Interreg FCRBE

Review of existing pre-demolition tools, policies, resources for identifying, quantifying and organizing the reclamation of reusable elements.

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Content

1. INTRODUCTION

1.1 Reusing construction elements

By 'reusing construction elements' we refer here to a series of practices consisting in using again a construction element or material after its first use. Reuse has to be distinguished from recycling, which entails the physical or chemical transformation of a construction product in order to recover its constituting matter (e.g. crushing concrete rubble to make aggregates, or mulching wooden elements to make chips).
In opposition to that, reuse tends to keep as intact as possible the relevant construction elements, although reusing a construction element can involve to undertake a series of repairing or renovating actions on the elements, such as cleaning, adapting dimensions, conditioning, etc.
A reclaimed construction element can be used either for a similar purpose than its original one, or for a completely different application.

Reuse is considered as an interesting strategy to reduce the environmental impact of the construction industry. It indeed prevents the environmental impacts related to the manufacturing of new construction products. By keeping the elements in circulation in the construction industry, reuse also reduces the amount of construction and demolition (C&D) waste. On top of that, reuse presents social and economic benefits. It is an interesting strategy to substitute the use of energy by manpower and, because it is more labour-intensive than traditional (destructive) demolitions and waste treatment strategy, reuse presents an important potential for creating local jobs. On a cultural level, reuse entails a more respectful approach towards the existing building stock. Instead of being considered as waste-to-be, it becomes a potential source of meaningful resources. In this sense, reclaimed elements can convey added-value to architectural projects. Equally well documented are the barriers hindering reuse practices[1].

Reusing a construction element is possible only if a succession of actions is correctly performed. The elements need to be carefully dismantled and possibly be cleaned, adapted, documented, etc. They usually need to be temporarily stored, before being reinstalled or replaced again. All these operations can happen on the same site (*in situ* reuse) or at different places (from a first building to a specialized reclamation dealer and then to another construction site). They can follow one another at a rapid pace or take much longer (storage is usually crucial as there is often an important gap between the design phase of a project, the removal and that of its actual construction). These operations can be executed by the same operator although, in more formal contexts, they tend to be spread over several actors and require good coordination between architects, clients and contractors.

This succession of operations depends on a first and crucial step: the identification of a potential to reuse. This is usually carried out in an early phase of a renovation or demolition project, quite upstream in the chain of operations. It generally involves the conduct of an assessment to identify the reuse potential in existing buildings. It is on this thematic that this report focuses, with the aim to give an overview of currently used practices.

1.2 Scope of the review

The FCRBE project aims to increase by +50% (in mass) the amount of reclaimed building elements in circulation within its territory, by 2032.

[1] See for instance Kay, T. & Essex , J, *Pushing reuse. Towards a low-carbon industry*, BioRegional, 2009; RDC Environment, éco BTP, I Care & COnsult (for ADEME), *Identification des freins et des leviers au réemploi de produits de construction*, 2016; Rotor (M. Ghyoot), *Objectif réemploi. Pistes d'actions pour développer le secteur du réemploi en Région de Bruxelles-Capitale*. As part of the ERDF-research project Le Bâti bruxellois, source de nouveaux matériaux (BBSM), Brussels, 2017.

This report has been drafted as part of one of the three thematic work packages of the FCRBE project, which aims to foster the reclamation of reusable building elements from the building stock. An expected output of this work package is the delivery of a new auditing method, tested and promoted through pilot operations.

The present report aims to collect examples and illustrations coming from different professional practices in which the assessment of the reuse potential in existing buildings plays an important role or is supported. It seeks to document the ways that reusable construction elements are identified and quantified, as their reclamation is organized. This collection of examples of practices and tools is a first step towards the development of an open-source and common method to assess reusable building elements, and organize their extraction from to-be-transformed buildings.

Although the review is mostly focusing on the project area (Belgium, France, United-Kingdom), it also illustrates other contexts (Luxembourg, Netherlands, Seattle, Switzerland) in which subject-related mandatory procedure exist.

As part of the introduction of this report, actual practices linked (or not) with more general waste management strategies are put in perspective by presenting the policy context related to reuse and reuse assessment. The methodology used is briefly described first, followed by a rapid explanation of the terminology used in this report. This approach helps to contextualize the review of existing reuse assessment tools, procedures and examples. Key findings are presented under the headings of 'resources to specify a reuse assessment before demolition work', 'resources to conduct a reuse assessment' and finally, 'resources concerning other aspects related to reuse assessments.'

Not only will this review contribute to the elaboration of an open-source method to conduct reuse assessments, it will establish connections with other aspects of the FCRBE project (recommendations concerning the integration of reuse in green certification schemes, possible role for digital tools in the conduct of reuse assessments, etc.).

1.3 Methodology

The present report is the result of teamwork between partners, both in terms of information gathering and writing. Between mid-March 2019 and end of April 2019, information about existing auditing tools, policies and resources within the project area (and beyond) were collected through the use of a collaborative spreadsheet. The spreadsheet catalogued existing reports, templates of reuse inventories, tools related to reuse assessments in the context of reclamation, pre-demolition audits and more general waste-treatment strategies. The spreadsheet can be used as a living tool throughout the project, allowing the ongoing integration of additional pertinent information.

In addition to the collection of reference documents, diverse practices of inventorying have been presented by the partners (notably through a workshop held at the end of April 2019) with the aim to better understand the common forms of reuse inventories, the kind of information that they include, and the contexts in which these inventories are carried out.

Although the collaborative method used to collect relevant information permitted covering a broad range of aspects related to the scope of the review, this report does not aim to be exhaustive. Its main ambition is to provide an overview of the different forms and contexts of the relatively new practice of conducting reuse inventories and assessments. This overview will act as input for the developments specified in the previous chapter (open-source method and other activities).

1.4 Vocabulary

Different terms and expressions are used to refer to the action of identifying and quantifying, in an existing building, construction elements which are worth reusing. It is the consequence of bringing together different approaches from different contexts (if only linguistic). During the elaboration of this review, we thus met terms such as 'audit', 'assessment', 'diagnostic', 'inventory', 'plan', etc. All of these convey some nuances and specificities related to their respective contexts.

In this review, we have made the choice to use these terms indiscriminately. According to us, this semantical diversity reflects the diversity of practices, concerns and habits that we encountered while constituting this state of the art.

We have made the choice to translate these different terms in English, while fully acknowledging that this operation might results in a loss of nuance. For instance, the expression *'diagnostic resources'* used in France and promoted, notably, by Bellastock derives from the expression '*diagnostic déchets*' used in the official waste regulation to designate the operation of identifying the nature and the quantity of C&D waste that is going to be produced during a demolition. The shift proposed here reflects a more general shift from a waste mitigation approach towards a resource conservation perspective. Incidentally, in French, the term diagnostic also evokes a forensic and holistic approach, that of a medical doctor examining a sick patient - which seems quite an appropriate metaphor for what would be at stake here.

In the next step of the Interreg NWE FCRBE project, choosing a more specific expression to designate this operation of identifying potentially reusable construction elements in the existing building stock would be appropriate.

2. REVIEW OF THE REGULATORY AND POLICY CONTEXT

2.1 Reuse and reuse assessment in the EU-context

In general, the existing policy context mainly concerns recycling.

For the moment, reuse mostly figures in non-binding regulations, such as circular economy programs and plans at EU and regional levels.

A notable milestone was the publication, in December 2015, of a communication from the Commission to the other European institutions entitled *Closing the loop. An EU action plan for the Circular Economy*[2]. In this document, C&D waste is identified as a key target to mitigate the environmental impact of the construction industry, and reuse figures in good place in the proposed strategies.

The communication *Closing the loop* summarizes a list of actions to accompany the transition towards a more circular economy (many of them having been developed in the meantime by different stakeholders within the European institutions). This list includes the elaboration of pre-demolition assessment guidelines for the construction sector (planned at that time for 2017). This action ultimately led to the publication of the document *Guidelines for the waste audits before demolition and renovation works of buildings*, by the European Commission in 2018[3].

For the moment, these guidelines are not binding; they can be adopted on a voluntary basis. In this document, it is stated that 'It is the duty of the waste holder to gain knowledge about the objects and substances intended to be discarded and their potential hazardous nature and contamination.'[4] Therefore, it recommends to conduct an inventory of materials and elements present in a building prior to its demolition (partial or total). This inventory, conducted by an independent auditor, combines field survey and desk study. It should mention the type and the quantity of the materials and elements that are going to be set free by the demolition. These should be classified under the general waste categories: inert waste, non-inert, non-hazardous waste, and hazardous waste. A more thorough classification can include a reference to the Eural codes[5] plus a short description of each element.

These actions thus mainly concern the implementation of best practices for general waste management strategies. However, these guidelines also suggest to include in this inventory additional information such as a list of elements recommended for deconstruction and reuse, their location in the building, an assessment of the quality of the elements (presence of impurities), and an assessment of their reusability.[6]

Ultimately, this inventory should achieve the goal of ensuring that the materials and elements set free by a demolition follow the best recovery routes possible, in accordance with the regulatory framework in effect. This refers explicitly to the 2008 EU Waste Directive[7] (amended in 2018[8]), a regulation in which reuse figures as a preferential waste treatment mode.

[2] COM/2012/0614 final, available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1453384154337&uri=CELEX:52015DC0614
[3] https://ec.europa.eu/docsroom/documents/31521/attachments/1/translations/en/renditions/native
[4] *Ibid.* p.7.
[5] These designate an official list of European waste categories.
[6] *Ibid.* p.7. This figures as additional information that can be required by the waste holder or building authority (as waste audit actor).
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0098
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0851
Article 9 of Amended Directive 2018 expands the provisions for prevention defined in the 2008 EU Waste Directive, notably by encouraging the reuse of products and the setting up of systems promoting repair and reuse activities, including in particular for electrical and electronic equipment, textiles and furniture, as well as packaging and construction materials and products.

In this directive, reuse is mentioned both as a prevention mode (i.e. extending the useful life of products by keeping them in circulation) and a waste treatment strategy (by transforming waste back into products thanks to specific treatments – referred to as 'preparation for reuse' in the directive).
The notion of its interpretation arises within the partnership.

Interpretation concerns triggers the question of the end-of-waste procedures, which are unequally developed in the different regional regulatory contexts. Most of the time, when an end-of-waste procedure does exist, it has mainly been developed with recycling, - in a perspective of waste management-, in mind. A good example of this is the development of a bespoke framework for the use of crushed aggregates made from inert C&D waste in Flanders. Although exemplary for the development of high recovery rates in the recycling sector, these procedures, as they currently stand, seem today of little help for reuse-actors when it comes to discuss reuse aspects.

In any case, we can observe that there's a general willingness to move towards more reuse.

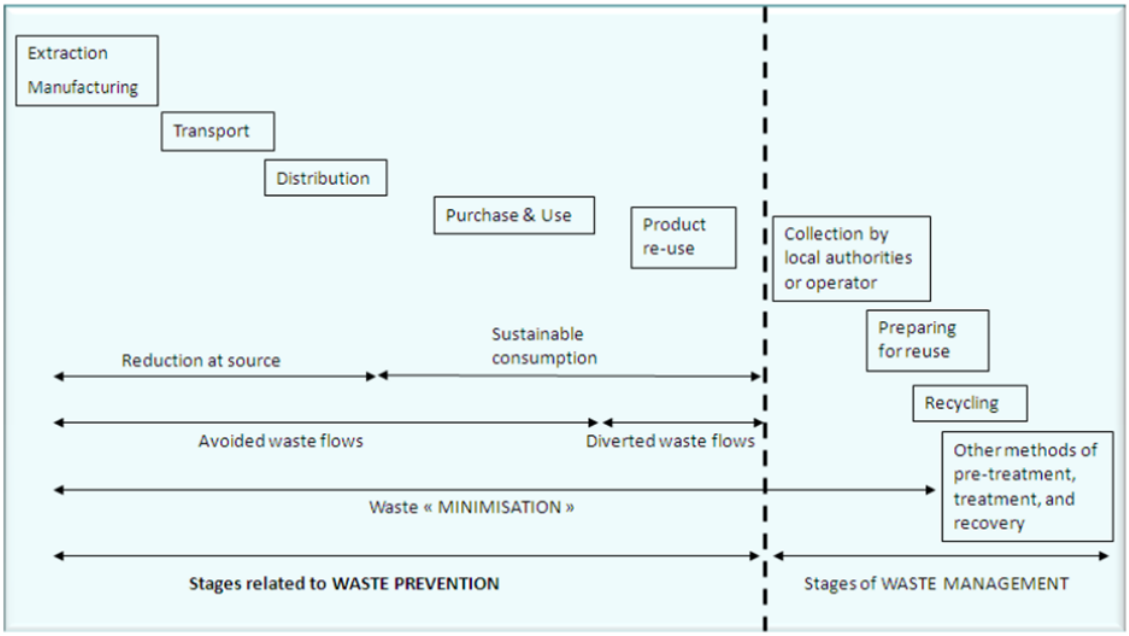

Fig.1 - Stages related to Waste Prevention and Waste Management. Source: European Commission DG Environment. *Waste Prevention – Handbook: Guidelines on waste prevention programs.* October 2012, p. 7.

2.2 Reuse assessment through waste management regulations at national and regional level

If reuse-oriented binding policies are still rare (not to say inexistent), recycling-oriented binding policies are more common. Some of them may concern the present work in as much as they include the conduct of a general inventory of all the C&D waste streams before a demolition. The existence of such procedures raises the question of their possible coupling with reuse-oriented inventories.

It may indeed sound more efficient to consider reuse as an additional layer to these existing inventory procedures - as suggested, for instance, in the waste audit guidelines published by the European Commission. However, if both approaches might converge for some aspects (they both take place before a demolition and seek to quantify outing material flows), they also present some points of divergence: in some contexts, the reuse assessment will happen earlier in the project development; the units and the ways of quantifying in both inventories are different; the status of the material coming out of a building can be different (they often will be products in the case of reusable elements and waste in other cases); therefore, the operators who will take these elements in charge can also be very different; the operators who conduct these assessments are likely not to be the same; etc.
The present review does not seek to settle this issue. However, it seems interesting to mention a few examples in which inventory procedures are part of more general waste management strategies. These are more common and, sometimes, even mandatory.

Belgium, Flanders

In Flanders, there is an obligation to conduct a 'pre-demolition plan' (*Sloopopvolginsplan*) for the demolition of buildings that are bigger than 1.000 m^3 (for non-residential buildings) or bigger than 5.000 m^3 (for residential ones)[9].

This obligation is introduced by VLAREMA[10], which is the executive order of the Materials Decree *(Materialendecreet)*[11], a decree adopted by the Flemish Government that establishes the Flemish regulations on the sustainable management of material cycles and waste materials. This is a partial transposition of the 2008 EU Waste Directive.

The Material Conscious Building in Circuits policy program (*Materiaal bewust bouwen in kringlopen*)[12] for the period 2014-2020 puts into practice a circular vision within the built environment, proposing a framework for cooperation between authorities and the actors of the construction sector, in order to support sustainable materials management. This policy focuses its efforts notably on the theme of selective demolition and deconstruction. For the demolition of smaller buildings, selective demolition on the basis of a demolition inventory which can be set up on voluntarily basis is stimulated.

Over 12 million tonnes of recycled granulates from C&D waste are produced and used in Flanders yearly. End of waste criteria are defined for these recycled granulates[13]. To improve the quality of the secondary granulates,

[9] Vlaamse Overheid. (2012). VLAREMA, art. 4.3.3.
'*Een sloopopvolgingsplan is vereist bij: 1° sloop-, renovatie- of ontmantelingswerken bij gebouwen waarvoor een omgevingsvergunning vereist is en waarvan het totale bouwvolume groter is dan 1000 m^3 voor alle niet-residentiële gebouwen waarop de vergunning betrekking heeft, of groter dan 5000 m^3 voor alle in hoofdzaak residentiële gebouwen, met uitzondering van eengezinswoningen, waarop de vergunning betrekking heeft ; 2° sloop-, renovatie- of ontmantelingswerken in het kader van infrastructuurwerken waarvoor een omgevingsvergunning vereist is; en onderhoudswerken aan infrastructuur waarvoor een omgevingsvergunning vereist is en waarvan het volume groter is dan 250 m^3. Het sloopopvolgingsplan wordt opgesteld in opdracht van de aanvrager van de omgevingsvergunning. § 2. Het sloopopvolgingsplan omvat de identificatie van de werf met daaraan gekoppeld een overzicht van alle afvalstoffen die zullen vrijkomen. […]*'.
[10] https://navigator.emis.vito.be/mijn-navigator?woId=43991
[11] https://navigator.emis.vito.be/mijn-navigator?woId=41707
[12] https://www.ovam.be/sites/default/files/atoms/files/Actieprogramma-Materiaalbewust-Bouwen-2014-2016-Beleidsprogramma-bouw.pdf
[13] VLAREMA, art 2.3.2.1 and 2.3.2.2.

specific regulations for crushers were set by the OVAM (Public Waste Agency of Flanders). The regulations require self-control and external control by an independent, accredited organization of both the crushing process and the secondary granulates.

Tracimat, a non-profit C&D waste management organization, was founded in 2014 and developed a traceability system providing quality assurance for the recycling companies treating the materials originating from selective demolition.

Tracimat facilitates and certifies the selective demolition process and issues a certificate of the materials collected and subsequently has gone through a tracing system. This tracing system and the certification by a recognized and independent organization, guarantees the selective collection of the materials, traces it from its point of origin down to the gate of the processing company, where it assures the environmental quality of the materials offered.

The 'inventory process' according to Tracimat procedures, operates in the phase prior the demolition and at the effective start of it. The tracking procedure starts with an identification of the different materials that will come free during the deconstruction and demolition of the building, and follows up on what happens with these materials during the selective demolition works.

The first step consists in the drafting of a pre-demolition audit by an expert (independent of the contractor), who's trained and certified by Tracimat. The pre-demolition audit constitutes an inventory of hazardous and non-hazardous materials that will be released during the demolition. The inventory includes information about type of materials, quantity and location. Recommendations for selective demolition (especially for asbestos) will have to be specified.

Including this audit as a part of the tender for demolition works has the advantage that the building owner is informed upfront about hazardous waste/materials which will be released during the demolition activities. This results in a clear indication of the expected costs of (correct) removal, which must be taken into account. Another advantage consists in offering to the demolition contractor a basis for price-setting which results in more transparency and insight upfront the process, and less risks for unforeseen costs during the demolition.

The second step is the phase of decontamination, deconstruction/ dismantling and demolition itself.
The different follow-up activities are ensured by the tracking procedure, as to know,
follow-up of the removal of different waste streams: tracing materials results in pure materials streams:

- Follow-up and tracking of removal of hazardous materials as a priority
- Follow-up and tracking of other non-hazardous (non-stony) fractions
- Follow-up and tracking of stony fraction

The implementation of the system should have a positive effect on selective demolition and on the quality of the recycled materials. According to his founder, the system offers the opportunity to extend the scope of the inventory with potential reusable building elements or to integrate supportive processes to identify those elements.

All materials of the pre-demolition inventory being putting into a database, this allows Tracimat to have data about amounts, type and location of different materials that will be set free on a short term by the future demolitions[14]. The ultimate goal for the latter is to have a complete database of the materials present in buildings, reflecting the potential of these materials for use in future construction projects or for reuse in other branches of industry.

[14] Those data could be valuable information for possible investors in recycling products, allowing them to dimension their recylcing plant, to estimate whether a specific material will ne available in continous flows, to organize logistics, etc.

The flow diagram below shows the different steps and stakeholders in the current process.

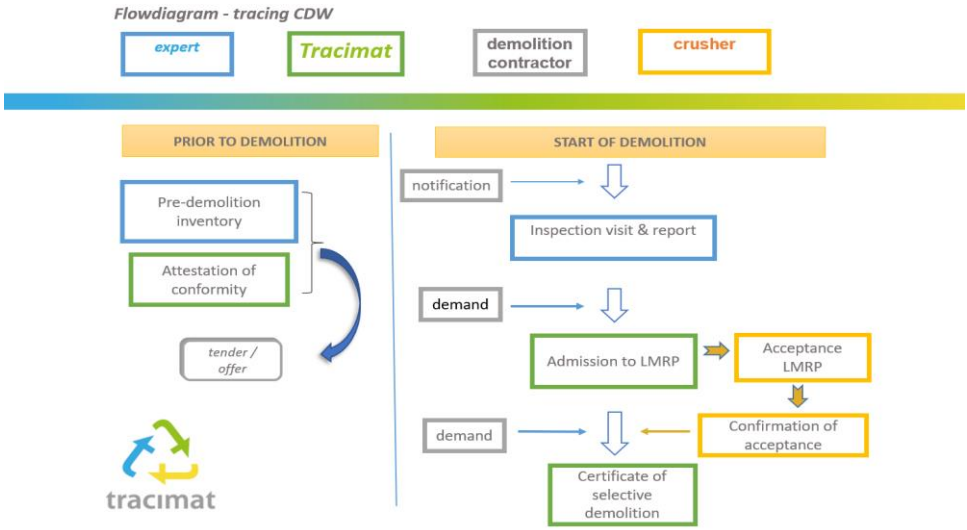

Fig. 2 – Flowdiagram – tracing CDW. Source: Tracimat

Belgium, Wallonia

In Wallonia, there's no obligation to conduct a waste inventory prior to the demolition of a building, but waste inventories are conducted on a voluntary basis.

The Walloon Waste-Resources Plan, adopted in 2018[15], is structured according to the principles of the circular economy. In particular, it encourages carrying out an inventory of the materials available in a building prior to its demolition or transformation. This approach is proposed as a way to enhance the recovery and reuse rates of the elements and materials, and to optimise the quality of the fractions resulting from demolition work.

In public tendering, standard specifications for road works and buildings take selective demolition into account. In this context, a specific waste management plan is required for the renovation and demolition of buildings. The specific waste management plan is a mandatory document to be completed by the successful tenderer, provided as an annex to CCT-B2022.[16] In addition, for demolition works, project owners can draw up a provisional inventory of waste. If there is an inventory carried out by an expert or by the architect, the successful tenderer must also complete the column of volumes/masses forecast based on this inventory.[17]

More recently, in May 2019, the Walloon Parliament published a resolution concerning the encouragement of a transition towards a more circular economy.[18] Relatively brief and general, this resolution does not state anything regarding reuse assessments. This resolution only recommends creating a dashboard with different indicators that must take into account the rate of reuse of deconstruction materials, allowing recovery in the Walloon Region.

[15] http://environnement.wallonie.be/rapports/owd/pwd/PWDR_3.pdf
[16] CCT-B 2022. See t.0, chap. 07., sect. 07.1., https://batiments.wallonie.be/home/iframe-html.html
[17] Waste inventory, available online: http://environnement.wallonie.be/forms/doc/186.docx. This document contains an assessment of the nature and quantities of waste that will be encountered during the execution of the work.
[18] http://nautilus.parlement-wallon.be/Archives/2018_2019/RES/1330_3.pdf
Through this resolution, the Walloon Parliament calls for the promotion of products from the circular economy as a priority in the public procurement contracts drawn up by the Region. It points to the need to stimulate demand for products resulting totally or partially from reuse.

Belgium, Brussels-Capital Region

In the Brussels-Capital Region, the existing waste legislation[19] does not include an obligation to conduct a waste inventory prior to the demolition of a building, but waste inventories are conducted on a voluntary basis.

The transposition of an inventory obligation similar to that of Flanders is an ongoing question in Brussels. So far, there is a proposal to apply this obligation for projects larger than 500 m^2 and for which an environmental declaration is required. According to a report of 2017[20], this proposal was mentioned in a first intermediate evaluation report on the 4th Resources and Waste Management Plan (2010-2017), which has not yet been enforced.

A similar obligation to conduct a pre-demolition inventory also figures in another non-binding document in which the Region states its ambitions in terms of transitioning towards a more circular economy: the Brussels Regional Program for a Circular Economy 2016-2020. *Mobilize resources and minimize wealth loss: for an innovative regional economy*. (*Programme Régional en Economie Circulaire 2016-2020. Mobiliser les ressources et minimiser les richesses perdues: pour une économie régionale innovante*)[21].
Construction, resources and waste are important themes in this document. 37 related sectoral measures are proposed, including a proposal to make it mandatory to conduct a pre-demolition audit and, wherever justified, to implement a selective deconstruction phase in the context of public tenders.

An essential action provided in the plan concerns the annual *Be Circular*[22] call for project. This measure provides financial and technical assistance to contractors and allows notably practical experimentation in dismantling and reuse of building materials on renovation sites in Brussels. In the context of this call, an inventory initiative, referred to as a 'material flow inventory' (*inventaire flux matériaux*) (cf. infra 3.2 i) is being pursued. At a regional level, this tool, which is still under development, seeks, up to now, to characterize the stocks and flows of materials and waste in the existing building stock.

In the Resources and Waste Management Plan 2018-2023[23], the Region pursues the objective of transitioning of the construction sector towards a circular management of construction resources and waste by fostering, through the annual *Be Circular* call for project, the experimentation and the development of selective deconstruction practices and reuse.

In the recently released non-binding *Roadmap of the actors of the construction sector in Brussels, Towards a circular economy*. (*Feuille de route des acteurs de la construction à Bruxelles. Vers une économie circulaire)*[24], the Region re-affirms its aim to encourage the realization of reuse inventories prior to the demolition and transformation of existing buildings. Stimulating selective deconstructions to enhance the reclamation of construction products is one of the short-term objectives (horizon 2025)[25]. Another objective is the use of administrative procedures to stimulate the circular economy. To meet this objective, the Roadmap introduces the idea of a requirement of a so mentioned 'inventory of materials (hazardous, recyclable, reusable)' by 2021 for all operations needing an urban planning permit[26].
The Roadmap proposes to progressively enforce this practice, starting with public tenders (horizon 2030) and extending it towards the private sector, for which it would become fully mandatory by 2040.

[19] http://www.ejustice.just.fgov.be/cgi_loi/change_lg.pl?language=fr&la=F&table_name=loi&cn=2016120133
[20] CERAA (for Brussels Environment). (2017). *Analyse du cadre réglementaire_Rapport (tâche 2). As part of a public service tendering for Brussels Environment.* Non published report.
[21] http://document.environnement.brussels/opac_css/elecfile/PROG_160308_PREC_DEF_FR
[22] https://www.circulareconomy.brussels/category/call-for-projects/?lang=en
[23] https://environnement.brussels/sites/default/files/user_files/pgrd_181122_fr.pdf
[24] https://www.circulareconomy.brussels/wp-content/uploads/2019/06/BE_beCircular_feuille-de-route-CD_def_FR1.pdf
[25] *Ibid.* p. 27
[26] *Ibid.* p. 31

France

In France, there is an obligation to conduct a waste inventory prior to the demolition of a building (*Diagnostic préalable aux chantiers de démolition)*. It should be completed together with the elaboration of a more general waste management plan (*plan de gestion des déchets*).

This procedure is mentioned in a law adopted in 2009 concerning the implementation of the '*Grenelle de l'environnement'*[27], which has been fully enforced by a decree published in May 2011[28] and a decision published in December 2011[29].

This *diagnostic* is mandatory in the following cases:

1. for buildings larger than 1.000 m²
2. for buildings that have been used for agricultural, industrial or commercial use
3. for buildings in which specific hazardous substances were produced, processed, stored or distributed.

The waste assessment should be based on an evaluation conducted on site. It has to specify the nature, quantity and location in the building of the construction materials, products and equipment that are going to be set free by the demolition.[30] It is interesting to note that the regulatory texts ask the assessor to also mention the possibilities for *onsite* reuse. And, when no onsite reuse is possible, the assessor should specify the appropriate waste treatment methods for each fractions of the C&D waste stream and identify the waste treatment chains on a local level. The waste assessment has to be carried out by a construction professional who is insured for such a mission. This expert has to be impartial and independent from the building owner and all the contractors likely to undertake all or part of the demolition work.

After the demolition, the building owner is also asked to produce a resume (*formulaire de récolement*) of all the materials and elements that have been (or are going to be) reused onsite, the waste produced at this occasion, and the recovery methods used for these fractions of the C&D waste flow . However, according to a report published in 2018 by ADEME[31], only about 5% of the demolition operations concerned by the waste inventory (*diagnostic préalable*) practice the implementation of this obligation[32].

United Kingdom

In the United Kingdom, the Site Waste Management Plans Regulations 2008[33] became law in April 2008 and applied to building projects with a value of more than £300,000, with additional updating requirements for projects with a value of £500,000 or more.

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[27] Loi n° 2009-967 du 3 août 2009 de programmation relative à la mise en œuvre du Grenelle de l'environnement (1), art. 46. '*Le rôle de la planification sera renforcé notamment par: l'obligation de mettre en place des plans de gestion des déchets issus des chantiers des bâtiments et travaux publics et d'effectuer un diagnostic préalable aux chantiers de démolition*'. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000020949548

[28] Décret n° 2011-610 du 31 mai 2011 relatif au diagnostic portant sur la gestion des déchets issus de la démolition de catégories de bâtiments, art. R. 111-46.
'Le diagnostic [...] fournit la nature, la quantité et la localisation dans l'emprise de l'opération de démolition : des matériaux, produits de construction et équipements constitutifs des bâtiments ; des déchets résiduels issus de l'usage et de l'occupation des bâtiments. Ce diagnostic fournit également : les indications sur les possibilités de réemploi sur le site de l'opération ; l'estimation de la nature et de la quantité des matériaux qui peuvent être réemployés sur le site ; à défaut de réemploi sur le site, les indications sur les filières de gestion des déchets issus de la démolition ; l'estimation de la nature et de la quantité des matériaux issus de la démolition destinés à être valorisés ou éliminés. Le diagnostic est réalisé suite à un repérage sur site.'
https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000024099263&categorieLien=id

[29] Arrêté du 19 décembre 2011 relatif au diagnostic portant sur la gestion des déchets issus de la démolition de catégories de bâtiments. https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000025145228

[30] The term of demolition includes here demolition, renovation and rehabilitation works.

[31] ADEME. (2018). *Mise en œuvre de l'obligation de télédéclaration du formulaire de recolement CERFA 14498 pour certaines operations de démolition*.

[32] According to the French reuse actor, there are, among those 5%, disparities in the quality of the waste diagrams that are carried out: very variable precision of numerical data, more or less exhaustive analysis of local recovery chains etc.).

[33] http://www.legislation.gov.uk/uksi/2008/314/contents/made

The regulations placed the initial responsibility for the production of the plan with the client. The client had to produce the plan before the project was started. If a project was started without a site waste management plan, then both the client and the principal contractor were guilty of an offence under these regulations. The SWMP had to identify the client, contractor, location, and estimated project cost. Records were kept of decisions on minimising waste. The SWMP had to estimate the quantity and the waste management action for each type of waste including reusing, recycling, recovery or disposal.

Once the project started the regulations place an obligation on the principal contractor to update the plan and record details of the person removing the wastes, the types of waste removed and the site the waste was being taken to. After completion a confirmation had to be made that wastes were monitored and the plan updated to reflect any changes along with an explanation of any deviation from the plan. If the project was worth more than £500,000, there had to be more clearly defined duty of care information by the principal contractor who had to review, record quantities and types of waste produced, record the types and quantities of waste that had been reused (on or off site), recycled (on or off site), recovered (on or off site) and sent to landfill. Within three months of the work being completed the principal contractor had to confirm that the plan had been monitored and updated in accordance with the regulations, make a comparison of estimated quantities of each type of waste generated against the actual quantities of each waste type, give an explanation of any deviation from the plan, and make an estimate of the cost savings that had been achieved by completing and implementing the plan.

UK Building Research Establishment (BRE)[34] started to offer 'pre-demolition audits' as part of legal requirements of Site Waste Management Plans which were introduced by the UK government. These usually emphasised recycling or downcycling, but sometimes included reuse and reclamation as a less-favoured option due to perceived added costs from the complications of careful dismantling and reclamation often with an uncertain market outcome.

Although the Site Waste Management Plans Regulations were repealed by Government on 1 December 2013 as part of the government's initiative to reduce red tape, Site Waste Management plans continued to be undertaken on a voluntary basis, notably as part of the BREEAM certification scheme.

The latest BREEAM 2018 for new construction[35] has a credit for producing a pre-demolition audit[36], which requires setting recycling and reuse[37] targets, where appropriate. The older version of BREEAM New Construction (2014) required a pre-demolition audit within another credit. Some projects continue to work from the 2014 version depending on when they were registered.
BREEAM Refurb and Fit out came in two versions - one for domestic and one for commercial[38]. This has not been updated since 2014 but has elements similar to that in new construction. The scheme foresees a credit for a pre-refurb audit and two credits for the direct reuse and recycling of materials. It is uncertain whether the housing credit is still in use.
In both schemes there are credits for the environmental impact of materials, where points are given for reuse in-situ.

[34] https://www.bregroup.com/
[35] https://www.breeam.com/NC2018/
[36] See Section 10 Wst01. The remaining part of the Wst01 has credits for reducing waste (which could include reuse) and diverting it from landfill, although no distinction is made between reuse, recycling and recovery. Other sections which can include reuse exist in the assessment and certification scheme. Same sect.10 (waste) that encourages the reduction of waste from construction and throughout the lifetime of the building: 2 credits are foreseen for designing for disassembly and adaptability (new for 2018 scheme) (Wst06)/ Sect. 9 'materials' (credit for material efficiency).

[37] Reused materials in BREEAM are defined as: Materials that can be extracted from the waste stream and used again without further processing, or with only minor processing, that does not alter the nature of the material (e.g. cleaning, cutting, fixing to other materials).
[38] https://www.breeam.com/ndrefurb2014manual/

It is interesting to note that the Royal Institute of Chartered Surveyors (RICS) runs a rating scheme[39] for commercial fit-outs, in which reuse measures are present.

Other geographical area

Although outside the territories in which the FCRBE project more specifically focuses, following relevant information was identified by the partners during the collect process.
This concerns territories that are auxiliary or totally independent of the project.

Luxembourg - In Luxembourg, the amended law of 21 March 2012 on waste[40], in which explicit reference is made to the application of the waste hierarchy, provides that waste prevention must be taken into account in the planning of a construction. The legislation includes an obligation to conduct an inventory of materials within a building before demolition, and to organize the collection of separated waste during the demolition phase. The main objective is to promote the collection of separated C&D waste so as to enhance their recovery rates. With regard to separated collection, the different materials used in the to-be-demolished structure must be identified and listed in an inventory. This inventory foresees the separate removal and collection of the various materials for their respective processing.

The 2018 National Waste and Resource Management Plan promotes planned dismantling and the elaboration of a deconstruction inventory with quality criteria for materials. This measure aims to move from the notion of 'demolition' to that of 'deconstruction' or 'planned dismantling'[41]. The Luxembourg Government provides templates[42] and guides for inventorying construction materials, in order to make an inventory of all materials present within a building prior to demolition/deconstruction (description of building, type and amount of materials, checklist for possible harmful substances, channel).

Netherlands – In the Netherlands, the Building Decree 2012[43] requires a notification for demolishing construction works when more than 10 m^3 demolition waste is created. In such a case, a complete inventory is requested covering the nature and quantity of the waste that is expected as a result of demolition, in addition a statement must submitted regarding the intended disposal destination of these substances.

In an effort to take concrete septs towards a sustainable society, and as to respond to its obligations in terms of sustainable procurement, the Dutch Government has developed criteria[44] and practical instruments to implement Sustainable Procurement within Dutch public organisations. The realisation of a material inventory (*stoffeninventaris*), and of a pre-demolition phase (*voorsloop*) are measures included in those criteria, in the framework of demolition operations. Those elements are more closely addressed in next chapter (cf. infra 3.1i – Sustainable Procurement web-tool).

[39] As a result of a research project initiated by Skansen, referred as SKA rating scheme. The scheme is for fit-outs (such as shopfitting) which has credits for reuse and pre-dems with slightly different schemes for office and retail. The scheme comprises more than a hundred 'good practice' measures covering energy and CO2 emissions, waste, water, materials, pollution, wellbeing and transport. An example of a good practice measure is that when wooden flooring is stripped out, it should be sent for reuse to a salvage yard instead of to landfill.
https://www.rics.org/uk/about-rics/responsible-business/ska-rating/, on-line SKA rating tool.
[40] http://legilux.public.lu/eli/etat/leg/loi/2012/03/21/n1/jo
[41] https://environnement.public.lu/dam-assets/documents/offall_a_ressourcen/pngd/plan/PNGD.pdf
[42] https://environnement.public.lu/fr/offall-ressourcen/types-de-dechets/dechets-construction-demolition-dcd/inventaire-dechets-construction.html
[43] https://wetten.overheid.nl/BWBR0030461/2019-07-01/
[44] Those criteria are accessible from an online criteria tool 'MVI', which is a tool for government organizations to view the criteria for socially responsible procurement. Government organizations can decide for themselves how high their goals should be. The tool enables to select selection criteria, requirements, award criteria as well as contractual clauses for sustainable procurement operations.

Launched in 2013, the certification scheme BREEAM NL[45], more specifically through the label BREEAM-NL Demolition & Dismantling, further reflects this priority of sustainable demolition by proposing the assessment of the sustainability of demolition projects.

Very recently, the Ministry of Infrastructure and Water Management has published the latest amendment of The National Waste Management Plan (*Landelijk Afvalbeheerplan)* 2017-2023 (LAP3)[46], which addresses within a specific chapter[47] the topic of assessing and clarifying the concept of 'waste' in order to promote better use within the scope offered by current European legislation and the judiciary to prevent materials from being unnecessarily classified as waste.

Switzerland - In Switzerland, the federal Council has published the Ordinance on the Avoidance and the Disposal of Waste 2015 (*Ordonnance sur la limitation et l'élimination des déchets 2015)*.[48] This law makes it mandatory to conduct a waste inventory in the cases the production of C&D waste is expected to be bigger than 200 m^3, and secondly, when it is likely that the C&D waste flow will contain harmful and hazardous substances.[49]

Seattle - The case of Seattle constitutes the only exception of a binding regulation for an assessment specifically dedicated to reuse found while conducting this review (cf. infra, 3.2.ii). There, a salvage assessment is mandatory for every demolition permit that is introduced to public authorities. It is coupled with – but kept distinct from – a general waste diversion strategy, in which building owners are asked to detail what kind of waste are going to be produced and how and by whom these are going to be handled. This procedure takes place as part of a more general target, which is the diversion of waste flows from landfill.

[45] https://www.breeam.nl/sites/breeam.nl/files/bijlagen/BRL_BREEAM-NL_Sloop_versie_1.0_juli2013_.pdf
[46] https://lap3.nl/
[47] *Ibid.* See Part B : *Afvalbeheer en overbrenging.* Chapter B.6. *Onderscheid afvalstof en niet-afvalstof.*
[48] https://www.admin.ch/opc/fr/classified-compilation/20141858/index.html
[49] Conseil fédéral suisse, Ordonnance sur la limitation et l'élimination des déchets (OLED), 2015, art. 16.
'Lors de travaux de construction, le maître d'ouvrage doit indiquer dans sa demande de permis de construire à l'autorité qui le délivre le type, la qualité et la quantité des déchets qui seront produits ainsi que les filières d'élimination prévues : a. si la quantité de déchets de chantier dépassera vraisemblablement 200 m^3, ou b. s'il faut s'attendre à des déchets de chantier contenant des polluants dangereux pour l'environnement ou pour la santé'.

3. EXISTING REUSE ASSESSMENT TOOLS, PROCEDURES AND EXAMPLES

Although reuse assessments are still conducted on a voluntary basis, a significant amount of tools already exists; procedures, documents and manuals which support the assessment process. This chapter details many of these already-existing resources. These are classified under three principal categories:

- The resources which help to *specify* a reuse assessment.
- The resources which help to actually *conduct* a reuse assessment
- The resources which help to address *other aspects* related to a reuse assessment

3.1 Resources to specify a reuse assessment before demolition work

Because reclamation assessments are not (yet) mandatory, they will only happen if a building owner opts for this strategy upstream in the project development. If these don't conduct the inventory themselves, they have to specify and contract this mission to specialized operators. This category groups examples and manuals addressing this question.

Brussels Environment's Sustainable Construction Guide [50]

The *Sustainable Construction Guide (Guide Bâtiment Durable)* is a website developed by Brussels Environment, providing information on green construction (in French and Dutch). The targeted audience is architects designing buildings for the residential and tertiary sectors (single family dwellings, collective housing, offices, etc.) in an urban context, including both new and renovation projects. The Guide mentions different aspects that should be taken into account for a sustainable approach: energy, water, comfort, etc.

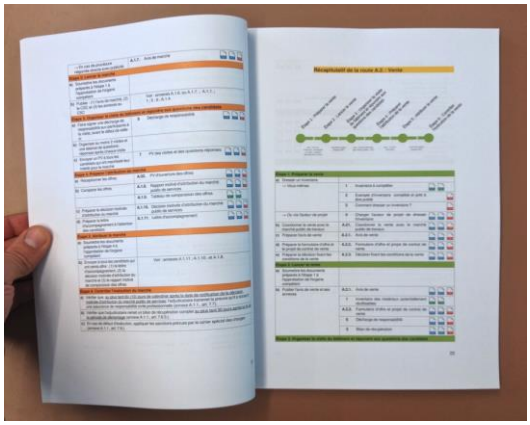
A new folder concerning in situ reuse has been recently added (2017). It approaches reuse through different aspects, and provides resources to assist designers in the elaboration of their projects. Conducting preliminary studies and inventories, managing the construction phase and following the right procedures are subjects that the guide notably addresses.
For each point, examples and documents used in projects are given to help architects and building owners integrate reuse in their own project. 17 case studies coming from Belgium or elsewhere in European are also developed, providing design plans, photos and explanations regarding in situ reuse strategies in these projects.

The Guide also acts as a portal, providing links to other interesting documents and websites.
A future folder on how to implement circular economy in buildings is being developed[51].

[50] https://www.guidebatimentdurable.brussels
[51] Building design will be tackled (prefabrication, disassembly, building reallocation) as well as tools helping to implement these strategies (material passports, reversible building design protocols, etc.).

Specifying a reuse assessment in the context of a public tender: the Vade-mecum for the extraction of reusable elements

The Vade-mecum (*Vade-mecum for Off-Site Reuse. Legal and practical guidelines for the reclamation of reusable materials from public buildings*) was published by Rotor in 2015 (in French and Dutch)[52]. It sets out comprehensive guidelines to accompany public authorities in salvaging building materials coming out of public works in the Brussels-Capital Region (although these guidelines are easily adaptable elsewhere in Europe). A legal expert joined Rotor's team for writing down this manual. It thus brings about a thorough investigation into the legal framework of material reuse and the hands-on expertise acquired by Rotor along the years. The Vade-mecum also sheds light on the often shady legal framework around reused materials and reclamation activities[53].



The Vade-mecum proposes a step-by-step method to organize the identification, reclamation and transfer of reusable materials in accordance with the public procurement legislation. It takes advantage of the vacancy period that usually precedes the refurbishment of a building.

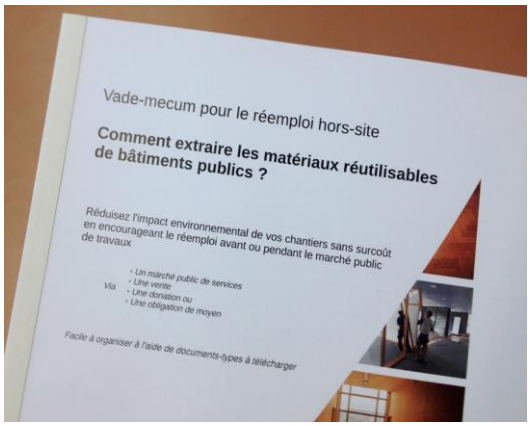


Fig. 3 & 4 - Vade-mecum for Off-Site Reuse, Rotor. Source: Rotor

Before the actual work starts, the extraction of the materials can be assigned by the public authority to a specialized reuse operator through 3 different ways:

- A public sale or a donation
- A public service contract
- A third possibility consists in assigning the general contractor a best effort obligation to salvage pre-identified construction elements. This option finds its place in the general specifications.

For each step, standard documents are provided in order to be used directly by the relevant public actor (the building owner, the site manager, the drafter of the tender specifications, the sustainable development manager, etc.).

[52] http://www.vademecum-reuse.org/Vademecum_extraire_les_materiaux_reutilisables-Rotor.pdf (in French) and http://vademecum-reuse.org/Vademecum_recuperatie_van_bouwmaterialen_Rotor.pdf (in Dutch).

[53] The results of this investigation were published in a peer-reviewed scientific journal: Sophie Seys, Lionel Billiet, 'Extraire les matériaux réutilisables de bâtiments publics. Produits à démonter dans le cadre d'un marché public de services, d'une vente ou d'une donation' in *Administration Publique (APT),* June 2016, p. 1-25. For the discussion on whether reclaimed building elements should be considered as products or as waste, cf. chapter 5, 'Les matériaux réutilisables, des déchets?' (p. 15-25). The article is openly accessible on http://www.vademecum-reuse.org/Vade-mecum_analyse_juridique-Rotor.pdf

The Vade-mecum thus provides different generic clauses to specify the elaboration of a reuse inventory. It assumes that, most of the time, it is the building owners themselves that will conduct it. However, for diverse reasons, the building owners might want to contract it to another operator. The Vade-mecum proposes a scenario in which the building owner contracts it to the architect in charge of the construction project and provides all the generic documents to implement that in the calls for tenders[54].

Sustainable Public Procurement web-tool, (MVI-tool)[55], Netherlands.

The Dutch-developed Sustainable Public Procurement web-tool, introduced in the previous chapter (cf. supra, 2.2) enables public authorities to quickly find appropriate Sustainable Public Procurement - criteria, by facilitating the choice of selection criteria, requirements, award criteria as well as contractual clauses for sustainable procurement operations. Government organisations can decide for themselves how high their goals should be.

Some of the criteria address more particularly the demolition phase. Among those[56], one, for example, concerns the selection criteria 'Safe and environmentally friendly demolition in accordance with BRL SVMS-007' (*Beoordelingsrichtlijn Veilig en Milieukundig Slopen*). According to this criteria, the tenderer must employ a working method that is in accordance with BRL SVMS-007 for demolition activities, a certification scheme to which contractors of the demolition sector can comply. BRL SVMS-007 describes a manner of working whereby guidelines are formulated notably for the elaboration of a material inventory- preparation work, and for the execution, treatment and removal of demolition materials.[57]

Another example consists in a contract clause which foresees the realization of a pre-demolition phase (*voorsloop)* by the tenderer. This involves notably scheduling sufficient time to dismantle and remove non-structural, non-stony material from a building.

3.2 Resources to conduct a reuse assessment

This category groups different templates, tools and procedures that are used in specific context and by specific operators to conduct a reuse assessment or inventory of reusable elements. These are shortly described and analysed. The description highlights who is conducting such assessment or inventory, in which context they have been developed, what are their respective objectives, etc.

i. Existing templates and procedures

Reuse inventory, as part of the Vade-Mecum, Rotor, 2015.

Assessing the reuse potential of the components of a building is a crucial step, as it determines the most adequate procedure (or whether a procedure should be undertaken altogether). The Vade-mecum proposes a two-step process:

[54] The clause is available online: http://vademecum-reuse.org/annexes/Annexe_4_charger_auteur_de_projet_de_dresser_l_inventaire.pdf

[55] https://www.mvicriteria.nl/en

[56] One of them concerns an award criteria relating to products reused in new constructions. Since the field is related to the integration of reused products and not to their extraction, the report does not elaborate further the content of this criteria.

[57] BRL SVMS-007 also stipulates requirements for the manner in which a tender is submitted. To this end, a work application assessment should be conducted and, if possible, a list of materials should be drawn up in advance. The work application assessment, together with a declaration that the work will be done according to BRL SVMS-007, constitute elements of proof. The tenderer may also hand over a certificate. The register of all certified demolition companies is also available. Additionally, there is a list of certification bodies. Both national and foreign businesses can apply for a certificate from these bodies (several certifying bodies are active throughout the whole European Union).

1. First, a **light assessment** is carried out to allow the building owner to evaluate if - and to what extent - organizing a salvage operation is relevant in the considered building. The Vade-mecum invites the assessor to adopt a curious and cautious approach for this step. Curious, so as to carefully investigate the reuse-potential of the building; and cautious, so as not to go too fast and point out elements that are ultimately impossible to reuse. As a general advice, it is recommended to take contact with professional reclamation dealers. On the basis of a very brief description and a few pictures, these are often able to estimate whether given construction elements from a given building are worth salvaging. In the end, the 'reusability' of an element is defined by the existence of a demand for it. This demand depends a great deal on the existing reuse market[58]. Being in perpetual evolution, the reuse market for construction elements does not make it possible to list the elements that would be *always* reusable. On top of that, the context of each building has also to be taken into account: the timing, the general state of the building, the types of elements it contains, their quantities, etc. are among the many factors likely to affect the desirability of a salvage operation - and its level of ambition. Clarifying this situation is precisely the role of this first assessment.
2. If the first assessment leads to positive conclusions (i.e. the building does indeed contain construction elements that are worth salvaging), a **more detailed inventory** is produced. The Vade-mecum assumes that any building owner is able to conduct such an assessment. To help them in this operation, the Vade-mecum offers a template[59] and a 5-pages manual on how to conduct an inventory. It answers most of the frequently-asked-questions[60]. In case the building owner does not wish to establish this inventory internally, the Vade-mecum suggests to mandate the architect to undertake it, and details a procedure to do so (cf. supra).

The detailed inventory takes the form of a spreadsheet. The different rows refer to the different elements that are identified as potentially reusable, whereas the different columns refer to different information that should be collected:

- A good picture of the element
- An identification number
- A reference to a package (and a possible sub-package). A package is a group of similar elements. For instances: a series of doors. It can be further divided in sub-packages, for instance: wooden doors and metallic doors). This reference is used to facilitate the communication with the tenderers and the elaboration of the bids.
- Quantity and unity.
- Dimensions.
- Type, brand, technical denomination…
- Date of implementation.
- Location in the building.
- Specific dismantling precautions.
- Other remarks.

It is recommended to fill in as much information as possible, while finding the right balance between the degree of details in regard with the general objectives and the complexity of the operations. The tutorial specifies which information is indispensable, and which is optional.

[58] The demand can also come from a refurbishment project on the same site. In this case, a good coordination between the architect, the building owner and the contractor is crucial to guarantee the success of the operation.
[59] http://vademecum-reuse.org/annexes/Annexe_1_Inventaire.xls
[60] How to conduct a reuse assessment: http://vademecum-reuse.org/annexes/Annexe_3_dresser_inventaire.pdf

If the tendering authority decides to organize a specific tender for the deconstruction of reusable elements, three additional columns are required:

- Unit weight
- Total weight
- Price fixed by the tendering authority to extract the whole package

The Vade-mecum indeed suggests to use the quantity of effectively salvaged elements as a criteria to retain a tenderer among the different bidders. Expressing the mass of the packages allows here to compare the bids.

The Vade-mecum invites the building owner to export the spreadsheet as a pdf file. It makes it easier to join it to the contract documents and/or forward it by mail. It is also suggested to join additional pictures of the different packages.

The Vade-mecum inventory template has been used in many different contexts for many different types of buildings, mostly in Belgium.

Bellastock's Resources diagnostic (*Diagnostic ressources*), 2014.

The resources diagnostic (*diagnostic ressources)* procedure has been developed by Bellastock in collaboration with many stakeholders (CSTB, project managers, test labs, technical engineers, environmental specialists, architects, technical controller, construction and demolition companies). The outcome (the general diagnostic methodology) is intended to be used by architects, building owners and regional authorities.

The 'resources diagnostic' (diagnostic resources) can be thought as a complement to the mandatory waste assessment (*diagnostic déchets*) enforced by French regulation. It suggests nonetheless a paradigm shift inasmuch as it considers that the matter set free by a demolition should be considered as a potential resource and not as waste to be discarded. This entails a broad cultural shift among the whole construction industry and society in general.

Although the 'resources diagnostic' (*diagnostic ressources)* is applicable in a large variety of contexts and can therefore take several forms, Bellastock underlines 3 main typologies of diagnostic:

- A **building inventory**, aiming to determine the reuse potential of the building elements and suggesting a list of operators that are likely to acquire the construction materials (e.g. reclamation dealers). The format of this type of diagnostic is variable. It can be kept relatively light for quick assessments (a simple identification of the reuse potential) or be developed more thoroughly (including decision-making tools and specific recommendations).
- A **building inventory coupled with an objective of direct reuse** in an identified construction operation (on the same site or in another project). This diagnostic is thus context-dependent. The identification of reusable elements is never considered *in abstracto* but in relation with an application in a given ongoing architectural project. In this sense, architectural innovation is considered in the research and expertise program REPAR[61] projects as a strong leverage to stimulate the reuse of specific construction elements (including very innovative and unconventional approaches). In other words, the reuse potential is often

[61] REPAR is a research and expertise program on reuse in construction, led by Bellastock in partnership with ADEME and CSTB. It presents the method established by Bellastock to implement reuse, in a project-by-project and general upscaling logic. The program consists of 2 parts: REPAR #1 which studies the upstream part of a reuse chain in construction, i.e. collection, in a complex case of selective demolition, and REPAR #2 which studies the downstream side of the supply chain: how to consider the architecture project as an outlet for reuse products in construction?

assessed in regard to the needs and opportunities of a specific project. In return, architects are invited to think and design their projects so as to open up reuse opportunities.

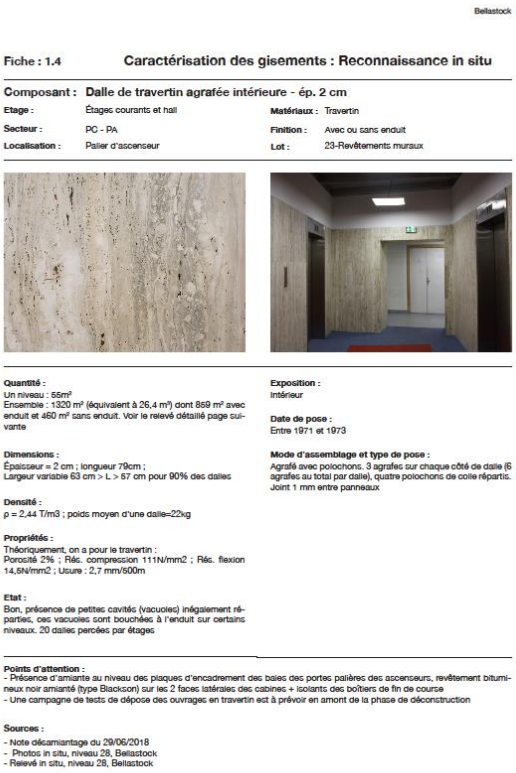
- A **territorial 'resources diagnostic'** (*diagnostic ressources)*, which objective is to organize the emergence of reuse process chains in a geographical area. In this case, the term 'resources' refers to material but also human and infrastructural resources. Regarding materials, different buildings are inventoried to identify the most recurring construction elements and match them with ongoing or planned construction operations. This approach is an attempt to develop metabolic synergies between the existing building stock and planned operations at an urban scale.

Because these approaches potentially cover the whole chain of operations, from very upstream (identification of reuse potential) to very downstream (integration in a new architecture project), the resources diagnostic cannot be limited to a general identification of a generic reuse potential. It may have to embed many additional considerations such as the technical fitness-for-use of the identified elements, the consequences in terms of the organisation of the work between the different operators (contractors, engineers, architects, etc.), the logistical aspects of the operations, etc. All these issues are addressed in a feasibility study.

In general, the methodology proposed by the resources diagnostic consists in the following steps:

- A **first inventory** is conducted on site to identify the main characteristics of the construction elements (chosen[62] by the operator leading the diagnostic) and their quantities, coupled with an out site analysis of the existing documents informing the building. This approach can be supplemented by further research and analyses (in labs, in the technical literature, etc.). For each material, a *characterization form* is produced (see fig. 5 below).
- This inventory leads to list a series of **possible uses** and functions for which these elements are fit to be used. For each field of use, a *fields of use form* is produced (see fig. 6 below: front page document).
- The inventory and the reuse suggestions can be complemented by recommendations on how to dismantle, process, condition and implement the elements so as not to alter their characteristics and to respect the current regulations.
- Last but not least, the building owner or the architect can also ask for a **general feasibility study** assessing the economic, logistical and environmental barriers and opportunities.

[62] Based on an assumed potential of reuse. The in site inventory is often preceded by a quick analysis of the reuse potential via photographs given by the commissioner, that gives a first intuition. It is nevertheless customary for the protagonist to identify new reusable materials during the visit.



Bellastock

Fiche : 1.4 **Caractérisation des gisements : Reconnaissance in situ**

Composant : Dalle de travertin agrafée intérieure - ép. 2 cm

Etage : Étages courants et hall
Secteur : PC - PA
Localisation : Palier d'ascenseur
Matériaux : Travertin
Finition : Avec ou sans enduit
Lot : 23-Revêtements muraux

Quantité :
Un niveau : 55m²
Ensemble : 1320 m² (équivalent à 26,4 m³) dont 869 m² avec enduit et 460 m² sans enduit. Voir le relevé détaillé page suivante

Dimensions :
Épaisseur = 2 cm ; longueur 79cm ;
Largeur variable 63 cm > L > 67 cm pour 90% des dalles

Densité :
ρ = 2,44 T/m3 ; poids moyen d'une dalle=22kg

Propriétés :
Théoriquement, on a pour le travertin :
Porosité 2% ; Rés. compression 111N/mm2 ; Rés. flexion 14,5N/mm2 ; Usure : 2,7 mm/500m

Etat :
Bon, présence de petites cavités (vacuoles) inégalement réparties, ces vacuoles sont bouchées à l'enduit sur certains niveaux. 20 dalles percées par étages

Exposition :
Intérieur

Date de pose :
Entre 1971 et 1973

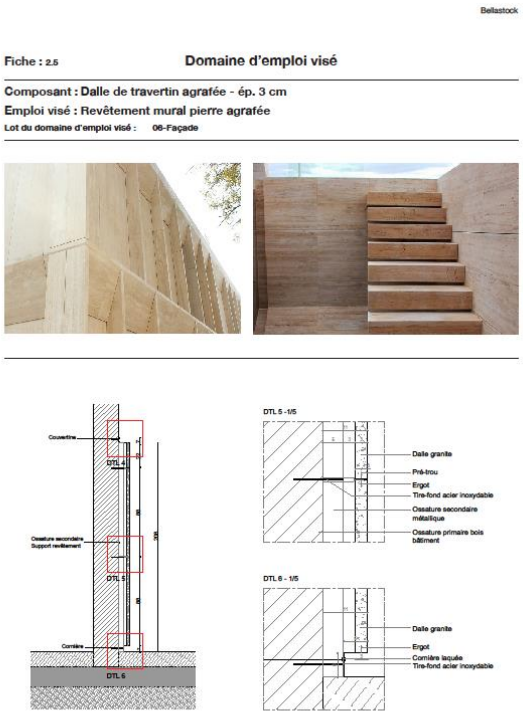
Mode d'assemblage et type de pose :
Agrafé avec polochons. 3 agrafes sur chaque côté de dalle (6 agrafes au total par dalle), quatre polochons de colle répartis. Joint 1 mm entre panneaux

Points d'attention :
- Présence d'amiante au niveau des plaques d'encadrement des baies des portes palières des ascenseurs, revêtement bitumineux noir amianté (type Blackson) sur les 2 faces latérales des cabines + isolants des boîtiers de fin de course
- Une campagne de tests de dépose des ouvrages en travertin est à prévoir en amont de la phase de déconstruction

Sources :
- Note désamiantage du 29/06/2018
- Photos in situ, niveau 28, Bellastock
- Relevé in situ, niveau 28, Bellastock

Fig. 5 – Example characterization form.
Source: Bellastock

Transl.: Component/ Localisation/ Material/
Finishing/ Lot
Quantity/ Dimensions/ Density/ Characteristics
Condition/ Exposure/ Installation date/
Assembly mode



Bellastock

Fiche : 2.5 **Domaine d'emploi visé**

Composant : Dalle de travertin agrafée - ép. 3 cm
Emploi visé : Revêtement mural pierre agrafée
Lot du domaine d'emploi visé : 06-Façade

Fig. 6 - Example Fields of use form (front page).
Source: Bellastock

Transl.: Intended field of use
Component/ Intended use/ Lot

Complemented by, in this case (next page of form):
- Characterization of the work component
- Requirements
- Complementary studies/ Sources
- Dismounting recommendations
- Preparation recommendations
- Installation recommendations

Brussels Environment's Material Flow Inventory, 2018.

The Material Flow Inventory (*Inventaire flux matériaux*), which is still under development, has been applied in a few case studies within the framework of the *Be Circular* call for projects (cf. supra 2.2), in particular as a support initiative to experiment more actively with the dismantling and reuse of construction materials. In the latter perspective, the tool is intended to stimulate the building team (architect and contractor) to assess the reuse potential for each material entering and exiting, prior to demolition. The tool is also currently used for statistical purposes (quantitative inventorying of material flows) and comparative analysis of projects (post-project phase).
Within the intention to help contractors in the management of their sites, both in terms of practical organization and economical aspects, the tool is thus oriented towards pre-demolition audit aims and/or to a follow-up activity of the material flows of the ongoing project.

The Material Flow Inventory consists in an elaborate set of calculation tables, generating summary tables and diagrams. Completing the calculation tables can take from a few hours to a couple of days, depending on the size of the project. The two successive steps are:

1. The user (either the architect during the conception phase of the project or the construction contractor in the retrofit phase) is asked to provide the **details regarding the (partition)** layers of the existing building (metrics, quality and quantities of every component) and of the projected building.
2. The user describes what **is planned for each layer/material**: is it kept in place, reused (on site or external reuse), or recycled? For incoming materials, the user describes if the will be new or second hand. This step questions the user's intentions and challenges them to think of reuse as much as possible and in a more systematic way.

Quantities are directly calculated from the data input from the first step.

After these steps the tool automatically issues:

- A summary table with each material use in the project: quality, quantities (both in tons and m^3), sources and destinations including (planned or achieved [when post-project]) reuse.
- Diagrams showing the incoming and outgoing material flows with cubage/ tonnage ratio indications by sector (source/ destination) including (planned or achieved [when post-project]) reuse. (see extract below).

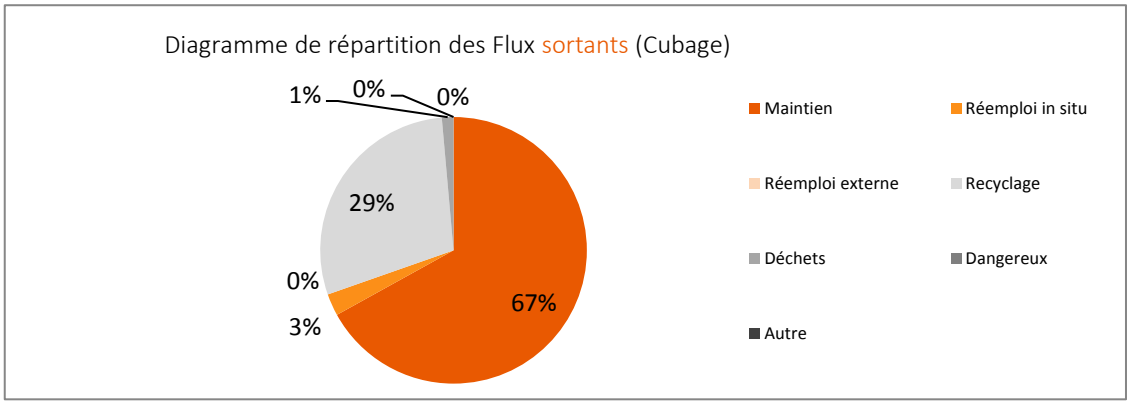


Fig. 7 – Example diagram outgoing flows (cubage). Source: Brussels Environment
Transl. fig.: Outgoing flow extract: maintained/ reuse in situ/ reuse ex situ/ recycling/ waste/ hazardous/ Other; (cubage).

- A table with a description of all the material that will be available for external reuse (i.e. for resell), these elements contributing for assessing interest(s) for effective reuse. The user can then add pictures, a date at which the material will be released/ available, detailed description, price indication, etc.

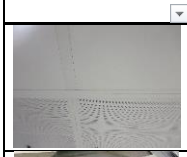
RÉEMPLOI EXTERNE								
INVENTAIRE MATERIAUX - REEMPLOI EXTERNE	QUANTITE DISPONIBLE		DESCRIPTION	PRIX		DISPONIBILITÉS		FILIERE IDENTIFIÉE
Photos	Quantité (kg)	Quantité (m³)	Description détaillée: complément d'informations	Prix	Unité Prix	Début	Fin	Pourcentage de matériaux pour lequelle la filière a été identifiée (%)
								
								

Fig. 8 – Inventory reuse ex situ. Source: Brussels Environment.
Transl. fig.: Reuse ex situ: available quantity (tonnage/ cubage)/ detailed description/ price/ availability periods/ identified channel with percentage of material for which the channel has been identified.

- A table with a description of all the materials that need to be sourced second-hand. Again, the user can add information (dates at which the material is required, etc.).

GRO's In Situ Inventory of Existent Construction Materials, 2017.

GRO is a tool that assesses a building's sustainability performance[63]. It has been developed by the *Facilitair Bedrijf* of the Flemish Region. The tool is currently used mainly to evaluate their own projects, but an eventual implementation in Wallonia and Brussels is an ongoing reflection.

Criteria 'MAT 1 Maintaining material resources' *(Behoud van grondstoffen)* directly addresses directly [64] the inventory of existing materials and elements, which can be integrated into the various stages of a construction project, when it comes to inventorying reusable elements. Under the first aspect of these criteria[65], as to know, 'Reuse of building materials and building elements present on site', an inventory of the materials and elements present must be conducted. This criteria only apply to projects where existing elements or buildings are present, and is not applicable in the case of new construction on an unbuilt site.
The assessment instructions clearly mention that, in some cases, local regulations may require that a pre-demolition inventory is provided. In this case, the content of such an inventory overlaps to some extent with the requirements of the inventory under MAT1 of GRO.

[63] It is structured in a manner similar to tools such as BREEAM in that it is divided into thematic chapters (such as Energy, Materials, Water etc.). Following the completion of calculation templates, scores by criteria are automatically generated. Difference performance levels are available, and bonus criteria can be awarded.
[64] Criteria MAT 2 Choice of materials *(Materiaalkeuze)*[64] and Criteria TOE 1 Circular and future-proof design *(Circulair en toekomstgericht ontwerpen)* are linked with reuse-aspects. However, as they do not directly address the inventory of existing materials and elements, they aren't further developed here.
[65] The scope of this criteria covers 2 aspects: Reuse of building materials and building elements present on site (*Hergebruik van in situ aanwezige bouwelementen en –materialen*)/ Closed cycle for earth excavation (*Gesloten grondbalan*). The second aspect 'Closed cycle for earth excavation' is related to inventorying excavated earth. As this aspect doesn't belong to the objective of the project, it will not be detailed here.

GRO provides the user with an inventory template in Excel-format (partial screenshot below).
All elements and materials present on site must be listed. Different categories are provided, ranging from 'Foundations' to 'Site'. Volume, weight and number of units per element/material must be filled in.

MAT1 Inventaris in situ aanwezige bouwelementen en -materialen

Resultaat						
	uitstekend	≥ 40% hergebruik	Hergebruik op locatie	70,00%	70,00%	100% van hergebruik op locatie
	beter	≥ 20% hergebruik	Afvoer naar elders	30,00%	0,00%	50% van hoogwaardig hergebruik elders
	goed	≥ 10% hergebruik		100%	**70,00%**	**Aandeel hergebruik**
	Bonuspunt	≥ 75% hergebruik	**Bonuspunt (≥ 75% hergebruik)**	**0**	**uitstekend**	**Prestatieniveau**

Identificatie element					Volume				
SfB-codering	Benaming element	Type/merk/afmetingen	Foto (verwijs/link naar foto)	Plaats in het gebouw/op het terrein	Hoeveelheid	Eenheid	m³	kg	%
				Totalen				**40**	**100%**
2	**Ruwbouw**							**40**	**100%**
22.11	VOORBEELD: Niet-dragende binnenmuur	15 cm kalkzandsteen		volledig gebouw	268	m2	37,5	40	100%

Fig. 9 – Reuse inventory format GRO. Source : https://do.vlaanderen.be/documenten-gro

Then, the inventory template requires specifying per element or material:

- its condition (ranging from 'excellent' to 'very poor quality / to be demolished');
  The provided inventory template refers to the Dutch standard NEN 2767[66] for its condition assessment measurements, which is an assessment tool to record the technical condition of the built environment.
- its projected reuse, 3 options are given: 'maintained', 'deconstructed and reused on site', and 'partially reused';
- the end of life scenario (for all materials that are not maintained or reused in situ), for which 4 options are given ('high value reuse off site', 'recycling', 'incineration' and 'landfilling'). If an element or material's EoL-scenario is either 'recycling', 'incineration' or 'landfilling', the user must provide an explanation of why the element or material cannot be reused.

Calculation platform: Reuse potential assessment tool BAMB[67], 2019

The Reuse potential assessment tool BAMB is developed in the framework of EU-project Buildings as Material Banks. The main purpose of the tool is to enable the assessment of the reuse potential of building structures - at the system and component level - in order to foster high quality recovery and reuse, and preserve the value of the building, its components and materials.

The Reuse Potential Tool addresses the performance of product structure (arrangement of elements within a structure) with respect to their reversibility. In particular, the ability to separate materials and reconfigure the product structure without damaging materials and creating waste has been analysed and assessed. Over the course of the H2020 BAMB project, design requirements for a high reuse potential (as part of the reversible building design), have been established based on case studies, desk research and previous experiences of the authoring experts. Desk

[66] The Dutch standard for assessment of buildings' condtiontion was published in 2006. The method intends to guide the implementation of rigorous and independent technical building assessments. The assessment is based on the detection of defects in functional elements, and on the definition of their importance, extent and intensity. (Vilhena, A., Branco, P. & de Brito, J. 2011)
[67] https://www.bamb2020.eu/. Buildings as Material Banks is a project funded by the European within Horizon 2020 program within the EU Research and Innovation, whose objective is to enable systemic change in the construction sector by creating and developing "circular" solutions.

research included a state of the art analysis of barriers and opportunities for implementing reversible buildings in four countries: the Netherlands, the United Kingdom, Belgium and Bosnia and Herzegovina.

The Reuse Potential Tool can be used by multiple users during different design stages. The Reuse Potential Tool consists of a report that describes the different reversible building design indicators, as well as an Excel file that enables the calculation of the reuse potential of different elements and systems based on a quantitative scoring of eight reversible building design indicators: functional independence, systematization, hierarchy, 'base element' specification, life cycle coordination, assembly sequences, type of connection and geometry.

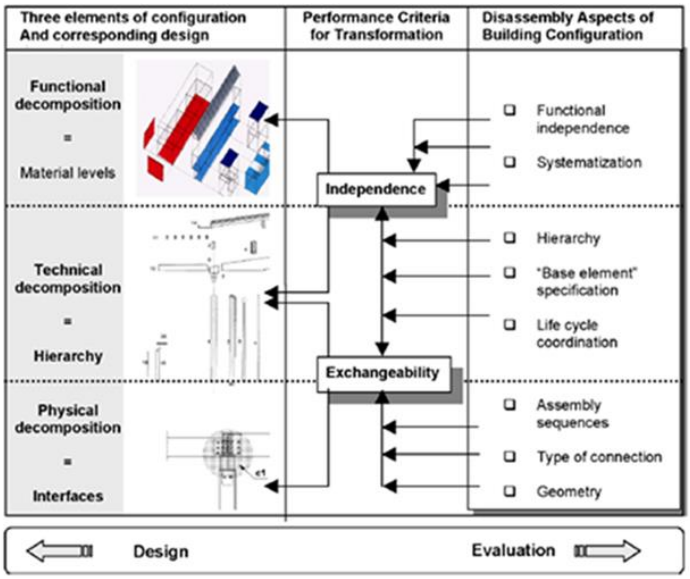


Fig. 10 - Reversible building design factors. Source: BAMB project.

If the tool is mainly designed with a view to assess the reuse potential in design stages and to identify points of improvements to increase reuse potential, using the tool for the assessment of the reuse potential of existing buildings is not excluded. The tool than can notably help interveners to get a better understanding of a building composition, the recovery potential of elements and provide information on the deconstruction process regarding the possible deconstruction steps. For this specific use, as to know, assessing the reuse potential in an existing building, it is nevertheless necessary that elements can sufficiently be documented by providing the required information to assess the 8 predefined indicators (see above).

The calculation tool used within this application joins reuse assessment tools in the sense of the current concern.

Salvo's practices, evolution

Salvo undertook around 30 of the earliest reclamation audits in the period 1995 - 2010 for clients such as local authorities, community housing associations, institutions, green architects and developers. The first recorded reclamation audit, made by Salvo in 1995 for the BRE (UK Building Research Establishment), resulted in same-site reuse of 80,000 reclaimed bricks in Building 16 which became the BRE's 'Environmental Building' as its 'Energy Efficient Office of the Future'. Despite adapting the methodology, over time in most cases very little was eventually salvaged and reused as a result of Salvo reclamation audits. Lack of advance planning was usually a problem.

In response to the subdued demand for reclamation audits, in the 1990s the printed SalvoNEWS introduced **'Demolition & Dismantling Alerts'** (cf. infra 3.3 ii) by contacting demolition contractors on a regular basis and enquiring whether they had any materials or items which they considered might be of interest to salvage dealers.

Salvo advertised a service for undertaking reclamation audits on its website in 1997. Self-generated demolition and dismantling alerts are still offered now, on SalvoWEB (cf. infra 3.3 ii).

ii. Templates out of the project area

Seattle's mandatory Salvage assessment, 2010

Seattle (USA) is one of the only (if not the only) public authority to have implemented an obligation to conduct a 'Salvage Assessment' prior to any demolition. This enforcement is part of a general effort to encourage diversion of C&D waste from the landfill. It is coupled with *but distinct from* a more general waste diversion plan, which is also mandatory to join to the demolition permit. The authorities, in dialog with various stakeholders, have estimated that conducting a salvage assessment requires a specific approach and depends on specialized expertise and know-hows. It should thus be conducted by a different expert than a more general waste-diversion strategy.

However, Seattle's authorities do not specify who exactly should conduct the salvage assessment. Neither are they expecting any positive results (the assessment can easily conclude that there is nothing worth salvaging in a given building).

In practice, evaluations have shown that the results of such an assessment depend a great deal on who conducts it. The professional reclamation dealers spot at least one batch of material worth salvaging in much more cases than when the assessment is conducted by demolition contractors, general contractors or the building owners themselves.

Building Material Salvage Assessment template, as part of a Deconstruction Guide, 2003

This procedure comes from a report published in the USA in 2003 entitled 'A Guide to Deconstruction'[68]. It is prepared by Bradley Guy and Eleanor M. Gibeau, and targeted at deconstruction managers, supervisors and workers conducting deconstructions, as well as salvage dealers. It takes the form of a manual full of practical aspects and empirical feedback.
Section 2 is entirely dedicated to the survey that needs to be conducted before any deconstruction: 'This is an overall survey and can be done in stages to minimize the upfront effort to decide whether deconstruction is a feasible alternative. If the general characteristics of the building indicate its viability for deconstruction, then more effort can be put into a detailed estimate for the purposes of calculating the cost of deconstruction, a time schedule and workforce and equipment requirements, and expected amount and types of salvage' . The guide thus suggests a two-step approach:

1. A first walk through, to assess the general condition of the building and evaluate whether a deconstruction operation is worthy in this case. During this walk through, the surveyor should pay attention to 'basic conditions such as fire damage, water damage, rot, obvious leaks, and possible biological hazards such as bird or rat droppings'.
2. A second walk through (if the first brought positive conclusions), during which a more detailed record of the reusable elements is undertaken. It takes the form of a table. For each element, a picture, a short description, an estimation of the quantity, and an estimation of the costs of the operation is given.

Such an inventory serves different purposes:

[68] Deconstruction Institute (Bradley Guy, Eleanor M. Gibeau), *A guide to deconstruction*. January 2003. Available online: http://www.fairmontwv.gov/DocumentCenter/View/1394/A-Guide-to-Deconstruction?bidId=

- It allows the deconstruction contractor to make a cost estimate of the operation and bid to the building owner. It has to be mentioned that, in the U.S., there is a well-established distinction between classical demolition companies and deconstruction contractors. The former proposes to tear a building down to clear the area, usually very fast and with destructive means. The demolisher charges the building owner for such a mission. The latter also clears the area, but with more careful means. It usually takes more time but does not charge the owner as much because the deconstruction earns a (variable) profit by selling salvaged material. Moreover, if the deconstruction is carried out by a non-profit organization (which is often the case), the owners can benefit from a tax-deduction which usually compensates the length of the works. In this case, the financial estimation also serves to determine the amount of the tax-deduction (this amount is assessed by an independent expert).
- It can be used to track the destination of the different elements coming out of the building and then produce a detailed report to the client or the public authorities (when required).

In addition to this, the manual provides more practical information, mostly concerning health and safety. It also suggests, when needed, to conduct an Engineer Survey to estimate the soundness of the structure. Such an evaluation is important to understand how the building stands and plan the successive steps of the deconstruction process accordingly.

The ReUse People of America's inventory template, 2006

The ReUse People of America (TRP) is one of the largest non-profit organisations active in the salvage and the sale of used building materials in the U.S.A. It has many warehouses and sale points all over the U.S. territory. TRP does not undertake all the deconstruction themselves. They work with certified contractor and provide certification training. Their training manual[69] covers many practical aspects, among which the inventory procedure.

The manual distinguishes different types of inventories, serving various purposes:

- The fixture inventory, which is established prior to any work by a supervisor from TRP. It mostly concerns non-lumber elements that are worth salvaging. It plays a triple role :
    - It is an accurate record of the elements that are going to be salvaged.
    - It alerts the contractor to items that have to be carefully dismantled - beside their presence in the inventory; all the identified elements are marked on site with a sticker.
    - It allows to track the salvaged items, and measures the quantities that are effectively reclaimed - which is helpful to calculate the landfill diversion rate (when required by public authorities) or the tax-deduction for the building owner (when applicable).
- The lumber, plywood and other specialized inventories. These are also filled by a TRP supervisor before the start of the works. They concern specific items (lumber, plywood, bricks, pavers), present in large quantities in the buildings. The effective quantities are calculated after the elements have been cleaned and conditioned (de-nailing, sorting, cleaning, etc.), which usually happens at a TRP warehouse.

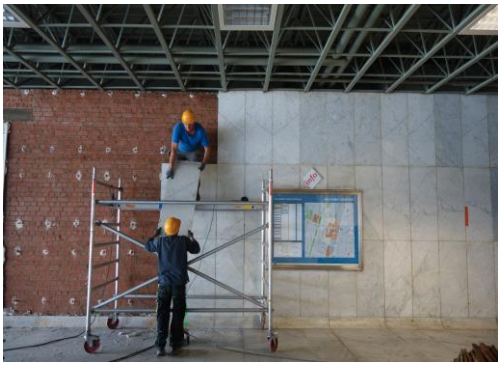
The form of the table provided in annex reflects the type of buildings on which TRP usually intervene. They mostly work with domestic buildings that are usually built with wooden-frame rigidified by plywood-like panels. Generally speaking, the salvage of lumber is well developed in the U.S. It is not that surprising that a specific inventory is developed to assess and monitor such elements.

[69] The ReUse People of America, Inc., *TRP Certified Deconstruction Contractor Manual. Part 1: Classroom training*. Oakland, 2006.

iii. Digital tools

Rotor DC's in-house app

Rotor DC (or Rotor Deconstruction) is a company that emanates from Rotor. Launched in 2016, it sells reclaimed construction elements. These are deconstructed in buildings under transformation, and then prepared for reuse at Rotor's DC facilities. Rotor DC also proposes related services, such as reuse inventories. Therefore, since 2016, together with Rotor, Rotor DC has developed an in-house application that is entirely dedicated to the conduction of reuse assessments.



This app is running on tablet and portable devices. It is used by Rotor DC's employees when visiting a site. These visits are usually conducted by collaborators who have built up a specific insight through prior experiences and a good knowledge of the reuse market. However, the app also assists the surveyors in guiding their attention to a series of details, such as the location of the identified materials in the building, their dimensions, etc. The app also allows to directly take pictures of the elements.

After the visit, the app generates a list of all the identified elements. This can be used either internally, with the rest of the team (to anticipate the logistics of dealing with new arrivals at the shop, for instance), or externally, with the commissioner. Such a list helps to decide whether a salvage operation is desirable - and under what form. The type and amount of information surveyed on site depends a great deal on the context, the commissioner's request, and the complexity of the operation.

This application has been developed on Filemaker Pro[70], a software for developing and managing database which is relatively easy to handle. It is developed by two collaborators of Rotor with fairly limited resources.

Overview of the inventory application

The start menu (see fig. 11)

Starting a visit in a new building triggers the creation of a new database, which will store all the data related to a given building. Three options are available to the user, corresponding to three phases.

Fig. 11 - Start Menu

- Phase 1: Data input. (see fig. 12).

[70] https://www.filemaker.com/fr/products/

This corresponds to the acquisition of data in a specific building.
The app allows to easily edit existing items (to update quantities when the same element is encountered at different places in the building, for instance).

It also allows to create a new entry and feed it with related information. At minima, just a name or a picture is sufficient to create an entry. But it is also possible to survey other aspects, such as the exact location in the building, the estimated quantities, the weight and size, the presumption of hazardous substances, etc.
This information is mostly useful to anticipate the organisation of the further salvaging operations. Each entry can be classified under a category (plumbing, lighting fixtures, furniture, partition walls…), that facilitates the sorting of entries later on.

Fig. 12 – Data input

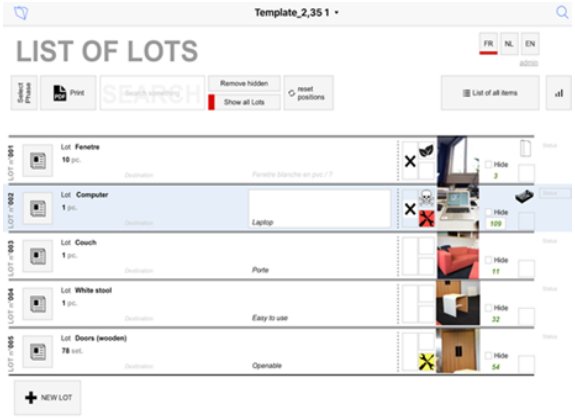


Fig. 13 – Reorganize data

- Phase 2: Reorganize data (see fig. 13)

This option allows to edit encoded data or to add information to existing entries.

- Phase 3: Publication (see fig. 14)

This part allows the user to export a proper deliverable which can be used internally or transmitted to the commissioner. It also allows to export the data in a spreadsheet, so as to enable further modifications.

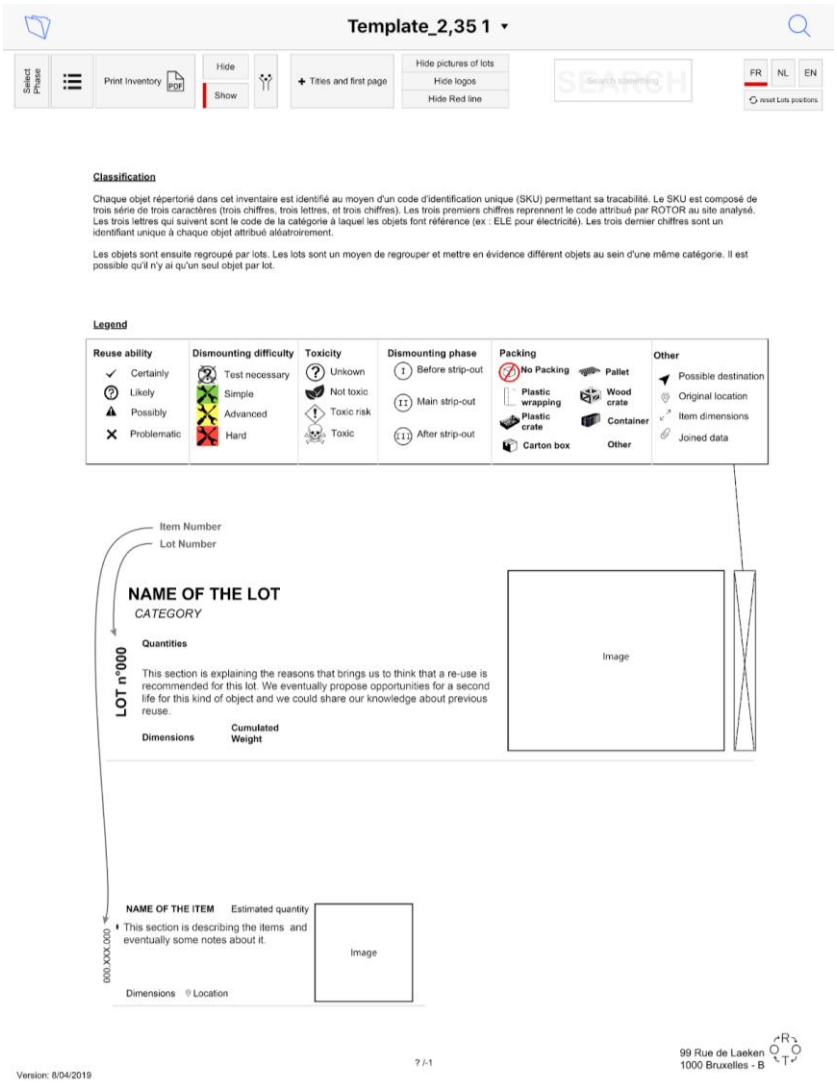


Fig. 14 - Publication

Actual daily use

This tool has been developed to meet the specific needs of Rotor and Rotor DC's teams. It has been kept as light as possible, with a focus on the most essential features.

It is interesting to mention that Rotor DC's main source of profit comes from the sale of reclaimed materials. In this context, there is a balance to find between the time spent on the inventory, the general costs of the operations and the expected sales incomes. It can be useful to spend some time on a very detailed inventory if this information helps to make the salvage operations more efficient. In this case, the evaluation of the degree of detail is let to the surveyor's estimations.

But there are also some contexts in which the clients are willing to get a more exhaustive assessment of the potentially reusable materials present in their buildings (as part of their commitment to more sustainable models, for instance). In this case, this mission is covered by a dedicated fee, which allows a much more thorough assessment (depending on the size of a building, it can take between a couple of hours to a few working days).

The application developed by Rotor and Rotor DC allows to meet the requirements of a variety of contexts. This versatility is probably its best asset. When used only internally, the level of detail can be kept minimal. The teams are indeed used to the routine of salvaging, and need only basic information to work fluently and efficiently. If the list of identified elements must be used as part of a contract with the building owner, the application allows to produce a better outlined and a more detailed list of elements. And if the client requires a thorough inventory, the apps allows to collect more information and export it to a desktop computer so as to produce a more exhaustive document, possibly completed with the explanation of more detailed reuse strategies.

Development prospects of digital technologies for reuse assessment procedures

Nowadays, there are many digital techniques and tools for conducting material assessments in existing buildings.

Regarding the possibilities of digitalization in the field of reclamation assessments, automatically acquiring and managing information on building elements (record, analyse, reconstruct and store the building digitally) are dominant aspects.
Laser scanning, photogrammetry, 3D photography, drones, BIM, deep learning, spectrometers, 3D reconstructions, object detection, etc. are all fast-developing technologies, which are notably used to identify and quantify building elements.

Digital techniques and tools are also currently used to conduct pre-demolition audits (waste management), in particular to identify and quantify building elements or to recognize contaminants or hazardous materials. They are also used in heritage contexts to acquire information on elements that should be restored.

In the near feature, such tools might serve reuse assessors.

3.3 Resources concerning other aspects related to reuse assessments.

In specific contexts, the reuse assessment is not limited to identifying (and quantifying) relevant construction elements in an existing building. It can also be used to anticipate further aspects that influence the possibility to effectively reuse the construction elements, such as confirming their technical fitness-for-use, suggesting possible alternative uses, identifying possible destinations, etc. This category groups examples of such procedures that can be coupled with a reuse assessment.

i. Assessing the technical performances of reclaimed construction elements

Bellastock's assessment procedure

As mentioned supra (cf. supra 3.2.i), Bellastock's resources diagnostic (*diagnostic ressources*) does not only serve to identify a reuse potential in an existing building, it also suggests prospective ideas on how the identified elements could be reused in a given project. In this sense, the diagnostic may have to address the question of the fitness-for-use of the reclaimed construction elements.

This question is always examined in regard to the new use, which can either be similar to the first use or different. In any case, the adequacy of the element must be considered in accordance with the requirements related to the new application. In this sense, the diagnostic never separates the material from its intended use.

Basically, the requirements are related to the material itself but also to the execution of the work it is going to be part of. The fitness for use is studied through the following criteria:

- Dimensional characteristics. They can be adapted to respect the regulation and normative context.
- The required performances (mechanical performances, reaction to fire, resistance to thaw and frost cycles, etc.). They can be evaluated by testing materials in laboratory.

CSTB's assessment procedures

CSTB has worked on a generic procedure to assess the technical fitness-for-use of building components[71]. The main steps are:

- Characterize the building component: year of the building permit, year of the implementation, technical description of the product, quantity, access, etc.
- Define the initial use of the component: current use in the existing building, location in the building, building type (according to fire regulations), humidity exposure, and other solicitations.
- Identification and classification of the different performances that need to be assessed: those that are unavoidable (enforced by current regulations or linked to people's security), those that are important for the new intended use, and other relevant characteristics (colour, etc.).
- Identify relevant procedures to demonstrate the fitness-for-use for each performance identified at the previous step. Three general procedures are proposed: an historical approach to find the initial characterization of the element, on site controls (visual or with portable technical means), and sampling and laboratory tests.
- Detail the precautions that need to be taken so as not to alter the elements and maintain their fitness for use during their deconstruction, transport, reconditioning and future implementation.

This procedure puts an important emphasis on the reuse assessment. At this moment, it is possible to identify a series of useful information concerning the fitness-for-use of the identified construction elements in regard with their intended new use.

BBRI research as part of BBSM[72]

BBRI is currently working a methodology to assess the fitness-for-use of reclaimed building elements. This work is undertaken as part of the Brussels-bases ERDF project 'Brussels' Buildings: Source of future Materials' (*Le bâti bruxellois, source de nouveaux matériaux)*. The methodology that is proposed there relies on the collection and the transmission of information about a specific construction element at the different steps of its reuse process. Among these steps, one plays a crucial role: the examination of the conditions of the element when it is still implemented in the building of its first use.

This is where the reuse assessment comes into play.

[71] CSTB, Circolab, *Fiche méthodologie/process diagnostic pour réemploi des produits de construction*, juillet 2018.

[72] ERDF BBSM project, the Brussels building, source of new materials, is a project financed by the European Regional Development Fund. Regional project bringing together several partners (UCL, VUB, Rotor asbl, BBRI and a series of actors active in re-employment in Brussels) whose objective is to enable a systemic change in the construction sector by creating and developing in RBC sectors for the recovery (recycling and reuse) of construction materials.

The method proposed by BBRI takes advantage of this first assessment to check the general state of the element and to verify whether it has been implemented in accordance with technical standards, good practices or other regulatory requirements in effect. BBRI's method recommends to only deconstruct and salvage elements for which it can be demonstrated that they were not damaged by a poor implementation during their first use - the rightness of the implementation being demonstrated here by a compliance with all the technical standards in effect.

On the top of this verification, BBRI's methodology also suggests to take advantage of this first assessment to collect as much information as possible on the considered elements: their general state, their origin, their history, etc. Keeping this information linked with the element will facilitate the evaluation of its fitness for use in a new construction project.

*

The three procedures outlined above have in common to assess the performance of reclaimed building components through the assessment of the successive steps of its reclamation - an approach in which the first assessment thus plays a crucial role. They all start with a characterisation of the product in place. They all are possibly supplemented by looking back to the moment of the initial production of the elements and their first implementations. Finally, they all provide a framework of recommendations for keeping the elements intact during the next phases, down to the new use (deconstruction, transport, stock, conditioning, etc.).

It appears that the technical fitness-for-use of the reclaimed elements is here demonstrated by observing simultaneously the construction product itself (i.e. the intrinsic characteristics that can be known) and the operations it undergoes (and, by extension, the operators who conduct them). It diverges from the classical industrial quality control, where the intrinsic characteristics of a product at the end of the production chain can be precisely stated, and are sufficient to define the framework of responsibility between all the involved operators (producer, architect and contractor).

Consolidate this approach for reclaimed building elements would help to clarify many questions concerning warranties, product liabilities, responsibilities, and ultimately insurances. It appears that the reuse assessment and the reuse assessors are likely to play an important role in this topic.

ii. Finding reclamation dealers (likely to acquire salvaged construction elements and ensure their future uses)

Assessing the reuse potential of a construction element depends a great deal on the existence of a demand for it. The new project can constitute a valuable destination for the deconstructed elements (i.e. in situ reuse). Professional reclamation dealers are another sensible destination. One of their main assets is to take in charge the storage of the elements, which, is often an important barrier that hinder reuse possibilities.

Opalis and SalvoWEB ensure online directories of those reclamation dealers. Their functioning is addressed in present chapter.

Opalis

Opalis is an online directory of reclamation dealers. It started in 2011 with an area limited to 100 km around Brussels. Since then, Opalis has benefited from diverse public subventions that allowed to expand its covered territory. The Interreg NWE project FCRBE will allow to cover an even bigger area, with an objective of 1.500 documented

reclamation dealers active in Belgium, France, Ireland, Luxembourg, The Netherlands and the United Kingdom by the end of 2020.

The main goal of Opalis is to give visibility to existing professional reclamation dealers. Each business is documented with practical information about the construction products it sells and the services it provides.
These can be helpful resources when it comes to conduct a reuse assessment.

First, these professional reclamation dealers generally have the know-hows and the capacities to conduct reuse assessments. Even if they are not in charge of said assessment, they can still be contacted in early phase of the process to evaluate the reuse potential of an existing building. Usually, even a few pictures of a construction material are enough to estimate whether a salvage operation is worthy. Opalis can also help to spot the adequate reclamation dealers depending on the construction elements that are considered and their respective locations.
Then, more generally, these companies are an excellent destination for reusable construction elements that are set free during a demolition. Because these dealers usually have a very good insight on the trade; possess the infrastructure to stock, process and condition correctly the elements; have an established customer base… they often constitute the most effective and the most comfortable way to keep a construction element in circulation and find it a new use.

SalvoWEB

Salvo compiled its first printed directory of dealers in 1991, mainly UK but including a few countries in Europe and elsewhere. The directory was established online in 1996 at the same time as it started a dealer code of conduct, known as the *Salvo Code,* for good practice in stock purchasing. Both the code and directories are continually updated. There are now approximately 2,000 businesses listed in the FCRBE area (including the whole of France). The directories are maintained by Salvo on a rolling basis which means that at any time some of the entries are not accurate. Readers are asked to inform Salvo of changes of address or businesses which appear to have ceased trading to which Salvo responds by investigating and amending the listings.

The current listings are broadly split into traditional architectural antique and reclaimed building material dealers, and more modern salvage, scrap and recycling dealers. Of the former there are 870 UK, 745 France, 52 Holland, 19 Belgium, 87 Ireland. Of the latter there are 146 UK, 91 France, 1 Holland. Salvo lists 'Reclamation-Friendly' and other allied businesses which may be designers or repairers whose local knowledge could be useful to someone who is deconstructing a building. These businesses have not been included in the totals above.

SalvoWEB has a free system for demolition and dismantling alerts which can be used by dealers, demolition contractors, private consumers, institutions, local authorities and government agencies in the UK and other countries. This differs from SalvoWEB's normal 'for sale' pages in that it must be stated that the items are in-situ and the ad cannot contain sale prices or other sale information. SalvoWEB's normal sale items for non-trusted users must include a photograph of the item dismantled and available for sale. Trusted users can show items in-situ prior to demolition or dismantling in normal 'for sale' ads.

There are two reasons why this system evolved. Firstly, it was important that Salvo had a system to allow disposers of potentially reusable building elements or materials to assess the market by alerting (mainly) dealers and other possible reusers to the fact that these materials would become available. It allows disposers of material to assess the market and results in more being saved.
Secondly, registered users are not allowed to post pictures of items in-situ on the regular 'For Sale' pages because this could allow (and was occasionally used for) someone who had photographed an empty building to obtain an agreement to buy, by an innocent third party. Using the demolition alert system means that this is much less likely to occur.

Salvo informs that caution needs to be exercised with advertising demolition alerts. Salvo staff moderates all ads usually every four to eight hours every day. No demolition alert is circulated by email until it has been moderated. Most users simple add a 'Demolition or Dismantling Alert' without asking Salvo for advice. For those which do ask Salvo suggests that the industry norm is for around 40% of the materials to find a local market of small buyers if the disposer makes full use of all methods to disseminate the information - including signs on the building itself, the local newspapers, signs in corner shops and stores locally, signs in friendly builders merchants, contacting local builders, developers, social housing admins and so on. The remaining 60% need to be placed with big commercial dealers who will take large quantities at a much lower price and then resell into markets relevant to them, which might mean materials being sent abroad so incurring a higher CO2 cost in transport.

The underlying assumption that if an item is reclaimed, marketed and then bought that it will be reused (eventually) is only correct in an (unknown) percentage of sales (unless the seller is tracking the reclaimed goods after the sale has been made).

The better an item can be tracked through the whole process from demolition to reuse, the more accurate will be the carbon and other environmental benefits, and social and economic benefits.
And only after these are known can the success or failure of its reuse be measured.

Variety in digital platforms

It has to be mentioned that there are many digital platforms on which it is possible to publicize the availability of specific construction elements[73]. Many exist.
Werflink[74], Harvestmap (*Oogstkaart*)[75] and Cycle up[76] are examples from Belgium, Dutch and French origin.

They follow their own and diverse operating and business models. In order to know or confirm their more specific and respective objectives, it would require a more detailed analysis.

As this topic is not the direct subject of this deliverable, the choice has been made not to elaborate further on this point in present report.

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[73] Dethan, G. "On a testé pour vous toutes les plateformes numériques de l'économie circulaire et le grand gagnant est ….", Article posted on Linkedin, on 27 April 2018. Available online: https://www.linkedin.com/pulse/test%C3%A9-pour-vous-toutes-les-plateformes-num%C3%A9riques-de-l%C3%A9conomie
[74] https://www.werflink.com/
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4. ABOUT THE FCRBE PROJECT

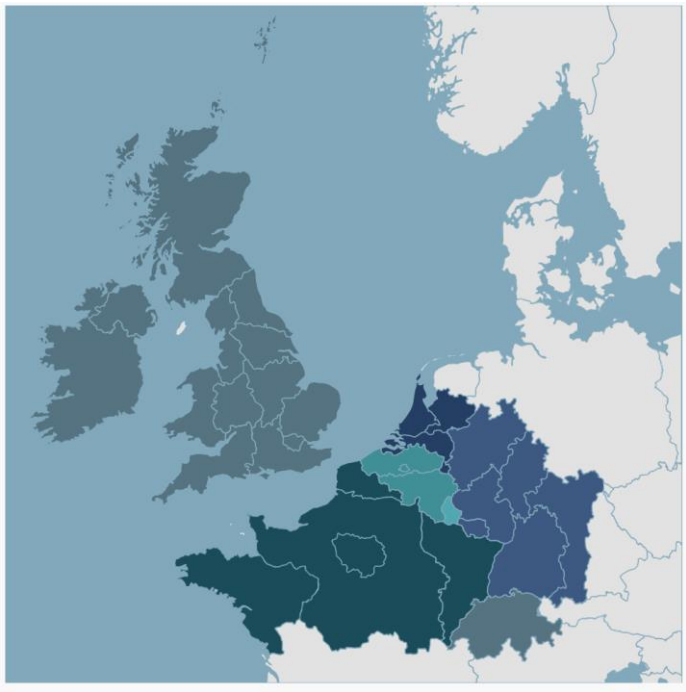
@Today in NW-Europe, only 1% of building elements are reused following their first application. Although a large number of elements are technically reusable, they end up being recycled by crushing or melting, or disposed. The result is a high environmental impact and a net loss of economic value.
This project aims to increase by +50%, the amount of reclaimed building elements being circulated on its territory by 2032.
Focusing on the northern half of France, Belgium and the UK, the project also covers, with a lesser intensity, the Netherlands, Ireland, the rest of France and Luxembourg. This area houses thousands of SMEs specialized in the reclamation and supply of reusable building elements. Despite their obvious potential for the circular economy, these operators face significant challenges: visibility, access to important projects and integration in contemporary building practices. Today, the flow of recirculated goods stagnate and may even decrease due to a lack of structured efforts.
To respond appropriately to these challenges, the project sets up an international partnership involving specialized organizations, trade associations, research centers, an architecture school and public administrations. It is rooted in earlier initiatives that were successfully initiated, on a local level.
The project will deliver:

- 1 online directory that richly documents more than 1500 specialized reuse operators,
- 1 pre-demolition audit method for reusable elements,
- a set of 4 innovative specification methods for reclaimed products,
- and more!

These tools will be tested and promoted through 36 pilot operations taking place in large (de)construction projects, whereby more than 360 tons of elements will be reused. Effective communication efforts towards the stakeholders of the construction industry (including public authorities) will facilitate a smooth integration of these outputs into field practices and policies.

Project Area

The Interreg NWE Programme involves Ireland, the United Kingdom, Belgium, Luxembourg, Switzerland, and parts of France, Germany and the Netherlands. It has an area of 845 000 km² and is home to 180 million people. Considered as one of the most dynamic and prosperous areas of Europe, it also faces a number of environmental, social and economic needs and challenges.



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