WPT1 SYSTEM DEVELOPMENT

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State of The Art Report

Digital products, services and tools supporting the recovery of building materials sourced from deconstruction operations

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CONTENTS

1. SUMMARY

This report consists in a review of digital products, services and tools already available in the market or in development that support the recovery of building materials sourced from deconstruction operations. Every product, service or tool is briefly explained with the help of information such as used technologies, explanation on how the products can help the recovery of reclaimed product, etc.

This review does not pretend to be exhaustive, but hopes to give an overview of what new digital technologies can bring to the world of repair, reclaim, reuse and recycle.

2. INTRODUCTION

This report is part of the Activity 1 of the Workpackage 1 of the project *DigitalDeConstruction* or *Advanced Digital Solutions Supporting Reuse and High-Quality Recycling of Building Materials*. DigitalDeConstruction aims to develop an innovative digital decision support system, integrating various digital tools (3D scanning, Building Information Modelling, a digital materials & buildings database, blockchain technology) that helps to define the most sustainable and economical deconstruction and reuse strategy for buildings.

WP.T1 contributes to the 1st sub-objective: to develop the DDC system through integrating various digital tools. Activity 1 consist in the development of the concepts of the systems and technical specifications of system components.

This report consists in a review of digital products, services and tools already available in the market or in development that support the recovery of building materials sourced from deconstruction or renovation operations. Every product, service or tool is briefly explained with the help of information such as used technologies or explanation on how the products can help the recovery of reclaimed product.

The tools are categorized by technology or digital concept. Where a tool uses more than one technology, it was placed in the category that seemed most appropriate.

This review does not pretend to be exhaustive, nor does it aim to speculate on possible future developments. It hopes to give an overview of what new digital technologies can bring to the world of repair, reclaim, reuse and recycle[1]. The tools and services were not validated or tested within the scope of the DDC-project. The review is mainly based on publicly available information.

In addition to the tools & instruments, some studies and general or specific publications covering the subject are listed in the bibliography at the end of this review.

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[1] Of course, a lot more digital tools exist and can help building professionals in their work but if their link with the circular economy and the recovery of materials was not strong enough, they were not covered in this review as it is not its purpose.

3. PRODUCTS, SERVICES OR TOOLS

The development of digital tools can facilitate the *acquisition, storage and transmission of data* concerning buildings, products and materials. It can also allow to work with the data (calculation, simulation, etc.). Therefore, these tools make it possible to have information on old building & reclaimed products that are often lacking them. Through a better knowledge management, analysis and automation, these tools thus facilitate the effective recovery of products that can, afterward, be reused or undergo high-quality recycling.

Scanners and cameras

" A 3-D scanner is an imaging device that collects distance point measurements from a real-world object and translates them into a virtual 3-D object."[2]

There are different type of scanners, including Terrestrial Laser Scanner, Depth Cameras, SLAM (handheld) or SLAM (on a drone, a vehicle).

Nowadays, most of existing buildings have little or no information in a digital format. A first step is to inventory and store them. Scanners make possible to (semi-)automatically capture a building in 3 dimensions both from indoor and outdoor. Point clouds generated by **laser scanners** or **photogrammetry** constitute raw as-built data.

3D scanners can help to gather information about the nature of elements, their condition, quantity, volume, surface area or dimensions. 3D scanning systems are also beginning to be complemented by advanced **algorithms** to make it easier to automatically identify building components, materials or even pathologies or presence of hazardous substances.

Tools and services

Different laser scanner models (suitable for building scans) with similar characteristics are proposed on the market by brand such as Leica, Faro or Trimble. These companies also provide their own software to help the managements of data.

Leica
This company propose different type of **scanners** from small handheld ones to bigger long range 3D scanners. This tools can also be combined with several **software's**

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[2] Citation from: https://whatis.techtarget.com/definition/3-D-scanner

facilitating the management of information collected. These can help to process, model and manage 3D point clouds or integrating point cloud into CAD.

Link : https://leica-geosystems.com/products/laser-scanners

Faro

Faro is specialized in 3D measurement and imaging technology. It provides **hardware** and **software** to achieve the digital representation of real objects. As Leica, the company propose different types and size of **scanners** which can be used for indoor and outdoor measurements.

Several softwares are proposed including a registration software that contains tools allowing users to process scan data, navigate through project, visualize data in detail and take the first measurement. This allows to calculate volume and site quantities, analyse the surface or map the damages of the materials and evaluate the state of some products (for example by analysing the deformation of steel structures) which will influence their possible recovery.

Solutions are also proposed to generate 2D and 3D deliverables such as plans, elevation or 3D models from point clouds (**scan-to-CAD** and **scan-to-BIM** solutions).

A **cloud-based platform** (Faro Scene WebShare Cloud) provides real-time access to **Digital Twins**. This platform can help, among other things to take measurements and to organize data using categories and tags, export 3D point clouds using common industry standard formats for **scan-to-BIM** workflows.

Link : https://www.faro.com/

Trimble

Trimble offer a large range of portable 3D **scanners** which can help to capture data quickly. As the two others, it can help to analyse the state and geometry of existing buildings. The company also provide a point cloud processing and analysis **software**.

Link : https://www.trimble.com/3d-laser-scanning/3d-scanners.aspx

Matterport

Matterport is a company that focuses on digitizing the build world. It provides a few service by working with a wide range of 3D and 360° **cameras** and providing an **3D data platform** that allow to visualize and document buildings by adding tags or taking measures directing in the 3D models.

By subscribing to one of the offer, the user can have access to the platform. After having used one of the cameras on site, the 3D model is automatically built and accessible on the online platform. The platform also allows to share information with partners and

possibly show existing recoverable elements in the building. This can also permit avoiding new visits and loss of time.

Link: https://www.matterport.com/fr

AR2BUILD

AR2BUILD is an **app** that link 3D **scans** with **BIM** model (in IFC format). This app works on smartphones. With the help of the app, the 3D scan is directly done with the camera of the phone itself. Once the scan is done, AR2BUILD offers the possibility to directly annotate the different scanned rooms in a BCF format. The app generates automatically an IFC model. It can also help to take automatic measurements and recognize surfaces and some objects.
Digital models can be found on BIMEO, a collaborative **platform**.

If this tool is more limited and less precise than a laser scanner, it can nonetheless be useful and more user-friendly than to have recourse to a point cloud.

The app is developed by BIMEO.

Link: https://blog.bimeo.fr/ar2build-application-scan-3d-et-maquette-ifc-bimeo/

"XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of material composition."[3]

Manual XRF Scanner for Analysing Materials

An **XRF** (X-ray fluorescence) **scanner** is an elemental analysis tool that allows the user to determine the elemental composition of virtually any solid sample. This portable tool can thus help to identify materials.

This tool was developed by Bruker.

Link: https://www.bruker.com/

XRF lead testing guns

This **XRF scanner** can analyse the presence of lead in materials or used as coating. This tool is non-destructive and portable which allows to use it directly on site.

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[3] Citation from: https://www.thermofisher.com/be/en/home/industrial/spectroscopy-elemental-isotope-analysis/spectroscopy-elemental-isotope-analysis-learning-center/elemental-analysis-information/xrf-technology.html

The tool was developed by Bruker.

Link: https://www.bruker.com/

Digital twins

«Digital Twin: A digital representation of a physical asset. When supported by IoT and AI, a digital twin can automatically update according to adjustments made in the real world. Digital twins are up-to-date copies of physical objects that deliver information on the object's properties and states. Information can include physical orientation such as shape, position, gesture, or motion, as well as insight into other statuses, interactions, and updates.

Digital twins align the real world with the virtual world and help illuminate the impact the environment has on a given physical asset. When the above technologies culminate, a digital twin is able to learn from multiple sources and automatically adjust to accurately represent the status, condition, and position of its real-world counterpart. »[4]

If digital twins are more often used during the construction and in use phase as these can allow construction simulations and an easier monitoring and maintenance, these can also be useful for the inventory and deconstruction phases. Indeed, these can give direct access to data gathered through the lifecycle of the building (technical data, information on the maintenance, warranties, location of materials, etc.).

Tools and services

BIM Y

The start-up offers to implement their solution of **digital twin** and **data management** in buildings and other infrastructure.

BIM-Y comes into the shape of a **web platform** that notably allows managing documentation during demolition phase. The use of a digital twin allows to have updated information (measurements and technical data) about materials and product to be dismantled. This particular digital twin doesn't necessarily rely on BIM. It is developed after scanning the building with a portable **scanner laser**.

Link : https://www.bim-y.com/

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[4] Citation from : https://constructible.trimble.com/construction-industry/what-are-digital-twins

Digitalcloning.io

This company propose different services such as creating interactive 3D models in **BIM** format or by **photogrammetry** and **3D scanning** that can be further processed in specialized software.

Link : https://digitalcloning.io/

Other start-ups and consultancy firms also offer **digital twin** related service, mainly to manage buildings and their performance during their in-use phase, these include:

- Incivara: https://invicara.com/solutions/digital-twin/
- Srinsoft: https://www.srinsofttech.com/digital-twin-services-and-solutions.html
- Iesve: https://www.iesve.com/digital-twins

BIM

"The term BIM can mean "Building Information Model", "Building Information Modelling" or "Building Information Management". These three designations actually represent three realities that should ideally coexist when talking about BIM. The first is the development of an advanced 3D digital model, where metadata is added to the geometric information consisting of parametric objects. The various objects that make up the building can thus be assigned parameters relating to their composition, performance, cost, etc., which can be used as a basis for the design of the building or its durability. It is also possible to encode relationships between objects or between data, with a potential chain effect of each modification."[5]

BIM related tools can help materials recovery by different means : documentation of materials (they keep their identity and therefore their value), automatic identification of reusable elements, quantities, dimensions, etc., help to generate pre-demolition audit, digitalization of elements that allows to store and analyse information, management of information to plan and organize selective deconstruction, identification and management of hazardous substances, calculation of environmental impact (LCA, LCC, carbon impact), analysis and simulation of end-of-life alternatives, assessment on material flows D and stocks in a spatial context, etc.

Tools and services

ValoBIM

Valobim is a **BIM** dedicated to sustainable development. From a model of an existing building, it is possible to identify, qualify and locate in a 3D environment the different equipment and materials. "We are developing the ValoBIM® method, which combines

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[5] Citation from: S. DUBOIS, M. DE BOUW, Y. VANHELLEMONT, *Le relevé géométrique à haute définition : la numérisation 3D à l'heure du BIM*, October 2018, p.41. Available online : https://www.cstc.be/homepage/download.cfm?lang=fr&dtype=publ&doc=Le_releve_3D_a_l_heure_du_BIM.pdf

modelling, databases, 4D planning and Mobile BIM (tablet) solutions to take into account the complete life cycle of structures and promote a new circular and solidarity-based economy by anticipating the obligation, by 2020, to recover 70% of construction site waste."[6]. This service can thus, help to take into account the LCA of the building that can lead to make informed choice concerning the conservation, recycle or reuse of certain part of a building.

This tool was developed by SXD for Engie.

Link: https://www.sxd-groupe.fr/nos-outils

WiseBIM, artificial intelligence for BIM

WiseBIM is a service that combines **artificial intelligence** and **BIM** for automatic modelling. The service can help the recovery of materials in the following ways : automatic extraction of surface, volume, quantities, quantification of waste, integration of diagnostic, inventory of existing parts for renovation and scenarisation for deconstruction.

This service is provided by the company of the same name.

Link: https://www.wisebim.fr/home/home.php

Batirim

This tool is based on **DRIM** or **RIM** : Deconstruction & Recovery Information Modelling. Based on the construction plans, the app allow listing in an inventory the materials present in the building. It quantifies, qualifies and maps the flows of products and materials from buildings being renovated, constructed or deconstructed and assesses their potential for reuse and recycling.

The drawings of the buildings are integrated in a 2D or 3D digital interface and used on a touch-sensitive tablet.

The tool then stores the collected information on a **digital platform**: audited information is returned and securely stored in an interactive **database** that can be shared with all the stakeholders of the project. This insures a traceability of information.

Batirim is developed by Suez.

Link: https://www.suez.com/en/news/press-releases/suez-launches-batirim-the-first-digital-solution-for-the-selective-deconstruction-of-buildings

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[6] Citation from: https://www.sxd-groupe.fr/nos-outils

Projects

Hiser project

This European project, developed a tool based on **BIM** to help the collection and management of information of materials that are going to be deconstructed. The software can be used in the pre-deconstruction stage to process more efficiently relevant data. Its interface was designed to be used on portable devices.

By providing a simple BIM model of the building, the editor can help to produce a pre-demolition inventory. The user can identify elements using a **database** that is linked to the tool. It provides information such as deconstruction processes, definition of materials, codes related to the European List of Waste or formulas to calculate the weight and volume of the identified elements which can help to complete the pre-demolition inventory.

The expected benefits of this tool include easier documentation of materials, improved reliability of calculation, easier traceability of materials and quicker evaluation of alternative demolition/recovery options.

Information on the project :

- *Partners of the project : Tecnalia Research & Innovation, ACCIONA Construcción S.A., Groupe Archimen, ASM - Market Research and Analysis Centre Ltd., Bureau de Recherches Géologiques et Minieres , Conenor Oy, RINA Consulting S.p.A., Dumoulin Bricks, Fundacion Gaiker, ADR Technology , Knauf GmbH Sucursal en Espana ,KS Laatuenergia Oy, Lafarge Centre De Recherche Sas , Leiden University, Institute of Environmental Sciences , Mebin B.V. , Rina Services Spa ,RTT Steinert GmbH ,Selfrag AG, Strukton Civiel B.V., Tiihonen Ismo Olavi, Confederatie Bouw vzw – Vlaamse Confederatie Bouw, Sociedad Publica Gestion Ambiental Ihobe S.A. , Technische Universiteit Delft , Vlaamse Instelling voor Technologisch Onderzoek , Teknologian tutkimuskeskus VTT*
- *Timing of the project : 2015-2018*
- *Website:* http://www.hiserproject.eu/

BIM4EEB, BIM based fast toolkit for Efficient rEnovation in Building

The aim of this European project is to develop a powerful **BIM-based toolkit**. The management system will be integrated with different tools including for fast mapping buildings and to track renovation operation. If the tools will mainly be useful for the design and construction phases, they can also support the planning and management of deconstruction (of certain parts), to ensure more efficiently the flow of information, and to perform assessment of options for renovations.

Information on the project :

- *Partners of the project : Politecnico di Milano, VTT, Solintel M&P, University college Cork, Rise research institutes of Sweden, Suites Data Intelligence Solution Limited, One Team, Technische Universitaet Dresden, Caverion Suomi Oy, Conseil des architetes d'europe,*

CGI Sverige, regione lombardia, prochem, Azienda Lombarda per l'edilizia residenziale di varese - como - monzabrianez - busto arsizio
- *Timing of the project : 2019-2022*
- *Website:* https://www.bim4eeb-project.eu/

Studies

A great number of papers and articles study the future functionalities that BIM could offer in the future if the related tools and algorithms are developed. Some of them are referenced in the bibliography below.

Material passports

« Material Passports provide the necessary information about materials, products and components for a circular use of building materials, products and components whilst supporting reversible design. »[7]

« In brief, material passport is a digital report containing circular economy relevant data that is entered into and then extracted from a centralized database in the form of reports customized to the needs of diverse users. »[8]

Material or building passports are not a new technology but these are useful digital tools that can be used to give identity to materials, products or even buildings. These new tools are still in development and, although a number of companies and projects have been working on the subject, a global consensus has not yet been reached on the format it should have and the information to be collected. Numerous guidelines and guides for best practice can be found in the literature. A part of the bibliography below is dedicated to them.

Material passports can have an added value in different phases of construction and deconstruction. Concerning the deconstruction and recovery, these can allow elements to keep their identity and therefore their value. Product reusers can have updated information about reuse potential and value recovery possibilities. Pre-demolition or reclamation audit can be done more quickly. It can also assure a safe and appropriate deconstruction and reuse of recycle by providing relevant information.

BIM models can be combined with material passports. This alliance can help to conduct more efficiently pre-demolition inventories because the building's composition and relevant information on deconstruction and reuse options are already known[9].

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[7] Citation from : https://www.bamb2020.eu/topics/materials-passports/
[8] Citation from : L. LUSCUERE, D. MULHALL, *Circularity Information Management for Buildings. The Examples of Materials Passports*, 2017
[9] In this case, the first step is still to develop a BIM model.

Information included in material passport can be technical information, labels, composition (rate of recycled material for example), loss rate to foresee, but also the way in which the material is fixed or instruction for disassembling, maintenance or how to reuse it.

Tools and platforms

Different **online platforms** propose to develop material passports but as they also offer other services, it was decided to list them in the section : *Digital platforms*.

Projects

BAMB, Building As Material Banks

BAMB is an EU funded project that aimed to create circular solution for the building sector to increase the value of building materials. One of the focusses was on **materials passports** involving characteristics related to the circular economy. The Materials Passports developed in BAMB consist in a set of data describing defined characteristics of products which give them value for recovery and reuse.

The project published as "Best Practices" document to help stakeholders to exchange more standardised information. It also developed a Materials Passports **Platform** Prototype which host some material passport of various buildings.

Information on the project :

- *Partners of the project : Brussels Environment, Bam, Bre, EPEA Part of Drees & Sommer, Drees & Sommer, IBM, Ronneby Kommun, Sarajevo green Design Foundation, SundaHus, Technishe Universität München, University Twente, University of Minho, Vito, Vrij Universiteit Brussel, Zuyd Hogeschool*
- *Timing of the project : 2015 -2019*
- *Website:* http://www.bamb2020.eu/

Platform CB'23

Platform CB'23 has the ambition of connecting various construction stakeholders with circular ambitions. Its aim is to establish national agreement and harmonizes framework concerning circular construction at the level of the construction sector in the Netherlands. In order to achieve this goal, different working groups have been created. One of them is dedicated to **material passport**, another to the **measuring of circularity**.

A first report cites examples of material passport :

- Antea: tooling and methodology to provide insight into a project's consumption of raw material
- Building Material Scout: tool to retrieve product information from suppliers, generate passports and evaluate circular potential
- Circular Cloud: BIM-driven materials passport
- EPEA: materials passport from product to building level

- Excess Material Exchange: platform for the exchange of materials. A material passport is part of this, in order to be able to determine the flows that are released
- Inside: materials platform for interiors
- NLGreen Label: passport to make the integral sustainability of products, plants and areas measurable and improvable
- ReNtry : to generate passports at different scale levels
- SGS search: building passport in which the data of a building is collected
- Drawplus: BIM-based solution for digitizing real estate

Information on the project :

- Stakeholders participating in the working group concerning material passport : *ABT, AM, Arcadis,BAM Infra, Betonhuis, BMBC, Boskalis, Bouwen met Staal, Buro Boot, Copper 8, Data & Consultancy Buro Re Use Materials bv, De Architekten Cie. B.V., Draaijer + partners, EPEA, Excess Materials Exchange, FAKRO Nederland, Gemeente Amsterdam, Heijmans, Houtwerf BV, Hunter Douglas Europe BV, Inbo, Ingenieursbureau Gemeente Amsterdam, KWS Infra, Lievense, Madaster Services BV, Mandel Circular Buildings, Miscancell, Olaf Blaauw Consultancy, Provincie Noord-Holland, Provincie Overijssel, Provincie Zuid-Holland, Reinbouw BV, Rijksvastgoedbedrijf, Rijkswaterstaat, Sant Verde BV, STABU, Techniek Nederland, Universiteit Utrecht, VELUX Nederland B.V., VMRG, WAM&VanDuren, Woningstichting Eigen Haard/Kerngroep, AEDES-UVIP ILS BIm in beheer, Xella Nederland BV*
- Timing of the project : 2019 -2023
- *Website:* https://platformcb23.nl/

Digital platforms

Digital platforms fostering materials and products recovery can be of different types: they can provide *services* or give access to tools (such as material passport), they can help to manage or to gather information, they can give visibility to reclaimed products through a digital *marketplace* or even inform users through a *database* to allow them to make considerate choices or to contact the right stakeholders.

« Services » platform

Madaster

Madaster is a public **platform** designed as an online library of materials from the building environment. The platform helps to organize, store and exchange data. By subscribing to the platform, the user (depending on its private or public status and its function) can have access to different tools and services including: generation of **material passports** (from a BIM model) describing materials in each layer of the building and how easy it is to retrieve it, estimation of how much they will be worth, access to a library of building-specific information on materials, components and products.

The platform also propose a **Circularity Indicator**, based on the Ellen MacArthur Foundation Material Circularity Indicator, which scores a building between 0 to 100%.

Besides an overall indication on building level, Madaster also indicate the level of circularity for each layer or each phase of the building: construction, use and end of life.

Link: https://www.madaster.com/en

Excess Material Exchange (EME)

The **digital platform** of EME gather different services: a digital matching platform that helps to find new high-value recycle and reuse options for materials or (waste) products and to link compagnies between them; Resources Passports, **material passports** that include information on composition, origin, toxicity and constructability and that allow the products to keep their identity; assessments of the financial, environmental and social impact for different possible solution for a product or waste stream, an internal **marketplace** for companies which want to manage their own resources.

Link: https://excessmaterialsexchange.com/#home

Greenstock

GreenStock's **digital platform** enables users to save materials, manage transport and storage, and gather documentation about the materials. An **internal marketplace** is proposed to organizations to manage their own stock between their construction, renovation and demolition projects. A **reporting tool** enables organizations to get an overview of the economy, carbon emissions saved as well as building waste saved. All materials are linked to their own **material passport**.

The company also provides other personalized services to help the logistical or planning aspect of deconstruction, reuse and recycling.

A public **marketplace** will be integrated to the platform.

This Finnish platform is still on development. A fully developed solution will be available by the end of 2020.

Link: https://www.greenstock.no/web/

BIMEO

BIMEO is a digital platform that allow users to visualize **BIM**, share information and extract reports and data which can help to identify retrievable products, to quickly gather information about them and to create pre-demolition audit.

Link: https://www.bimeo.fr

This **digital platform** is for organizing and centralizing all the information of a construction (or demolition) project, sharing information with all partners, generating automatic reports and sending them to selected contacts. The user can access 2D or 3D drawings and tag points directly with pictures and description. Reports or lists of information are then accessible in function of the criteria. An **app** was developed and can be use on mobile phone or tablet, on- or off-line.

Link : https://www.finalcad.com/

Digital marketplace

Numerous online platforms dedicated to the sale, donation or exchange of reusable or surplus materials are available online. They help to give visibility to these materials or to buildings planned to be demolished. Some of them also include other services and tools such as templates to describe the elements or a map that allows interested parties to locate materials (soon) available nearby. The information they provide about the materials and products for sale varies according to the type of platform (different audience) and the elements on it. Nevertheless, photos and information such as quantity, dimensions, condition and location are almost always available as they are a minimum requirement.

Cycle up

Cycle up is a French **marketplace** that allow to sell and find reclaimed elements. It provides environmental impact analysis and economical follow up of operations. It generates contracts to sell and buy elements and also proposes templates for the description of products. The platform is open to professional or private individuals. Information provided on materials are : location, quantity, price, state, technical info and pictures.

Link: https://www.cycle-up.fr/

Backacia

Backacia is another French **marketplace** for reusable or surplus elements. It is open to professional and private individuals. Information on materials includes: location, quantity, price, state and pictures.

A mobile **app** is also available.

https://www.backacia.com/

Rotor DC

The Belgian organisation Rotor DC propose on their **selling platform** construction products or furniture that were dismantled or retrieved and conditioned by them. The team can also provide assistance to building owners, contractors and architects on reuse. Information of materials include: quantity, price, dimensions, pictures and eventual advices.

Link: https://rotordc.com/store/

Werlink

Werflink is a Belgian **platform** to allow companies active in the construction sector to share, sell and buy materials and equipments, mainly surplus materials, or equipment they temporally do not use.

Link: https://www.werflink.com/

Globechain

This **marketplace** is also dedicated to reusable products including construction related materials. All items are free for collection by charities, SMEs and individuals. By creating and account and participating in the chain, business can access the environmental, social and economic impact of the donation. Globechain is active in the UK, Africa, Ukraine and Libya.

Link: https://www.globechain.com/

Materialen Marktplaats

Materialen Marktplaats was developed by Re Use Materials to sell and buy second hand construction materials and furniture. These can be sorted by type or by project. Information on products includes: price, picture, description, quantity, location and when the products can be picked up.

Link: https://materialenmarktplaats.nl/

Genbyg.dk

Genbyg is a large Danish **marketplace**. Products are sorted by type but also by buildings which are accompanied by a description and their history. Complete information on materials are given including: price, quantity, dimensions, advices to retrieve the products, description, commentaries on the state or specificities of the lot (ex: origin of the product or diversity of length).

Link: https://genbyg.dk/

Resources asbl

The **website** of Resources asbl gives information on salvage dealers including their location in Belgium and the type of products they reclaim.

Link: https://www.res-sources.be/

Rs-source

This French **marketplace** allows to buy and sell reusable construction products and excess of materials. A lot of information is given about the products: brand, quantity, dimension, price, location, picture, state, constituents.

Link: https://www.rs-resource.fr/

Readymader

This French digital **marketplace** allow to buy and sell reusable construction products and excess of materials. It also provides a map indexing available items. Information on materials includes: type of materials, dimensions, picture, quantity, price, location.

Link: https://readymader.com/

Harvestmap/Ooskaartmarketplace for professional upcyclers

Harvestmap (Oogstkaart in Dutch) is an online **marketplace** for redundant and second hand materials (including construction ones) to be reused or recycled. Items range from small quantities to continuous flow of, for example, industrial leftovers.

Harvestmap allows companies or individuals to make an inventory of their supply of materials and components. The platform wish to put in relation a community to share materials but also tips&tricks.

The map allows to find available resources in the surroundings of a project. Information on materials includes location, quantity, price and picture.

Link: https://www.oogstkaart.nl/

R-place: réemployer, réutiliser, recycler

R-place offer a **platform** to sell and donate building materials and products between professionals. It does not only concern reusable material but also materials destined to be recycled. A map locating materials is also included on the website. Information on

items can include: category (second hand or surplus), location, accessibility, packaging, traceability document, brand, dimensions, quantity, picture, price.

Link: https://www.r-place.fr/home

Batiterre

Batiterre proposes another Belgian **marketplace** for reclaimed building products. Information about the products are: picture, price, dimension, quantity, state, origin (building). The company also provides support concerning deconstruction of materials.

Link: http://batiterre.be/boutique/

YouBric

YouBric is a Belgian **platform** that propose a digital **marketplace** for reusable products and surplus for professionals and individuals. It also provide a directory of specialized services and stores and some tutorial for non-professionals.

Link: http://beta.youbric.be/fr/

Salza

This Swiss **marketplace** is dedicated in first instance to building owners. They can document their building before its demolition. The platform allows architects and designers to find valuable elements that they can reuse. It put in contact building owners and the interested parties. In that way, they can find an agreement before dismantling the element. Products are organized by type or by building. Information on element includes: Location, date of dismantling, material, dimensions and quantity, description, condition for the dismantling.

Link: https://www.salza.ch/

SalvoWEB

SalvoWEB is a British organization that propose different service on its **platform** including a digital **marketplace** for architectural salvage and reclaimed building materials, a listing that allow to find reclamation yards and architectural salvage dealers and demolition alerts which permit to be aware, in advance of future demolition in order to organize a recovery of certain elements.

Link: https://www.salvoweb.com/

Digital database and knowledge platform

Some online platforms offer technical information, inspiring examples, guide to deconstruct or contact of reuse operators. Here is a sample of these platforms and what they can provide.

Opalis

This **platform** provide explanation on commonly reused products and materials and their characteristics, illustration of inspiring examples and list salvage dealers in North-West Europe (Belgium, France, The Nederlands, etc.). A map allow to locate these salvage professionals. They are also sorted by type of items sold by them.

Link: https://opalis.eu/fr

Mosard

Mosard has developed a belgian digital **platform** dedicated to connect certified partners within the construction chain. In the portal, the user can find and contact architects, contractor, manufacturers and suppliers. If the platform is now more focused on the construction process and adaptable buildings, it could be interesting to expand its concept to link deconstruction related partners.

Link : https://www.mosard.be/

Kroqi

The **platform** was set up by public authorities in the framework of the Digital Transition Plan in the Building Sector (PTNB, Plan Transition Numérique dans le Bâtiment) in France. KROQI is a public and free collaborative work platform intended for all construction professionals. This platform can be useful to spread knowledge about digital solution and to put actors in contact with each other.

Link: https://www.kroqi.fr/

Materiautheek

The purpose of this **website** is to facilitate the identification and reuse of construction elements within an existing building. Through the model of a "typical" Brussels, the user can visually identify elements that can be easily reused, whether for personal reuse or for external purposes: donation or resale of this element. The platform informs on how to check if the item can be reused (general check-up), deconstruction methods (detailed explanations), example of possible reuse.

Link: http://materiauteek.brussels/

Bazed project

The **platform** aims to share knowledge about circular construction: products, reversible ways to build/deconstruct, inspiring examples, etc.

Link: https://www.bazed.fr/

Apps and other software solutions

Applications and software can be used to facilitate the recovery of construction products or wastes. They offer a large range of applications: assistance in the creation of pre-demolition audit (automation of product quantification and qualification), database creation, environmental impact assessment (LCA) or assessment of feasibility of deconstruction techniques.

Tools about pre-demolition audits and dismantling process

Rotor DC

Rotor Deconstruction developed its own inventory tool which can be used during a visit of a building to list products with a reuse potential and to product reclamation inventories. The **app** allow to list products and materials present in a building a to give important information about them. Different type of information can be added: picture, type of material, quantity, dimensions, location, remarks on quality, advise to dismantle, presence of hazardous substances, advice to dismantle. After the visit, the app generate a list of all identified elements which can be share internally or directly with the client.

The app was developed on Filemaker Pro which is a software for developing and managing database. It can be use on mobile or tablet by member of the organization.

Cirdax

Cirdax is a material management **software**. It consists in a combination of practical tools and methods that allow to foster reuse and recycling.

An **inventory app** can produce pre-demolition audit. The system is filled with materials that are suitable for reuse and trading because they were dismantled in a suitable manner during deconstruction operations or renovation. The mobile app help to map materials present in the building, register them and allow to view collected information at all time.

A **material passport tool** provides insight into the identification and evaluation of materials at product, space and building level. The passport gather information about quality, quantity, size, colour, recyclability and demountability of materials. The set of passports thus created make the recovering of materials easier during demolition or renovation. These are stored in Cirdax's **database**.

A performance dashboards allow to share visual representation of the performance of a project and demonstrate results with stakeholders. It can concern circularity and CO_2 emissions.

A **marketplace** is also available to trade materials that can be reused before they have been deconstructed. This public portal proposes that elements are dismantled with care during the sale and directly collected by the buyer which eliminate the need to find another storage place and unnecessary transport.

Other tools are in development : an analysing centre, a (BIM) design tool, a lifecycle manager, a tool for management and maintenance, a CO_2 calculator and a social return tool

These tools are developed by Re Use Materials.

Link: https://www.cirdax.com/

2F BAT, Solution de diagnostic et de gestion des déchets issus de la démolition et des travaux neufs

This **software** offer solutions to analyse and manage deconstruction waste. Its functionalities consist notably in analysing the existing : quantification of existing works, evaluation of envisaged demolition techniques, capitalization of knowledge in a **database** ; editing audit reports and comparison of scenarios according to financial and environmental criteria.

It was developed by Trinov and Felix Florio Consultants

Link: http://www.trinov.com/logiciel/logiciel-diagnostic-demolition-travaux-neufs.html

REP, Modélisation du démantèlement de produits en fin de vie

REP is a **graphic tool** dedicated to modelling the dismantling of end-of-life products. It's functionalities are divided in 3 categories : end-of-life cycle modelling which includes the graphical representation of products dismantling steps, the visualization of resources associated with each sub-component and the calculation of several simulations; evaluation of the optimal scenario which includes the optimization of the valorisation rate; logistics and follow-up which involves the traceability of flows. In brief, this tool allows to generate simulations, analyse results, evaluate optimal scenarios, keep a traceability and produce reports.

It was developed by Trinov and Felix Florio Consultants

Link: http://www.trinov.com/logiciel/logiciel-responsabilite-elargie-producteur.html

Environmental impact assessment tools

Environmental impact assessment tools can help businesses in understanding the environmental impacts of their actions.

There is a large range of **software** for carrying out Life Cycle Assessment, both generalist and specialist, with varying degrees of modelling capacity. Among them we can mention *SimaPro, GaBI, Umberto, openLCA or Totem*. These softwares can calculate Life Cycle Assessment, Carbon footprint and several other indicators which can help sustainable decision-making for renovation and (de)construction. They contain specialized **databases** and **reporting tools**.

Links:

- https://simapro.com/
- http://www.gabi-software.com/international/index/
- https://www.totem-building.be/
- https://www.ifu.com/en/umberto/
- http://www.openlca.org/

EC3 Tool

The Embodied Carbon in Construction Calculator is a free cloud based tool that allows benchmarking and assessment of embodied carbon of construction products. This tool use building materials quantities from **BIM** models or construction estimates and a **database** of digital Environmental Product Declarations (EPDs). If the tool was created to be implemented in design and procurement phases of a construction project to help designers and engineers to compare, choose and procure the adequate materials and products, it could also help to assess the environmental impact (carbon impact) of reclaiming products and reusing them instead of recycling. This can lead to recovery decisions.

The project was initially started by construction company Skanska and software developer C Change Labs, and realized by a non-profit alliance that includes the Carbon Leadership Forum, American Institute of Architects, Autodesk, Interface, the MKA Foundation, Charles Pankow Foundation and Microsoft.

Link: https://www.buildingtransparency.org/en/

IMPACT

IMPACT is a specification tool and database that can be used by developers to develop their tools. Its overall aim is to integrate **Life Cycle Assessment** (LCA), **Life Cycle Costing** (LCC) and **BIM.** By taking quantity information from the BIM and multiplying it by the environmental impact and/or cost 'rates', it can produce an overall impact and cost for

the operation. It can analyse the design to optimize cost and environmental impacts. This tool can therefore help to make informed decisions about design or deconstruction.

IMPACT was developed by BRE.

Link : https://www.bregroup.com/impact/

Other tools : Excel files

Even if these following excel tables are not strictly speaking digital tools, it was nevertheless decided to quote them in this review, notably because it would be possible to develop them in application while keeping their principles.

A guide for identifying the reuse potential of construction products, FCRBE project

Within the framework of the Interreg project FCRBE (Facilitation the Circulation of Reclaimed Building Elements), the consortium has developed a good practice guide to explain how to conduct reuse audits (reclamation audits) in order to assist the various actors in the construction industry and to help to increase the reuse of construction products. To help to standardize the approach, templates in the form of **excel sheets** have been developed. The auditors can consequently directly use these templates to complete the inventory as soon as they visit the building for the first time.

Link: https://www.nweurope.eu/projects/project-search/fcrbe-facilitating-the-circulation-of-reclaimed-building-elements-in-northwestern-europe/#tab-5

Inventaire des matériaux de construction lors de la déconstruction d'un bâtiment

To help to get a standardized inventory and to increase the exhaustivity of the inventory, Luxemburg's administration propose a guide to conduct pre-demolition inventories. It is completed with an **excel file** and templates to establish a material inventory including check-list for building description and a part about identification of potential pollutants.

Link: https://environnement.public.lu/fr/offall-ressourcen/types-de-dechets/dechets-construction-demolition-dcd/inventaire-dechets-construction.html

Reuse potential assessment tool, BAMB project

The Reuse potential assessment tool was developed in the framework of the European project BAMB (Building as Material Bank). The main purpose of the tool is to enable the assessment of the reclaimable potential of building structures - at the system and component level - in order to foster high quality recovery and reuse and preserve the value of building elements. The tool analyses the ability to separate materials and reconfigure the product structure without damaging materials.

A report was written to describe the different reversible building design indicators. It is joined be as an **Excel file** that enables the calculation of the recovery potential of different elements and systems.

If the tool was mainly designed to assess the reuse potential during design stages, using the tool during a pre-demolition audit for the assessment of the reuse potential of existing buildings can be considered. The tool then can notably help to get a better understanding of a building composition, the recovery potential of elements and provide information on the deconstruction process.

Link : https://www.bamb2020.eu/

Blockchain

« Blockchain [...] is a shared digital record book of transactions (called blocks) that are linked together in sequence (chain). Everyone who shares this record book has the ability to validate the transactions and add records, but not modify existing records. »[10]

« Blockchain is a distributed ledger (a simple database, but with special properties) of information, such as transactions or agreements, that are stored across a network of computers. That information is stored chronologically, can be viewed by a community of users, but is decentralized [...]. Once published, the information on the blockchain cannot be changed.»[11]

The role of blockchain technology in material recovery can be summarized quite simply : it ensures the validity of data. Let's recall that data is the central link to ensure that the elements keep their identity, their value and therefore can be more easily reused and up-cycled.

Services

Blockmaterials
Block materials is Dutch start-up that apply **Blockchain** technology to real estate and circular economy. The company include this technology while providing larger services. After starting with conducting the inventory of materials present in the building, the data collected is combined with Blockchain to issue certificates. The ownership of materials

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[10] Citation from : https://www.intelliwavetechnologies.com/how-sitesense-uses-blockchain-for-construction-transactions/
[11] Citation from :
https://www.designingbuildings.co.uk/wiki/Blockchain_technology_in_the_construction_industry

can also be guaranteed. Blockmaterials also summarizes its other added values in these words : "This implements various value propositions for customers, such as being able to use residual values of buildings, reducing various management and maintenance costs (transaction costs) which are linked to the materials, reducing CO2 issues and making the materials marketable."

Link: http://www.blockmaterials.com/

BIMCHAIN

BIMCHAIN is another start-up, based in France, that combine **BIM** and **Blockchain** to reinforces BIM processes and enhances the Quality Data (quality, liability, traceability). It also provides traceability and create a trusted environment that ensure collaboration. A trusted Data management directly linked to a BIM model can ensure data validity of reclaimable materials.

Link: https://bimchain.io/

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Blockchain

Tools and services

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