routines on- or off-site, nor in waste data reporting on a national level.

Table 2: *A comparison between the countries on legislative framework surrounding minimum sorting of CDW mentioned in the waste law. There are some differences in what fractions are required to sort out (e.g., asphalt, roofing felt), as well as differences in where the requirements are written. Many EPR schemes or sector guidelines require sorting, even if not mentioned in the waste legislation, and thus not included here.*

	Denmark	Greenland	The Faroe Islands	Finland and Åland	Iceland	Norway**	Sweden
WASTE FRACTION							
Wood*	x			x	x		x
Treated (e.g., oil, paint) wood and untreated wood				x			
Mineral (concrete, bricks, tiles, ceramics and stones)*	x			x	x	x	x
Concrete	x					x	
Bricks						x	
Asphalt	x			x			

Surplus soil and aggregates	x	x	x				
Mineral wool insulation	x			x			
Mixed mineral fraction (content may vary between countries)	x						
Metals*	x	x	x	x	x		x
Glass*	x	x		x	x		x
Plastic*	x			x	x		x
PVC	x		x				
Gypsum/plaster*	x			x	x		x
Hazardous waste*	x	x		x	x	x	x
Other separately collected waste fractions							
Bitumen (roofing felt)				x			
Paper and cardboard***	x			x			
Thermal windows***	x						
Electronic waste***	**x**						

*Separate collection is obligated in EU waste directive amendment (EU) 2018/851
**Legislation in Norway demands minimum 70 w% sorting of all CDW, the fractions (other than hazardous waste and concrete and bricks from demolition) are not mentioned in the legislation. The other fractions (metals, glass, wood, plastic and plaster) are mentioned in guidelines to the legislation.
***May be included in EPR schemes, and therefore not necessary listed separately in the waste legislation under CDW requirements

In Table 3 and Table 4, data for treated CDW per capita are showcased. Table 3 shows the amounts of treated CDW per capita according to each of the Nordic countries. The data is shown according to the main CDW categories, and the amounts are reported in kg waste per capita. This was done to put the amounts of treated CDW into context as the size of the countries differs, and therefore different volumes of CDW are treated in each of the countries. When looking at the table, Denmark reports significantly more volumes of treated CDW when compared to the other countries, especially the countries that have similar numbers of inhabitants. This can be due to several reasons, for example the detail of the data and reporting, and the other cultural differences, such as traditional building methods and materials and the norms in the industry. Short distances also can lead to that more material is transported as waste instead of e.g., direct backfilling or recycling of mineral materials on-site. Also, the statistics can vary a lot from year to year.

Better statistics that measure all the waste, will lead to higher number of kg waste per capita, whereas in some regions, e.g., in Iceland, the statistics are not as detailed as the other countries which might be the cause for lower amounts reported in the statistics. Difference in statistics among countries could also stem from variations in how the source data is generated, for instance, waste companies categorizing waste fractions differently in the respective regions. Differences in building stock can also explain the numbers for Denmark, where houses are largely made of bricks instead of wood, that weigh less than bricks. Also, the amount of asphalt waste reflected in the CDW statistics could explain the differences, since asphalt do not necessary get reported as CDW waste if recycled internally by the infrastructure company.

Table 3: *The amounts of treated CDW total and per capita in 2020 according to the Nordic countries. The data is showed in 1000 t and in kg treated waste/capita.*

	Denmark [5]	Greenland [6]	Faroe Island[7]	Finland [8]	Åland Islands [9]	Iceland [10]	Norway [11]	Sweden [12]
CDW total (1000t)	4600	4	0,5	1900	5	62	2100	4000
Population (2020)	5.831.000	56.367	52.415	5.530.000	30.129	366.463	5.379.000	10.350.000
CDW Category	Data in kg waste per capita							
Wood	26	18	8	49	8	26	50	90
Minerals	533	17	2	230	140	74	235	280
Metals	78	28	1	39	14	N/A	22	13
Glass	5	6	N/A	10	0	N/A	2	1
Plastic	1	N/A	N/A	N/A	0	N/A	2	0
Plaster	14	8	N/A	14	N/A	N/A	15	9
Other CDW	136	N/A	N/A	5	-	69	72	-
Total	**793**	**77**	**11**	**348**	**163**	**168**	**397**	**393**

5. Data on the amounts of CDW was received from The Danish Environmental Protection Agency, Miljøstyrelsen, for the year 2020. See section 2.1.1 for more information on the data source.
6. Data on the amounts of CDW was received from Sermersooq Municipality, Sermersooq Affaldscenter, Drift og miljø, for the year 2020. Other municipalities and waste facilities in Greenland did not respond to request for information or did not have knowledge on waste volumes.
7. Data on the amounts of CDW was received from the Faroese intermunicipal waste and recycling company, IRF, for the year 2020 and does not include data for Torshavn. The waste company in Torshavn did not respond to request for information for this study.
8. Data on the amounts of CDW was mainly gathered from Statistics Finland, Tilastokeskus, and was complimented with additional data sources. See section 2.1.4 for more information on the additional data sources.
9. Data on the amounts of CDW was gathered from Statistics and Research Åland, ÅSUB, for the year 2020. See section 2.1.5 for more information on the data source.
10. Data on the amounts of CDW was received from The Icelandic Environment Agency, Umhverfisstofnun, for the year 2020.
11. Data on the amounts of CDW was gathered from Statistics Norway, Statistisk sentralbyrå, for the year 2020. See section 2.1.7 for more information on the data source.
12. Data on the amounts of CDW was received from The Swedish Environmental Research Institute, IVL, for the year 2020.

Table 4 shows the End-of-life treatment of the CDW per capita according to each of the Nordic countries along with the recycling and recovery rate. Again, the data is shown in kg waste per capita. The data shows that Denmark has the highest recycling and recovery rate of 92 %, while Sweden reports the lowest rate of 43 %. The data for Greenland and Faroe Islands is not considered to give the correct indication on the treatment of CDW due to the lack of publicly available data.

Table 4: *The End-of-life treatment of the CDW in the Nordic countries according and the recycling & recovery rate. The amounts for the EOL-treatments are showcased in kg treated waste per capita.*

Data in kg waste per capita	Denmark	Greenland	Faroe Island	Finland	Åland	Iceland	Norway	Sweden
Recycling & Material recovery	683	28	1	188	154	147	174	168
Energy recovery	22	9	2	105	24	1	98	125
Disposal	35	40	8	51	10	20	100	35
Other/unspecified	-	-	-	-	-	-	25	61
Recycling & recovery rate (%)	92%	36%	12%	55%	82%	87%	44%	43%

2.1.1 Denmark

The Danish legislation on management of CDW is based on the EU Waste Framework Directive and is embodied in several laws and decrees. Overall, the EU (European Union) waste hierarchy applies, which states that prevention must be preferred before material recycling, material recycling before incineration and incineration before landfilling.

The rules on the management of CDW in Denmark are put forth by the Ministry of Climate, Energy and Utilities and the Danish Environmental Protection Agency and can be found in the following laws and decrees: Environmental Protection Act; Miljøbeskyttelsesloven[13] (2023:5), The Statuary Order on Waste; Affaldsbekendt-gørelsen[14] (2021:2512), Affaldsaktørbekendtgørelsen[15] (2022:1536), Restprodukt-bekendtgørelsen (2016:1672) and Deponeringsbekendtgørelsen[16] (2019:1253).

In accordance with the Statuary Order on Waste, *Affaldsbekendtgørelsen* (2021:2512), CDW must be sorted out at the place where it is generated in at least the following waste type categories:

- Hazardous Waste
- PCB-containing waste
- Thermal windows
- Natural stone
- Unglazed tile
- Concrete
- Mixtures of natural stone, unglazed bricks, and concrete
- Iron and Metal
- Plaster
- Stone wool (insulation)
- Soil
- Asphalt
- Mixtures of concrete and asphalt

In accordance with other sections of the Statuary Order on Waste, Affaldsbekendtgørelsen (2021:2512), waste producers are obligated to ensure that the following types of waste that are suitable for material recovery is prepared for re-use, recycled or used for other final material recovery:

13. Miljøbeskyttelsesloven. LBK nr 1218 af 25/11/2019. Available: https://www.retsinformation.dk/eli/lta/2019/1218
14. Affaldsbekendtgørelsen. BEK nr. 2512 af 10/12/2021. Available: https://www.retsinformation.dk/eli/lta/2021/2512
15. Affaldsaktørbekendtgørelsen. BEK nr 2097 af 14/12/2020. Available: https://www.retsinformation.dk/eli/lta/2020/2097
16. Deponeringsbekendtgørelsen. BEK nr 719 af 24/06/2011. Available: https://www.retsinformation.dk/eli/lta/2011/719

- Glass
- Metal
- Plastic
- Paper
- Cardboard
- Food
- Garden/green
- Wood
- Textiles
- Food- and drink cartoons
- Reusable hazardous waste, like batteries and electronics
- Reusable PVC

Furthermore, the Statuary Order on Waste (2021;2512) contains the rules screening and mapping buildings and constructions for hazardous substances, rules for waste notification and rules for classification of waste.

The laws and decrees on the management on CDW are more extensive and stricter than the EU regulations state, which can be seen in the statuary order of waste (2021;2512) requiring sorting of CDW into more fractions than listed in the WFD.

Figure 4 shows the waste streams for the CDW treated in Denmark for the year 2020 where the CDW streams are visualised in a Sankey-diagram. The data reporting for treatment of CDW in Denmark is done at a detailed level and the data is publicly available. Denmark reports on several waste categories, as well as having information on sub-categories. The data also covers the treatment method of each of the waste material.

The diagram below shows that mineral waste accounts for the largest amounts of the total treated CDW. Furthermore, the majority of the CDW is recovered and goes into backfilling operations. The second largest treatment method for the CDW is recycling, but the type of recycling largely is unspecified. Only a small fraction is sent to energy recovery and landfill.

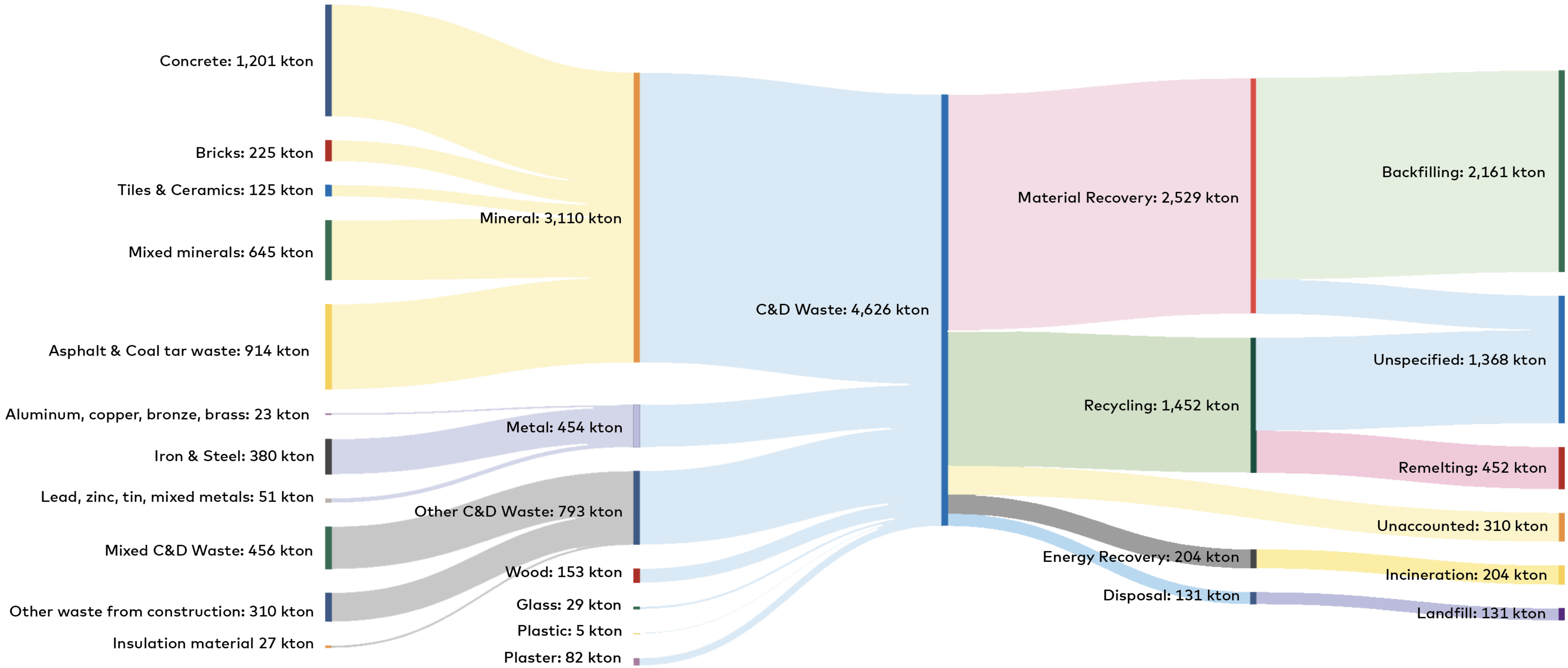

Figure 4: *The material flows for CDW in Denmark for the year 2020. Data on the amounts of CDW was gathered from The Danish Environmental Protection Agency, Miljøstyrelsen, for the year 2020*[17]

17. *Affaldsstatistik 2020, Miljøstyrelsen. Available:* *https://mst.dk/publikationer/2022/december/affaldsstatistik-2020*

2.1.2 Greenland

The Greenlandic legislation on management of construction and demolition waste is based on an environmental protection law[18] and a decree on waste[19]. Overall, like in EU-countries, a waste hierarchy applies. Construction and demolition waste must be sorted according to waste regulations in the five Greenlandic municipalities.

Waste that is generated in connection with new construction, renovation and demolition must be reported to the local authorities (municipality) when the amount of construction waste exceeds 50 m^3 per week. In addition, notification must be made when the total amount of waste exceeds 100 m^3 for the entire construction period for the individual project, regardless of the weekly production of waste (according to waste regulations in the municipalities of Sermersooq[20], Kujalleq[21] and Avannaata[22]*)*.

Waste that is handed over to the municipality's waste reception facilities must, as a minimum, be sorted into the following waste fractions:

- Landfill waste (asbestos, soft PVC, insulation, bricks, glazed bricks)
- Tires without rims
- Glass and bottles
- Iron and metal
- Soil
- Environmentally hazardous waste
- Waste suitable for combustion

Figure 5 shows the material flows for the CDW treated in Greenland in the year 2020. The data have been visualised in a Sankey-diagram. It is important to note that there was limited availability of data, and therefore the diagram may not give the complete picture of the total amounts of treated CDW in Greenland. The data is more aggregated and do not specify detailed information on e.g., different mineral fractions.

The diagram below shows that the largest fraction of the CDW is disposed of in landfills, while the second largest fraction goes to recycling. Furthermore, the largest waste fractions are metals and wood.

18. Inatsisartutlov nr. 9 af 22. november 2011 om beskyttelse af miljøet. Available: https://www.fao.org/faolex/results/details/en/c/LEX-FAOC108561/
19. Selvstyrets bekendtgørelse nr. 3 af 7. januari 2021 om affald. Available: https://nalunaarutit.gl/Groenlandsk-lovgivning/2021/bkg-03-2021?sc_lang=da
20. Affaldsregulativ 2021. For affaldsproducenter i Kommunequarfik Sermersooq. Available: https://sermersooq.gl/da/regulativer-lovgivning-og-pligter/
21. Regulativ for affald fra erhverv Kommune Kujalleq 2022.
22. Regulativ for affald fra erhverv Avannaata Kommunia 2019.

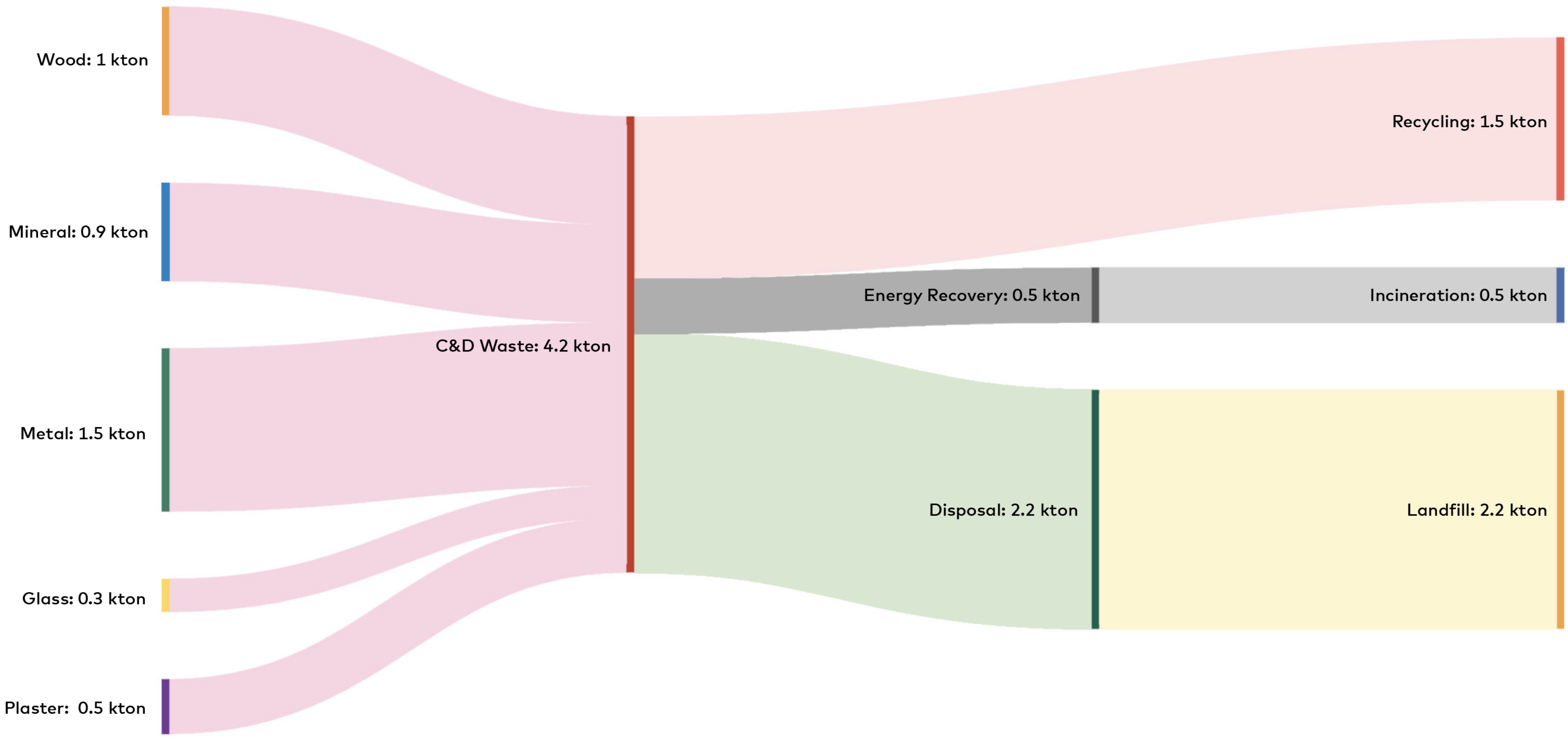

Figure 5: *Material flows for CDW in Greenland for the year 2020. Data on the amounts of CDW was received from Sermersooq Municipality, Sermersooq Affaldscenter, Drift og miljø, for the year 2020. Other municipalities and waste facilities in Greenland did not respond to request for information or did not have knowledge on waste volumes.*

2.1.3 Faroe Islands

Faroe Islands are an autonomous part of the Danish Kingdom with its own legislature on construction, waste handling and environmental issues, as well as on other issues.

The legislation on management of waste is based on an environmental protection law, by which prevention must be preferred before material recycling, reuse and material recycling before incineration and incineration before landfilling. At this point, Faroe Islands have no special legislation on CDW handling. The current Faroese government has initiated a process towards a new regulation and national plan for waste handling. The intention is to tighten the control with hazardous substances in construction materials and to increase the sorting and quality of the construction waste[23].

Figure 6 shows the material flows for the CDW treated in the Faroe Islands in the year 2020 and data have been visualised in a Sankey-diagram. It is important to note that there was limited availability of data, and therefore the diagram does not give the correct picture of the treated CDW in the Faroe Islands.

The only reported waste categories were for wood, minerals and metals, hazardous waste and soil, and plaster is included in the numbers for minerals. The diagram shows that the largest CDW fraction reported goes to incineration, and another fraction goes to landfills. A very small fraction goes to recycling.

23. Personal communication Rúna Hjelm, Umhvørvisstovan, The Environment Agency of Faroe Islands. 2023.

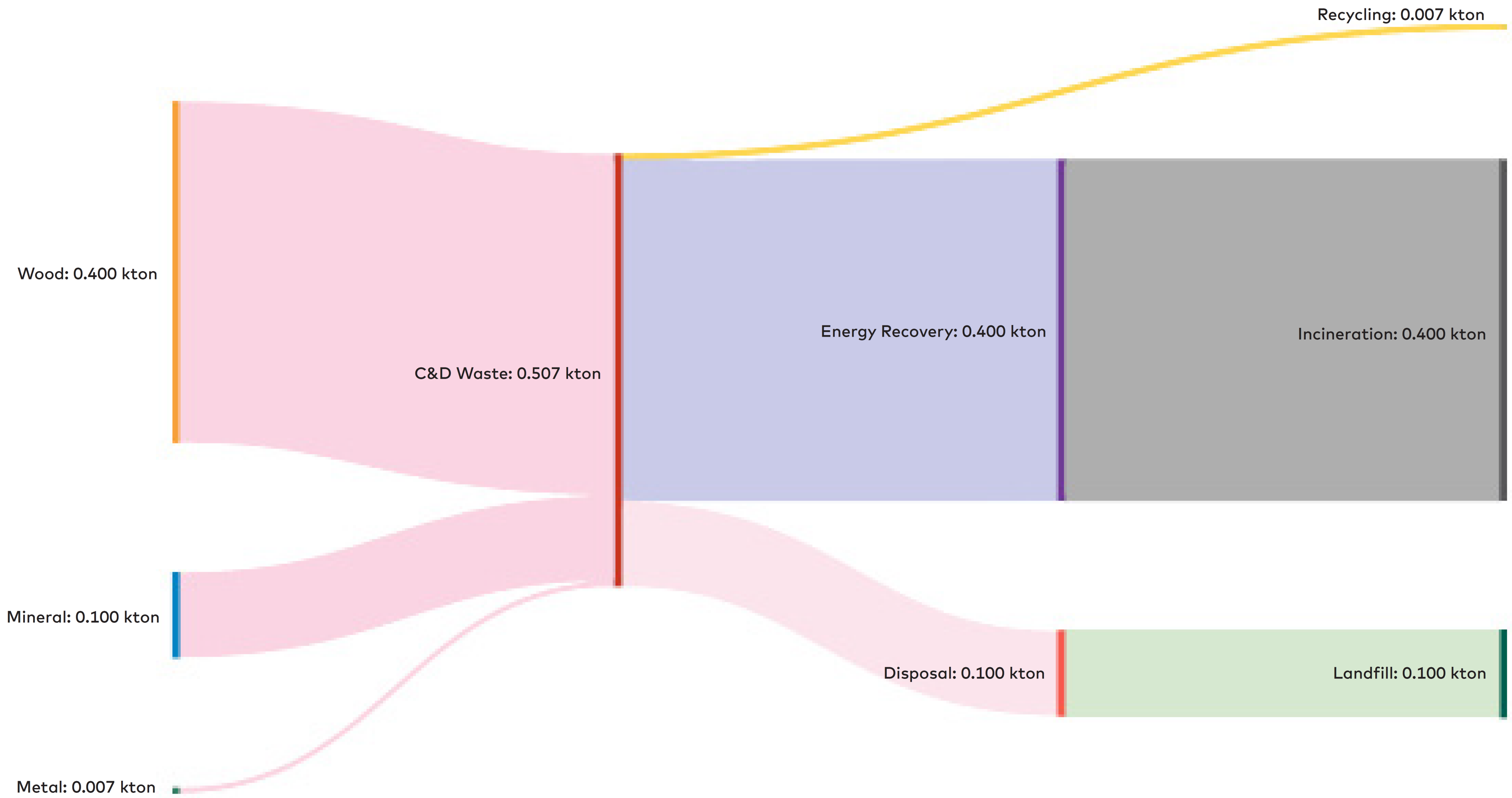

Figure 6: *The material flows for CDW in the Faroe Islands for the year 2020. Data on the amounts of CDW was received from the Faroese intermunicipal waste and recycling company, IRF, for the year 2020 and does not include data for Torshavn. The waste company in Torshavn did not respond to request for information for this study.*

2.1.4 Finland

The legislation regarding construction and demolition waste in Finland follows the development of European Union waste legislation and regulation, as the Waste Framework Directive and the waste hierarchy. In some respects, however, Finnish legislation is more extensive and stricter than EU regulations.

Waste law, *Jätelaki* (646/2011[24] includes the definition for construction and demolition waste. The Government Decree, *Valtioneuvoston asetus jätteistä* (978/2021[25]) defines e.g., the objection to reduce the CDW amount (reuse), the separate collection obligation and recycling rate objective for CDW.

In Finland, the following materials are to be separately collected in construction and demolition sites according to the Finish national legislation:

- Concrete, bricks, stone slabs, and ceramics, sorted by grades when possible.
- Asphalt
- Bitumen, roofing felt
- Gypsum
- Untreated wood
- Metal
- Glass
- Plastic
- Paper and cardboard
- Mineral wool insulation
- Surplus soils and aggregates

Current land use and construction Law, *Maankäyttö- ja rakennuslaki 132/1999*[26] is under revision and new construction Law will step into force in the beginning of 2025[27]. New construction law obligates both construction and demolition projects to do CDW report (*rakennus- ja purkujäteselvitys*) which defines the estimated amounts of generated CDW. The report needs to be updated after finishing the project so that the realized amounts, place of delivery and treatment are specified. This will help to get more detailed information about the generated CDW in the future. In addition, the Finnish government has set focus in the "*strategic programme to promote circular economy*" on material circularity and increment of recycling rate especially in the construction sector in Finland[28].

24. Waste law. 17.6.2011/646. Finlex. Available: https://www.finlex.fi/fi/laki/ajantasa/2011/20110646
25. Government Degree 978/2021. Finlex. Available: https://finlex.fi/fi/laki/alkup/2021/20210978
26. Land Use and Construction Law 132/199. Available: https://www.finlex.fi/fi/laki/ajantasa/1999/19990132
27. Proposal of the Government HE 139/2022 vp. Available: https://www.eduskunta.fi/FI/vaski/HallituksenEsitys/Sivut/HE_139+2022.aspx
28. Ministry of Environment. 2021. Strategic program to promote circular economy. Available: https://ym.fi/kiertotalousohjelma

Few important national legislations concerning especially mineral CDW recycling are Government Decree, *Valtioneuvoston asetus eräiden jätteiden hyödyntämisestä maarakentamisessa* 843/2017[29] which defines utilization criteria for asphalt, concrete, and tile waste for earth construction application. If the requirements given in the Decree are met, the material can be utilized in predefined earth construction purposes with declaration procedure without extensive environmental permit process.

In addition, Finland has defined national End of Waste, EoW, criteria (Government decree, *Valtioneuvoston asetus betonimurskeen jätteeksi luokittelun päättymisen arviointiperusteista* 466/2022[30]) for concrete waste. The Decree enables material producer (e.g., concrete crush producer) to obtain EoW status for the end product (e.g., concrete crush) if the production facility has environmental permit or it has been registered according to Government decree, *Valtioneuvoston asetus kiinteän betoniaseman ja betonituotetehtaan ympäristönsuojeluvaatimuksista* 858/2018[31] as fixed concrete mixing or production plant. The operator informs local environmental authority about the implementation of EoW criteria in certain production plant 30 days in advance. Concrete waste with EoW status can be used for house or earth construction purposes, aggregate for ready mixed concrete and concrete products, fertilizer, or soil conditioner. Crushed concrete recycling scheme variations are visualized in Figure 7 below.

29. Government Degree 843/2017. Finlex. Available: https://www.finlex.fi/fi/laki/alkup/2017/20170843
30. Government Decree 644/2022. Finlex. Available: https://www.finlex.fi/fi/laki/alkup/2022/20220466
31. Government Decree 858/2018. Finlex. Available: https://www.finlex.fi/fi/laki/alkup/2018/20180858

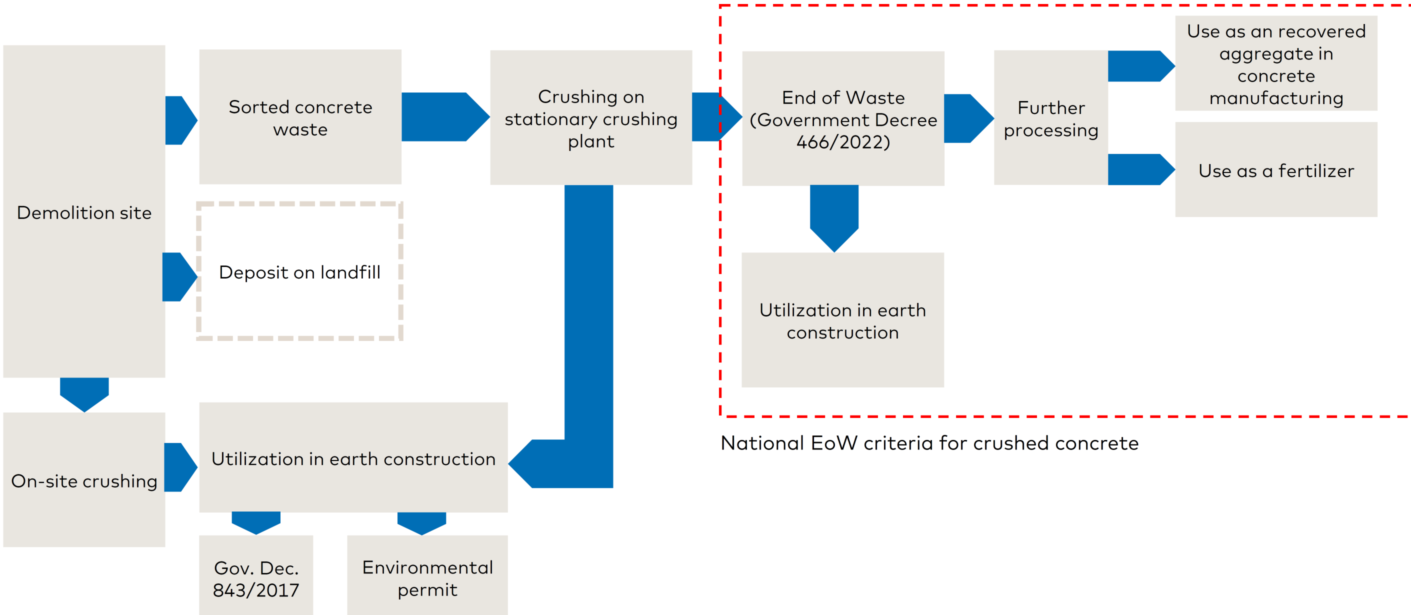

Figure 7. *Recycling scheme for concrete waste according to Finnish legislation.*

As mentioned above, the laws and decrees on the management on CDW in Finland are more comprehensive than the EU regulations states. Figure 8 shows the waste streams for the CDW treated in Finland for the year 2020 where the CDW streams have been visualised in a Sankey-diagram. The data reporting for the treatment of CDW in Finland is done at a higher level, and it was challenging to find data at a sub-category level and for the treatment methods of the waste fractions, such as what type of material recovery operations take place.

The diagram shows that mineral waste accounts for the majority of the total treated CDW and the second largest material flow is wood waste. The available data is reported at most detailed on according to EWC-Stat codes, meaning that mineral waste includes fractions of e.g., bricks and asphalt. The treatment methods are recycling or material recovery, energy recovery and disposal to landfill.

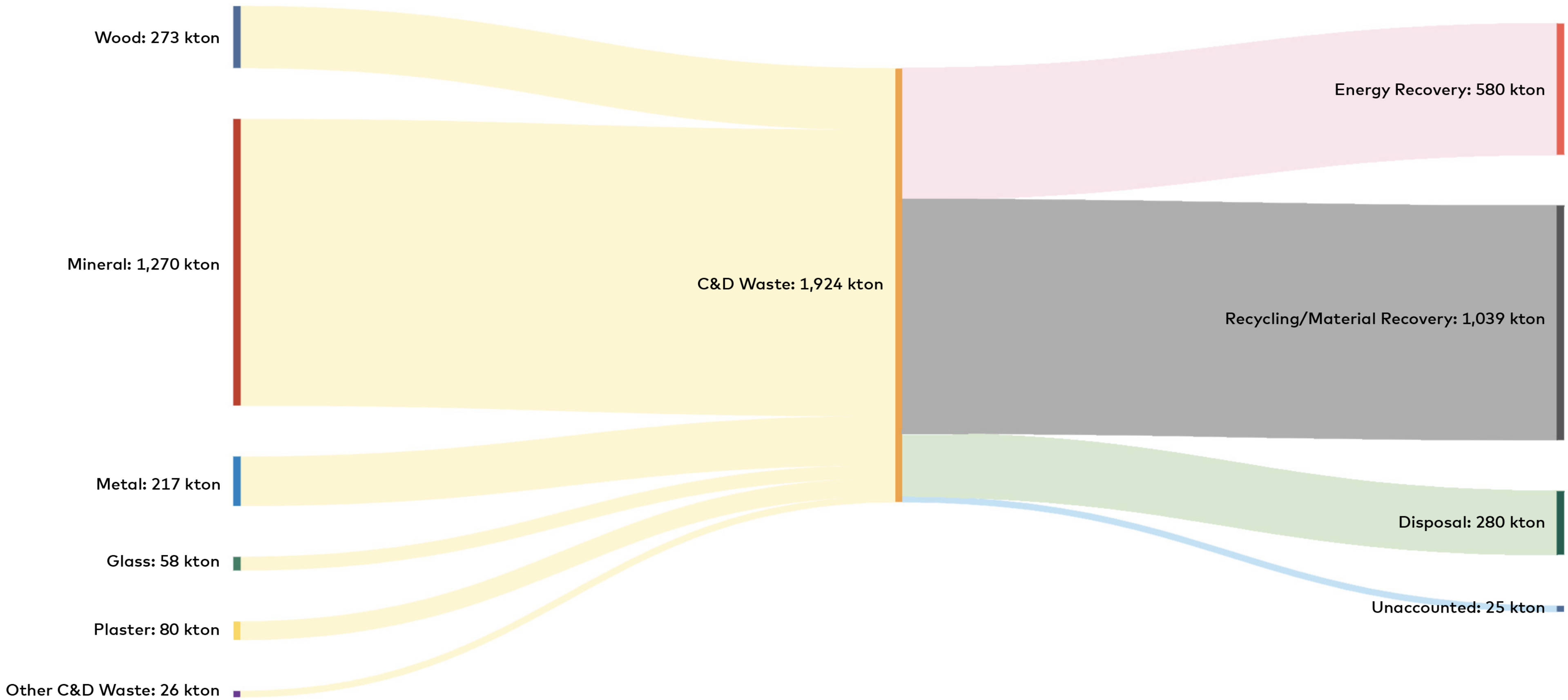

Figure 8: *Material flows for CDW in Finland for the year 2020. Data on the amounts of CDW was mainly gathered from Statistics Finland, Tilastokeskus*[32]*, and was complimented with additional data sources*[33]*.*

---

32. *Tilastokeskus 2023. Jätetilasto. Available: https://pxdata.stat.fi/PxWeb/pxweb/fi/StatFin/StatFin__jate/*
33. *Additional sources used during the data gathering process of CDW amounts for 2020:*
- Muovitiekartta Suomelle 2020 https://ym.fi/documents/1410903/40549091/rakentamisen_muovit_A4_v3.pdf/9999a63d-a09e-b840-4ab1-fb1de6672fbd/rakentamisen_muovit_A4_v3.pdf?t=1694178723504
- Liikanen, M., Helppi, O., Havukainen, J., & Horttanainen, M. (2018). Rakennusjätteen koostumustutkimus–EteläKarjala. LUT Scientific and Expertise Publications/Tutkimusraportit–Research Reports 82
- Uusiouutiset 2015 https://www.uusiouutiset.fi/asukkaat-innostuivat-kipsilevy-ja-kattohuopajatteen-kierratyksesta/
- Kauppalehti, available: https://www.kauppalehti.fi/uutiset/knauf-oy-kaynnistaa-kipsilevyjen-kierratyksen/b5583945-0e84-37e5-bbd5-adee14b082cc
- Seloy, Lasitietoa, available:
https://seloy.fi/lasin-kierratys/

2.1.5 Åland

Åland islands is an autonomous region of Finland, with its own application of the Finnish waste law, Åland waste law, *Landskapslag om tillämpning av rikets avfallslag* 2018:83[34], which largely follows the same objectives as the national law. The responsibilities and objectives are specified in the Governmental Decree on Waste, *Landskapsförordning om avfall* 2022:22[35]. The Åland governmental decree *Landskapsförordning om återvinning av vissa avfall i markbyggnad* 2010/79 defines utilization criteria for asphalt, concrete and non-hazardous bottom and fly ash waste for earth construction application[36].

In the waste decree 2022:22 the materials that are to be separately collected are specified, and they are the same as in Finland nationally. The goal is a 70 % recycling rate for CDW. Figure 9 shows the material flows for the treated CDW in the Åland Islands in 2020 and the data have been visualised in a Sankey-diagram. Although the Åland Islands is a small region, with around 30.129 inhabitants reported in 2020, the data transparency on the treatment of CDW is considered quite high.

The reported waste categories were for wood, minerals and metals, with plaster waste being included in the amounts for minerals. According to information from the waste handlers in the Åland Islands, the reason for the large amounts of mineral waste was due to a large construction of the road systems in the island. The diagram shows that the largest CDW fraction reported goes to recycling and material recovery. Small fractions end up in landfill and energy recovery.

34. Åland waste law 2018:83. Ålex. Available: https://www.regeringen.ax/alandsk-lagstiftning/alex/201883
35. Åland Governmental Decree on Waste. Ålex. Available: https://www.regeringen.ax/alandsk-lagstiftning/alex/202222
36. Åland Government Decree 2010/79. Ålex. Available: https://www.regeringen.ax/alandsk-lagstiftning/alex/201079#an_201895

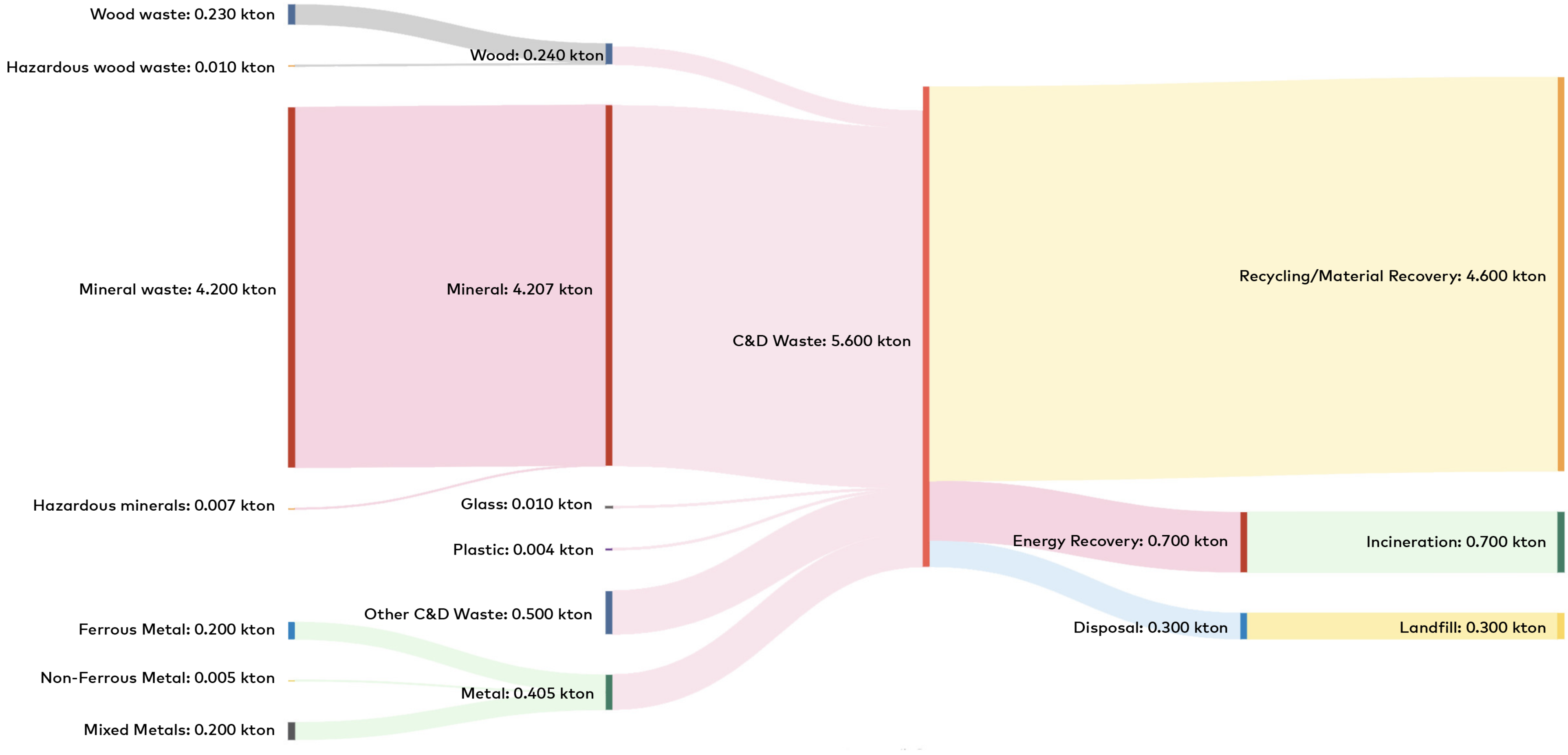

Figure 9: *Material flows for CDW in the Åland Islands for the year 2020. Data on the amounts of CDW was gathered from Statistics and Research Åland, ÅSUB, for the year 2020*[37].

37. *ÅSUB 2021. Avfallsstatistik 2020. Statistik 2021:5. Available: https://www.asub.ax/sites/default/files/statistics/avfall20_0.pdf*

2.1.6 Iceland

The Icelandic national laws on waste treatment, *Lög um meðhöndlun úrgangs (55/2003)*[38], follows development of European Union waste legislation and regulation, as the Waste Framework Directive and the waste hierarchy. The law states that the Ministry of Environment, Energy and Climate is responsible for setting a general waste management policy, as well as general policy on waste prevention, for twelve years at a time, and the policy applies to the whole country. The policy should include information on; the state of waste issues in the country, the role of the government and policies to improve reuse, recycling, and disposal. It is the role of the Environmental Agency in Iceland to prepare the proposal for a policy on waste management and prevention which is to be submitted and approved by the Ministry. A new waste management policy, Í átt að hringrásarhagkerfi[39], was implemented in 2021 where the main focus is working towards the circular economy when it comes to waste management.

The national waste law (55/2003) was amended, and the changes entered into force January 1st, 2023. According to the amendments, CDW is defined as all waste resulting from construction and demolition activities, including maintenance and changes during the life of buildings, and their demolition. This definition also includes waste resulting from minor public construction and demolition activities in private homes. The law also states that CDW is to be sorted, at the minimum, into the following categories:

- hazardous materials,
- wood,
- minerals,
- metal,
- glass,
- plastic, and
- plaster

In addition to the national law, Iceland has regulations that further define the management of CDW, one being the Regulation of waste management (803/2023), and the National building regulation (112/2012).

The Waste management regulation, *Reglugerð um meðhöndlun úrgangs*[40] *(803/2023),* is set by the Ministry of the Environment, Energy and Climate and was entered in to force in July 2023. The regulation states that preparation for reuse,

38. Lög um meðhöndlun úrgangs (55/2003). Alþingi. Available: https://www.althingi.is/lagas/nuna/2003055.html
39. Í átt að Hringrásarhagkerfi – ný stefna í úrgangsmálum. Stjórnarráðið. Available: Stefna um meðhöndlun úrgangs 2021-2031
40. Reglugerð um meðhöndlun úrgangs (803/2023). Reglugerðir. Available: https://island.is/reglugerdir/nr/0803-2023

recycling and other material recovery (including backfilling) of CDW shall be at minimum 70% (of weight).

The national building regulation, *Byggingarreglugerð*[41] *(112/2012)* is set by the Housing and Infrastructure Agency in Iceland and acts as a minimal standard for design and construction of new buildings to help protect the health and safety of people living/operating in them. The Ministry of Infrastructure oversees the Housing of Infrastructure Agency in Iceland. The regulation states that from January 1, 2020, at least 70% of CDW must be sorted in such a way that is suitable for recovery before it is returned to a waste reception facility. Furthermore, the regulation states the following for management of CDW.

- New buildings should be designed and built in such a way that all the waste that may come from them, i.e., due to construction works, maintenance and changes during their lifetime as well as demolition, causes the least possible damage to the environment.
- Before constructions of buildings that require a building permit begins, the owner must submit to the license provider a plan for the management of construction and demolition waste, which includes information on planning, registration, classification, reuse, and disposal, if the project is expected to amount more than 10 ton of waste.
- A list of construction and demolition waste generated during the construction shall be made. Material types and their quantities must be recorded.
- All construction waste must be transported to an approved waste reception facility.

In Figure 10, the material flows for the CDW treated in Iceland in 2020 can be seen, and the data have been visualised in a Sankey-diagram. When comparing the waste categories shown in the diagram to the minimum sorting categories of waste defined in the Icelandic national waste laws, some differences can be seen. That is due to the amendments of the national waste laws came into force in the beginning of 2023 and therefore, data is not available for those categories for the year 2020.

The waste diagram shows that mineral waste and other CDW, mainly asphalt waste, accounts for the largest amounts of the total treated CDW. Furthermore, the majority of the CDW is recovered and goes into backfilling operations. The second largest treatment method for the CDW is recycling, but the type of recycling is unspecified to a large extent. A very small fraction is sent to energy recover as there is no such facility operating in Iceland.

41. Byggingarreglugerð (112/2012. Húsnæðis- og mannvirkjastofnun. Available: https://www.byggingarreglugerd.is/

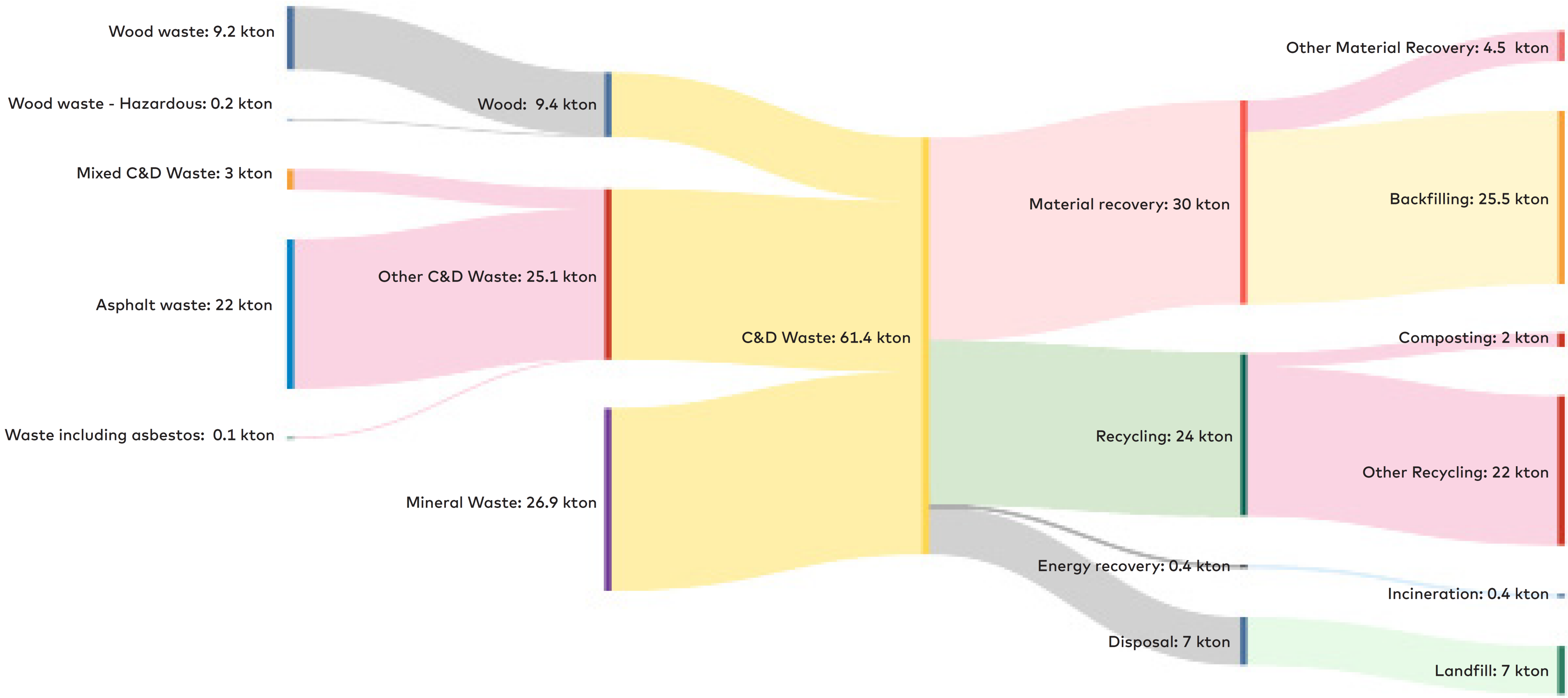

Figure 10: *Material flows for CDW in Iceland for the year 2020. Data on the amounts of CDW was received from The Icelandic Environment Agency, Umhverfisstofnun, for the year 2020.*

2.1.7 Norway

The law and regulations concerning CDW are set in the "Regulations on technical requirements for construction work" (Byggteknisk forskrift – TEK17)[42]. The Norwegian waste regulations are included here, with regulations relating to hazardous waste and the recycling and treatment of waste, *Avfallsforskriften: Forskrift om gjenvinning og behandling av avfall*[43] (FOR-2004-06-01-930) and in the Pollution Control Act, *Forurensningsloven*[44] (LOV-1981-03-13-6). Waste handling in Norway is also regulated by EU regulations which is incorporated into the EEA agreement, like the EU Waste Directive.

The Norwegian Environment Agency prepare the laws and regulations for waste from construction and demolition projects and provides guidance to how the rules are to be put in practice[45]. The Norwegian laws and regulations state that the following waste fractions are obligated to be separated in construction and demolition projects:

- Polluted concrete, bricks and similar (but under limit for hazardous waste)
- Electric and electronic waste
- Hazardous waste

In addition to these it is recommended in guidelines to the legislation and in standard schemes[46] for reporting of how waste is treated that the following fractions (and more) are separated in construction and demolition projects:

- Wood waste (not impregnated)
- Paper and cardboard
- Glass
- Iron and other metals
- Plastic
- Gypsum/plaster waste
- Concrete, bricks and similar

In the guidelines to the legislation, it is also mentioned fractions like roof covering, ceramics, sanitary porcelain (for reuse), textiles and furnishings.

42. Forskrift om tekniske krav til byggverk. Available:https://lovdata.no/dokument/SF/forskrift/2017-06-19-840/KAPITTEL_9#KAPITTEL_9
43. Avfallsforskriften (FOR-2004-06-01-930). LOVDATA. Available: https://lovdata.no/dokument/SF/forskrift/2004-06-01-930
44. Forurensningsforskriften (LOV-1981-03-13-6). LOVDATA. Available: https://lovdata.no/dokument/SF/forskrift/2004-06-01-931
45. The Norwegian Environment Agency web page. Available: https://www.miljodirektoratet.no/om-oss/dette-er-miljodirektoratet/
46. Sluttrapport med avfallsplan. Available: https://www.dibk.no/globalassets/blanketter_utfyllbare/alle-blanketter/5178-sluttrapport-med-avfallsplan-for-nybygg_2017.pdf

The technical requirements for construction works are found in Byggteknisk forskrift[47] (TEK17), which states that projects regarding demolition and rehabilitation must perform mapping of hazardous waste before demolition and from all building fractions that shall be removed. The projects must also perform mapping of materials that are suitable for reuse. Reporting of the results is required, but there are no requirements of using of the materials that are suited for reuse. All hazardous waste must be delivered at an approved waste facility. This kind of waste is not suitable for reuse if the materials or products contains hazardous substances that are prohibited in use by the "produktforskriften"[48]. All new buildings must be planned and built for easy disassembly in the future, to increase reuse of materials and thereby reduce waste from demolition projects. Building projects are required to sort out minimum 70 % of the waste from the construction site. The waste will then be sent for further material recycling, to landfill or to incineration for energy use. Before new buildings are allowed to be taken in use there must be a final report showing the actual disposition of the waste, broken down into different waste types and waste quantities. Delivery to approved waste facility, reuse or direct recycling must be documented.

In Figure 11, the waste streams for the treated CDW in Norway for 2020[49] can be seen and the waste streams have been visualised in a Sankey-diagram. The diagram shows that mineral waste accounts for the largest amounts of the total treated CDW, and mixed waste and wood waste has the second largest amounts. The treatment methods in the available data reports are recycling including material recovery, energy recovery and disposal to landfill. The majority of the CDW goes into material recovery or recycling, whereas the disposal to landfill and energy recovery remains as the other most common treatments of CDW.

47. Byggteknisk forskrift (TEK17). Direktoratet for byggkvalitet. Available:https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17
48. Produktforskriften. Available: https://lovdata.no/dokument/SF/forskrift/2004-06-01-922
49. Statistisk Sentralbyrå, Statistikkbanken, Avfall fra byggeaktivitet, tabell 09781. Available: https://www.ssb.no/statbank/table/09781/

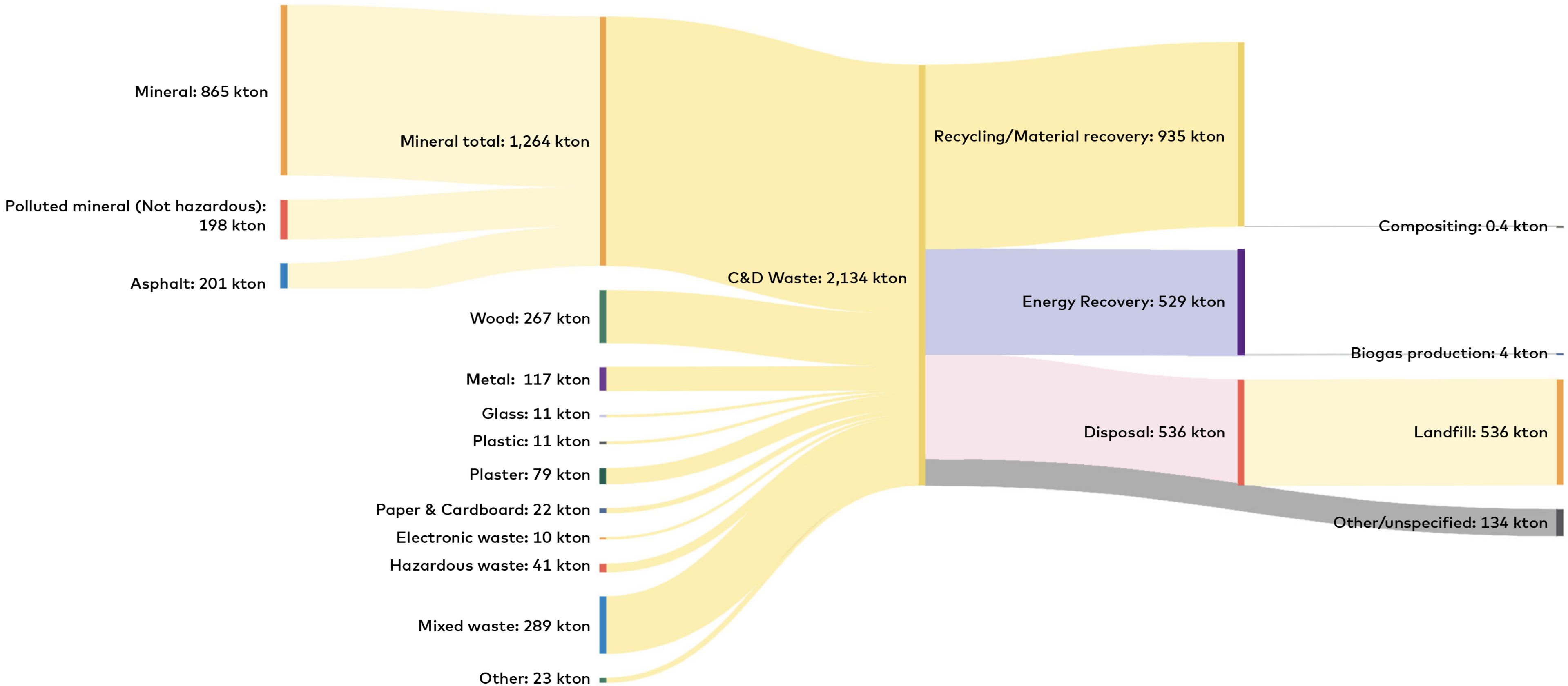

Figure 11: *Material flows for CDW in Norway for the year 2020. Data on the amounts of CDW was gathered from Statistics Norway, Statistisk sentralbyrå, for the year 2020*[50]*.*

50. *Statistisk Sentralbyrå, Statistikkbanken, Avfall fra byggeaktivitet, tabell 09781. Available: https://www.ssb.no/statbank/table/09781/*

2.1.8 Sweden

The legal framework governing Sweden's waste management system is established by both Swedish and European waste legislation, adhering to the waste hierarchy: prevention, preparation for reuse, material recovery, other recycling (including energy recovery), and disposal. This prioritization is contingent on environmental justification and financial feasibility.

The prioritization order for waste prevention and management is outlined in the framework directive for waste, integrated into Swedish legislation through the Swedish Environmental Code (1998:808), specifically in Chapter 2, 5§ and Chapter 15, 10§[51].

The Swedish Environmental Code (1998:808) encompasses regulations for waste management, running concurrently with additional waste-related provisions stemming from construction and demolition activities found in the Planning and Building Act (2010:900) (PBL)[52].

Mandatory on-site sorting of construction and demolition waste is mandated by the Waste Regulation (2020:614)[53]. At the point of generation, a minimum of six types of waste must be sorted out:

- Wood
- Mineral materials (e.g., concrete, clinker, ceramics)
- Metal
- Glass
- Plastic
- Plaster

In Figure 12, the waste streams for the treated CDW in Sweden for 2020 can be seen and they have been visualized in a Sankey-diagram. The diagram shows that mineral waste accounts for the largest amounts of the total treated CDW, and wood waste is the second largest waste category. Treatment methods in Sweden are reported as recycling including material recovery, energy recovery, further sorting and disposal to landfill. The majority of the CDW is recovered or recycled as material, and the second largest fraction go to energy recovery.

---

51. Swedish Environmental Code, Miljöbalken SFS 1998:808. Available: https://rkrattsbaser.gov.se/sfsr?bet=1998:808
52. Plan och bygglagen SFS 2010:900. Available: https://rkrattsbaser.gov.se/sfst?bet=2010:900
53. Avfallsförordning SFS 2020:614. Available: https://rkrattsbaser.gov.se/sfst?bet=2020:614

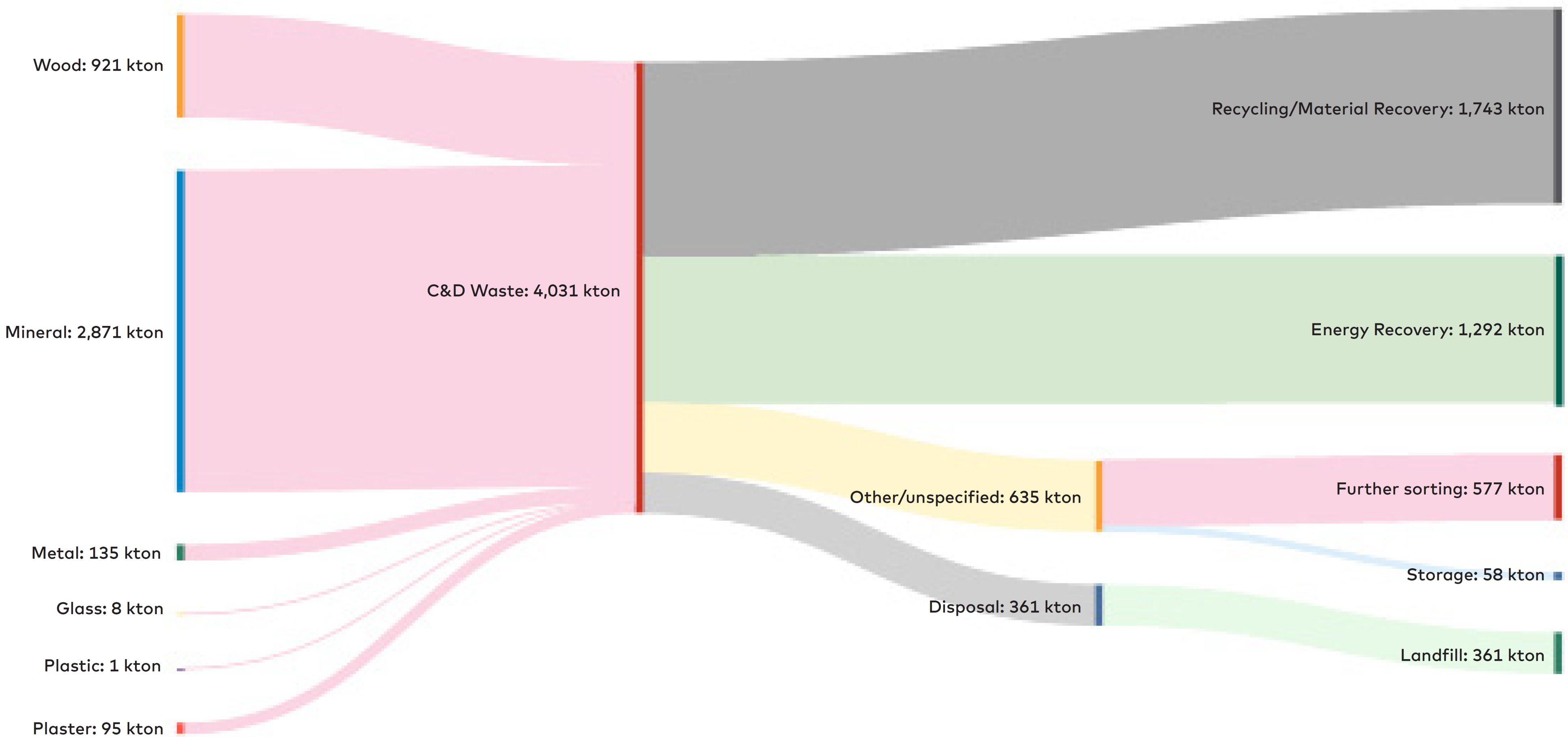

Figure 12: *Material flows for CDW in Sweden for the year 2020. Data on the amounts of CDW was received from The Swedish Environmental Research Institute, IVL, for the year 2020*[54].

54. *IVL 2023. Personal communication, Jan-Olov Sundqvist.*

2.2 CDW treatment processes in the Nordics

This chapter summarizes the typical CDW treatment process in different Nordic countries on a general level. In addition, the current situation of treatment methods for different CDW fractions are evaluated for each country. The largest CDW treatment facilities are listed in Appendix 1. Lists of CDW treatment facilities.

Concrete-, tile-, wood- and metal waste represents the majority of the overall CDW stream. Smaller waste fractions include plastics, glass, plaster/gypsum, mineral insulation, bitumen, ceramics and miscellaneous.

Within the construction and demolition sector, a distinction is drawn between construction waste and demolition waste. Construction waste includes waste from installation and assembly, while demolition waste arises from renovation or complete demolition activities. The degree of purity in construction and demolition waste can vary significantly. Nevertheless, the overall waste management process remains consistent for both construction and demolition[55].

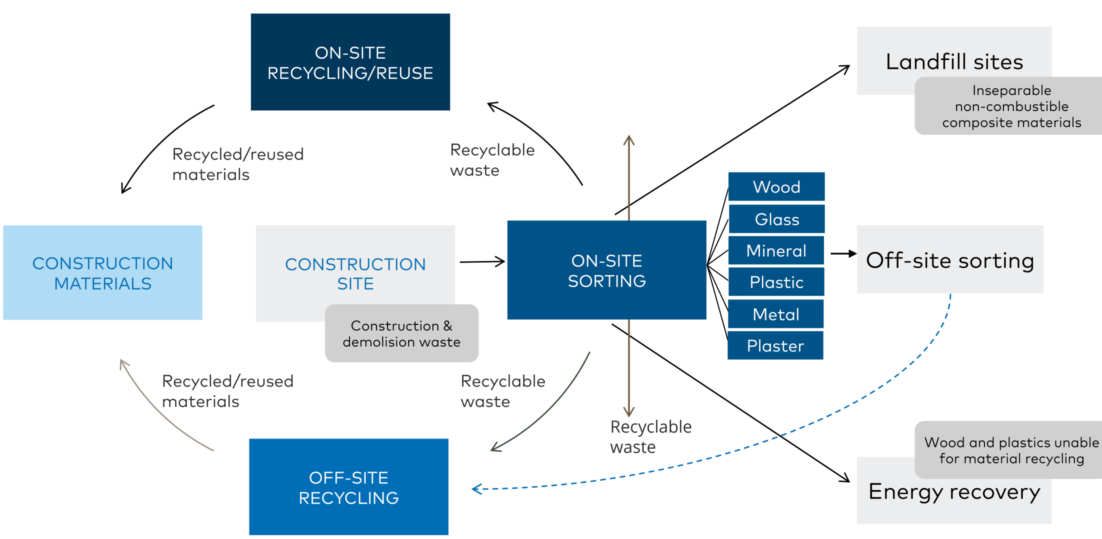

Figure 13. *The relationship between on-site and off-site material flows.*

55. Swedish Construction Federation. 2019. Resource and Waste Guidelines for Construction and Demolition. Available: https://byggforetagen.se/app/uploads/2020/02/Resource-and-waste-guidelines-2019.pdf.

CDW recycling can generally be categorized into two main approaches: off-site and on-site recycling. The relationship between on-site and off-site recycling refers to the interdependence of recycling efforts that occur within a facility or property (on-site) and recycling efforts that occur outside of the facility or property (off-site), see Figure 13. On-site recycling establishes the foundation for off-site recycling by reducing the amount of waste that needs to be transported off-site and by separating materials for recycling. Off-site recycling complements on-site recycling by processing the materials that cannot be recycled on-site. If sorted waste cannot be recycled or reused, it may be destined for landfill or energy recovery[56].

Wastes containing harmful substances are to be separated from other non-hazardous waste fractions as described in EU waste directive. In demolition sites pre-demolition audit is typically carried out in all Nordics. Typically, a pre-demolition audit includes also waste audit where potential reusable or recyclable materials are determined and materials containing hazardous substances are identified so that they can be demolished separately.

Currently the main methods in the Nordics for treating CDW are energy recovery and material recovery (e.g., use of mineral fraction as backfilling material) or landfilling. Even though these methods have a low rank in the waste hierarchy they are typically the most cost effective especially for smaller scale renovation and demolition projects. Larger projects have typically more comprehensive on-site separation of CDW materials compared to smaller sites. The smaller sites typically only separate largest streams like mineral, wood and metals and rest mixed CDW is transported for further treatment. The current primary treatment methods for different CDW fractions in different Nordic countries are summarized Table 5.

56. Naturvårdsverket. 2023. Bygg- och rivningsavfall. Available: https://www.naturvardsverket.se/vagledning-och-stod/avfall/bygg--och-rivningsavfall/

	Reuse	Recycling	Material recovery	Energy recovery	Disposal
Mineral (concrete, tiles, etc.)			DA, FI, IS, NO, SE		
Metal		DA, FI, IS, NO, SE			
Glass		DA, FI, NO, SE	IS		
Wood		DA		FI, IS, NO, SE	
Plastic				DA, FI, IS, NO, SE	
Plaster		DA, NO, SE			FI, IS
Mineral insulation wool		DA			FI, IS, NO, SE
Reject from mechanical CDW separation					FI, IS, NO

Table 5. *Summary of the main CDW treatment methods for different fractions in Nordics*

2.2.1 Denmark

For years, Denmark has been characterized by a high degree of material recovery, which is mainly due to the use of crushed construction waste as a substitute for primary raw materials. In the 2010s, attention was drawn to hazardous substances in construction materials and the waste legislation was tightened to increase the sorting and quality of the construction waste.

Now, prior to demolition and renovation work, existing buildings and constructions are surveyed, and the presence of hazardous materials are mapped. These materials are then handled in a separate waste stream in the very beginning of the projects. In the last few years, some builders have expanded the surveys with mapping of resources to identify and highlight materials suitable for reuse or recycling. Architects are increasingly focusing on incorporating recycled materials into new constructions.

Waste generated from demolition work, renovation work and maintenance work on buildings and facilities must be reported to the local authorities prior to starting the work and must be sorted on site if it amounts to more than 1 ton of waste, or if the work involve the replacement of double-glazed windows that may have been manufactured in the period 1950 to 1977. If the total amount of waste from a demolition or construction site is expected to be less than 1 ton, on-site sorting is not mandatory. In that case, the waste must be sorted at an off-site facility. The waste-producing company may let unsorted construction and demolition waste, which is suitable for material recovery, be sorted at a suitable registered sorting facility.

Most of the construction waste is handled by large private waste management companies that operates nationwide and have large facilities for treatment of waste (sorting, shredding, crushing etc.). In many cases concrete is crushed by mobile machinery and backfilled on site or used on other projects close by. In Denmark it is usually cheaper to sort and recycle materials, since the landfill fees are very high. There is an emerging market for reusable construction materials but as of today the volume is small and the market is hampered by lack of uniformity and difficulties to comply with building code requirements.

For some specific sorted construction materials (like glass, gypsum, and metals) close to 100 % of the generated waste is recycled in the production of new materials, e.g., glass insulation wool (Isover), glass packaging (Ardagh) and new plasterboards. Metals are largely exported for recycling. Wood waste primarily is recycled into chipboards, but the amount depends largely on the market prices and can therefore fluctuate between recycling into chipboard or used for energy recovery.

The summary of current treatment methods for different CDW fractions are shown in following table below. A list of the largest treatment facilities in Denmark are shown in Appendix 1.

Table 6. *Summary of current CDW fraction treatment methods in Denmark*

	Reuse	Recycling	Material recovery	Energy recovery	Disposal	Comment
Wood	●	●●●	-	●●●	-	Wood waste, both treated and untreated, are mainly used for recycling and energy recovery. A large proportion is recycled and used in the production of particleboards. Small scale reuse of high-quality untreated wood in new constructions.
Metals	●	●●●	-	-	-	Majority of the metals ends up in recycling. Reuse of steel structures has been done in small scale, mainly project-wise.
Plastic, PVC	-	●●●	-	-	●●●	Hard PVC is collected and recycled through VinylPlus (the European PVC industry), and soft PVC is landfilled.
Plastic, other	-	●●	-	●●●	-	On large building sites soft and hard plastic waste is collected for recycling. Plastic waste from smaller sites is energy recovered. Plastic mixed with other waste or plastic compounds are energy recovered.
Plaster/ gypsum	-	●●●	-	-	●	Dry gypsum material is recycled and used in the production of new plasterboards. Wet gypsum is landfilled.
Mineral insulation wool	-	●●●	-	-	●●	Mineral insulation wool is recycled and used in the production of new insulation materials. Some of the glass wool insulation is recycled and used in the production of Leca – lightweight expanded clay aggregate. Insulation mixed with other materials is landfilled.
Reject from mechanical CDW separation						This fraction is not part of the waste stream in DK.
Mineral (concrete, tiles, etc.)	●	-	●●●	-	-	Concrete and tiles are material recovered. Bricks laid in lime mortar can be reused. Bricks laid in cement mortar is difficult to separate and is material recovered.
Glass	-	●●●	-	-	-	Glass is recycled in the production of new glass and in the production of glass wool insulation.

- Seldom used. ● Small scale use ●● Medium scale use ●●● Large scale use

2.2.2 Greenland

Greenland is a vast country with a small and dispersed population. The amount of generated waste is relatively small. All kinds of waste in Greenland have traditionally been disposed by means of discharge to the sea or by landfill.

Since the late 1990s the waste system in the settlements and in the smaller towns have typically consisted of a landfill and an incineration plant, as well as some system for collecting hazardous waste.

In 2019 the five municipalities joined and founded a national waste management company with the purpose of creating solutions for the handling of all kinds of waste in Greenland. This includes the building of two new incineration plants in Nuuk and Sisimiut which will replace the current six regional incinerators and the many outdated small settlement incinerators. Waste suitable for incineration will be collected in the villages and settlements and shipped to the new larger facilities.

Other types of waste will be sent for processing to other locations in Greenland or abroad. The waste will have to be shipped or airlifted, as the villages and settlements do not have interlinking roads. This combined with a relatively small production of waste make many of the solutions used in continental Europe unsuitable since the economic costs will be disproportionately high.

As of today, there are no public or private companies approved for the reception, treatment, or recycling of any type of waste. When asked about recycling of construction waste in Greenland two of the five municipalities answer that they have no knowledge of reuse or recycling of construction and demolition waste in connection with the renovation of existing buildings or for the construction of new buildings.

Metal waste is collected and shipped for treatment in Denmark. Wood and plastic waste is incinerated at local waste incineration plants and glass waste, mineral waste and gypsum waste is landfilled locally. Some mineral waste (concrete) is crushed and used locally as backfilling.

The largest bank in Greenland, Grønlandsbanken, plans to offer loans on more favourable terms for environmentally friendly and sustainable building-/renovation projects.

All hazardous waste (such as waste oils, chemical, paint residues and electronics) throughout Greenland is sorted and then sent to Denmark for further processing.

Waste that is handed over to the municipality's waste reception facilities must, as a minimum, be sorted into the following waste fractions:

- Landfillable waste (asbestos, soft PVC, insulation, bricks, glazed bricks)
- Tires without rims
- Glass and bottles
- Iron and metal
- Soil
- Environmentally hazardous waste
- Waste suitable for combustion

The only CDW-fraction that is systematically collected for recycling is iron and metal. All other fractions are incinerated or landfilled depending on the available local facilities.

2.2.3 Faroe Island

The municipalities are responsible for pickup and waste handling in Faroe Islands. The capital and largest municipality, Tórshavn, has its own waste handling entity, KB. All other municipalities have a common waste handling company, IRF. Both KB and IRF have an incineration plant and work together on landfilling and handling of recycled fractions.

In general, there are facilities for sorting and handling of cardboard and paper, soft plastic waste, aluminium beverage cans, iron scrap and other metals, glass, and hazardous waste, which is collected for recycling and shipped off for recycling or other treatment. To some extent, glass is also landfilled. Building materials such as concrete slam, PVC, window glass, mineral and glass insulation and asbestos, are generally landfilled. Excess soil and stones are landfilled. The biggest fraction that is systematically collected is iron and metal. The collection of plastics and glass waste has not been systematized and hence consist of a modest quantity.

Although older houses are demolished from time to time, in most cases, older houses and industrial buildings are refitted and reused for new purposes. No legislatively controlled mapping of heavy metals and environmentally hazardous waste of buildings takes place prior to reuse or demolition and landfilling.

2.2.4 Finland

Demolition waste treatment process varies in Finland depending on the size of demolition site. Typically, biggest waste fractions like mineral (concrete and tiles), wood and metals are separated on site with excavator. In larger demolition sites the concrete waste can be crushed on site with a mobile crusher or pulverized with excavator. Alternatively, the concrete waste fraction can be transported to stationary treatment plant where it is refined as concrete crush. A lot of demolished material ends up in mixed fraction which is delivered to mechanical treatment plant where it is separated. Certain materials such as gypsum waste is difficult to separate afterwards from mixed waste as it pulverizes easily.

In practice, the separate collection of different waste fractions does not realize in construction and even less in demolition sites, even though it is obligated in the legislation. The separate collection obligation is not generally supervised or there is no penalty for neglecting the obligation. Overall, the costs are main driver to determine what happens to the demolition waste. Largest fractions, such as metals, wood and concrete, have existing recycling or recovery practices and reasonable or even positive price for recycling as a material or energy recovery. However, the waste fractions which requires more work to separate in the demolition site, such as plastics, mineral wool or gypsum waste, typically ends up in mixed CDW and are used for energy recovery or deposited to landfill instead of recycling. The separate collection of many waste fractions would increase the overall costs for demolition projects. Especially the public demolition projects are typically tendered based on lowest price.

As the recycling rate targets for CDW are not achieved, new recommendations and practices arise in a fast pace. Pre-demolition audit is voluntary in Finland, but it is recommended for all buildings over 100 m^2. Only the mapping of hazardous substance and asbestos is currently mandatory for all buildings which are constructed or renovated before 1994. Emerging markets in reuse and recycling can be seen, even though still in relatively small scale compared to total amount of CDW.

Finland has variety of treatment plants for mixed CDW. Municipal waste management companies are responsible to arrange waste management for CDW from households, for example waste from renovations. Larger CDW streams from building demolition and construction are typically source separated and delivered for utilization to private waste management companies. Common practice is that the contractor does only limited source separation (for example separation of steel and wood) and sends the mixed CDW to the other private waste management companies for further treatment and recycling. For example, mineral waste fractions, such as concrete and brick waste, are quite often utilized by the demolition contractors themselves for backfilling or other infra construction purposes.

The biggest mixed CDW treatment facilities are located near the major centre of population in Finland (Helsinki metropolitan area, Turku, Oulu and Tampere). The major CDW treatment and recycling plants in Finland are listed in the appendix 1. Especially for the mixed CDW treatment and recycling plants the list is not comprehensive as there are plenty of smaller enterprises which separates and treats mixed CDW around Finland. Typically, the smaller treatment facilities do not have stationary treatment/separation lines and therefore the separation is mainly done with excavator.

The general processing for the different CDW materials is described below:

- Untreated, treated and impregnated wood are typically separated on-site. Untreated wood can be directed to recycling, but still majority of all wood CDW ends up in energy recovery. New recycling alternatives, such as biochar production, are upcoming in Finland. Treated and impregnated wood goes mainly to energy recovery facilities with permission to handle this fraction.
- Mineral CDW, especially concrete waste and bricks, can be used for certain infra construction applications if they fulfil given requirements concerning hazardous substances and technical requirements and they are crushed on site or sent to stationary crushing stations. Mineral waste which is not suitable for infra construction purposes are used as a backfill in landfill structures.
- Mineral insulation wool waste from demolition typically ends up in mixed CDW fraction and in landfills. Small amounts of mineral wool waste have been separated and directed to recycling. However, Finland currently lacks large-scale recycling alternatives for mineral insulation wool which origins from demolition or renovation activities. For new constructions there are collection systems for excess mineral wool insulation materials.
- Metal is sorted out and is delivered for recycling, the metals are melted and used in new products of metal. Metal products can also be reused but it is still relatively small-scale operation.
- Glass is sorted out and is delivered for material recycling and production of new products (e.g., foam glass), the rest ends up in landfill.
- Plastic waste from demolition sites typically ends up in mixed CDW and it is sorted off-site in mechanical sorting facilities. The new construction sites, at least larger ones, have separate collection for packaging plastics. Overall majority of plastic CDW ends up in energy recovery, small amounts end up in recycling and landfill (e.g., majority of PVC).
- Separation of plasterboard waste on-site in demolition sites is typically considered too expensive and therefore it mainly ends up in mixed CDW fraction where only small amounts can be separated off-site for recycling. Plasterboard waste collection from construction sites is easier and it is done in some extent. Good quality plaster waste can be sent to plasterboard production facilities. Currently most of the plaster waste ends up in landfill and small fraction to incineration.

The main treatment methods for different CDW fractions in Finland is summarized in Table 7.

Table 7. Summary of current CDW fraction treatment methods in Finland

	Reuse	Recycling	Material recovery	Energy recovery	Disposal	Comment
Wood	●	●	-	●●●	-	Wood waste, both treated and untreated, are mainly used for energy recovery, only minor part is recycled or reused.
Metals	●	●●●	-	-	-	Majority of the metals ends up in recycling. Reuse of steel structures has been done in small scale, mainly project-wise.
Plastic, PVC	-	●	-	●	●●●	PVC plastics ends up mainly in landfills. A small fraction ends up in energy recovery even though it is problematic in energy recovery due to its chloride content. Recycling is possible but only few companies accepts separately collected PVC waste (e.g., pipes). Overall, FI lacks wide collecting network or commercial recycling facilities for PVC plastic.
Plastic, other	-	●	-	●●●	●	Many other plastic grades are also technically possible to recycle the dirtiness and mixing with other waste fractions make it difficult to recycle and only few facilities are currently able to process it. Energy recovery is often more cost efficient. A small fraction ends up in landfill.
Plaster/ gypsum	-	●●	-	●	●●●	Gypsum waste is technically recyclable, but the separation of gypsum waste during the demolition is considered problematic. Relatively small proportion of gypsum waste ends up in recycling in FI. Most of the material ends up in landfill as a part of mixed CDW and small amounts ends up also in energy recovery as a part of mixed CDW.
Mineral insulation wool	-	●●	-	-	●●●	Mineral wool waste from demolition has currently only minor recycling options, which are mainly still under development. One example is using as raw material for geopolymers. Majority of the material ends up in landfills as it does not possess significant energy value. Mineral wool from construction sites can be collected and recycled back in production process.
Reject from mechanical CDW separation	-	-	-	-	●●●	Low calorific value inhibits energy recovery and material is typically disposed in landfills. Some research has been done about the recycling of the materials, but it lacks any potential large scale recycling options.
Mineral (concrete, tiles, etc.)	●	●	●●●	●●	●●	In FI most of the mineral CDW fraction is recovered or recycled as a material in infra construction. Small scale reuse of bricks and concrete elements have been conducted, mainly in pilot-projects. Smaller amounts ends up in energy recovery together with mixed CDW or in landfill.
Glass	●	●●●	-	-	●	Most of the glass waste from construction and demolition activities is recycled as a raw material for the new plate glass, foam glass or glass wool insulation production. Occasionally some windows and frames are reused.

- Seldom used. ● Small scale use ●● Medium scale use ●●● Large scale use

2.2.5 Åland

In Åland, CDW is collected by municipal waste management companies, as well as private actors. The biggest waste companies for CDW on Åland are Svinryggen Deponi Ab and Ålands Renhållning Ab. Svinryggen is publicly owned waste management company and landfill for inert non-hazardous material. Ålands Renhållning Ab, which is a part of Transmar, is the largest private waste company handling CDW[57]. They receive waste from both private and public building sector on the Åland Islands and separate manually mixed CDW and prepare it for recycling, transport, or landfill. Asphalt is mainly recycled locally, as well as some of the wood waste that is used in composting[58]. Inert and non-hazardous waste, such as mineral waste, is landfilled at Svinryggen Deponi landfill. All other material for recycling or energy recovery is transported to Sweden or Finland[59]. Hazardous CDW is transported mainly to Finnish mainland for recycling, while other highly recyclable waste, such as metals, are transported mainly to Sweden for material recycling. Mixed waste for energy recovery is transported to Sweden, whereas wood waste is largely transported to Finland for energy recovery[60].

2.2.6 Iceland

In Iceland, it is in the responsibility of the holder of waste to ensure that waste is moved to appropriate treatment, either it is moved directly to recovery, or to a collection or reception centre[61].

The municipal waste management companies are responsible to arrange waste management for CDW occurring from households, such as waste accumulated from home renovation projects, and it is therefore the responsibility of the municipalities to ensure that there are waste reception stations available for the public.

For larger quantities of construction and demolition waste, such as from construction projects or from businesses, it is most commonly a private service provider that is chosen and appointed to take care of the waste management. The waste is usually pre-sorted at the job site into appropriate containers, in which the service provider then picks up and transports to appropriate facilities. As the waste categories have different processing fees, it is in the economic interest of the construction contractor/businesses to do the initial waste sorting the correct way.

57. Personal communication Jesper Svanfelt, Svinryggen Deponi Ab. 2023. https://www.svinryggen.ax/
58. Personal communication Jonas Karlsson, Ålands statistik- och utredningsbyrå. 2023. https://www.asub.ax/sv/statistik/avfallsstatistik-2020
59. Personal communication Robert Nylund, Ålands Renhållning Ab / Transmar. 2023. https://www.renhallningen.ax/
60. ÅSUB Ålands statistik- och utredningsbyrå. 2022. Avfallstatistik 2020. Statistik 2021:5, Ålands officiella statistik. Available: https://www.asub.ax/sites/default/files/statistics/avfall20_0.pdf
61. Í átt að Hringrásarhagkerfi – ný stefna í úrgangsmálum. Stjórnarráðið. Available: https://www.stjornarradid.is/Stefna_umhverfis_og_auðlindaráðherra_í_úrgangsmálum.pdf

The private service providers are a diverse group of contractors and operators that offer waste services. Some of these service actors specialize in a specific field and have a license for the reception, transport of waste or other treatment of a specific type of waste while others undertake a wide range of waste services for almost all types of waste. The service providers do business with each other and there are many examples of waste being transferred between parties. Parties that handle waste must have a work permit from the health committee or the Environmental Agency in Iceland according to the nature of the treatment, and the best available techniques should be used for waste management.

Service providers and recycling companies which handle the waste submit a report to the Environmental Agency on the waste they handle, with information on types of the waste and quantity, origin by industry category and municipalities and disposal of each material. Waste producers who dispose of their own waste at the production site or export their own waste for further treatment must submit a similar report. The Environment Agency therefore has an overview of registered waste for each municipality, both for households and legal entities.

Iceland has several waste facilities located around the country, both public and private facilities, but not all treat the same categories of construction and demolition waste. Some only handle a few materials, while other plants have the capacity of taking care of more categories of CDW. The main receivers of construction and demolition waste in Iceland are:

- Public landfills
- Disposal sites for inert waste
- Composting plants
- Mines
- Waste incineration (without energy recovery)
- Scrap metal companies
- Various private service providers
- Other reception points, e.g., occasional landfills in the sea or other

General landfill sites and various service providers are the ones that handle the largest part of construction waste in Iceland. However, it is not known exactly how big a part of the total amount of construction wastes these service providers handle, due to the registration of the amount of construction waste with them is not publicly available. The major CDW treatment facilities in Iceland are listed in Appendix 1. The main treatment methods for different CDW fractions are summarized in Table 8.

Table 8. Summary of current CDW fraction treatment methods in Iceland

	Reuse	Recycling	Material recovery	Energy recovery	Disposal	Comment
Wood	-	●●	●●	●●●	●	Untreated wood waste is mainly used for energy recovery, as a carbon source in the production of silicon metal, but some treated wood waste is recycled through composting. Treated wood waste is recovered through backfilling at landfill sites (e.g. used as biofilter against odour pollution).
Metals	-	●●●	-	-	-	Majority of the metals are exported abroad for material recycling.
Plastic (plastic without processing fee & Styrofoam from C&D)	-	●●	-	●●	-	The majority of the plastic that accumulates in IS (not only plastic from CDW) is pressed and baled at the reception and sorting facilities. The plastic is then shipped abroad, for further material recycling, or energy recovery. PET, LDPE, HDPE and PP plastic is shipped abroad for recycling, while other plastic types, e.g. PVC, PS, EPS and other mixed plastics, are shipped abroad for energy recovery.
Plaster/ gypsum	-	-	-	-	●●●	Gypsum waste is technically recyclable, but the separation of gypsum waste during the demolition is problematic. All of the gypsum waste in IS ends up in landfill and is kept at separate location at the landfilling sites.
Mineral insulation wool	-	-	-	-	●●●	Mineral wool waste from demolition has currently only minor recycling options, which are mainly still under development. There is possibility to reuse offcuts from new construction projects instead of disposing of it. However, there is little statistic on how much of the material is reused in IS. The majority of the material ends up in landfills as it does not possess significant energy value.
Mineral waste (concrete, tiles, etc.)	-	-	●●●	-	●	Mineral waste from CDW (classified as inert waste) goes into material recovery as it can be used for backfilling in various settings, such as in construction projects, which reduces the need for mining. A small fraction ends up in landfill.
Glass	-	-	●●●	-	●	Glass from CDW is classified as mineral waste and is therefore treated as mineral waste as described above, where the majority is recovered and used in backfilling operations.
Mixed construction and demolition waste	-	-	-	●	●●	Heterogeneous material which consists mainly of miscellaneous wastes from construction and demolition sites. The materials are sorted manually at the sorting centres, where e.g. large metal parts, wood, recyclable plastics and minerals are sorted into the right material category. For the leftover material which is deemed unsortable is shredded, put through a magnetic separator, baled and placed at the landfill sites.
Asphalt waste	-	●●●	●	-	●	The asphalt waste is reused in road constructions. Small fraction is recovered through backfilling activities or is disposed at landfilling sites.
Waste including asbestos	-	-	-	-	●	The waste is landfilled at specific location at the landfill sites to avoid contamination of asbestos particles.

- Seldom used. ● Small scale use ●● Medium scale use ●●● Large scale use

2.2.7 Norway

Waste management in the construction sector in Norway is well regulated in the Building Regulation (TEK), which requires the preparation of waste plans before new construction and renovation or before demolition starts. The sorting takes place in large scale on the site for all types of projects if the project is not too small (for projects over 300 m^2 for new buildings, over 100 m^2 for changes or projects generating over 10 tons of construction and/or demolition waste). Each fraction is collected and sent to reception for the waste. If there is lack of space on the site for many containers for the sorting of each fraction, there may be performed sorting of waste at the reception site. Sorting at the waste reception site will not be accepted as a fulfilment of demand to 70 % sorting of the construction and demolition waste.[62] For all projects hazardous waste is registered for separate sorting. Non-hazardous waste is registered for sorting into different fractions by materials for either reuse, recycling, incineration, or landfill (e.g., plaster). Some waste ends up as unsorted and is sent to incineration and/or landfill.

For construction waste from sites of new buildings or other constructions (roads, harbours and likewise) it is a similar process with sorting of hazardous waste for no reuse and other waste sorted into fractions for further transport to reception of waste and next for reuse, recycling, incineration, or for landfill.

At the reception site for waste the different fractions will be treated as needed with removing of materials that is not sorted in the correct fraction, removing materials for a cleaner or more homogenous fraction, crushing, if necessary, sort for transport to handling the fraction in another site in Norway or transport to Europa, or handling the fraction at the place. The fractions can be delivered for incineration (energy recovery), reuse, recycling of materials or landfill. Norway do not have an additional landfill tax, which is different from most other Nordic countries.

The general processing for the materials is described below:

- Untreated wood from construction and demolition waste is sent to energy production by incineration. Some amounts can be used for new production of for example chipboard. Treated wood, like painted, varnished and pressure treated (impregnated) wood is delivered to waste facilities with permission to handle this fraction.
- Materials with minerals, like concrete, brick and stone, can be used as backfilling if proved to be free from hazardous substances. Waste facilities will crush the fraction, or this fraction can be crushed at the construction site and be used if needed there as backfilling. If the fraction has a small amount

62. Byggteknisk forskrift (TEK17). Direktoratet for byggkvalitet. Available: https://www.dibk.no/regelverk/byggteknisk-forskrift-tek17

of hazardous substances, it can be used if permission is given after application to Miljødirektoratet/Norwegian Environment Agency. If the fraction is under a given limit for several hazardous substances, it can be used to replace virgin materials, without need to seek for permission, like in backfilling. The limits values are regulated in legislation "avfallsforskriften kap. 14a". If the amount of hazardous substances is so high that the materials will be categorized as hazardous waste it must be transported to waste facility which is approved for handling this kind of waste. Surplus of insulation made of stone or glass is reused or recycled by delivering the fraction back to the producer or to a recycling site witch also delivers to the producer. Most of the fraction minerals goes to material recovery and landfilling[63].

- Metal is sorted out and is delivered for recycling, the metals are melted and used in new products of metal. Metal products can also be reused but it is still relatively small-scale operation.
- Glass is sorted out and is delivered for material recycling and production of new products (e.g., glass wool), and some goes to landfill. All glass with hazardous substances must be delivered to waste facilities with permission to handle this waste. In Norway, insulating glass units containing PCB, are under an EPR scheme. Ruteretur AS operates as the approved nationwide take-back system for discarded insulating glass units containing PCBs in Norway. Norsk Gjenvinning AS work as a contracting company to recycle the glass and breakdown hazardous components through incineration with energy recovery.
- Plastic is sorted in several fractions, of which some goes to energy recovery, some goes to recycling and production of new products and some goes to landfill.
- Gyspum waste is sorted out and it is delivered for recycling to producer of plasterboard, after it has been crushed and cleaned to plaster powder. Some also goes to incineration, and some goes to landfill.

When a container of waste is delivered to a waste reception the content will be controlled to make sure that it is the right category name that has been used on the fraction. It will be controlled visually, by documents and by random samples. If needed the fraction will be sorted further done manually or with crane and claw.

Fractions that go to energy production will be cleaned for unwanted materials and crushed to the wanted size for the incinerator the fraction is sent to. The fractions used for this is combustible waste and combustible wood (meaning untreated wood).

---

63. Avfall fra byggeaktivitet. (2022). Statistisk sentralbyrå. Available: https://www.ssb.no/natur-og-miljo/avfall/statistikk/avfall-fra-byggeaktivitet

There are seven large waste incineration plants in Norway, i.e., plants that burn more than 100,000 tonnes of waste per year. They incinerate household waste and some commercial waste. The seven large facilities are in Oslo, Stavanger, Bergen, Trondheim, Kristiansand and Ålesund[64].

Fractions that are delivered for material recycling will be handled with removal of unwanted materials. Some fractions will be crushed, like concrete, asphalt, bricks and plaster. Others will be cut into smaller parts to make it easier to handle, like wood and metal. Metal will be sent to facilities which will melt it and use it or sell it for new production. If materials are suitable for reuse, they will be sorted manually and registered in different database depending on which waste reception the material is delivered to.

For construction and demolition waste there are facilities and sites with databases like Loopfront, Resirquel, Rehub, Sirken. These companies receive materials from demolition and rehabilitation projects, and excess material from construction of new buildings. The responsibility for quality control of the reused products has been moved from the seller to the buyer, which increases availability of products for reuse. The materials and products are stored until sold for reuse.

The current treatment methods for different CDW fractions in Norway are summarized in the following table (Table 9). The list of the major CDW treatment facilities in Norway are listed in Appendix 1.

64. Miljøstatus. 2022. Avfallsforbrenning med energiutnyttelse. Available: https://miljostatus.miljodirektoratet.no/tema/avfall/avfallshandtering/avfallsforbrenning-med-energiutnyttelse/

Table 9. *Summary of main CDW treatment methods in Norway.*

	Reuse	Recycling	Material recovery	Energy recovery	Disposal	Comment
Wood		●●	-	●●●	-	Wood waste, both treated and untreated, are mainly used for energy recovery. Latest data shows that more material from wood waste is used for material recovery than previous years. Material recovery of wood waste is used in production of particleboards. Data from amount of reuse of wood and wood materials is not available.
Metals	●	●●●	-	-	-	Majority of the metals ends up in recycling. Reuse of steel structures has been done in small scale, mainly project-wise.
Plastic	-	●●●	-	●●	●●	Based on the statistics, in NO around 50% of plastic CDW is delivered to recycling and another half ends up either in energy recovery or landfill.
Plaster/ gypsum	-	●●●	-	-	●●●	In NO around half of the plaster waste ends up for material recycling for the new plaster board production and another half is deposited to landfill.
Mineral insulation wool	-	●●	-	-	●●●	Mineral wool waste from demolition has currently only minor recycling options, which are mainly still under development. In NO majority of the material from demolition sites ends up in landfills as it does not possess significant energy value and lacs recycling alternatives. Excess mineral wool from construction sites can be recycled back into the production process.
Reject from mechanical CDW separation	-	-	-	-	●●●	Mixed residual CDW ends up mainly in landfill in NO. However, mixed CDW disposal is expensive and therefore the residual fraction is to be minimized by separating materials on-site when possible.
Mineral (concrete, tiles, etc.)	-	●	●●●	-	●●	In NO the majority of mineral waste ends up in material recovery such as backfilling. Bricks laid in lime mortar can be reused. The rest goes to landfill.
Glass	-	●●●	-	●●●	●●	In NO around 35% of glass ends up in recycling, and another 35% ends up in energy recovery. The energy recovery part includes thermal treatment of PCB containing fraction of glass. Around 15% landfills and last 15% in other recovery. Recycled glass is used in the production of new glass and insulation of glass wool. Reuse of windows are considered but typically they are not reused.

- Seldom used. ● Small scale use ●● Medium scale use ●●● Large scale use

2.2.8 Sweden

In Sweden, waste from construction and demolition (CDW) represents approximately 40 % of all generated waste, when waste from the mining industry is excluded. Of this, approximately 5 % of CDW is hazardous material. Sweden reports a material recovery rate of approximately 50 % for CDW excluding soils and excavation masses[65]. The statistics of CDW in Sweden is inadequate and a progress of collecting data of generated as well as recovered CDW is necessary and an ongoing work for Swedish authorities.

Prior to demolition, identification of hazardous materials and components is (exceptions may occur) required, as well as identification of possible material recovery and what the recovery process will look like. Either permission from, or a notification to, the local authorities is required prior to demolition.[66]

Hazardous CDW, such as asbestos and impregnated wood, demands specialized handling and must be transported to a treatment facility with permission to receive hazardous waste.

In January 2023 all CDW generated from households became municipal responsibility. Municipalities exclusively have the right to transport and treat waste within their waste management jurisdiction. This means that for private individuals renovating at home, waste can only be professionally transported and handled by the municipality or contractors authorized by the municipality[67].

CDW is received and treated by private waste management companies, as well as by public actors. Facilities often accept all fractions of CDW, and the mixed CDW is usually mechanically sorted, crushed and stored before being delivered to recycling or other treatment. Smaller companies often rely on municipal recycling centres. The bulk of sorted waste is then transported for further treatment[68]. Of the mixed CDW sorted mechanically approximately 34 % go to material recovery or recycling, and the rest is treated by energy recovered or disposed of to landfill[69].

The wood waste from construction and demolition is most often used for energy production. Mineral waste such as concrete is often crushed and used on site as backfilling material.

The Swedish Construction Federation intends to improve resource management within the construction sector by creating industry standards for waste management that comply with the Swedish Environmental Code and the EU Waste

65. Naturvårdsverket. 2022. Bygg- och rivningsavfall-statistikblad. Available: https://www.naturvardsverket.se/49d418/globalassets/amnen/avfall/statistikblad-bygg-och-rivningsavfall.pdf
66. Naturvårdsverket. 2023. Vägledning för bygg- och rivningsavfall. Available: https://www.naturvardsverket.se/vagledning-och-stod/avfall/bygg--och-rivningsavfall/
67. Avfall Sverige. 2022. Annat avfall än kommunalt avfall. Available: https://www.avfallsverige.se/fakta-statistik/avfallsstatistik/annat-avfall-an-kommunalt-avfall/
68. Naturvårdsverket. 2023. Vägledning för bygg- och rivningsavfall. Available: https://www.naturvardsverket.se/vagledning-och-stod/avfall/bygg--och-rivningsavfall/
69. Naturvårdsverket. 2022. Bygg- och rivningsavfall-statistikblad. Available: https://www.naturvardsverket.se/49d418/globalassets/amnen/avfall/statistikblad-bygg-och-rivningsavfall.pdf

Management Hierarchy. These guidelines prioritize waste reduction, reuse, and recycling over disposal methods like landfill and energy recovery. They aid construction companies in managing waste correctly, promote sustainable construction practices, and encourage recycling and reuse.

The list of the major CDW treatment facilities in Sweden are listed in Appendix 1. The current treatment methods for different CDW fractions in Sweden are summarized in Table 10.

Table 10. Summary of current CDW fraction treatment methods in Sweden.

	Reuse	Recycling	Material recovery	Energy recovery	Disposal	Comment
Wood	●	●	-	●●●	●	Wood waste, both treated and untreated, are mainly used for energy recovery.
Metals	●	●●●	-	-	-	Majority of the metals ends up in recycling. Reuse of steel structures has been done in small scale, mainly project-wise.
Plastic, PVC	-	●●●	-	-	●●●	PVC plastics ends up mainly in landfills. Recycling is possible but only few commercial players. PVC is problematic in energy recovery due to chloride content.
Plastic, other	-	●●	-	●●	-	Many other plastic grades are also technically possible to recycle the dirtiness and mixing with other waste fractions make it difficult to recycle and only few facilities are currently able to process it. Energy recovery is often more cost efficient.
Plaster/ gypsum	-	●●	-	-	●●	Gypsum waste is technically recyclab-le, but the separation of gypsum was-te during the demolition is problema-tic. Based on the SWE statistics around half of the material ends up in recycling and other half is landfilled either mixed with other mineral fraction or as a surplus from sieving after mechanical separation process.
Mineral insulation wool	-	●●	-	-	●●●	Mineral wool waste from demolition has currently only minor recycling options. Majority of the material ends up in landfills. Mineral wool from construction sites can be collected and recycled back in production process.
Reject from mechanical CDW separation	-	-	-	-	●●●	Heterogeneous material which consists mainly of miscellaneous mineral wastes, wood, plastic and mineral insulation wool and other mixed waste. Low calorific value inhibits energy recovery and material is typically disposed in landfills.
Mineral (concrete, tiles, etc.)	●	-	●●●	-	●	In SWE majority of the mineral fraction is material recovered
Glass	-	●●●	-	-	●	In SWE the majority of CDW glass is recycled in the production of glass wool insulation.

- Seldom used. ● Small scale use ●● Medium scale use ●●● Large scale use

2.3 Challenges with recycling and reusing of CDW

The treatment and transportation costs are probably the major factor which guides the selection of treatment method for CDW. For example, the energy recovery option is more easily applied for certain CDW fractions, especially for wood and plastic waste, even though recycling alternative would be available. On-site separation of smaller CDW fractions is in many cases considered too expensive and time consuming and therefore these fractions end up in mixed CDW which is transported to off-site sorting facilities. The mixing of different CDW fractions may prevent the further recycling due to contamination or pulverization during the process. The good availability of cheap virgin raw materials (e.g., aggregates for concrete production) can inhibit the usage or recycled materials even though they would be available.

Hazardous substances are also one factor that limits recycling and reuse of CDW materials. The hazardous substances are especially problematic in certain product categories from previous decades such as mortars, jointing materials, impregnated wood structures, insulation materials, paints or glues. Hazardous substances containing materials needs to be disposed properly to prevent accumulation. Energy recovery can be done from certain hazardous fractions (e.g., treated wood) other fractions are typically landfilled (e.g., asbestos) to remove harmful substances from circulation.

The level of detail of available CDW statistics from different Nordics varies and most of the Nordic countries have only limited data available especially from the smaller CDW fractions. For example, mineral fraction typically includes many smaller fractions, such as gypsum or mineral wool waste, which makes the evaluation of total volumes and current treatment methods difficult.

Mineral waste and wood waste represents the largest CDW fractions in all countries and the increase of recycling or reusing of these materials would have the biggest impact on all CDW recycling and reuse. Certain waste fractions, such as mineral wool waste, plaster waste and reject from mechanical CDW separation, were identified as the most problematic fractions in the terms of recycling in many Nordic countries as these materials typically ends up in landfill. However, the situation between Nordics varies and especially Denmark was identified to have a functional recycling process as these fractions mentioned above were not considered problematic in the terms of recycling.

2.3.1 Mineral waste (concrete and bricks)

Most of the concrete and tile CDW is recovered and backfilled as supporting layers under roads and foundations. This represents a low rank in the waste hierarchy. A step up could be using the materials in the production of new concrete. The main obstacle preventing recycling of concrete waste in new concrete production is good availability of cheap virgin aggregates which makes the recycling unprofitable in many cases.

Another obstacle is possible contaminations. Today the concrete producers typically use concrete waste from element production or other sources where the concrete materials are guaranteed free of contaminations. The concrete waste from demolition activities may contain contaminants (e.g., PCB, PAH, lead compounds, or asbestos), which typically origins from coatings, jointing materials, paints or for example water sealants. In addition, other impurities, such as plastic, ceramic or wood, may mix into concrete during demolition process which limits the use as aggregates in new concrete production. The European waste legislation prescribes that hazardous substances needs to be separated from other waste streams and treated only in specially designed facilities that have obtained permission for hazardous waste treatment. This applies also for demolition waste.

A further step up for concrete waste could be reuse of concrete elements or pillars, but it is difficult to make old materials comply with the new regulations and it is more expensive and time consuming than simply ordering custom fit or standardized new building materials. The regulations are less restrictive when designing outdoor areas and elements, pillars or tiles might find use as outdoor walls or pavement on paths and squares. Different Nordics have or are developing guidelines and practices for concrete structure and brick reuse, but so far, the reuse is estimated to be still rather small-scale activity. The Nordics lacs of unified statistical data concerning the reuse of structural elements.

Most of the Nordic countries have set limit values for hazardous substances which needs to be fulfilled for mineral waste fractions, mainly for concrete and bricks, that are to be utilized e.g., in infra construction purposes. There are variations between countries for example at which point the material needs to be analysed prior to utilization and for what purpose the material can be used. The limit values in Finland differs from other countries as the limit values are mainly set as leachable solutions (L/S = 10) not as a total concentration as in other countries. Finland also has two different limit values: limit values for concrete and brick waste when they are used for certain infrastructure purposes and national EOW criteria for concrete waste. The hazardous substance limit value comparison for utilization is presented in Table 11.

Table 11. *Comparison of hazardous substance limit values for concrete or brick waste prior to utilization. Limits values for Iceland were not available for this report.*

Substance	**Norway**	**Iceland****	**Sweden***	**Finland[70]**	**Finland[71]**	**Denmark***
Limit value (mg/kg dry solids)						
Heavy metals:						
Arsenic - As	15		10	0,5-2**	0,1**	20
Antimony - Sb				0,3-0,7**	0,2**	
Cadmium - Cd	1,5		0,7	0,04-0,06**	0,02**	0,5
Chromium (III) - Cr	100 (tot)		40 (tot)	0,5-10 (tot)**	0,6 (tot)**	500 (tot)
Chromium (VI) - Cr	8					20
Copper - Cu	100		40	2-10**	1**	500
Lead - Pb (inorganic)	60		60	0,5-2**	0,1**	40
Mercury - Hg	1		0,3	0,01-0,03**	0,01**	1
Nickel - Ni	75		35	0,4-2**	0,3**	30
Zinc - Zn	200		120	4-15**	4**	500
Vanadium				2-3**	0,3**	
Selenium				0,4-1**	0,2**	
Barium				20-100**	5**	
PCB:						
∑ 7PCB	0,01			1	1	0,1
PAH-compounds:						
∑ 16 PAH	2			30	30	4
Benzo(a)pyrene	0,1					0,3

70. Gov. Decr. 843/2017, Limit values for concrete and brick waste utilization in earth construction
71. Gov. Decr. 466/2022, National EoW criteria for concrete waste

Aliphatic hydrocarbons:						
C5–C6	7					
C6-C10						25
>C6–C8	7					
>C8–C10	10					
>C10–C12	50					
C10-C15						40
C15-C20						55
C20-C35/40						100
>C12–C35	100					
Total C6-C35/40				500 (C10-C40)	200	100
Sulphate				1200-18000**	300**	
Chloride				800-11000**	200**	
Fluoride				10-150**	12**	
DOC				500**		
Other requirements:						
Floating impurities				10 cm^3/kg	5 cm^3/kg	
Other impurities (metal, clay, gypsum, rubber etc.)				≤1 w-%	≤1 w-%	

* There are no national limit values for the substances in Denmark. Limit values in the table here are set in 2020 by a number of Zealand municipalities and as of 2023 the majority of the Danish municipalities follow these guidelines.
** Soluble concentration (mg/kg) determined with SFS-EN 12457-3 batch leaching test or CEN/TS 14405 column leaching test in L/S = 10
*** There are no national limit values for the substances in Sweden. Presented limit values are recommendations based on Naturvårdsverket quideline[72] for waste utilization in construction (incl. road and railway, noise barriers and fields).
**** Iceland has not defined these limit values, but regulations refer to European Legislations on the limit values of hazardous substances. This is therefore still under development in Iceland[73].

72. Naturvårdsverket. 2010. Handbok: Återvinning av avfall i anläggningsarbeten. Available: https://www.naturvardsverket.se/globalassets/media/publikationer-pdf/0100/978-91-620-0164-3.pdf
73. Personal Communications. Several actors; Húsnæðis-og Mannvirkjastofnun, Umhverfisstofnun, Hornsteinn, Vegagerðin. 2023.

2.3.2 Metal waste

Metal waste possess significant value and therefore the recycling rate for long has been very high in all the Nordics and possibilities for increasement in recycling rate is negligible. A step up in the waste hierarchy could be reuse of the materials which has been done in some extent nearly in all Nordic countries. However, as for concrete, the reusable steel structures must comply with existing building regulations and technical requirements which makes it typically more difficult and cumbersome compared to construction with new construction products.

2.3.3 Glass waste

The reuse of windows and window frames is possible, and it has been done project-wise in all Nordics. However, a majority of glass waste generated in demolition and construction sites ends up for recycling in Nordics. Glass waste can be recycled for example in glass production, glass wool production or foam glass production. Older glass frames may contain PCB or other hazardous substances in the jointing materials which needs to be separated in recycling process.

2.3.4 Wood waste

Wood waste is mainly across the Nordics recovered as energy and there are limited options for recycling such as use in the production of particle boards or biochar. Wood waste is typically divided in three categories: untreated, treated and impregnated. All kind of treatment such as paintings, wood preservatives, anti mould agents and impregnating agents limits the recycling possibilities of wood waste and treated wood fraction typically ends up in energy recovery[74].

Untreated wood has the highest potential for recycling and reusing. Denmark stands out with a dedicated large plant for recycling wood waste in particle board production. A step up in the waste hierarchy is reuse of wood in new constructions. In a smaller scale some companies specialise in seeking out higher quality wood waste for use in production of sheds or use more ordinary wood for building interim measures on construction sites. There is a potential to increase the recycling of wood waste and in some extent also to increase the reuse but generally, wood is in large supply in the Nordics (at least in Sweden, Norway, and Finland) making the case for recycling and reuse of wood waste less economical clearcut. A big obstacle in increasing the recycling or reuse of wood waste is the work required in separation into different qualities and grades of wood, including certification and technical control.

74. Zhu et al. 2022. Purkumateriaalien kelpoisuus eri käyttökohteisiin turvallisuuden ja terveellisyyden näkökulmasta. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 20212:15. Available: http://urn.fi/URN:ISBN:978-952-383-253-4

2.3.5 Plastic waste

Construction and demolition waste contains a wide variety of plastics. Major plastic grades used in construction are polyethene (PE, both PE-LD and PE-HD) and polypropene (PP). PVC is also commonly used plastic grade in construction e.g., in cables and pipes as well as polyurethane (PU) and polystyrene used in various insulation products. A smaller amount of technical grade (TPE, EP, PC) and special grade (e.g., PI) of plastics are used for special applications where for example high temperature, acid/base or solvent resistance is needed.

Currently majority of the plastics from demolition sites goes to energy recovery or disposal, only minor fraction is directed to material recycling. Especially increasing of the PE and PP grade plastics recycling, which represents the major volume of the plastics in construction, are seen as the most promising way to increase the recycling rate of plastic waste in construction and demolition[75]. However, the practices of separation of plastics during the demolition are still rather undeveloped and often time consuming. In addition, only few recycling facilities were identified which accepts plastic waste from demolition sites.

Most plastic waste is in mixed combustible streams for energy recovery. Distinguishing construction from demolition waste is essential, as construction waste, including plastic packaging and install waste (e.g., pipes, insulation, floors), is readily separable for material recycling. Recycling plastic from demolition waste is possible but requires careful evaluation due to mixed plastics from various eras and potential undesirable substances, necessitating a balanced discussion on climate benefits and risks[76] For example, old insulation plastics may contain fire retardants (e.g., bromium compounds such as tetrabromiumbisphenol A) or propellants (e.g., HFC-gases) which use is nowadays prohibited[77].

PVC grade plastic waste recycling would also need more development. PVC is undesired in energy recovery due to its chloride content which can have corrosive effects in incinerators, and it typically ends up in landfills. The recycling of hard PVC plastic is technically possible, but it has certain difficulties such as rather small volumes, lack of collection network and treatment need (e.g., sorting and cleaning of PVC material before recycling and possible residues of contaminants such as phthalates, lead or asbestos)[78]. Currently only few companies do PVC plastic recycling and for example in Finland none has been identified[79]. In Denmark hard PVC is collected and sent for recycling. Soft PVC is landfilled. Swedish flooring manufacturer Tarkett has implemented a recycling solution to accept and collect

75. Ministry of Environment. 2020. Roadmap for construction plastics in Finland. Available: https://ym.fi/documents/1410903/40549091/rakentamisen_muovit_A4_v3.pdf/
76. Naturvårdsverket. 2021. Kartläggning av plastflöden i byggsektorn RAPPORT 6973:2021 Available: https://www.naturvardsverket.se/publikationer/6900/kartlaggning-av-plastfloden-i-byggsektorn/
77. Sirviö, S. 2007. Rakennusten haitta-aineet. Thesis, available: https://www.theseus.fi/bitstream/handle/10024/12084/2008-03-19-02.pdf?sequence=1
78. Circhubs. 2018. PCV-Plastic material flow analysis. Available: https://circhubs.fi/tietopankki/pvc/
79. Nordic Council of Ministers. 2019. PVC Waste in Nordic countries. Available: https://norden.diva-portal.org/smash/get/diva2:1287469/FULLTEXT01.pdf

old Tarkett vinyl floor covers. This system applies to both homogeneous and heterogeneous PVC and polyolefin flooring, extending to cover installation waste from plastic floors as well. The collection of installation waste in Sweden is handled by Tarkett through GBR Floor Recycling, on behalf of the flooring industry. Conversely, in other Nordic countries, Tarkett has devised its own recycling systems [80],[81]

2.3.6 Gypsum waste

Gypsum waste, especially plaster boards, are technically fully recyclable material. Overall, the gypsum waste presents a relatively small fraction, estimated 5-10 w-%, of the total demolition and construction waste. The material pulverises easily and therefore the gypsum boards need to be sorted separately and usually by hand during the demolition process. To recycle the gypsum, it can only contain small number of impurities, such as nails, screws, wallpaper, and wood and it needs to be stored under dry conditions.

According to legal requirements in Denmark, Norway, Finland and Sweden, gypsum waste must be sorted separately as its own waste fraction on site. In Denmark the gypsum waste is sorted and handled separately and recycled and only wet or contaminated materials are landfilled. In Norway approximately 50 % of the gypsum waste is recycled. In Sweden the appropriate treatment for gypsum waste is determined in consultation with the waste contractor and depends on the distance to recycling facilities and landfills, as well as the quality of the gypsum8. In Finland only a small fraction of gypsum waste from demolition sites are recycled because the gypsum waste typically ends up in mixed CDW fraction where it is difficult to sort out due to pulverization. Even though separately collected gypsum can be directed to recycling with lower costs compared to disposal as waste, the overall costs can be still higher for recycling than disposal due to higher demolition costs.[82],[83],[84]

2.3.7 Mineral insulation wool waste

Various producers, such as Rockwool, Knauf, Paroc, have developed collection and recycling system for surplus mineral wool (rock and glass wool) waste which is generated during construction[85],[86],[87]. However, mineral wool insulation waste

80. Tarkett. (n.d.). Återvinning av plast-, linoleum- och textilgolv. Available: https://proffs.tarkett.se/sv_SE/node/atervinning-av-plast-linoleum-och-textilgolv-4105
81. Tarkett. Undated. Recycling of dismantled floor covers. Available: https://kohdemyynti-lattiat.tarkett.fi/fi_FI/node/purettujen-lattioiden-kierrattaminen-16289
82. Saint-Gobain, 2023. Gypsum recycling article in webpage. Available: https://www.saint-gobain.fi/news/kipsi-kiertamaan
83. Liikanen et al. 2018. Rakennusjätteen koostumustutkimus – Etelä-Karjala. Available: https://urn.fi/URN:ISBN:978-952-335-228-5
84. AFRY. 2022. Rakennuspurkumateriaalien liiketoimintaselvitys – unpublished report for VIRKE-project governed by Iin Micropolis.
85. Paroc. 2023. REWOOL recycling service. Available: https://www.paroc.fi/kampanjat/rewool
86. Knauf. 2023. RESULATION recycling service. Available: https://www.knaufinsulation.com/new-era-of-recycling
87. Rockwool. 2023. Rockcycle recycling service. Available: https://www.rockwool.com/group/about-us/sustainability/rockcycle/

from the demolition activities has been identified as a difficult waste fractions to recycle and it possess low calorific value and therefore majority of it ends up in landfills[88].

The recycling of old mineral wool material has certain challenges such as quality variation between products (glass and rock wool) and additives used in different decades. The material would require additional work to be separated during demolition and current material recycling options, such as use in geopolymers, requires that the mineral wool waste is stored and transported dry during demolition. In DK mineral insulation wool waste from construction and demolition activities is collected and recycled in the production of new insulation wool. In Sweden, mineral wool is sorted for material recovery or landfill, and while some stone wool manufacturers recycle their insulation waste, there is no industry-wide system[89].

2.3.8 Reject from mechanical CDW separation

Reject from mechanical CDW separation is mixed waste fraction which is generated during mechanical CDW separation. In Finland a large amount of CDW nowadays ends up as a mixed CDW which is transported from the demolition site to the mechanical CDW separation facility. In the facility it is separated to different fractions which are directed to landfill, energy recovery or recycling. The reject is heterogeneous fraction which typically consists of minerals (concrete, ceramic, gypsum, mineral wool), plastics and wood. In 2022, it was estimated that 10% of all CDW ends up as a reject in Finland[90]. However, the CDW handling methods varies in Nordics and for example Denmark this waste fraction is not considered a major issue as CDW is separated more efficiently on-site.

88. Wool2Loop. 2023. Final report. Available: https://www.wool2loop.eu/en/
89. Byggföretagen. (2021). Resurs- och avfallshantering vid byggande och rivning. Available: https://byggforetagen.se/app/uploads/2021/09/20210915-Resurs-och-avfallshantering-vid-byggande-och-rivning.pdf
90. Puhakka, Ville. 2022. Rakennus- ja purkujätteen mekaanisen käsittelyn rejektit Päijät-Hämeen alueella. Available: https://www.labopen.fi/lab-rdi-journal/rakennus-ja-purkujatteen-mekaanisen-kasittelyn-rejektit-paijat-hameen-alueella/

Figure 14. *Example of reject from mechanical CDW separation*[91]*. (Source: Puhakka 2020)*

91. *Puhakka, 2020. Rakennus- ja purkujätteen kierrätyksessä haasteita, blog text. Available: https://blogit.lab.fi/labfocus/rakennus-ja-purkujatteen-kierratyksessa-haasteita/*

3. Good examples from the field in the Nordics

In the Nordic countries there are several companies focusing on recycling or reusing material and items from the construction and demolition sector. A few of them are described below. These case examples have been chosen as they represent a variation of materials as well as a variation of reusing and recycling of the materials. The examples represent actors that have recycling, reusing and recovering of construction and demolition material as part of their business idea and who do this on a regular basis rather than single projects. Some of the exemplified actors operate in several of the Nordic countries but are only described for one of the countries to avoid too much of repetition.

3.1 Denmark, Faroe Islands and Greenland

3.1.1 NÆSTE

NÆSTE is a company that builds architect-designed wooden sheds in recycled materials. NÆSTE collaborates with the waste management company RGS Nordic, which finds and prepares high-quality wood waste (e.g., heartwood) from demolitions to NÆSTE. In the coming years, NÆSTE expects to have a production of sheds with a total annual material consumption of 700 tons of wood waste. Within the next three years this is expected to rise 3.500 tons of wood waste. By using handpicked material of high quality, a long durability of the sheds is ensured, minimum 30 years, according to a study from the Danish Technological Institute.

The sheds are easy to maintain and do not require painting or oiling. By using recycled wood, NÆSTEs wooden sheds score points in DGNB construction and can be used in buildings where environmentally conscious material choices are required. The wooden sheds are labelled with the FSC label "FSC Recycled" which is a guarantee that the sheds are built from 100% recycled materials.

The building system consists of recycled rafter timber that is prefabricated at a construction factory with recycled or sorted industrial materials (e.g., terrace boards) as facade cladding. The building module system is put on foundation screws, which allows for dismantling and subsequent reuse. As a roofing material, red bricks, slate, as well as "green" sedum or dry meadow roofs are used. An integrated solar roof can also be made from recycled solar cells, which can function as a local energy generator so that no power cables must be drawn to the shed. NÆSTE delivers the construction system throughout Denmark and collaborates with both nationwide and local contractors on fast and efficient installation on site.

3.1.2 Gamle Mursten

Gamle Mursten is a company that specializes in cleaning used bricks that can be disassembled from old houses in demolition and renovation projects.

Gamle Mursten has developed a patented technology where they clean old bricks mechanically using vibration technology that rattles off the mortar. This means that neither water nor chemicals are involved in the process. After cleaning, the company sorts, and quality check the bricks manually by quality, type and color. The cleaned bricks are then placed on conveyor belts, which guide them to a robot that stacks and packs the bricks according to color and customer wishes.

Gamle Mursten receive bricks exclusively from buildings that are bricked up in lime mortar. These are typically buildings built up to the year 1960. In the 1960s, cement mortar began to be used in masonry. Cement is harder than the brick, which means that the bricks break during cleaning. There are techniques for reusing bricks used with cement-based mortar in the Nordics, see 3.5.2.

Up to 65 percent of the cleaned bricks can be reused directly. The more gently the demolition method used, the higher percentage of reuse. Previously, you had to discard the damaged bricks, but now you cut shells in the thickness of 25 mm from the neat sides of these bricks. This gives a utilization rate of up to 80 percent of the material that the factory receives for cleaning. The company also clean and stack the half stones, called cups, which have often been used in every other shift in older buildings.

The company states that if you introduce requirements for the preparation of resource mappings of buildings and facilities before demolition and renovation and pre-testing of the bricks, it will be possible to identify and reuse a much larger part of the stones that today are just crushed and used for backfilling.

The cleaned bricks are CE marked and tested according to EN 771-1.

Gamle Mursten has a capacity to handle approximately 10.000.000 bricks per year (equivalent to approx. 25.000 tons of bricks). Now the production covers approx. 6% of the market for bricks used for facades in Scandinavia. Within the next couple of years, the capacity is projected to increase to 50.000 tons of bricks per year.

3.1.3 Kronospan

Kronospan is a company that recycles wood waste in the production of particleboard for the construction, furniture, kitchen, and wood industries.

Up to 90 % of the raw material in the production is pure wood waste delivered to recycling sites and collected by waste management companies in connection with construction projects. The rest is thinning wood from Danish forests and offcuts from the wood industry.[92]

The company has an annual consumption of wood waste of approx. 380.000 tons.

3.2 Finland and Åland

3.2.1 Finnfoam

Finnish insulation company Finnfoam has developed collection system for insulation plastics (EPS, XPS, PIR, PUR, EPP, EPE and XPE) where cuttings and surplus insulation materials are collected from construction sites in large sacks which are transported back to Finnfoam production plant. Surplus materials can be brought to local hardware store which acts as a collection point for private customers. The company also receives products from other insulation producers. The recycled plastic materials are currently recycled by pre-treating and grounding the material as a filler for FF-Silent roofing insulation products or FF-FRAME assisting frame insulation products.

Currently the company is constructing innovative chemical polystyrene recycling plant in Salo which is supposed to be completed by the end of 2023[93]. The company aims to recycle polystyrene fraction (EPS and XPS) from the received insulation waste with chemical recycling after the recycling plant is operational. The remaining fraction is used as a recycled material for various products. The company does not accept insulation waste from demolition sites yet, however, the chemical recycling technology enables also recycling of dirty insulation plastics and the recycling of polystyrene wastes from the demolition sites might be in consideration in the future.

92. Kronospan. 2023. Company web page. Available: https://kronospan-dk.dk/baeredygtighed
93. Finnfoam. 2023. Company web page. Available: https://finnfoam.fi/

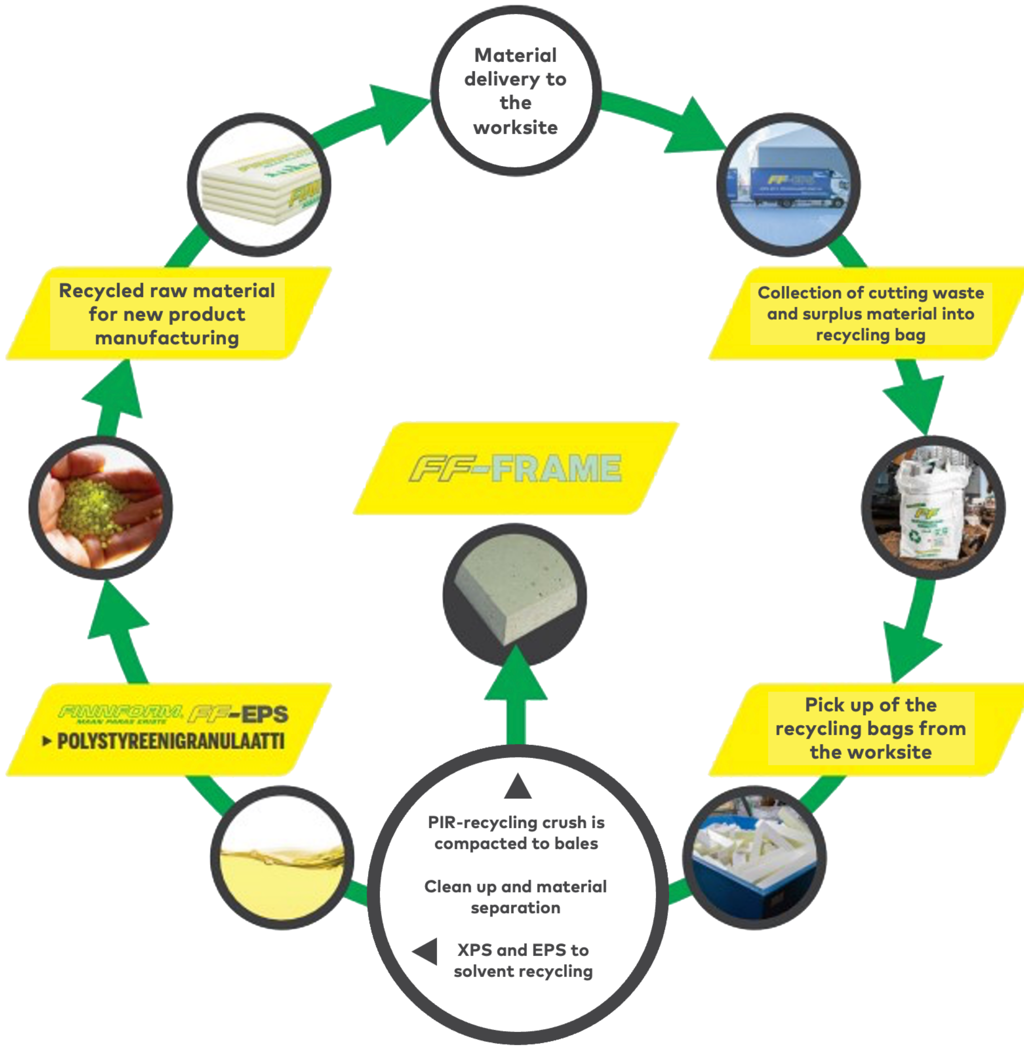

Figure 15. *Recycling process for insulation plastics by Finnfoam. (Source: Finnfoam)*

3.2.2 EcoUp

EcoUp is a Finnish corporate group specialized in insulation manufacturing (ekovilla thermal insulation made from recycled wood fibers) and providing circular solutions for construction wastes, especially insulation wools. The company produces CE marked mineral-wool loose materials from the surplus mineral wool from house construction factories. The group has also developed technology to recycle mineral wools waste (glass and rock wool) from demolition sites to a raw material for example geopolymer concrete or concrete products, such as environmental concrete products, which allows the use of such material.

The company has pilot sized manufacturing line operational with capacity to grind 6000 tons of mineral wool waste a year in one shift[94]. However, the utilization of waste-based products needs extensive quality assurance process. In addition, the current waste and building product legislation is a bit unclear for the recycling of waste-based materials which limits the use of mineral wool waste. Currently the mineral wool waste is possible to use in certain products such as concrete blocks, pavers, and façade elements. The company has possibility to scale-up the technology and capacity if the market for recycled end products increases.

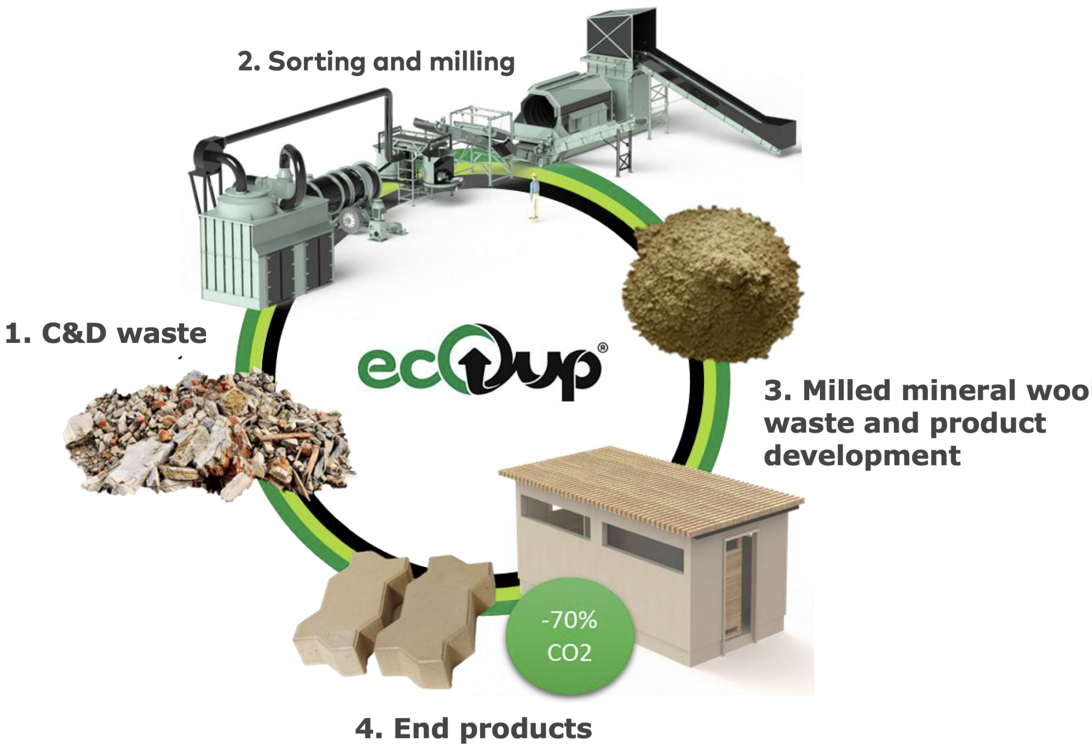

Figure 16. *EcoUp concept for mineral wool recycling. (Source: EcoUp)*

3.2.3 Remeo

Remeo, a Finnish owned waste management company, which has in 2021 built a new recycling and sorting facility in Vantaa. The facility utilizes novel technology for AI (artificial intelligence) assisted automated sorting of different waste fractions and it is one of the most developed CDW treatment facilities in Finland. The flexibility and machine learning enables higher recovery rate and better quality for different waste materials. With the state-of-the-art technology the facility is also possible to adjust to separate new waste fractions if needed in the future. The

94. Ecoup. 2023. Company web page. Available: https://ecoup.fi/

facility has capacity to treat of CDW 120 000 tons per year and additional 60 000 t/a capacity for energy waste treatment according to Remeo web page[95]. However, the environmental permit of the facility enables receiving max. 240 000 tons of CDW annually[96].

3.2.4 Material marketplace

The Finnish Waste Law requires those waste holders including public waste holders, whose need for their municipality's supplementary waste management services exceeds EUR 2,000 in value to use the Materiaalitori (material marketplace) service. Materiaalitori is a digital platform intended for the professional exchange of waste and production side streams or reusable products from companies and organisations. Materiaalitori also allows searching for and offering related services, such as waste management and specialist services. The requirement helps forming industrial symbioses for reuse and recovery of waste and side streams by providing operators in the field with one meeting place that enables those offering and needing recycled materials and products to find each other.

3.2.5 Other examples

Many other innovative companies are working on demolition waste recycling and reusing. For example, GRK, a Finnish infra construction company, has started production of biochar from demolition wood waste. Compared to typical energy use of wood waste, biochar is multi-use product for infra and agricultural use and it acts as a carbon sink[97].

Revisol is a Finnish waste management and circular economy company which offers wide variety of waste management services such as waste collection and waste treatment (mechanical separation facility). The company is also specialized in recycling of the windows and doors. The company has separate recycling line for used door and window recycling where all materials (frames, metals, pure glass, and glass with impurities) are separated and directed to energy use or material recycling[98].

Suomen Ovimarket Oy/Ylijäämävarasto (surplus stock) has developed a business on surplus construction product market. The company buys surplus construction materials and fixtures from construction sites, wholesalers and bankrupt's estate and resells them for individuals and building enterprises in online shop (ylijaama.fi) and also in fixed location in Hämeenlinna[99].

---

95. Remeo. Undated. Article in web page. Available: https://remeo.fi/kiertotalous/tulevaisuuden-kierratyslaitos/
96. AVI. 2023. Permit journal number ESAVI/31542/2022. Dated 6.4.2023. Available: https://ylupa.avi.fi/fi-FI/asia/2278869
97. GRK. 2023. Product web page. Available: https://www.grk.fi/palvelut/biohiili/
98. Ylijäämävarasto Oy. Undated. Company web page. Available: https://www.ylijaama.fi/
99. Ylijäämävarasto Oy. Undated. Company web page. Available: https://www.ylijaama.fi/

YIT is Finland's biggest construction company which operates in housing, facility and infra construction sectors. The company has group level target (>75%)[100] for sorting rate of construction and demolition waste. The company has been in frontline in developing source separation practices in construction and demolition sites together with other waste management companies.

3.3 Iceland

There are several discussions and projects ongoing in Iceland to finding a path for the CDW that usually ends up in landfill. Due to Iceland being of smaller size, there are not many available established facilities working on reuse and recycling of CDW, and the good examples from the field are more based on the various ongoing and planned building and demolition projects in Iceland. One such project was a construction of a new social housing in Reykjavík (Háteigsvegur 59[101]) This included having the flooring in the housing made from waste stone left from the preparation of building cladding from another construction project, used windows installed in the common area, and used insulation wool was used instead of a virgin insulation wool, to name few initiatives during the design and construction of the housing.

For this report, several individuals working with the circular economy in the building and demolition sector in Iceland were contacted and interviewed in order to identify good examples in the field[102]. The interviewees all agreed that the awareness is increasing in the sector, and that there is high motivation and will in minimizing the amount of CDW ending up in landfill or in another disposal.

3.3.1 Hornsteinn

The holding company Hornsteinn is the parent company of three subsidiaries: BM Vallá (concrete producer), Sementsverksmiðjan (cement importer) and Björgun (aggregate producer)[103]. Hornsteinn is actively working towards implementing the circular economy in the operations of their daughter companies and have ongoing projects for avoiding generation of waste from production.

Hornsteinn tries to ensure that any leftover concrete from daily operations is utilized, either by being mixed with new concrete or to produce concrete bricks. Due to the time sensitivity of concrete, concrete that has been left over from projects early in the workday can be mixed in with new concrete, but concrete that is left

100. YIT Group. Undated. Sustainability targets. Available: https://www.yitgroup.com/fi/vastuullisuus/vastuullisuuden-johtaminen
101. Lendager. Undated. Form fylgir framboði. https://www.graennibyggd.is/_files/ugd/54e708_80733cb74c564b789844f18b7704350b.pdf
102. Personal communications, several actors: VSÓ, Grænni Byggð Island, Ríkiskaup, Umhverfisstofnun, Hornsteinn. 2023.
103. Personal communications Máney Guðmundsdóttir, Hornsteinn. 2023.

over at the end of the workday is used to produce concrete bricks that can be used in various settings.

Furthermore, Hornsteinn is actively working on redefining their process for defective paving stones that cannot be sold due to either defect in appearance or quality. For pavings that are faulty in looks, Hornsteinn aims to sell them as a B-product as they have seen an interest amongst some buyers for these types of pavings. For the paving stones that have quality issues, such as leaking, Hornsteinn has been testing them as recycled aggregates in their concrete, that is, replacing 5% of virgin aggregates with crushed paving stones in concrete.

3.4 Norway

3.4.1 Rockcycle-Rockwool

A program where Rockwool products removed from demolition projects can be reused in the production of new rockwool insulation[104]. Rockwool is present in all the Nordic countries excluding Iceland.

3.4.2 Norsk Gjenvinning AS

Norsk Gjenvinning AS, under contract with Ruteretur AS, collects the insulation windows containing PCB under the EPR scheme from both the municipal reception points and from their own 18 regional reception centres. Norsk Gjenvinning AS separates the glass and the frames. The glass goes to recycling and the frames containing the PCB-sealants are incinerated in high temperature rotary kilns with the breakdown of the PCBs and with recovery of energy. The company handles both Ruteretur and glass outside of the system, i.e., glass free from hazardous materials, as well as other hazardous glass containing chlorinated paraffines. The non-hazardous glass waste is used in e.g., in the production of new insulation of glass wool from Glava[105].

3.4.3 New West Gipsgjenvinning AS

Facility for reception and handling of plaster board/gypsum waste. Delivers recycled gypsum (powder) to plasterboard production from Norgips (Knauf) and Gyproc (Saint- Gobain), which utilises waste gypsum in the production. New West Gypsum recycling is also located in Canada, UK, France, Belgium and Germany[106].

104.Rockwool. Website: https://www.rockwool.com/no/radgivning-og-inspirasjon/rockwool-retursystem/
105.Ruteretur. Website. https://www.ruteretur.no/
106.New West Gypsum. Website. https://www.nwgypsum.com/

3.5 Sweden

3.5.1 Tarkett

Tarkett has manufactured floors in Sweden since 1886 and invests a lot of resources in developing products for circularity but also on developing techniques to identify, handle and process installation waste and torn-up floors to then use it as raw material in new floors. Tarkett has two big production facilities in Sweden, one in Hanaskog and one in Ronneby[107].

The recycled raw materials consist of fractions such as own production waste, waste from other business, installation spill from floors and old floors. Old floors as recycled raw material is the fraction containing the highest volume of recycled raw material. Currently Tarkett have systems in place to be able to collect and recycle some of our homogeneous vinyl flooring and loose plastic floors as well as textile tiles.

3.5.2 Brukspecialisten

Brukspecialisten is specialized in reusing brick as they consider it to be the construction material with highest potential for reuse. Since they started out as brick producers, they already have good knowledge of the market. They also state that it is of great importance to establish contact with the contractors at an early stage to save the bricks for recycling.[108]

According to the CEO about 90 percent of the invented brick can be reused. After inventing the brick at the demolition site Brukspecialisten establish an inventing protocol and pay a deposit for the brick. By getting control of the product, they can classify it and get it CE-marked, which make it attractive for the buyers.

The company has developed a technique for reusing bricks using cement-based mortar, since lime-based mortar is fairly uncommon in Sweden, compared to e.g., Denmark. The company has worked with this concept for five years and during this period they have experienced a higher demand and understanding for reused brick compared to when they started. They work throughout entire Sweden and have also been involved in single projects in Oslo.

Brukspecialisten has a capacity to handle approximately 2.500.000 brick per year. This is equivalent to approximately 40 - 50.000 square meters facade gathered from demolition brick meant for new facades. The capacity is projected to increase to 5.000. 000 bricks in year 2025. According to the CEO 15.000.000 bricks are thrown away each year at the Swedish market.

107. Tarkett, webbsite. Available: https://proffs.tarkett.se/sv_SE/node/atervinning-av-gamla-plastgolv-4633
108. Brukspecialsten. 2023. Available: https://brukspecialisten.se/ and Personal communication Jacob Steen. 2023.

3.5.3 Marketplaces for reused building materials

There are several marketplaces for reused building materials. These often operate locally and/or on digital platforms. Both public and private marketplaces are found.

Brattöns återbruk is a recycling company that focus on construction goods and building materials from 2012[109]. The warehouse is located in Gothenburg but they have customers all over Sweden. During 2022, they sold recycled construction goods and building material corresponding to a climate saving of 195 ton CO_2. There are more recycling companies in Sweden that handles construction goods and building materials as well.

Malmö Återbyggdepå is another company that receives and sells used building materials[110]. They started their operations in 1998 and since then the demand has grown significantly. About 90 percent of the material they receive come from construction companies and large construction or demolition sites, but they also receive material from private individuals. The range varies from single items to materials in large quantities. The rebuilding depot cleans the bricks and then cuts the bricks into floor tiles. Malmö Återbyggdepå sells recycled bricks, window, tiles, stones & concrete and used doors, among other things.

3.5.4 Norditek

Norditek business idea consists of helping companies in the construction sector finding a concept and providing the suitable equipment for separating and refining construction and demolition material for on-site sorting. As they provide services all over Sweden, they don't have stationary facilities but temporary facilities in connection to the construction or demolition site. The company has their own production of equipment located in Umeå in Sweden but operates all over the country. According to the interview the key to succeed in recycling material from construction and demolition sector is first to be able to separate materials from each other and then to have a deep knowledge about the different materials.[111]

109.Brattöns Återbruk, Website. Available: https://www.brattonsaterbruk.se/
110. Malmö Återbyggsdepå, Website. Available: https://www.malmoabd.se/
111. Norditek. Available: https://norditek.se/atervinning-av-byggavfall/ (2023-08-24) and Personal communication. 2023. Andras Pettersson

4. Looking outside the Nordics

In the EU, construction and demolition waste (CDW) accounts for more than a third of all waste generated[112]. Under the Waste Framework Directive, construction and demolition waste is a priority waste stream. The objective is to promote selective demolition to enable removal and safe handling of hazardous substances and facilitate re-use and high-quality recycling by selective removal of materials and establishing sorting systems, as well as to reduce waste generation. The recycling and material recovery rate target is set at 70 percent. About 450–500 million tonnes of construction and demolition waste are generated annually in the EU. This figure contains all the waste produced by the construction and demolition of buildings and infrastructure, as well as road maintenance, but exclude excavation material. Technology for separation and recovery of construction and demolition waste is well established, readily accessible and generally inexpensive, but recycling and recovery rates vary between countries. Even if definitions and reporting routines vary and can explain for some of the differences, it is a fact that some countries perform better when it comes to recycling.

Current available data is in some areas lacking but do provide some insights to why the data varies[113]. The quantities of CDW generated is highly dependent on the rate of new constructions built and/or replacing old buildings and therefor reflects the economic growth of the country. Also, architectural habits and types of materials used in construction shows great regional variation, e.g., in some regions brick is the main construction material, whereas in others concrete represents the majority. Wood is a major construction material in northern countries like Finland, Norway and Sweden. Culture does also play a part, and for example in regions in France is demolition seen as a failure, whereas it is regarded in a more positive way in other countries, and the overall technical issues of for example the age of built environment and the quality of the materials used in the old construction influences the rate of demolition. However, an accurate analysis of geographical variations would require more reliable data over time, which is not the case with the current reporting system.

Material recovery rates vary greatly between countries, from some 10 percent to 90 percent, with the Nordic countries somewhere in the middle. Even though there are different definitions and methods to reporting CDW, this shows that is possible to achieve a high rate of recycling and recovery in the sector.

112. European Commission. 2022. Construction and demolition waste fact sheet. Available: https://environment.ec.europa.eu/topics/waste-and-recycling/construction-and-demolition-waste_en
113. Monier, V. et al. 2011. Study on the management of construction and demolition waste in the EU. Report for the European Commission.

This chapter will look on some initiatives and methods used in Europe of how construction waste streams are handled at facilities and describe how these can be implemented on the Nordic market, as to give inspiration and recommendations for new initiatives that could be introduced in the Nordics.

In order to find good examples on techniques and policy that could be implemented in the Nordics to improve the recycling and reuse of construction waste, focus was on high performing European countries. It was decided to focus on Europe, mainly due to available data and due to a similar policy landscape, which helps implementing the ideas in the Nordics.

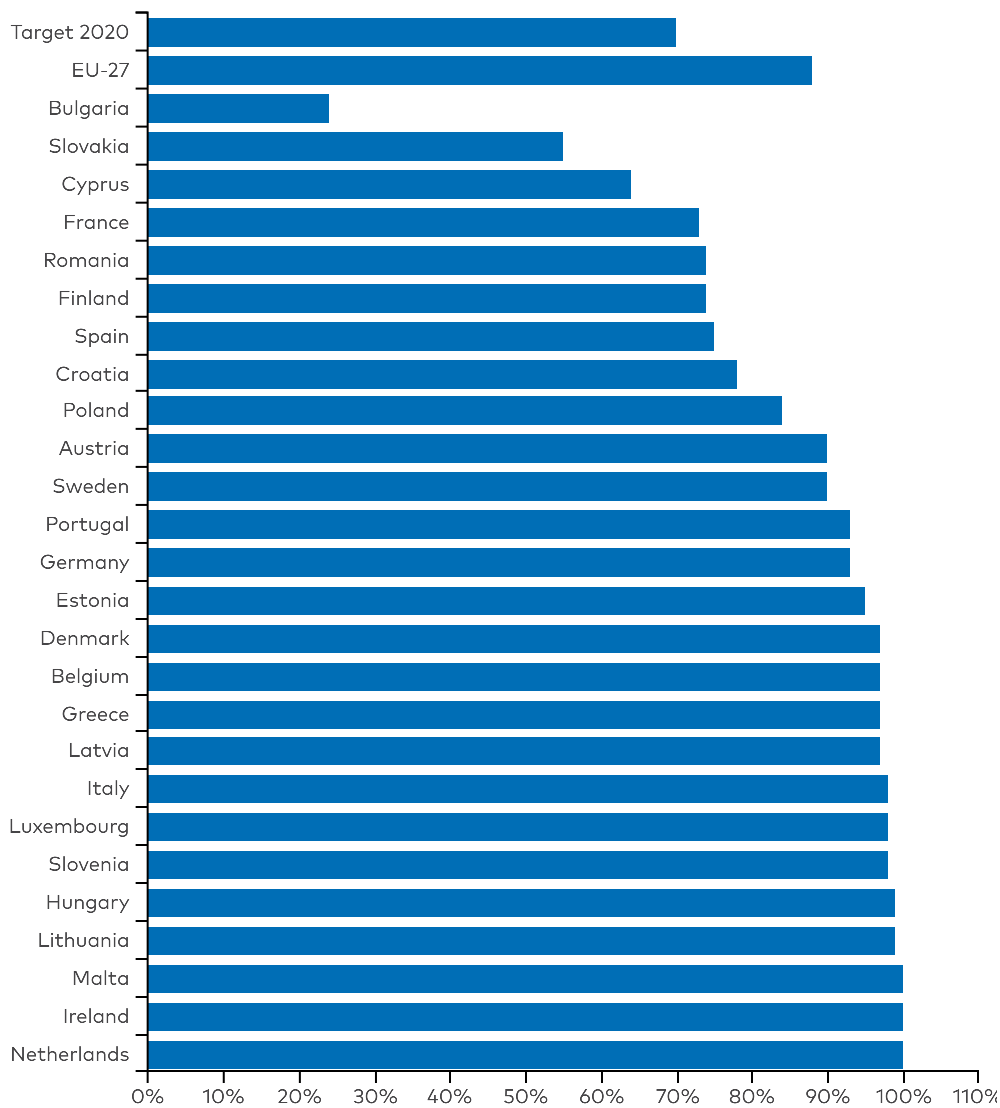

Figure 17.

Recovery rate iof CDW in the EU member states 2018. Source: Eurostat, Statista [114]

114. Statista. 2023. Recovery rate of construction and demolition waste in the EU-27 2018, by country

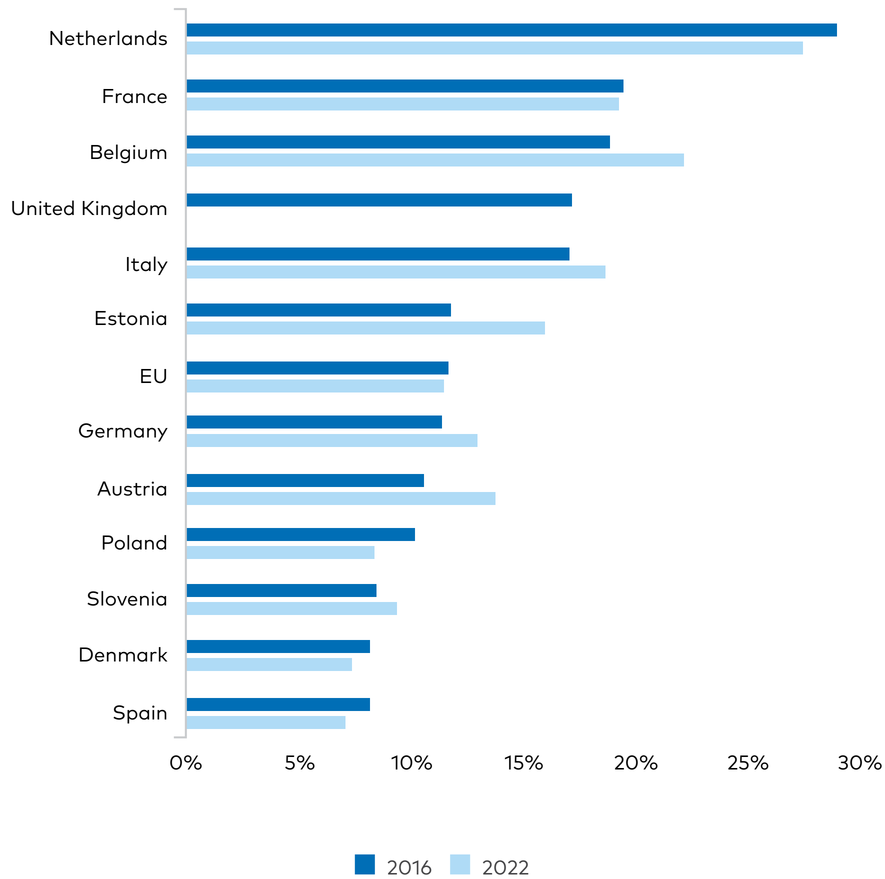

Figure 18. *Circular material use rates for all materials in 2016 and 2022 in EU member states. Source: Eurostat*[115]*, CBS*

According to Eurostat-data in Figure 17, the recycling and material recovery rate of CDW is at 88 % (2018). The indicator is the ratio of construction and demolition waste, which is prepared for re-use, recycled or subject to material recovery, including through backfilling operations, divided by the construction and demolition waste treated as defined in Regulation (EC) No 2150/2002 on waste statistics. The indicator covers the waste category 'Mineral waste from construction and demolition' (EWC-Stat 12.1). Only non-hazardous waste is considered. Studies find that most of the recovery is low-value material recovery, such as backfilling operations[116]. As CDW is a major waste stream in many European countries, by comparing the figures for CDW and statistics showing overall circular material use rate in Figure 18, countries like the Netherlands, France, Belgium, and the UK perform well[117].

115. *Eurostat. 2023. Circular Material Use Rate Dataset.*
116. Schimek et al. 2023. Critical review of the recovery rates of construction and demolition waste in the European Union – An analysis of influencing factors in selected EU countries. Available: https://www.sciencedirect.com/science/article/pii/S0956053X23003616
117. CBS Statistics Netherlands. 2019. Construction section leading in waste and recycling. Available: https://www.cbs.nl/en-gb/news/2019/45/construction-sector-leading-in-waste-and-recycling

[118].

For the countries reporting high recycling rates, several commonalities exist. The first and perhaps most important thing is legislation and policy that both drives the construction sector towards circular economy and facilitates and enable for circular economy. When the legislative policy tools are in place, the technology and market follow. The key to high recycling rates and successful waste prevention, is the availability of suitable businesses, operators and facilities in the region. Long distances with small amounts of materials often makes it unprofitable for recycling and reusing facilities. A third thing the forerunners have in common, is projects and initiatives driving and testing new innovative methods for recycling and reuse in often public-private partnerships. There is an abundance of projects in e.g., data collection and reuse methods that can be seen as now paving way for new policy in these countries.

4.1 Recycling construction and demolition waste

As Europe moves away from landfill towards recovery of waste, are the targets set on recycling of higher value. Countries performing well usually have higher value recycling for easily recyclable materials, such as metals and clean glass, that preserve their value though recycled, and lower value recycling for the rest of the materials. The biggest waste stream in especially demolition waste is mineral waste. This is often used for backfilling or for covering landfills, which are relatively low value recovery. In high performance countries, almost all the mineral waste is sorted into sub-categories, so e.g., gypsum and asphalt can be recycled into new gypsum products and asphalt road materials. Mixed mineral waste, largely concrete waste is used for road and other ground works, replacing use of virgin materials, such as gravel. Concrete rubble can also be used in making of new concrete, replacing a part of virgin cement and sand. This is not yet done in large scale, as a mainstream activity, but is an example of how techniques are moving from lower value recycling (rubble in ground works) to higher value recycling (old concrete to new concrete). When making recycled concrete, only a part of the input (around 30 %, depending on technique and quality needs) can be replaced with recycled concrete, and therefore recycled concrete cannot completely solve the pressure on primary material used in concrete production.

Materials usually recycled:

- Mineral waste, including e.g., plaster, concrete and asphalt.
- Wood

118. Bilsen, V. et al. 2018. Development and implementation of initiatives fostering investment and innovation in construction and demolition waste recycling infrastructure. Available: https://environment.ec.europa.eu/system/files/2020-12/CDW%20infrastructure%20study_0.pdf

- Plastic
- Glass
- Metal

4.1.1 Case examples on recycling construction and demolition waste

4.1.1.1 Recycled materials in buildings

The Alliander headquarters is an office building opened in 2015, consisting of 83 % recycled material[119]. The wood used was reclaimed from a waste processor. The demolition concrete from the old building was turned into a gravel substitute that went into the new concrete for the building. The ceiling tiles are largely reused, and the lamps refurbished from old transformers. The insulation of the building is made from recycled materials and textiles. The building is one example displaying that it is possible to build with recycled materials.

4.1.1.2 Recycling concrete

Concrete is the largest structural material in terms of volume. At the End-of-Life phase, concrete is mainly landfilled, backfilled or recycled into road-based aggregate (RBA), quite often in a mix with other mineral waste materials such as bricks and tiles. Recycling concrete into RBA has important advantages: steel rebars are recovered, crushed concrete is reused in a suitable application and transport of bulk materials (energy, dust) is minimal. Road and other infrastructural construction are not a sustainable solution for concrete waste since the building of new roads needs less and less material while the volumes of EOL concrete are rising.

Different techniques for large scale concrete recycling are being developed, where EOL concrete is crushed and turned into aggregates for new concrete and a fine cement paste concentrate for making new low-CO_2 cementitious binders. One company doing this is Sika, with a concrete recycling process plant in Zurich[120]. Skanska in the Czech Republic has started producing concrete that uses recycled concrete and/or masonry to completely replace natural aggregates[121].

4.1.1.3 Wood recycling replacing energy recovery

In Central Europe, especially Germany, wood waste is used to produce wood-based particleboards or chipboards. In North America, Great Britain, and the Netherlands, wood waste is used in, e.g., the manufacture of wood panels and as floorboards, external cladding boards, and loading pallets. Furthermore, untreated or clean

---

119. CFP Green Building. 2022. Top circular buildings in the Netherlands. Available: https://cfp.nl/en/news-and-cases/our-top-5-circular-buildings-in-the-netherlands/
120. Sika n.a. Can concrete be recycled. Available at: https://www.sika.com/en/knowledge-hub/can-concrete-be-recycled.html
121. Parsi, N. 2022. Mixed-use development outside Prague uses a material made from leftover bricks. Available at: https://www.bdcnetwork.com/mixed-use-development-outside-prague-uses-material-made-leftover-bricks, Skanska 2019. Making better mixes. Available at: https://group.skanska.com/media/articles/creating-better-mixes-low-carbon-and-circular-concrete/

wood waste is also used as mulch and a base material for, e.g., animal shelters, playgrounds, and footpaths[122].

4.1.1.4 Recycling of PVC

In Europe, around two-thirds of PVC produced is used in building applications such as PVC window frames and other profile applications, pipes and fittings, flooring, electric cables and conduits, a variety of plastic linings, membranes and water-proofing applications, and in coated fabrics[123]. PVC can be recycled several times, but a problem with old PVC. These substances should not be recycled but can be destroyed through incineration with energy recovery. Conventional mechanical recycling covers processes which do not break polymer chains into small components. It is well suited to pre-sorted, single waste-stream waste, and has been done in Europe for decades.

4.1.1.5 Flat glass

Despite its recyclability, end-of-life building glass is almost never recycled into new glass products. Instead, it is very often crushed together with the other building materials and put into landfills or recovered together with other CDW. This is facilitated by its inert characteristics. It currently has a low market value because there is a lack of properly organised collection and recycling systems to generate what would be a valuable glass-making raw material. Glass recyclers biggest limitations is not technique but receiving enough feedstock[124].

Flat glass can be recycled into flat glass or to fiberglass, insulation or highway beads. Laminated glass, such as insulation glass must be additionally processed, but can even so be recycled.

4.2 Reusing building elements

Reusing building elements and materials in construction, results in higher preserved value of materials, and at the same time waste reduced. All kinds of material can be reused in different phases in both construction and demolishing. In construction project, leftover products and materials can be sold for reuse, and reused items and materials can be used in construction. In demolition projects, the process is usually that the project is mapped for what material is available, and the demolishing starts with dismantling all the materials and products that can be reused as is. These can be e.g., doors and windows, all kinds of interior, panels, bricks, beams, and even whole elements and buildings.

---

122. FIR. Undated. Technical Factsheets Construction & Demolition Waste Recycled Aggregates (example The Netherlands). https://www.fir-recycling.com/wp-content/uploads/2023/02/FIR-Factsheet-on-Recycled-Aggregates-Example-The-Netherlands.pdf
123. Vinylplus 2017. PVC recycling technologies. Available at: https://vinylplus.eu/wp-content/uploads/2017/02/VinylPlus_PVC_recycling_tech_20092017.pdf
124. Devlin, K. 2022. Flat glass recycling. Available at: https://www.glassmagazine.com/article/flat-glass-recycling

The reusing of building elements from demolished buildings however faces certain challenges. Construction products must fulfil certain technical requirements. The eligibility of a construction product is generally indicated by the CE mark inside European Union if the construction product falls within the scope of the harmonized product standard or has a European technical assessment (ETA). CE mark is generally applicable for new construction products, not for the reused construction products. Currently the reuse of building elements has certain approval practices which have some variation between Nordic Countries. Especially the quality control and quality verification of reused construction elements lack of unified guidance and the applicability of reusable construction elements are typically evaluated case by case.

Materials usually reused:

- Fittings
- Tiles, bricks
- Steel structures

4.2.1 Case examples of reuse in the construction sector

4.2.1.1 Reused and reclaimed material as business as usual in the UK

UK is one example country where the markets for reusing and reclaiming of construction materials are evolving and growing. Especially traditional materials such as bricks, certain wood construction products and fittings have moderate markets run by SME's. Various digital marketplaces for retailers with physical storage locations and online exchange platforms for ad-hoc listings informing upcoming buildings to be demolished. One of the biggest market players in the field is Salvo which runs digital marketplace SalvoWEB[125]. Salvo is the original marketplace started in 1991 for architectural salvage and reclaimed building materials such as bricks, stone, beams, timber, roof tiles and slates, flooring, windows, doors and sanitary ware[126].

4.2.1.2 Reusing steel structures by being included in design

Grosvenor is a British property group working globally. The family-owned company is a prominent in the property market in environmental, low-carbon and circular initiative[127]. Grosvenor's UK property business is working to reduce the carbon of projects through circular design strategies, and material reuse is key. An example of material reuse is the Holbein Gardens project, where structural steel from the demolition of an office building was used directly in the construction of the new building, preserving the value of the structural steel and saving almost 70kg/CO^2e/m^3.

---

125. Salvo. 2023. About futuREuse. FRCBE Interreg NEW project. Available: https://futureuse.co.uk/about/
126. ReLondon. 2021. Sourcing reclaimed construction materials. CIRCuIT EU Horizon project. Available: https://relondon.gov.uk/wp-content/uploads/2021/06/ReLondon-Sourcing-reclaimed-construction-materials-May-2021.pdf
127. Grosvenor. 2023. Website: https://www.grosvenor.com/materialreuse

The project was done in cooperation with Cleveland Steel, which is a steel stock company specialized in reclaimed and reused steel. Cleveland Steel also delivered reused steel tube from an existing surplus to be used in the London Olympic Stadia [128]. Being involved early in the project, the design could be configured to use the already existing pipes, enabling the stadium to be completed in time and significantly reducing the carbon footprint of the project.

4.2.1.3 Reusing wood through decentralized network of actors

The Community Wood Recycling (CWR) is a network of 30 enterprises across the UK recycling and reusing wood[129]. The enterprises sell timber that has been rescued from construction projects. The wood waste from construction and demolition sites is stocked and then sold by local enterprises for reuse or recycled or upcycled into new products. CWR started in 2003 and estimates that it since then has reclaimed almost 223 000 tonnes of wood.

4.3 Reducing construction and demolition waste

Reducing waste is the first step in the waste hierarchy. In order to reduce construction and demolition there are several areas to focus on: the prerequisites for the company, choice of material and building design, construction methods, logistics and material management and procurement, for example[130]. These will affect the generation of waste during construction as well during the life and end of life phase. The design and quality of materials and methods are the key factor in whether the building can be renovated or refurbished instead of demolished, disassembled for reuse, as well as for possibilities for reuse and recycle before and during demolishing, all of which are methods for reducing waste.

The most effective way to prevent waste is to prevent demolition, by designing modular buildings and design for disassembly. This is though possible mainly for new buildings. For existing buildings, refurbishing and renovating instead of demolition usually generates less waste. The first step when demolishing should be to map, assess and dismantle all materials that can be reused, to reduce the amount of waste generated. During construction, logistics play an important part in prevention of waste.

128. Cleveland Steel. 2023. Website: https://cleveland-steel.com/case-study/london-olympic-stadia
129. Community Wood Recycling. 2023. Website: https://communitywoodrecycling.org.uk/
130. Fredriksson, G. & Höglund, E. 2012. Att minska byggavfallet – En metod för att förebygga avfall vid byggande. Tyréns, Stockholm.

4.3.1 Case examples of waste prevention action

4.3.1.1 Logistical hub for construction projects

The construction company Volker Wessels started a logistical hub for building projects, Bouwhub, at the edge of Utrecht city back in 2015[131]. The hub takes in materials in for the outfitting phase, for example tiling, pipe fittings, drywall, for several projects and repackages the materials to fit the daily needs for each of the projects in the area. The first years, the hub was underutilized, but turned into a profitable service in 2018. The hub lowers the traffic into the city by collating deliveries to hub and provided every sub-contractor with necessary materials in site. Every round of deliveries leads to the possibility of to get rid of waste and the possibility to collect materials for reuse. The hub stores building materials, tools and other materials like fence and security materials. The area was created in collaboration with local policy makers, as it requires a suitable area and space, as well as help to get started.

Due to planning and logistics, the hub has reported a reduction of waste by 30 % since it started, and a reduction of traffic into the city by 60 %. Reusing of packaging material in the hub is 50 %, which is above average in the sector, and report that 15 % of materials recovered is reused.

A similar hub was established temporarily for the construction of Barts Hospital in London in 2004 by the construction company Skanska[132]. The logistics centre was situated outside the construction site, which allowed for smoother collated deliveries and better space for loading and unloading. This led to less damaged goods and leftover material, resulting in less waste.

4.4 Policy overview in high-performing countries

4.4.1 The Netherlands – Leading the way in recycling

As an EU member state, the Dutch policy follows the EU legislation in the form of a policy programme 'From Waste to Raw Material' (Van Afval Naar Grondstof - VANG) that promotes the transition to a circular economy. The Netherlands implementation programme encourages voluntary 'Green Deals' as an instrument to ensure bottom-up initiatives from stakeholders. Green Deals exists for e.g., sustainable concrete, circular building and bio-based buildings. In the Netherlands, there is an obligation to provide information about the environmental performance of building materials that are covered by the Buildings Decree. In the environmental

131. Interreg Europe. 2022. Good practices – Bouwhub smart building logistics. Available: https://www.interregeurope.eu/good-practices/bouwhub-smart-building-logistics
132. Fredriksson, G. & Höglund, E. 2012. Att minska byggavfallet – En metod för att förebygga avfall vid byggande. Tyréns, Stockholm

performance of building materials, the emphasis lies on the climatic effects, but there is no requirement in the Buildings Decree concerning the degree of circularity. The Soil Quality Decree allows since 2007 for recycling of CDW mineral material in construction projects without environmental impact reporting or permits, which allows for high recycling rates. The role that the Netherlands has as the frontrunner in the recycling of building materials is, to an important degree, a result of these regulations.[133]

The construction sector uses large volumes of material and generates large volumes of waste, some 40 percent of total produced waste[134]. The waste is largely recycled (88%) and less than 10 % end up in landfill. Almost 38 percent of all the materials used by the Dutch construction sector were recycled materials. However, only 8 percent of the material used for buildings is from recycled material. The demolition waste is sorted and treated on a large scale, most of the recycled demolition waste is used as a foundation material for infrastructure (e.g., ground works and road construction).

The processing of good quality recycled materials starts before demolition. The Dutch National Building Decree and Soil quality decree require that during demolition and recycling, the material may not cause negative effect for health or environment. The regular process for demolition waste is described in Figure 19 and consists of crushing with sieves and magnets. This is combined with new techniques that efficiently widen the range of recycled materials. Examples include screening techniques, washing techniques, optical or infrared sorting, thermal processing of asphalt and new technologies that offer opportunities to bring back the original source materials.[135]

133. Rijkswaterstaat. 2015. Circular Economy in the Dutch construction sector Available: https://www.rivm.nl/bibliotheek/rapporten/2016-0024.pdf
134. Circular Gap Report 2022: Built Environment, The Netherlands. Available: https://www.circle-economy.com/resources/circularity-gap-report-built-environment-the-netherlands
135. FIR. Undated. Technical Factsheets Construction & Demolition Waste Recycled Aggregates (example The Netherlands). https://www.fir-recycling.com/wp-content/uploads/2023/02/FIR-Factsheet-on-Recycled-Aggregates-Example-The-Netherlands.pdf

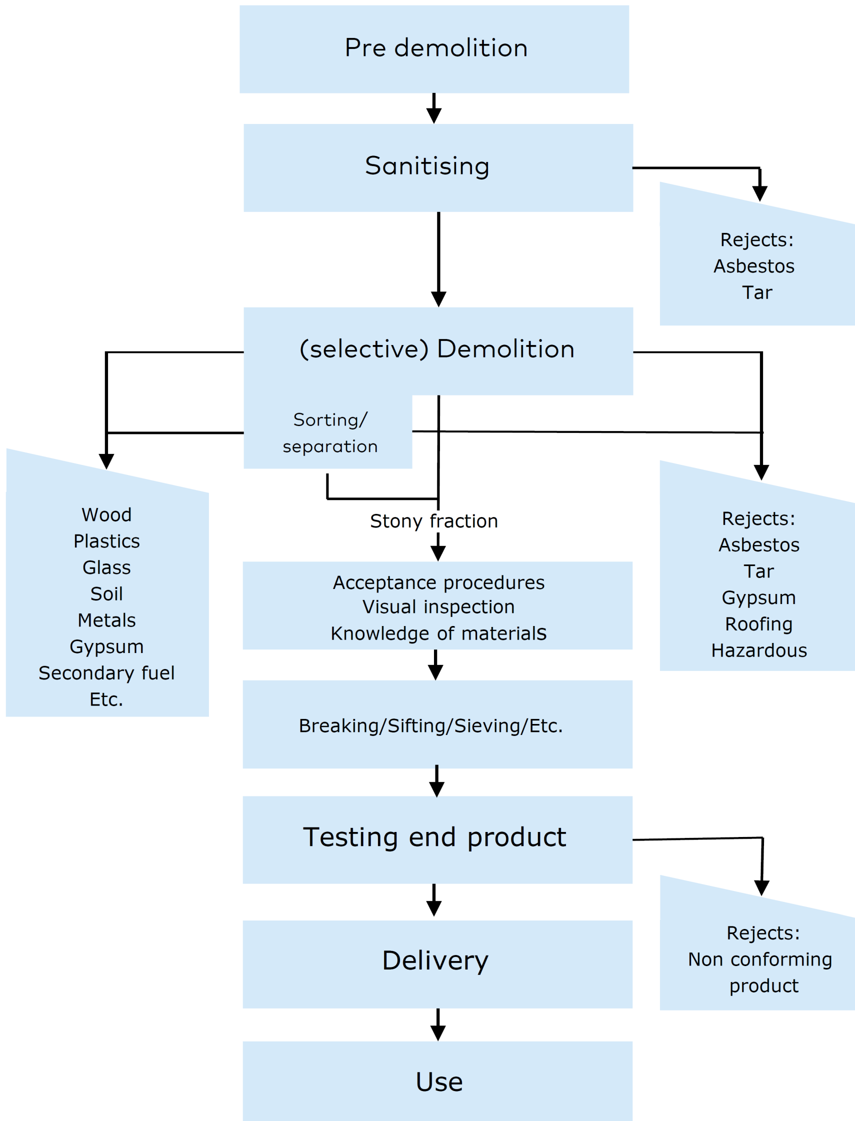

Figure 19. *Typical recycling process of demolition waste in the Netherlands (Source: FIR)*

As most of the CDW is demolition waste, recycling begins before the dismantling. In the Netherlands, material passports for buildings have been tested and used for several years[136]. Materials passports are digital documents containing information on all the parts of a building. These are becoming more and more frequent, and the possibility for them to become mandatory for new buildings is being discussed across Europe. In the Netherlands, where the idea is arguably most used and advanced, the Dutch government has introduced tax incentives for developers who register material passports[137].The passport provides insight into what materials

136. Madaster. 2019. Amsterdam metropolitan area uses material passports to boost the circular economy in the region. Available: https://madaster.com/inspiration/amsterdam-metropolitan-area-uses-material-passports-to-boost-the-circular-economy-in-the-region/
137. Barnard, L. 2022. How are material passports changing construction. Construction Europe. Available: https://www.construction-europe.com/news/how-are-materials-passports-changing-construction-/8020985.article

products and components go into a building, typically in the form of digital data sets, making it easier at the end of the building's life to recover everything of value, preventing these materials from being incinerated during demolition or renovation [138]. Typically, material passports and done for new buildings, since during planning and building it is easier to keep records, but it can also be done for existing buildings. These are usually not as specific but can be used to describe the materials on a larger scale. The information in material passports makes it easier to assess what materials can be used for reuse and recycling when renovating or demolishing. The challenge with material passports today is the lack of unified approach and standards, and the fact that a detailed passport can mainly be done for new buildings, when it is the older ones that are demolished.

4.4.1.1 Case example: Madaster

The Madaster material passport, launched in 2017, is a widely used tool for material passports[139]. It started as a prototype in an EU-sponsored Buildings as Materials Banks (BAMB) programme which started in 2015, with the idea to make it easier for construction firms to incorporate as many materials as possible from old buildings rather than buying new ones. The Madaster material passport is a database that stores information about the identity of a building, object or work of art and their underlying materials, with the aim of stimulating the careful use of resources so that waste and wastage is reduced. The Madaster company, founded in the Netherlands, runs the public platform for the entire real estate sector.

Madaster has been used for several building projects in the Netherlands and public buildings in Amsterdam Metropolitan Area[140], as well for the 1 Broadgate campus area in the City of London[141].

4.4.2 France – Policy as driver towards anti-waste

The construction sector stands for 70% of all the waste produced in France. Of the CDW, 49% comes from demolition, 38% from renovation and refurbishing and 13% from new construction[142]. Approximately 70 % is recycled.

The recycling rate in France in driven by policy. French legislation has been a forerunner in Europe, setting the tune for the EU. In the Law on Energy Transition for Green Growth from 2015, recovery targets for construction waste, as well as targets for used recycling materials in construction were set:

---

138. Metabolic. 2020. Materials passport for a circular economy. Available: https://www.metabolic.nl/news/circular-economy-materials-passports/
139. Madaster. Website: https://madaster.com/
140. Madaster. 2019. Amsterdam metropolitan area uses material passports to boost the circular economy in the region. Available: https://madaster.com/inspiration/amsterdam-metropolitan-area-uses-material-passports-to-boost-the-circular-economy-in-the-region/
141. Considerate Constructors Scheme. 2022. Materials Passport - 1 Broadgate. Available: https://ccsbestpractice.org.uk/
142. Diemer, A. et al. 2022. Waste Management and Circular Economy in the French Building and Construction Sector. Front. Sustain. 3:840091. doi: 10.3389/frsus.2022.840091. Available: https://www.frontiersin.org/articles/10.3389/frsus.2022.840091/full

- 70% of the materials and waste produced on construction sites to be recovered as material.
- 60% of the use of road construction materials must be derived from reuse, re-utilization or recycling of waste.
- 20% of the use of road construction materials must come from reuse, re-utilization or recycling of waste materials in surface layers.
- 30% of the use of road construction materials must come from the re-use, recycling or recycling of waste materials in the sub-base layers.
- 70% must come from the reuse, recycling or material recovery of materials and wastes generated on road construction or maintenance sites, excluding "natural geological materials".

The Environmental Code (Article L.541) ensures traceability of the CDW, defining the project owner as the responsible for the waste and its traceability from the construction site until its final disposal or recovery. Each actor in the waste management chain remains responsible for the traceability obligations.

The Law on Anti-waste and Circular Economy (AGEC Law) issued in 2021, allows materials or products to be removed from their waste status under the guise of being useful, reused or recovered. It also facilitates the removal of excavated soil from waste status, as environmental permits no longer are necessary for material that are safe for reuse. The AGEC law also introduces EPR for construction products or materials in the building sector. What can be seen as the predecessor of the AGEC Law, the National Waste Prevention Programme for the period 2014-2020 resulted in a reduction of 7 % of waste in 2020 compared to 2010. The targets for and estimations of the effects of the AGEC Law are a reduction of 5 % of waste from the building and public works sector, in 2030 compared to 2010 (AGEC, Article 3)[143]. The Anti-waste Law is a forerunner in banning unnecessary waste and putting circular economy and waste prevention measures activities into law. Waste prevention methods that are listed specifically for the construction sector is to "develop the reuse of products and materials in the building sector and set up a territorial network of collection points with areas dedicated to the reuse of construction products and materials from this sector". It can be expected that other countries will follow with similar policy, and for example in the UK the Environmental Act 2021 and Waste Prevention Programme are also targeting the construction sector with e.g., EPR schemes and regulations on minimising waste, designing for adaptability, reusing components and materials, recycling and improving demolition systems, with the overall aim to eliminate avoidable waste by 2050.

143. European Environment Agency. 2023. Waste Prevention Country Profile – France. Available: https://www.eea.europa.eu/themes/waste/waste-prevention/countries

5. Analysis of the results

The quality of different CDW determines the recycling and reuse possibilities. To ensure good quality of the CDW for recycling, the different fractions should be dismounted and sorted separately when possible. The on-site separation is considered a better alternative as it results in cleaner waste fractions, although it has more limitations like higher costs or limited amount of space on the site. The treatment and separation technologies for mixed CDW fractions have been developing rapidly in recent years, which also enables high-quality off-site sorting. However, upscaling of new technology and innovation is slow. Some waste materials, like plaster boards, are very difficult to separate from mixed CDW if they get pulverized during the treatment process. The pre-demolition audits make it possible to identify materials that need to be separated. The audits also help to define which order the disassembling should be done to avoid unnecessary contamination or wetting of materials.

The level of construction elements or material reuse remains relatively low across Europe, and achieving higher rates would necessitate a more standardized approach and guidance at the EU level. Presently, the Nordic countries have their own national practices regarding the verification and approval of construction elements or materials prior to reuse. The existing European Construction Product regulation and CE-marking requirement only pertains to new construction products, such as bricks.

Considerations for recyclability and reusability should be integral to the design of new buildings and construction materials. The current building stock lacks designs suitable for reuse, which complicates disassembly. Additionally, construction materials from previous decades contain numerous hazardous substances and structural complexities (e.g., composite structures), which poses challenges for recycling or reuse.

5.1 Output from the workshop

A stakeholder workshop was held to present the preliminary results and findings from the project, as well as to gather additional information from the participants for this study. During the workshop, stakeholders representing entrepreneurs, recycling companies, consultants and authorities, discussed potential knowledge gaps, challenges and opportunities for recycling and reuse in the construction sector, as well as what the Nordic countries could learn from each other.

A summary of the challenges and opportunities from the workshop discussions and findings are presented in Table 11 below. The discussions identified the need for unified ways of working to increase cooperation and opportunities within the Nordics and EU. As an example, a common terminology and more detailed statistics were seen as necessary for identification of materials which have potential for increased recycling or reuse. The terminology concerning material recycling, recovery and reuse is still regarded as difficult, as certain terms are understood differently. In the Nordic countries, this is mainly due to language differences and that the term recycling is commonly also used in all countries for recovery treatment. In addition, the need for more unified EU-wide practices and guidelines especially for construction product reuse was seen as necessary. Currently the Nordic countries have country specific practices on how construction elements or material reuse can be done or reported on. A lot of development work is going on regarding this at the EU-level e.g., Construction Product Regulation revision, Eco-design and product passports. The best practice cases and statistics from Denmark were recognized as something to learn from to increase recycling. In the long run, the focus should be more on reducing waste by demolition, only when essential and preference placed on preserving and renovating instead. In addition, the reusing of construction elements and materials have a lot of potential in waste reduction and some good examples were identified, like Cleveland Steel in UK, Brukspecialisten in Sweden and Gamle Mursten in Denmark.

The workshop discussions concluded that technologies exist to solve most of the problems, but there is a lack of drivers. The participants called for stricter requirements. Drivers for increased recycling and reuse of CDW was mentioned through legislation and regulation, e.g., climate requirements and EOW regulations, waste taxation, EPR schemes and demands in public procurement. As a good example, it was mentioned that in Norway, requirements for design for disassembly are included in the building code, which is something that could be included in other countries as well.

Table 12: *Summary of discussion points from the workshop.*

Opportunities
• Data and statistics on the CDW at a detailed level, split into many subcategories, including data on sorting and treatment would help recognise opportunities. • Sorting of CDW into more fractions is possible and only a matter of planning. This would create new possibilities for the new business. • Climate legislation can work as a driver for reuse. • Taxes and costs are effective in driving the change in behaviour. • Process for the reusing of construction materials needs to be developed at the EU level. • Building passports and long-term routines will increase information about materials included in the buildings. • Consistency and flexibility in legislation concerning construction material reuse. • On-site separation/treatment process is possible for demolition sites. Transport costs determines if off-site or on-site treatment is carried out. • Extended producer responsibility for certain products (isolation, plaster boards) could help in closing the loops.
Challenges
• Mixing of waste streams prevents further recycling/reuse. Technical challenges occur especially when the mixed materials are needed to be separated. • Material availability. Demand for circular construction products, for certain product categories, is larger than the current availability. • Ease and low costs of landfilling or energy recovery of CDW. • Good availability and low cost of virgin raw materials partially prevents the use of recovered materials. • Quality demands, e.g., CE-certifications in construction, needs clarification when using recovered materials. • Obtaining behaviour change is harder than the treatment techniques. • To scale up start-ups is expensive and not incentivised. • Insufficient statistical information of CDW is a challenge. More detailed data would help to show low hanging fruits and where improvements could be made. • The reuse of construction products needs a uniform process and criteria in EU. • High cost of recycling, especially due to long transportation distances. • Timing and local availability of reused materials to meet the demand.

5.2 Challenges and impact drivers

The EU Waste Frame Directive (WFD) and the Waste Hierarchy set the tone in waste legislation through all the Nordic regions. Differences in how they are implemented can be found, and they often depend on regional factors. There are slight differences in the requirements for sorting CDW materials, including the number and nature of fractions sorted. Discrepancies in the fractions to be separated may stem from different building techniques.

This study finds that despite the sorting requirements for CDW in all countries, waste statistics indicate that not all materials are separated but instead culminate as mixed CDW. Consequently, the study concludes that while regulations for on-site sorting exist, they are not consistently adhered to, potentially due to a lack of adverse consequences for companies. Moreover, the sorting requirements are not reflected in publicly available waste data from the sector, as the data is aggregated in reporting. This can be seen for all Nordic regions.

The definitions for the different treatments, fractions, and recovery targets are established within the WFD. One prevalent challenge observed across the sector and in all countries is the lack of consistent interpretation of the terminology. While the official terminology between 'recycling' and 'material recovery' differs in English, the term 'recycling' is often used interchangeably in the Nordic languages. In some cases, backfilling is considered a part of recycling, as it falls within the recycling and material recovery target (frequently referred to as the CDW recycling target). Among the Nordic countries, only Denmark publicly reports the ratio of backfilled or recycled mineral waste.

Waste statistics vary across the different Nordic regions, and the sorting requirements stipulated in the legislation are not reflected in the available waste data. Denmark stands out as the Nordic country with the most comprehensive publicly available CDW data, encompassing statistics for various fractions and information on treatment methods. In contrast, Sweden's waste data was accessible solely through a designated contact person.

Most countries present aggregated CDW data, which combines all waste from the sector, often including soils and excavation masses. This could stem from variations in how the source data of the CDW is generated, that is, waste companies might categorize waste fractions differently. Additionally, most countries and regions also report on mineral waste at the required EWC-Stat code level, where e.g., code 12.1 for mineral waste includes concrete, asphalt, plaster and mineral wool. However, totals for plastics and glass often includes packaging materials, which do not accurately represent the construction sector.

The aim of this study was to focus on recycling and reusing techniques for CDW, uncovering both new and established methods for recycling, reuse, or preparing for reuse that are currently available. These techniques exhibit variations across countries, for instance, in the case of reuse of bricks with lime-based or concrete-based mortar, yet this variation seldom hinders increased recycling and reuse rates. The technical aspects are mostly in place, except for mixed and dirty demolition waste such as plastics, combination materials, and for some mineral wastes. The study has investigated interesting case examples in chemical plastic isolation recycling, sorting facilities, mineral wool recycling, and potential concrete recycling methods. The obstacles for expanding these techniques or implementing them in various regions appears to be economic, legislative, cultural, and, in some instances, geographical.

The economic aspects are the main drivers in this sector, as it is in other businesses as well. What is profitable or not, on the other hand, can be adjusted and influenced by policy and regulation. A higher waste tax on disposal or low value recovery can guide the material flows to recycling processes. This can lead to limitations where producers or companies providing recycling or reuse techniques, such as for flat glass or bricks, have trouble getting enough material to cover demand of their circular product. In Denmark, where the cost of landfill is high, it is less expensive to sort and recycle CDW, which is reflected in better recycling rates. Quite often it can also be the case that the recycling process leads to higher costs, and this in combination with other aspects of recycled or reused material, such as uncertain or fluctuating availability and quality assurance, can lead to a limited demand. Both cases can be helped by policy changes, making it more profitable to buy circular products due to e.g., regulation demanding climate or material saving option, or making it much more expensive to dispose of waste or producing mixed waste. Especially for rural and vast areas, the potential recoil effect of raised fees should be considered, where unethical disposal could increase.

Another challenge in advancing towards increased recycling and reuse of CDW relates to supply and demand dynamics. The supply of recyclable or reusable materials is inconsistent and fragmented, while the demand for these materials remains unpredictable. This pattern is typical across various recycling endeavours and is recognized as a significant barrier to establishing a circular economy in all sectors across countries. Additionally, waste materials may emerge in different locations or times than where the demand for these materials exists and knowledge gaps regarding available materials, their timing, and locations remains a significant obstacle. Limited awareness and education among stakeholders, including builders, contractors, and consumers, contributes to a lack of understanding of the benefits associated with construction waste recycling. This hinders the creation of a robust demand for recycled materials. Fluctuating demand for these materials impacts the economic feasibility of recycling initiatives. Efforts have been made to establish platforms for demand and availability of materials, with some platforms mentioned in the case examples, such as SalvoWeb, Materiaalitori, Malmö Återbyggdepå, and Ylijäämävarasto. However, some of these platforms faced challenges during the implementation phase. For instance, despite its general recognition as a valuable and necessary initiative, an Icelandic platform of this kind was discontinued due to insufficient funding and disagreements regarding ownership and operational responsibilities[144].

Despite similarities among the Nordic countries, notable differences also exist. For instance, the building stock varies between countries, as does the use of materials such as wood, bricks, and insulation, and building techniques and age of buildings for demolition can differ, which affects the composition of the CDW.

Regional aspects play a crucial role in determining the treatment of CDW. For instance, in island regions like Greenland, the Faroe Islands, Åland, and to some extent Iceland, local recycling treatment for every waste fraction is often unavailable due to small waste streams and cost-benefit considerations. Consequently, waste from these areas tends to be exported or used for low-value recovery methods like backfilling or disposal. Additionally, industries within the region influence CDW treatment approaches. In Finland and Sweden, most of the wood from construction and demolition sites is incinerated for energy recovery since the forestry industry provides the particle and chipboard producers and other wood product industry with enough wood waste that is clearer and more locally generated. In Denmark, where the forestry industry is less dominant, wood waste from construction is an important material stream for the wood product industry.

Harmful substances pose a perpetual challenge in the circular economy because, while materials are meant to circulate, these substances should not. It's crucial to separate them from other materials and treat them safely. The identification and separation of harmful substances from CDW have long been a focus in all Nordic countries. The construction product categories from a certain era, which may contain harmful substances, are generally well known and considered during the demolition in all Nordic countries. Hazardous substances have been utilized in various construction materials such as mortars, jointing materials, impregnated wood structures, insulation materials, paints, and glues. Each country seems to adopt a similar approach to mapping hazardous substances in materials prior to demolition and separating them during the process. This study did not focus on the technologies which are used to treat hazardous substances, but typically, they are disposed of through incineration with energy recovery.

144. Personal communications, Daði Rúnar Pétursson, Ríkiskaup. 2023.

5.3 Potential to increase recycling and reuse of CDW

This study found that the largest fraction of CDW is mineral waste. Looking into good examples and techniques available, there appears to be significant potential to enhance high-value recycling across all countries. Particularly in the regions lacking an End-of-Waste scheme, redirecting materials away from backfilling towards recycling could be beneficial. Additionally, it could facilitate the recycling of concrete into new concrete aggregates. Establishing a market for recycled concrete could be driven by climate requirements for new buildings and waste pricing. The optimal reuse of elements is achieved in buildings designed for disassembly. It should be a requirement for new buildings to adhere to this principle, coupled with comprehensive documentation of materials used via a building material passport.

Other potential for increased recycling or even reuse can be seen for mineral wool, PVC and wood waste. These are materials that are largely recycled in Denmark, but not in other Nordic regions. For PVC, clean surplus pipes, and more from building sites could easily be sorted out. The barriers in Finland for example, seem to be the small volumes and long transportation distances to recycling plants. For mineral wool, as well as for plaster boards, there are return schemes for surplus material from construction sites, where the mineral wool and plaster boards are recycled into new products. Recovering materials from demolition sites is challenging, as the materials are often mixed, contaminated, and exposed to weather conditions.

The wood waste is an interesting fraction, which would have recycling or reuse increment potential in other Nordic countries other than Denmark. However, wood waste is important and cost-effective fuel for energy production and security of supply in the Nordics and would in the case of large-scale shift towards recycling need a replacement for energy production. In the longer run, though, the energy production via combustion is declining. One potential use of wood waste from construction and demolition are programmes with companies for reuse, working in smaller scale in the UK but also as pilots in the Nordics. In addition, utilization of wood waste as material for biochar, which may be the most feasible large-scale use, is already happening to some extent.

To enhance recyclability and reuse, the significant potential lies in improved sorting, documentation, and reporting. "You can't lead what you can't measure" applies here, indicating new business opportunities through better-sorted fractions. On construction sites, several methods can enhance sorting, such as offering sorting possibilities and assigning responsibilities. For larger construction sites or on a city-level scale, establishing a logistical hub outside the site, similar to Bouwhub in the Netherlands or Skanska Bart Hospital logistic site detailed in Chapter 4, could be an effective solution. Regarding demolition sites, effective planning, and the dismantling of reusable and recyclable materials before demolition are crucial.

On-site sorting of demolition waste is imperative, and the implementation of requirements and economic incentives, such as procurement requirements and waste taxes, are vital for successful implementation.

Quality assurance for reusable material is vital, and schemes for CE-certification for reused material would create huge opportunities in the field. This has been seen in the case with bricks, where the demand for reused certified bricks exceeds the supply.

5.3.1 Impact drivers for reaching potential

Understanding the possible impact drivers is important to reach the potential of reusing and recycling CDW. The four main categories of impact drivers have been identified as the following: Legislative or political drivers, economical drivers, technical drivers, and social or cultural drivers. The drivers will be described in more detail in the following section.

The legislative and political impact drivers to enable the reuse and recycling of CDW have been identified as the following:

- End-of-Waste regulations that makes it easier to recycle and reuse safe material will enable an increase in higher-value recycling of mineral wastes and reusable building products, for example.
- Establishing Extended Producer Responsibility (EPR) schemes require producers to establish or contribute to developing systems for collecting and recycling their products. This will encourage producers to think of the end-of-life use during the design of the product, making it easier to close the loop, as the financial responsibilities at the end-of-life of the products are shifted to the producers.
- Establishing more comprehensive and transparent climate and resource targets in national regulation can lead to a common understanding of the stakeholders' roles and responsibilities in the implementation of change. The targets and goals should be easily understandable and easy to follow up and should be transparently reported on.
- Design for disassembly integrated in building code.

The economic impact drivers to enable the reuse and recycling of CDW have been identified as the following:

- Increasing the waste tax or other fees on the disposal practices that do not promote reuse or recycling, such as landfilling or energy recovery, will discourage the use of those treatment alternatives. This will create an incentive for waste reduction and better waste sorting for the possibility of using disposal practices such as reuse, recycling, and material recovery.

- Creation of market value through other policy, e.g., obligations or procurement requirements, or benefits for climate or resource saving practices.
- Investment funds for innovative practices.

The following technical impact drivers were identified to enable increase recycling and reuse of CDW:

- On site sorting and technological innovations which enables production of good quality waste for recycling.
- Importance of proper timing (pre-demolition audit, assorting disassembling) in demolition projects to ensure high quality recycling and reuse.
- Development of uniform guidelines and approval process, reusing of construction elements and materials.
- Clarify the verification process of the reusable construction elements or materials.
- New buildings and construction materials should be designed so that they would be more easily recyclable or reusable.

The following social and cultural impact drivers were identified to enable increase recycling and reuse of CDW:

- The public sector plays an important role in implementing a change in old ways of working as they are a significant developer in the construction and demolition sector. Implementing stricter procurement requirements to enable the use of reused or recycled materials can drive this change.
- Clearer and common guidelines and practices for reuse of CDW should be developed and implemented to unify the process and make it understandable for as many actors. The guidelines could include definition on how material quality is verified for reusable materials and how waste status or End-of-waste is determined.

Refitting, refurbishing and renovation efforts before demolishing.

6. Conclusions

In this study, the current situation of recycling and reuse of construction and demolition waste in the Nordics, including techniques and facilities, was described. The results show that, while many things are similar, there is also differences between the countries. The recycling and reuse rate targets are not being met, but the barriers are not technical. Techniques for recycling and reuse exist and are available, but the upscaling of these are met with legislative, economic and social barriers in all countries.

For the island regions, the main challenge for large-scale reuse and recycling operations is long distances and small volumes. To some extent, these are also a factor in Finland. The small volumes often make recycling and reuse operations non-profitable, and new material is usually cheap, and more easily available. In Denmark, with short distances and high landfill fees, it is usually less expensive to sort and recycle, which leads to higher recycling rates, whereas in Norway where there is no landfill tax, a larger share is landfilled. Short distances in e.g., southern Finland and southern Sweden can lead to better recycling regionally than on the national level, but this was not the focus of this study. The reporting and availability of waste statistics varies in the regions, with the smaller regions partly lacking and Denmark performing well. Better and more detailed data would help to identify opportunities for improvement.

Differences in material treatment occur, especially in the handling of wood waste and mineral waste. In Finland, Sweden and Norway, wood waste per capita is high, compared to Denmark. This is explained by different building techniques and materials used. In Denmark, the wood is often recycled, whereas in Finland and Sweden, where wood is an abundant resource, it is mostly directed to energy recovery. Here is the potential to improve, and to use wood waste in a more circular way. For mineral waste, it is noticeable that if there is an End-of-Waste regulation for concrete waste, it can be used in more high-value construction. The building traditions are evident here; for example, companies providing techniques for brick reuse have had to adapt to different techniques based on prevalent mortar used in brick buildings. Companies for brick reuse are mostly successful in Denmark and Sweden, whereas the use of bricks is not as common in the other Nordic countries.

The main problem in raising the reuse and recycling rates in the Nordic is the lack of on-site sorting. Where sorting on both construction and demolition waste is done on-site, the easier the materials recycle. Harmful substances used in previous decades pose a relatively small risk, and as long as the sorting keeps this material separated, it can be handled safely. The case examples showing reuse and recycling of materials indicate that the better the materials are separated, the more high-value recycling is possible. Many require work and labour which can increase the costs, highlighting the need for economic incentives or drivers. As many good examples were found, most are still on a quite small scale, driven by start-ups or projects getting external funding. For this study, only examples that are a main part of a company's business model were included.

The most important step remains in the prevention of CDW. Measures to keep buildings from being demolished, for example by renovating and refurbishing, produces less waste. When demolishing a building, mapping of the materials and reusable materials is key in preventing waste. Then the building can be dismantled, and reusable and recyclable materials sorted out on site. For new buildings, design for disassembly and adaptability should be a prerequisite, as well as building passports that keep track on what materials are used in the buildings. This will help prevent waste and promote reuse and recycling in the long run.

Appendix 1. Lists of CDW treatment facilities

Below are listed some of the main facilities for recycling of CDW in the Nordic countries. The lists have been compiled by looking into environmental permits and contacting authorities and sector experts, and listing the biggest facilities found, that handles CDW. The lists are not complete but give a picture of what kind of techniques are used in the different Nordic countries.

Denmark

Owner	Location	C&D waste treatment capacity [t/a]	Facility description
C&D waste recycling plants			
RGS Nordic	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Marius Pedersen	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Norrecco	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Gypsum waste recycling plants			
Saint Gobain / Gyproc Danmark	4400 Kalundborg	n/a	Plasterboard production, which utilises waste gypsum in the production.
Knauf A/S	9500 Hobro	n/a	Plasterboard production, which utilises waste gypsum in the production.
Wood waste recycling plants			
Kronospan	8550 Ryomgård	380.000 t/a (wood waste max. Received amount annually)	Chipboard production from various raw materials, including wood waste.
Glass waste recycling plants			
Reiling Glasrecycling Danmark ApS	4700 Næstved	n/a	Sorting and crushing of glass waste from various raw materials (including glass waste from construction).
Ardagh Glass Holmegaard A/S	4684 Holmegaard	n/a	Glass packaging production from various raw materials (including glass waste from construction).
Isover	Vamdrup	n/a	Glass recycling into glass insulation wool

Plastic waste recycling plants (only sorting and shredding)			
WUPPI (by Marius Pedersen)	Multiple	n/a	Hard PVC plastic waste is sorted, pressed into bales, and exported for pre-treatment and granulation.
ReSource	6705 Esbjerg	160 000 t/a (planned max. received plastic waste amount)	Waste plastic recycling facility that separates unsorted plastic waste (including plastic waste from construction) into mono fractions suitable mechanical and chemical recycling *(planned commissioning end 2023)*
Metal waste recycling plants (only sorting and shredding)			
Stena Recycling	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
HJHansen Recycling	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
Marius Pedersen	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)

Finland

The study strived to list the major facilities in the field of recycling and reuse in Finland. As a method, publicly available environmental permits were studied, and sector experts contacted. The list is not complete but gives nevertheless a picture of typical treatment facilities available. Many sorting actors and facilities for sorting, crushing and storing CDW are left out the list, and reuse facilities excluded due to lack of information.

Owner	Location	C&D waste treatment capacity [t/a]	Facility description
Mixed C&D waste recycling plants			
Syklo	Oulu	50 000	Mechanical separation facility for C&D and other mixed waste treatment. Technologies includes magnetic and non-magnetic metal separation, sieving, ballistic separation, optical and NIR plastic separation.
Remeo	Vantaa	120 000	Pre-treatment of mixed C&D waste with material handling machine (wood waste and metal initial separation). The residual material is treated with separation lines. Separation lines includes sieving, crushing, hand separation and robotic separation of different waste fractions. Facility has also additional 60 000t/a capacity to treat energy waste fractions from commerce and industrial sectors.
L&T	Kerava	190 000	Pre-treatment (separation of large objects) with machinery before feeding to separation line. Separation includes crushing, sieving, material separation (metals, wood, mineral, and REF production) and baling of separated materials if needed.
Kuusakoski	Lahti	250 000	Mixed C&D waste is pre-treated/separated with machine (wood, minerals, combustible fraction, metals). After that residual material is fed to the separation line, including crushing, magnetic separation, sieving, air separation, floating separation (water immersion), hand separation and vortex metal separation.
Tehokierto	Hämeenlinna	55 000	Mixed C&D waste is pre-treated with machine before feeding to separation line. In separation line wood, metal, mineral and energy fraction for REF production are separated from the stream. Unit operations include crushing, sieving, magnetic separation and air separation.
Revisol	Nokia	30 000	Mixed C&D waste is pre-treated/separated with machine before feeding to separation line. Separation line includes sieving and magnetic separation. Different separated waste fractions can be crushed afterwards.

Gypsum waste recycling plants			
Saint Gobain Finland Oy/Gyproc	Kirkkonummi	around 15000 t/a gypsum waste is received annually	Plasterboard production, which utilises waste gypsum in the production.
Knauf	Kankaanpää	n/a	Plasterboard production, which utilises waste gypsum in the production.
Wood waste recycling plants			
GRK	Utajärvi	20000 t/a (wood waste max. Received amount annually)	Biochar production from various raw materials, including wood waste. Facility should start production in 2023
Glass waste recycling plants			
Uusioaines	Forssa	45000t (sheet glass max. Received amount annually)	Foam glass production from various raw materials (including glass waste from construction)
Plastic waste (from C&D) recycling plants			
Lassila & Tikanoja (Muoviportti)	Merikarvia	20000t (max annually received plastic waste amount)	Waste plastic recycling facility, mainly plastic waste from packaging industry. Recycling of dirty plastic waste from construction is also planned (investment?), but the current status is not clear.
Keskinen recycling	Kuortane	n/a	Mechanical recycling and pelletising of construction plastics such as plastic pipes, containers, foils etc. Recycled plastic grades are as follows: PP, LDPE, LLDPE and HDPE.
Metal recycling plants			
Ovako	Imatra	n/a	Steel production with electric fusion furnace, utilises recycled steel
Boliden	Harjavalta	n/a	Copper works, utilises recycled copper
Outokumpu	Tornio	160 000 t/a (capacity to crush waste steel)	Stainless steel production with electric-arc furnace, utilises recycled steel
SSAB	Raahe	around 500 000t recycled steel	Blast furnace, utilises recycled steel
Kuusakoski	Heinola	250000t/a (capacity of crushing facility)	Copper and aluminium recycling/separation facility.

Iceland

Owner	Location	C&D waste treatment capacity [t/a]	Facility description
C&D waste recycling plants			
Sorpa ehf.[145]	Multiple	n/a	Pre-treatment, sorting, mechanical processing (e.g., shredding, and crushing), intermediate storage, landfill and other recycling or disposal of C&D waste.
Efnismiðlun Sorpu[146]	221 Hafnarfjörður, 110 Reykjavík	n/a	A market for used construction materials and other products that can be used for construction and artistic creation. The market offers materials such as timber, timber parts, doors, windows, interiors, slabs, tiles, logs, sinks, flooring to name a few.
Wood waste recycling plants			
Fura[147]	221 Hafnafjörður	5 000	Production of wooden chips from untreated wood waste which is sold as an underlay for livestock.
Plastic waste recycling plants (only sorting and pressing)			
Sorpa	Multiple	n/a	Waste plastic recycling facility that separates unsorted plastic waste (including plastic waste from constructions and Styrofoam (EPS)). The plastic is pressed and shipped to Sweden to further recycling or energy production.
Metal waste recycling plants (only sorting and shredding)			
Hringrás ehf	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction). The material is prepared and shipped abroad for material recycling.
Fura[148]	Hafnafjörður	n/a	Sorting of metal waste (including metal waste from construction). The material is prepared and shipped abroad to Europe for material recycling.

145. Sorpa. https://www.sorpa.is/
146. Efnismiðlun Sorpu. https://www.sorpa.is/um-sorpu/starfsstodvar/efnismilun-goa-hirisins/
147. Fura – Furuflís. https://fura.is/furuflis
148. Fura – Endurnýting. https://fura.is/umhverfisvernd

Norway

The study strived to list the major facilities in the field of recycling and reuse in Norway. As a method, publicly available environmental permits were studied. The list is not complete but gives nevertheless a picture of typical treatment facilities available.

Owner	Location	C&D waste treatment capacity [t/a]	Facility description
C&D waste recycling plants			
Norsk Gjenvinning AS	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Franzefoss AS	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Ragn Sells AS	Multiple	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
Gypsum/plaster waste recycling plants			
Ragns Sells AS and Saint-Gobain Byggevarer AS	Gipsgjenvinning AS, 1630 Gamle Fredrikstad	n/a	Facility for reception and handling of plaster Board/gypsum waste. Plasterboard production, which utilises waste plaster/gypsum in the production.
Norsk Gjenvinning AS and New West Gypsum recycling	New West Gipsgjenvinning AS, Holmestrand	40.000 tons/year (dimensioned)	Facility for Facility for reception and handling of plaster Board/gypsum waste. Delivers recycled gypsum (powder) to plasterboard production from Norgips (Knauf) and Gyproc (Saint-Gobain), which utilises waste gypsum in the production. New West Gypsum recycling is also located in Canada, UK, France, Belgium and Germany.
Wood waste recycling plants			
Omtre AS	3515 Hønefoss	n/a	Reception of wood, sorts and reuse of wood to new use in buildings.
Forestia AS	Våler	100.000 tons/year (dimensioned)	Sorting, handling and treatment of wood waste for use in production of wood fiber plates.
Retura IR	Skogn	25.000 tons/year (dimensioned)	Sorting, handling and treatment of wood waste for use in production of chipboards

Glass waste recycling plants			
Norsk Gjenvinning	Multiple sites for reception, sorting and crushing in Fredrikstad	1 000 000 PCB-windows since 2002	Sorting and crushing of glass waste from insulting glass with or without PCB. The glass waste that is free of PCB is transported to factory in Fredrikstad and is used in production of new insulation of glass wool from Glava. PCB is transported to Europa for safe destruction by combustion.
Plastic waste recycling plants (only sorting and shredding)			
Ragn Sells	Multiple	n/a	Plastic waste is sorted out, pressed into bales, and exported for recycling. Mainly plastic packaging.
Norsk Gjenvinning AS	Multiple	n/a	Plastic waste is sorted out, pressed into bales, and exported for recycling. Mainly plastic packaging.
Franzefoss	Multiple	n/a	Plastic waste is sorted out, pressed into bales, and exported for recycling. Mainly plastic packaging.
Stena Recycling	Multiple	n/a	Plastic waste is sorted out, pressed into bales, and exported for recycling. Mainly plastic packaging.
Metal waste recycling plants			
Norsk Hydro ASA	Multiple in Norway and worldwide	n/a	Melting aluminium to use in new production
Celsa Nordic	Mo I Rana	800 000 tons/year	Recycling of sorted metal waste to new products
Ragn Sells	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
Norsk Gjenvinning AS	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
Franzefoss	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
Stena Recycling	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)
Metallco AS	Multiple	n/a	Sorting and shredding of metal waste (including metal waste from construction)

Waste incineration plants			
Hafslund Oslo Celsio	Oslo, Haraldrud	>100 000 t/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
Hafslund Oslo Celsio	Oslo, Klemetsrud	>100 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
Forus Energigjenvinning	Stavanger	>100 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
BIR Ressurs AS	Bergen	220 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
Statkraft Varme AS	Trondheim, Heimdal	>100 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
Returkraft AS	Kristiansand	>100 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.
Tafjord kraftvarme	Ålesund	>100 000 tons/year	Incineration of waste for production of energy (heating), waste is mainly domestic waste but also some amounts of construction and demolition waste.

Sweden

The study strived to list the major facilities in the field of recycling and reuse in Sweden. As a method, the national organisation for the recycling sector Återvinningsindustrierna was contacted. Also, the County Administrative Boards (Länsstyrelsen) were contacted, and environmental permits studied. Companies and experts were also contacted. It proved to be a difficult method, and the list is not a complete list of all facilities. Reuse facilities are not generally listed, but some actors were mentioned in the research by contact persons.

Owner	Location	C&D waste treatment capacity [t/a]	Facility description
Gypsum waste recycling plants			
Gyro Gips-återvinning	Bålsta, Asarum	50 000[1]	Mechanical sorting, processing, and mixing with raw materials into new products
PR Slamsugning	Falköping	50 000	Receives and treats plasterboard waste by recycling the gypsum for use in the gypsum board industry and as a sulfur supplement in agriculture
Wood waste recycling plants			
Octowood AB	Bräcke	60 000	The permit covers the treatment, storage, and incineration of forestry waste, waste from wood processing and the manufacture of boards and furniture, waste from wood protection treatment, and construction and demolition waste, including wood containing hazardous substances such as creosote.
Glass waste recycling plants			
Svensk Glas-återvinning AB	Hammar	280 000	Glass recycling facility, sorted, crushed and recycled. Disposal to landfill of recycling rejects.
Planglas Recycling i Sverige AB	Östansjö	25 000	Recycling of flat glass
Scandinavian Glass Recycling	Kristianstad	1000	Recycling facility, where flat glass is roughly sorted, crushed, and then sent to ISOVER, which uses the material in the production of glass wool.
Swede Glass United	Otterbäcken	10 000	collects all the qualities of flat glass; laminated and tempered glass from vehicles and building structures; mirror glass; colored flat glass (green, smoked, bronze, pink, blue) and reinforced glass

Plastic waste (from C&D) recycling plant			
Stena Nordic Recycling Center	Halmstad	n/a	Recycling, collection, and sorting of transparent LDPE plastic waste. Industry waste is sorted manually before being granulated, washed, dried, melt-filtered, and pelletized.
Novoplast	Örebro län	n/a	At two facilities in Örebro County, soft LDPE materials such as sacks, bags and wooden sacks are recycled. The fraction undergoes mechanical recycling with shredders, dry washing, extrusion and pelleting
Van Werven	Borås	na	Recycles hard plastic packaging, including buckets, cans and barrels
Tarkett	Ronneby	n/a	Teared homogeneous plastic floors and installation spillage from plastic floor and wall is granulated, washed, and used as raw material in new floors.
Remondis	Staffanstorp och Röstånga		Washing, crushing, melting and granulation of different plastic waste streams.
Metal recycling plants			
Stena Aluminum	Älmhult	90 000	They manufacture secondary aluminium from aluminium scrap and are alone in the Nordics in supplying liquid aluminium
*Mineral CDW waste recycling**			
Swerock	Multiple locations.	n/a	Crushing, mechanical sorting of mineral waste
NLF Nora-Lindefrakt AB	Lindesberg	10 000	Excavation site, with permission to mechanically sort and recycle mineral CDW waste max. 10 000 tonnes annually
Sibelco Nordic AB	Lindesberg	10 000	Excavation site, with permission to mechanically sort and recycle mineral CDW waste max. 10 000 tonnes annually
ABT Bolagen	Stockholm, multiple locations		Receiving, crushing of mineral CDW and delivering as backfilling material
EW group	Multiple locations		Receiving, crushing of mineral CDW and delivering to recycling or backfilling material. Separation of rebars for recycling.
Hummeltorp	Multiple locations		Receiving, crushing of mineral CDW and delivering to recycling or backfilling material

Brukspecialisten	Multiple locations		Recycling and reusing bricks
Paroc	Multiple locations		Recycling mineral wool
Skanska	Multiple locations		Recycling asphalt
*Reuse facilities***			
Malmö Återbyggdepå	Malmö		Receiving and selling used or surplus construction material
Dala Återbyggdepå	Borlänge		Receiving and selling used or surplus construction material
Brattöns Återbruk	Göteborg		Receiving and selling used or surplus construction material
*Mixed C&D waste recycling plants**			
Ragn-Sells	Multiple locations.	n/a	Facilities for sorting, separating, shredding, and crushing C&D and other waste
PreZero	Multiple locations, incl. Örebro	95 000 (Örebro)	Pre-treatment, sorting, mechanical processing (e.g shredding, and crushing), intermediate storage, landfill and other recycling or disposal of C&D waste.
Wiklunds/Eds Återvinning	Upplands-Väsby	110 000	Pre-treatment, sorting, mechanical processing (e.g shredding, and crushing), intermediate storage, landfill and other recycling or disposal of C&D waste.
Stena Nordic Recycling Center	Halmstad	350 000t metal	Non-ferrous metal processing, Shredder light fraction (SLF), first treatment of electronic products, circular electronics, recycling of precious metals and plastic recycling

*There are several actors mechanically sorting, crushing and storing CDW. The actions are usually combined with other services.
**There are several actors with reuse services and marketplaces for reused building products are on the rise. The treatment facilities are usually small and not listed in e.g., permit databases.

About this publication

Reuse, recycling and recovery of construction and demolition waste in the Nordic countries

Katarina Svedmyr, project lead
Andrea Weckman, assistant project lead
Tuomas Suikkanen
Jóhanna Wium Pálmarsdóttir
Brita Grønhaug
Jacob Damsgaard
Mathilda Lund
Anna Karin Jönbrink, project supervisor

A steering group with representantives from the Nordic countries has assisted with proof reading and quality control of this report.

TemaNord 2023:544

ISBN 978-92-893-7765-2 (PDF)
ISBN 978-92-893-7766-9 (ONLINE)
http://dx.doi.org/10.6027/temanord2023-544

Cover photo: Elvir K/Unsplash
Published: 12/1/2024

Disclaimer

This publication was funded by the Nordic Council of Ministers. However, the content does not necessarily reflect the Nordic Council of Ministers' views, opinions, attitudes or recommendations.

Rights and permissions

Nordic Council of Ministers/Publication Unit
Ved Stranden 18
DK-1061 Copenhagen
Denmark
pub@norden.org

Nordic co-operation

Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and the Faroe Islands, Greenland and Åland.

Nordic co-operation has firm traditions in politics, economics and culture and plays an important role in European and international forums. The Nordic community strives for a strong Nordic Region in a strong Europe.

Nordic co-operation promotes regional interests and values in a global world. The values shared by the Nordic countries help make the region one of the most innovative and competitive in the world.

The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

Read more Nordic publications on www.norden.org/publications