FutuREuse

Understanding Urban Stocks

Brussels Environnement for

Interreg North-West Europe FCRBE

European Union
European Regional Development Fund

REUSE IN THE CIRCULAR ECONOMY

In the European Union and around the world, construction materials have a massive impact on climate change, ecosystems collapsing and natural resource overconsumption. As a waste prevention strategy, reuse is a great solution to overproduction and natural resource depletion.

Despite its waste prevention potential, the salvage and reclamation trade is largely overlooked, especially in the context of formal construction projects. Better consideration for this approach in tools widely used by the construction industry would be interesting leverage to foster, support and further develop the reclamation sector.

THE FCRBE PROJECT

FCRBE stands for Facilitating the circulation of reclaimed building elements and aims to increase by 50%, the amount of reclaimed building elements being circulated on its territory, by 2032. The project involves 7 partners:
Rotor, lead partner (BE), **Bellastock** (FR), **Brussels Environment** (BE), **The university of Brighton** (UK), **Salvo** (UK), **Construction Confederation** (BE), **Belgian Building research Institute** (BE) and the **Scientific and Technical Center for Building** (FR)
For more information on FCRBE: *http://www.nweurope.eu/fcrbe*

FUTUREUSE: 7 SHORT INTRODUCTIONS TO THE WORLD OF REUSE

This is one of a series of seven booklets that have been produced to serve as a taste of what the FCRBE project aims to achieve. The subjects span the broad spectrum of reuse, covering considerations before, during and after with useful information to guide and inspire working with reclaimed materials. The booklets also highlight environmental benefits, clarify grey areas and frequently asked questions regarding best practices, whilst sparking curiosity for a future where use is reuse.

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List of acronyms

BU	Bottom-Up
GIS	Geographical Information System
LCA	Life Cycle Assessment
MFA	Material Flow Analysis
MSA	Material Stock Analysis
NTL	Night-Time Lights
TD	Top-Down
UM	Urban Metabolism

The development of this booklet aims to explain what flow and stock studies consist of, how they are developed and how they can be used in the implementation of a more circular economy with regard to reuse. This booklet is therefore aimed at public authorities, decision-makers, urban planners or anyone who wants to know more about these issues.

1.

The Urban Metabolism[1] to meet the current and future challenges of cities

The human population is growing fast, and with more than half living in urban areas. This growth is expected to continue in the coming years, with an estimated 60% of the world population expected to be living in cities by 2030 [1]. Cities have always relied heavily on the surrounding countryside to supply resources that cannot be produced directly in the city (i.e. energy, food, water, materials, etc.). Urban discharges (waste, sewage, pollution, etc.) are also often returned to these territories for treatment. Demographic growth and densification in urban areas have thus driven the intensification of both the import of goods and energy as well as the export of waste, increasing the pressure on the environment (natural resources extraction, waste production) and the distances to be covered. These observations and the awareness of our planet's limits have led some researchers to draw a comparison between cities and the functioning of living organisms. Although the term 'metabolism' as applied to societies was formulated in social science works (such as Marx) as early as the nineteenth century, its concrete application as a quantitative study of the city and its relationship with the environment is more recent. The term 'metabolism of cities' was coined in 1965 by Abel Wolman, an American engineer. In 1977, a Belgian botanist, Paul Duvigneaud, proposed one of the first 'urban ecosystem' studies on Brussels city. Until then, the environmental study of urban environments had been relatively compartmentalised, and offered little overview of pollution and the extractions of resources associated with cities.

By comparing a city to a living organism, urban metabolism (UM) considers that cities depend on external resources which they consume, transform, store and reject. However, unlike the metabolic process of living beings, which could be considered 'optimal' because it is relatively 'cyclical' (the waste of some can serve as a resource for others), cities do not appear to be as efficient or sustainable. The nature of their flows is indeed completely different[2]: flows are mainly of an anthropogenic nature (fuel and electricity, water mains, food products, manufactured goods, waste and polluting emissions, etc.) and follow a linear pattern (little circulation of flows by reuse or recycling in the city or via synergies between companies).

UM aims to understand the flows and stocks and assess the impacts of this metabolism. Then, UM studies can be a part of Circular Economy (CE) or sustainable development strategies designed to generate efficient, resilient and circular cities. To this end, accounting methods have been developed, such as Material Flow Analysis (MFA). Based on mass conservation principles, MFA proposes to carry out mass (and energy) balances in a given context (a city, for instance). According to this model, inputs (extractions + imports) should equal outputs (consumption + exports + accumulation + waste). This kind of analysis requires meticulous work to collect and harmonise data from multiple and varied sources (public database, industries, etc.). But beyond simple accounting, UM is a rich concept that brings together many methods and draws on the intersections of various disciplines and scientific fields[3]: engineering, urban planning, environmental studies, but also social disciplines [2].

Resources imported into the city are used for various purposes and 'stored' for varying lengths of time before they leave the city, usually in the form of waste. In this respect, the case of the built environment is highly illustrative. Building materials and components are transported to the city, where they are assembled to form coherent entities such as buildings, infrastructures and public spaces. Urban areas do indeed *present a high*

1. Subsequently referred to as UM in the text.

2. See more on https://environnement.brussels/lenvironnement-etat-des-lieux/rapports-sur-letat-de-lenvironnement/rapport-2011-2014/environnement-7

3. See more on https://www.sciencepresse.qc.ca/blogue/liride/2019/05/30/metabolisme-urbain-transition-ecologique

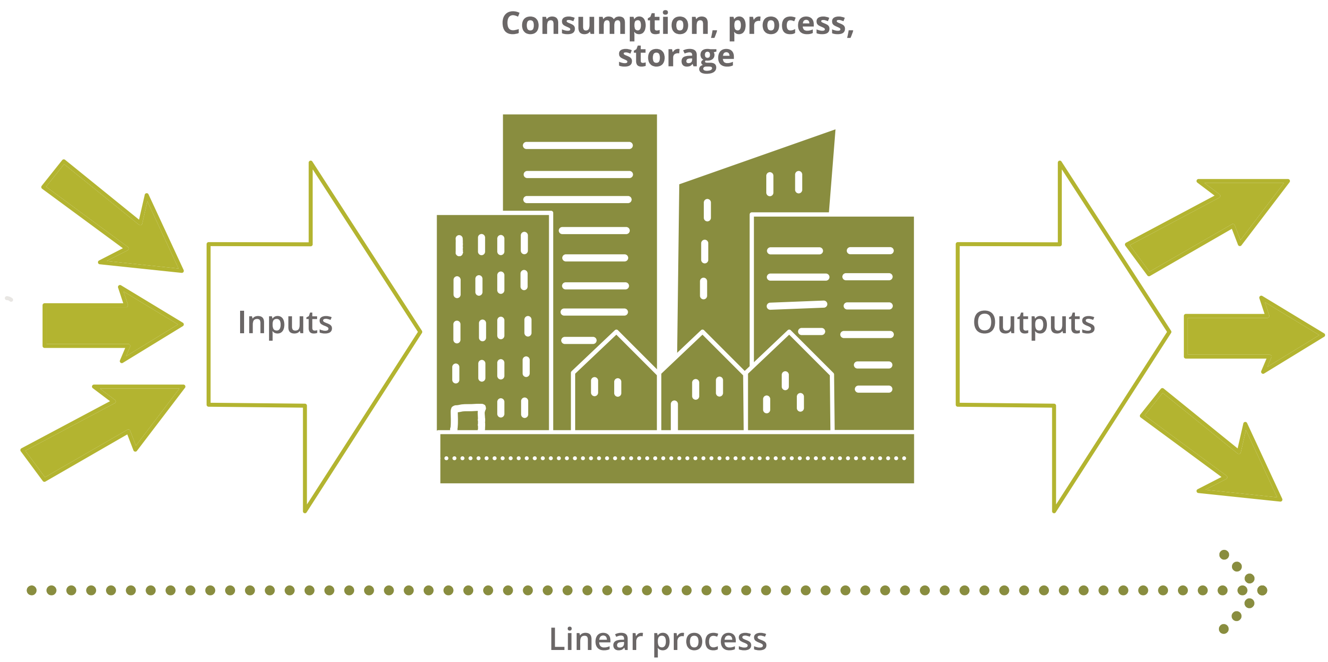

Figure 1: Urban Metabolism in a linear pattern

intensity of materials contained in buildings and infrastructures [3]. A study conducted in Brussels shows that buildings represent 84% of all materials present in the city [4]. An increasing number of 'stock studies' have analysed this accumulation of materials in the urban built environment intending to anticipate its subsequent use and valorisation [5]. Nevertheless, despite relatively long life spans and under the effect of various technical and socio-economic factors, the materials comprising this built environment stock do end up being 'released' one day.

In this context, the current need for energy retrofitting [6] will involve the use of new materials and require demolition works (total or partial), during which the constituent parts of a building are separated and put back into circulation – usually in the form of construction and demolition (C&D) waste streams. Stocks will also be affected by these interventions. The possibilities for reusing the released flows depend very largely on the specific case, but also on the initial composition, i.e. the materials that have been (and are) used and how they are assembled in buildings.

It is in this perspective that some organisations and researchers have proposed the term 'urban mining'. This approach aims to consider the city as a vast deposit of potential resources waiting to be exploited subsequently (at the end of their useful life). More specifically, this approach aims to avoid potential resources being disposed of as waste, to reduce pressure on natural resources by extending the life-cycle of materials already extracted, and to develop local economic activities linked to the development of the 'urban mine'.

Since they directly contribute to these objectives, reuse practices figure prominently in the regulatory and incentive frameworks that frame the transition of cities, regions and states towards principles of circularity[4]. However, reuse practices remain relatively marginal compared to the logic of recycling (which is often rather down-cycling). It is estimated today that less than 1% of construction materials are reused[5]. In this context, the study of the composition of the urban built environment stock and its renewal dynamics can play an important role in consolidating, stimulating and increasing the

4. Refer to *How to build a roadmap*: *The do's and don'ts of reuse in the construction sector* of the futuREuse booklet series (by Emilie Gobbo for Brussels Environment, 2021).

5. This figure is an estimate developed within the framework of the FCRBE project and is based in particular on the figures from the latest BigRec surveys conducted by Salvo, and several variables including the number of companies active in reuse as a function of C&D waste production and population. Several worksite assessments have confirmed this estimate, and the statistical study also carried out within the framework of the FCRBE project should consolidate this result (https://www.nweurope.eu/projects/project-search/fcrbe-facilitating-the-circulation-of-reclaimed-building-elements-in-northwestern-europe/#tab-1).

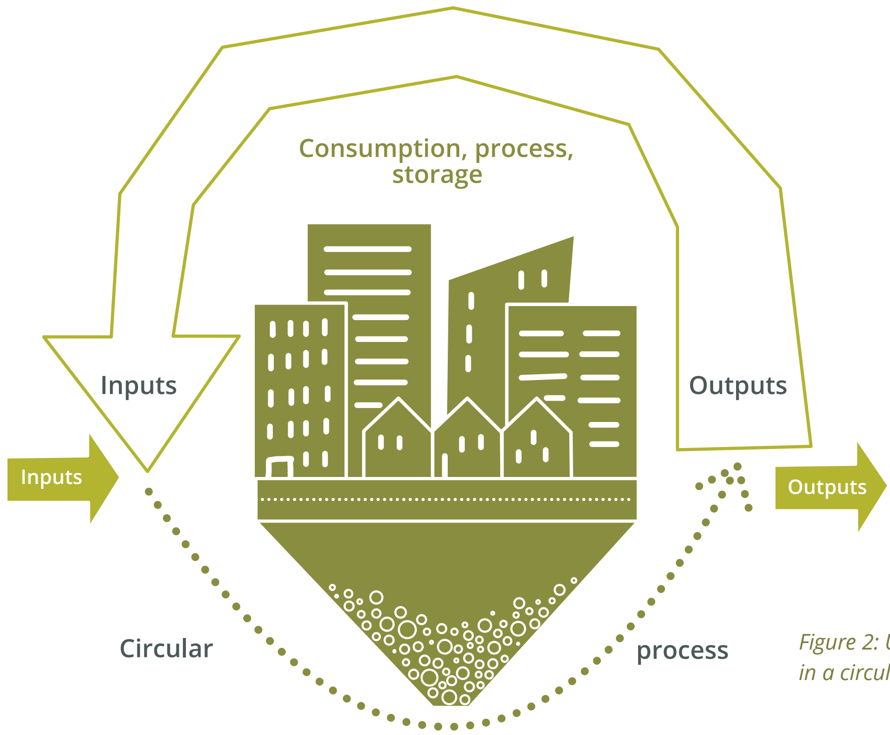

Figure 2: Urban Metabolism in a circular pattern

reuse of construction materials. To date, however, UM studies that focus specifically on reuse are scarce.

More broadly, UM studies are also aiming to assess the environmental effects of cities with a view to reducing them. They couple Matyerial Flow Analysis (MFA) and Material Stock Analysis (MSA) with methods such as Life Cycle Assessment (LCA). Considering reuse through this integrated lens also demonstrates its advantages of saving resources and reducing waste production[6].

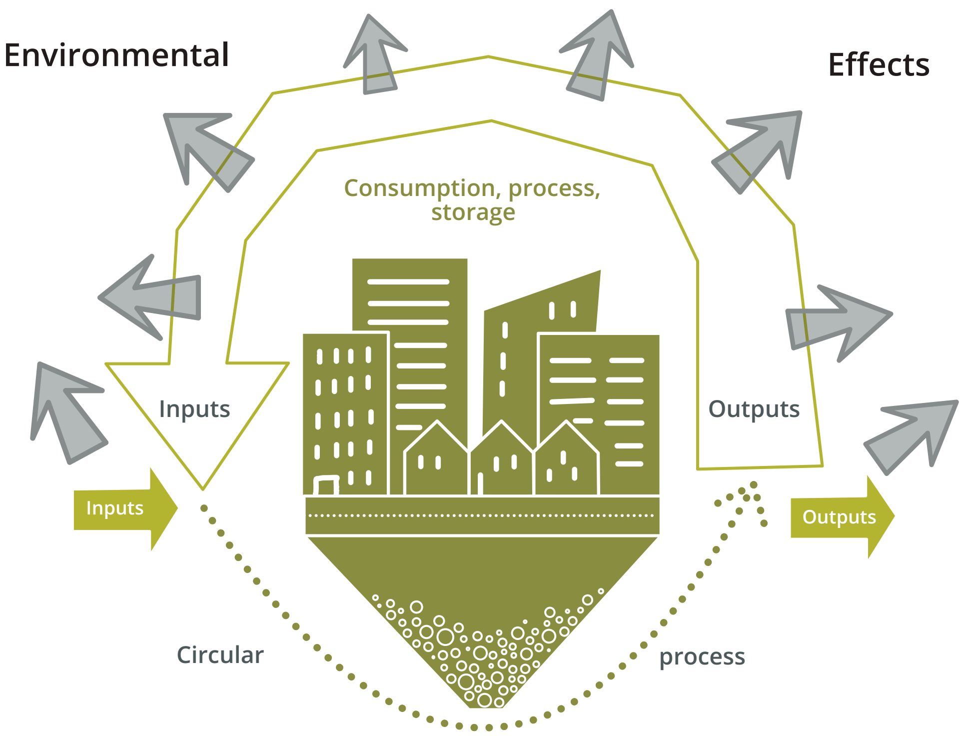

Figure 3: Environmental effects related to Urban Metabolism

6. Refer to *The environmental impact of reuse in the construction sector* of the futuREuse booklet series (by Etienne Douguet, Florence Wagner and Mona Nasseredine for CSTB & BBRI, 2021).

2.

Understanding the stocks

Definition and characteristics[7]

Globally, built environment stocks *consist of materials and products staying in the anthroposphere[8] over a certain period of time* [7, p.5]. However, despite the analogy suggested above by the term 'urban mining', there are essential differences between the city as a 'deposit' of potential resources and the classic geological deposits that the mining industry is accustomed to exploit. The most important characteristics and specificities of the urban built environment stock are:

1. The **heterogeneous nature of the city**, which presents enormous diversity in the types of materials stocked.
2. The **lack of accessibility** to the deposit related to **land and property** aspects: the materials are dispersed in buildings that belong to different owners. It is therefore difficult to ensure their coherent and unified management (although regulatory tools can help, for example, by prohibiting or limiting the use of certain materials, or by requiring them to be managed in a particular way);
3. The **densely built-up nature** of cities does not lend itself well to the application of largely mechanised industrial extraction methods: due to the concentration of people, special attention should be paid to minimise emissions (e.g. dust and noise), truckloads, and others.
4. The **dynamic nature** of the city, the renewal of which takes place at variable and unpredictable rhythms. As they are changeable and shifting over time, it is challenging to qualify and quantify the urban stocks with precision.
5. The long lifespan of the buildings and infrastructure tends to increase the uncertainty and unpredictability of the **future availability** of built environment stocks, making them harder to study. *Even though the average demolition age of buildings has decreased from over 200 years to 70 years* (or even less*), it is still a long lifespan* [3, p.3] in which several changes and modifications can indeed take place: changes of use or purpose, heavy/light renovation, demolitions, extensions, technical compliance, improved performance.
6. Urban stocks can have a different **status**. Stocks can be **'expended'**, i.e. discarded after use or dissipated and no longer recoverable. Alternatively, they can be **'employed'**, which correspond to in-use stocks. Two additional types of stocks exist, namely hibernating or obsolete stocks that are not removed or disposed of when they are no longer in use. These include obsolete underground technical pipes or materials stocked underground and remaining there after the above structure was removed (foundations), or even vacant buildings and installations [8]. Hibernating stocks may be included as expended stock or added to the in-use stock to represent the employed stock. This illustrates the fact that there is currently no real consensus on the precise definition of stocks and their status [7].

Ultimately, one could also argue that the mines metaphor may not be the most fitting to refer to sound resources principles management and low environmental effects, which should be the core of circular approaches. Accordingly, any activity helping to preserve the use-value of goods (such as retaining, preserving, repairing, reusing, refurbishing) should be preferred over waste mitigation strategies.

7. This section mainly refers to two recent publications providing an overview of urban flow and stock studies [7] [3].

8. The Anthroposphere is a term used to define the total mass of human production, including the human population and its interaction with the Earth's systems.

How to address the dynamic nature of urban stocks

As referenced in previous sections, one of the unique characteristics of urban built environment stocks is their changing nature over time. For this reason, there are two approaches to studying and understanding the dynamic nature of urban areas: the first – the retrospective approach – is concerned with past changes; the second – the prospective approach – examines possible future changes. They can also be considered complementary, as retrospective studies provide an additional analytical base that can be used to develop scenarios for a prospective approach. A 'snapshot' of the built environment stock taken at a given time 't' (determined, for example, according to the information available for a reference year) is often used at the start of these studies. Even if the speed at which this stock evolves makes it virtually impossible to obtain and simulate completely accurate and up-to-date data, these approaches remain useful in understanding how built environment stocks evolve over time, especially for service units with long life spans such as buildings.

This dual temporal approach also echoes reuse practices. The collection of data, information, construction techniques, and understanding of evolution of stocks over time (which a retrospective approach requires) is effectively used to characterise and evaluate certain construction elements' reusability. However, this needs to be complemented with an on-site assessment to ensure the practicality of reusing components[9].

A prospective approach to reuse materials introduces an additional dimension to the knowledge of existing stocks and their evolution. Indeed, the reusable nature has to be introduced from the design stage and across the different scales of the built environment stock:

- the design of products/elements and their assembly systems to make them durable, compatible and easily disassembled,
- the design of buildings to ensure flexibility, adaptability, versatility and facilitate their renewal according to the lifespan of their different layers[10].

9. Refer to *Guide for the Identification of the Reuse potential of construction products* produced by the Interreg FCRBE project (2021).

10. These considerations are further developed in a number of other European projects such as the H2020-BAMB project (https://www.bamb2020.eu/) and the EFDR-BBSM project (https://www.bbsm.brussels/en/productions-en/).

Time line

Type of Approach	Retrospective	Snapshot	Prospective
	Existing stock	Current stock	Future stock
	Historical and/or socioeconomic analysis Analyse the stock either through their historical evolution		Scenario-based models
	> What changes in the building stock over time (morphology, composition, techniques)? > What are the influencing factors (normative, legislative, economic, social)? > What is the state of the market (materials/waste/supplies)?	Analyse a specific reference year (depending on data availability)	> What are the strategic programs and plans in terms of fleet renewal (renovation strategy), energy savings, circular economy? > What are the objectives of materials recovery? > What are the expected developments (technical, normative)? > What are the housing needs (demographic forecasts)? > What major works are planned for the year (planning of large demolition sites)?
	"Understand" the evolution of stocks over time		"Anticipate" future developments of stocks

Figure 4: Retrospective or Prospective approach of UM studies

In addition, a prospective approach in a reuse perspective could:

- make it possible to anticipate the flows of certain elements subject to frequent replacements which offer the potential for reuse (for example, office elements such as partitions, doors, false ceilings or false floors).
- make it possible to assess the impact of certain intervention strategies and, more broadly, the potential gain generated by the reuse of elements (potential deposit of reusable elements, economic value, environmental benefits, labour impact).

3.

Existing studies talking about stocks

Brief overview

Knowing the source of materials in existing buildings is a key issue for developing the circular economy and thus considering reducing our consumption of raw materials and generation of waste. While much work has been done to model energy use and, at the same time, greenhouse gas emissions from buildings, initiatives aiming to model the materials' stocks and flows dynamics are more limited. Nevertheless, the recent evolution of studies on this subject shows that there is a growing interest in understanding built environment stock.

Recent scientific articles refer to current publications dedicated to the built environment stock and account for almost 250 publications on the subject[11]. One of the reviews shows that many existing studies focus on specific material stocks, mainly metals [7]. The potential future scarcity and the economic value of these kinds of resources can explain this finding. Concerning non-metallic mineral secondary materials, studies show that they would be insufficient to fully meet future demand [9]. About a quarter of existing studies focus on buildings [7]. Those relating to infrastructure are fewer in number, although infrastructure makes up the bulk of the stock in the European Union[12].

The fact that much of the infrastructure is underground makes data collection harder, and methods such as remote sensing are not possible. In general, a phenomenon of stock accumulation can be observed, but until when? Some studies provide a better understanding of the factors that can influence this accumulation: population, building life, traffic, technology [9,10]. While numerous existing studies focus on the quantification of stocks, their impacts, socio-economic drivers, and the opportunities they may represent in the development of relevant resource and environmental policies remain largely unexploited [7,9]. In addition, it is important to point out that stabilising existing stocks by extending the life of existing infrastructure and buildings would make it easier to reduce materials use [12].

Unfortunately, very few existing studies incorporate reuse considerations in their analyses, especially as it is often confused with recycling. This situation is challenging when we know that reuse is an important component of circular economy strategies[13]. The reasons for this relative absence can be explained in part by: the availability of data, which is already particularly difficult and painstaking to collect (even more so for reuse?) [3]. This shortcoming is directly related to the scale of the study (is the urban level too broad for a reuse focus?), to the use of units of measurement and quantification (not completely suitable for reuse?). Moreover, to implement circular economy strategies, it's necessary to understand the nature and quantity of materials with a view to adding and preserving the value of the secondary resources.

In the section on 'comparative methodologies', we will discuss the different methods and propose how they could be used to study urban building stocks concerning reuse. The following section aims to present different MSA to highlight their objectives and methods, and how they can be used in the implementation of a more circular economy, especially considering reuse (when this is made possible by the analysis).

11. [7] [3] [9]

12. [9] [7] [10] [11]

13. Refer to How to build a roadmap The do's and don'ts of reuse in the construction sector of the futuREuse booklet series (by Emilie Gobbo for Brussels Environment, 2021).

Selected examples of built environment stock studies and their impact

THE URBAN METABOLISM OF PLAINE COMMUNE, PARIS, FRANCE (2021)

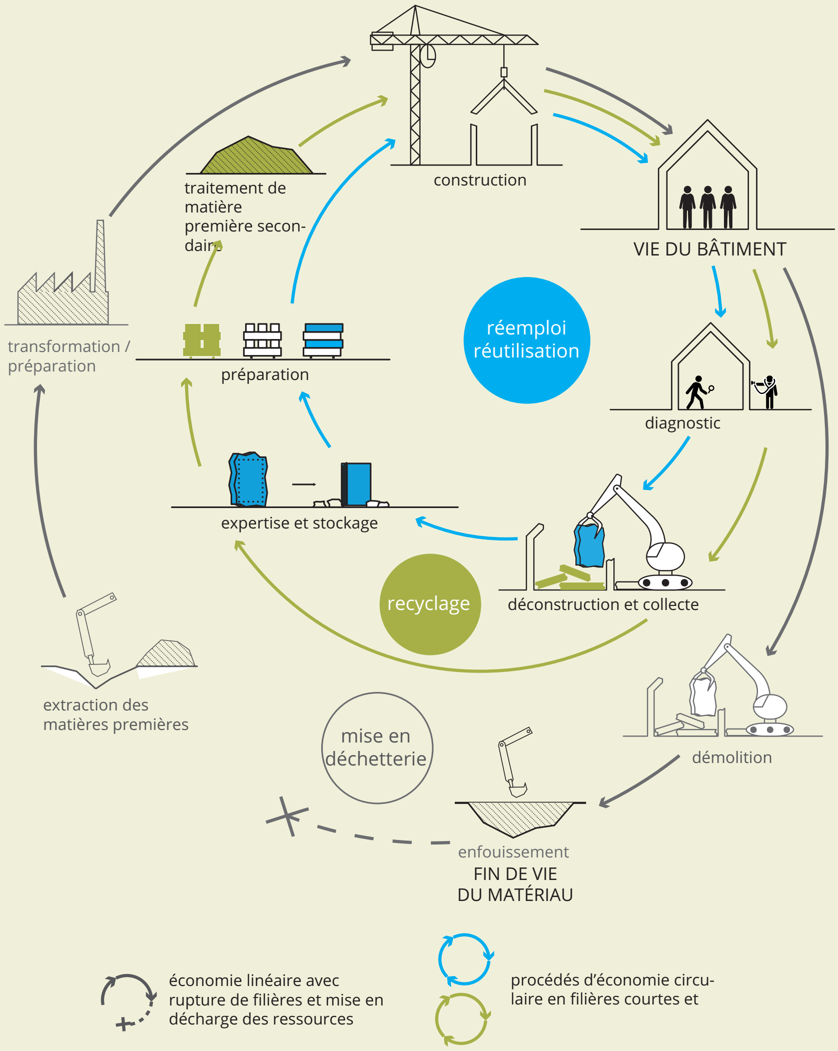

Figure 5: Urban Metabolism of Plaine Commune

(Source: Bellastock, 2017)

CONTEXT

The Urban Metabolism project led by Plaine Commune is a circular economy approach applied to the building and public works sector. This experimental approach aims to plan and optimise resource management around 5 axes of work[14]:

- Experimenting with an inter-site reuse approach for building materials from 30 pilot sites Setting up platforms for sorting, storing and recycling site resources
- Supporting the deployment of local channels for the reuse/recycling of construction materials
- Developing a digital tool to make deposits visible and to account for the externalities induced by the circular economy approach implemented
- Supporting the upskilling of local actors, from project managers to companies, through training, conferences, visits, and fostering a culture of reuse among the various actors and users of the area.

14. See more about the project on: https://www.bellastock.com/projets/metabolisme-urbain-de-plaine-commune/

WHAT WERE THE STUDY OUTCOMES?

This project is still ongoing in 2021. It is characterised by both a study and an experimental approach in the field. This is undoubtedly its strength, and allows us to identify the tangible benefits of the project. The latter include: the characterisation of the urban mine and identification of the materials eligible for reuse and recycling in the area through the resource diagnosis of the 30 pilot sites (representative sample of the area);the operational implementation of reuse via several means of action planning, through the introduction of 'Urban metabolism' clauses in the framework documents and land use planning references, support for project owners to create opportunities for synergy);the drafting of documents and generic methodologies enabling the various actors to deploy the approach on completion of the three-year project.

STUDY FEATURES: Bottom-up, Flows (and stocks to a lesser extent), Snapshot. Reuse is directly addressed by the study and implemented concretely in projects including the various actors.

THE URBAN METABOLISM OF THE BRUSSELS-CAPITAL REGION, BELGIUM (2015)

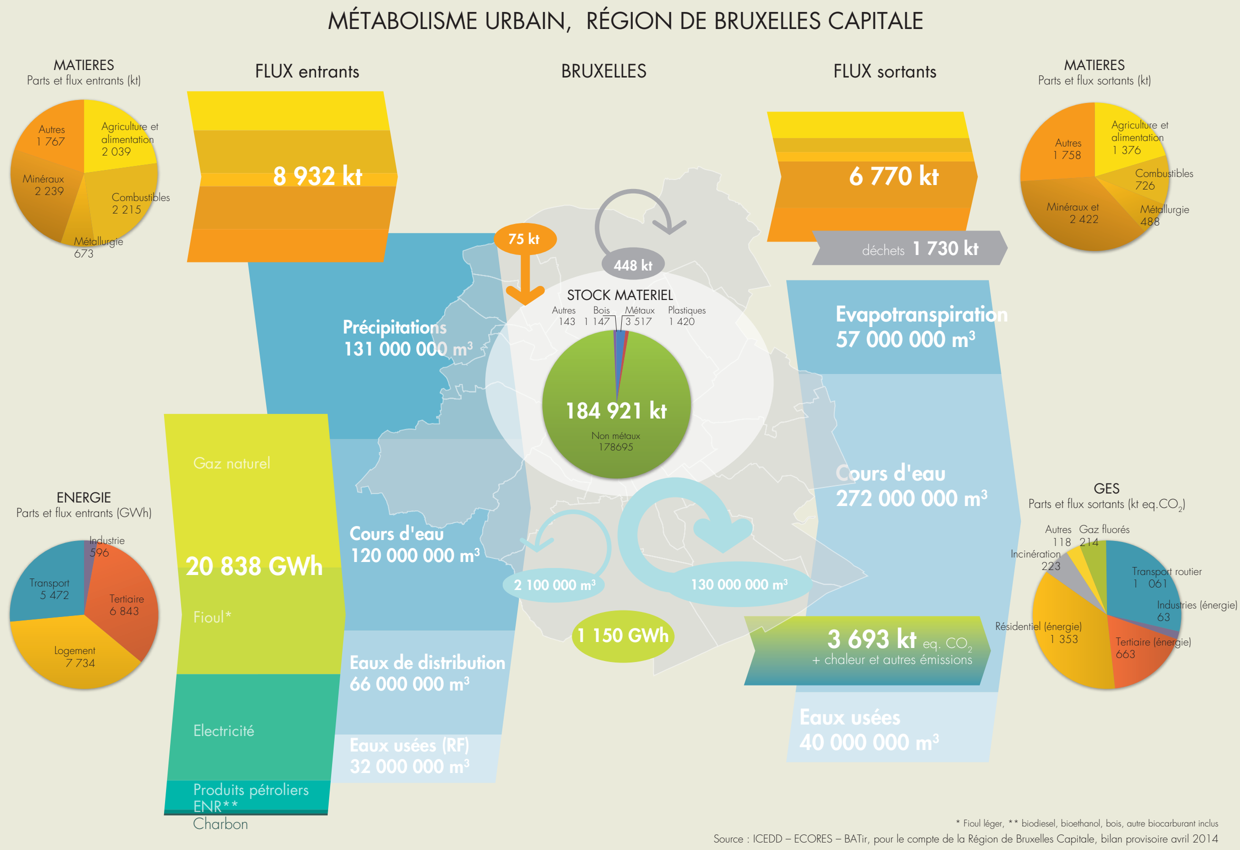

Figure 6: Urban Metabolism in Brussels (Source: ICEDD – ECORES – BATir, 2014)

CONTEXT

A study of the urban metabolism of the Brussels Capital Region was undertaken in 2015[15]. Based on statistical data and some assumptions, this study conducted by ECORES (Belgium) highlighted the considerable impact of the construction industry:

- The majority of energy (75%) and water (98%) flows, as well as greenhouse gas (GHG) emissions (65%), originate from the use of buildings, while the construction phase consumes very little energy and water.
- The construction sector is responsible for more than a third of outgoing waste and a third of incoming materials.
- The urban stock was estimated at around 185,000 kt, of which 84% would be contained in buildings and 15% in infrastructure.

An additional study is then carried out specifically considering this sector which identified some key flows in terms of potential circular savings (modular partitions, carpet tiles, technical floor tiles and false ceilings). This would involve 8,500 tons/year coming out of the Brussels stock. If a quarter of these elements were resold at a quarter of their initial price, more than €8,000,000 and around 50 non-relocatable FTEs could be generated. The economic potential of reusing technical equipment in tertiary buildings is estimated at around €12 million annually, which could create 70 non-relocatable FTEs.

15. See more on
http://document.environnement.brussels/opac_css/elecfile/RAP_20150715_Metabolisme_RBC_rapport_compile.pdf.

WHAT WERE THE STUDY OUTCOMES?

The study of urban metabolism was used as a basis for developing the circular economy vision in the Brussels construction sector[16] and for creating the regional circular economy program[17], which includes a roadmap for construction sector stakeholders[18]. However, some limitations persist. Precise data concerning the construction sectors' activities and the existing stock are often incomplete, difficult to find or even non-existent. Material flow accounting is therefore based on several assumptions and estimates. By extension, this lack of precise data makes it hard to measure the potential for re-circulating these flows within the Brussels-Capital Region.

STUDY FEATURES: Top-down, Flows (and stocks to a lesser extent), Snapshot. Reuse is not directly addressed, but some key flows are cited in the additional study as potential circular savings.

16. See more on https://www.circulareconomy.brussels/wp-content/uploads/2017/10/RAP_2017_Economie-Circulaire-Construction.pdf.
17. See more on http://document.environnement.brussels/opac_css/elecfile/PROG_160308_PREC_DEF_FR.
18. See more on https://www.circulareconomy.brussels/wp-content/uploads/2019/06/BE_beCircular_feuille-de-route-CD_def_FR1.pdf.

AN URBAN MINING STUDY FOR THE CONSTRUCTION SECTOR IN THE BRUSSELS CAPITAL REGION, BELGIUM (2021)

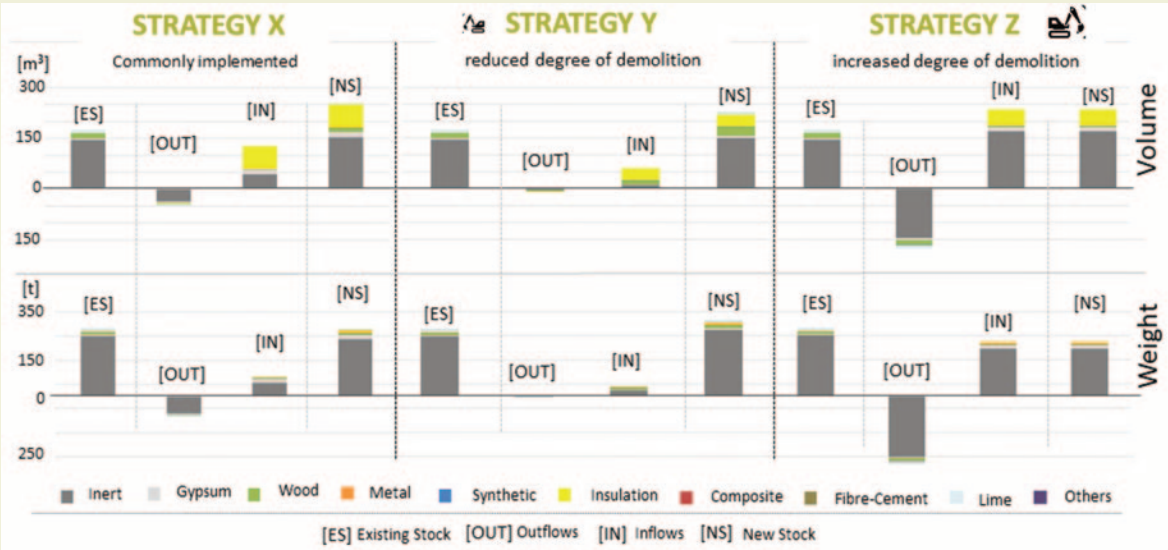

Figure 7: Material Balance comparing 3 energy retrofit strategies on a specific building archetype

CONTEXT

The ERDF-funded BBSM project (Brussels Building Stock as new Material resources)[19] aims to evaluate the potential value of the materials contained in buildings in a circular perspective. The research examines the opportunities offered by the value-chain and recovery channels, the technical and legal aspects linked to recovery (concerning reuse and recycling), and the impact of circular design and the possibilities of introducing reuse in the design process. The study moreover aims to address the lack of data concerning the building stock highlighted in the study of urban metabolism. Based on a bottom-up approach and the definition of building archetypes, the project develops a prospective approach to anticipate possible stocks and flows generated by the energy retrofit operation of the Brussels' building stock. A tool is scheduled for release in 2021, which should make it possible to simulate and compare up to 3 energy retrofit strategies. Encoding is undertaken on a building scale, allowing the user to choose the improved wall combinations for a given building archetype. The results should provide the material balances of the strategies, their impact in terms of CO_2 and embodied energy, and their potential in terms of circularity (through reuse and recycling). The combined quantitative and qualitative assessment provides results which can be scaled-up to simulate the impact of certain strategies on an urban scale.

WHAT WERE THE STUDY OUTCOMES?

This study is expected to be completed in the first half of 2021. It has therefore not resulted in any concrete measures in terms of policy or urban planning as of yet. However, the study is based on the region's expected strategies and requirements to develop its scenarios. By anticipating flows and comparing strategies, this study could represent a decision-making tool in the efficient management of resources and waste, but also in the development of renovation and circular economy policies.

STUDY FEATURES: Bottom-up-Archetypes, Stock & Flow, Retrospective and Prospective. Reuse is included in this study as part of the qualitative assessment.

19. See more about BBSM project on https://www.bbsm.brussels/en/productions-en/

THE BUILT ENVIRONMENT STOCKS OF THE CITY OF MELBOURNE, AUSTRALIA (2018)

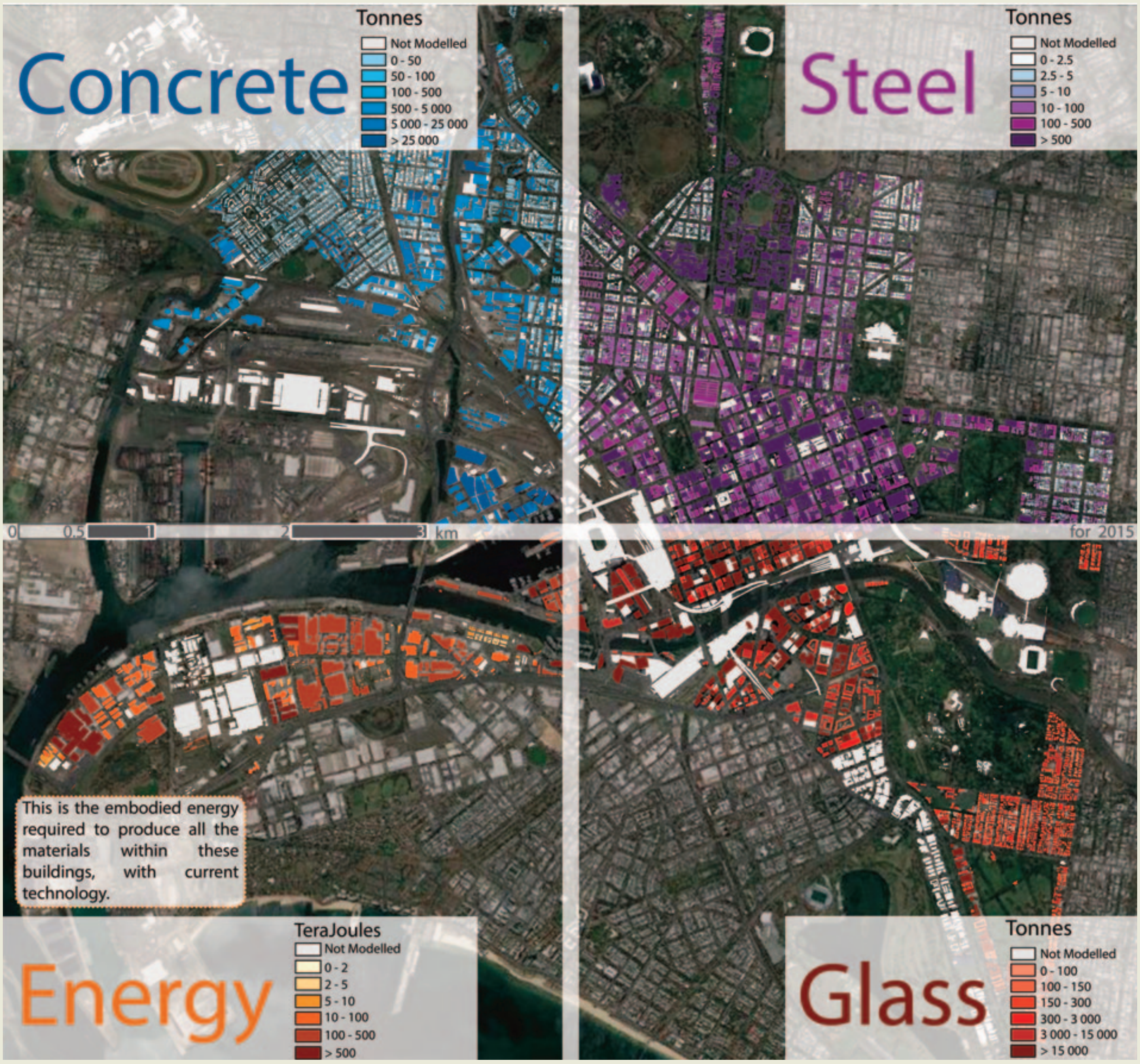

Figure 8: Material stock and Embodied Energy of the city of Melbourne (reproduced with the permission of A. Stephan, 2017) [21]

CONTEXT

The study of the existing built environment stock was a preliminary step in the pursuit of two objectives: the evaluation of embodied environmental effects, and the estimation of materials flows caused by the replacement of non-structural materials at the end of their useful life, from 2018 to 2030. The proposed method is based on a bottom-up approach and defines 48 building archetypes which leads to the modelling of 13,075 buildings to spatially model urban built environment stocks. To achieve this, a range of datasets were required, including land-use per building, building footprints and geometry, a database of material embodied flows ,and a database of construction elements definitions (lifespan, material type, functional unit, etc.). Results are presented in different ways: mapping material intensities for the total material stock, but also considering initial embodied energy and greenhouse gas emissions, focusing on an estimated accumulation for a specific type of material (plasterboard, timber, aluminium, carpet, ceramics, glass, steel, insulation), or even presenting an age pyramid of materials, representing the accumulation of materials in the stock, according to their service lives.

WHAT WERE THE STUDY OUTCOMES?

As of 2020, this study has not yet resulted in any policies or actions being taken directly by the City of Melbourne or the construction sector in Victoria or Australia. In contrast to the other studies on Geneva and Brussels, the Melbourne study was not financed by public authorities, which may also explain why there is no direct take-up of the findings by local authorities. As the state of Victoria recently decided to release a budget to develop the circular economy[20], the study would prove useful in this context. Indeed, this type of spatial and temporal study has significant potential for informing decision-making and urban planning tools that lead to a better management of material stocks and replacement flows. The analysis helps identify the major flows (in terms of quantities of materials) and anticipate periods when intense material replacement will be required. An important element to emphasise, and which facilitated the realisation of this study, is the existence and accessibility to the necessary datasets, provided in open-access by the City of Melbourne[21].

STUDY FEATURES: Bottom-up-Archetypes, Stock & Flow, Retrospective and Prospective. Reuse is not directly addressed in this study.

20. See more on https://engage.vic.gov.au/circulareconomy.

21. See more on https://data.melbourne.vic.gov.au

MATERIAL STOCK AND MATERIAL FLOW AT ILE DE FRANCE REGION, FRANCE (2021)

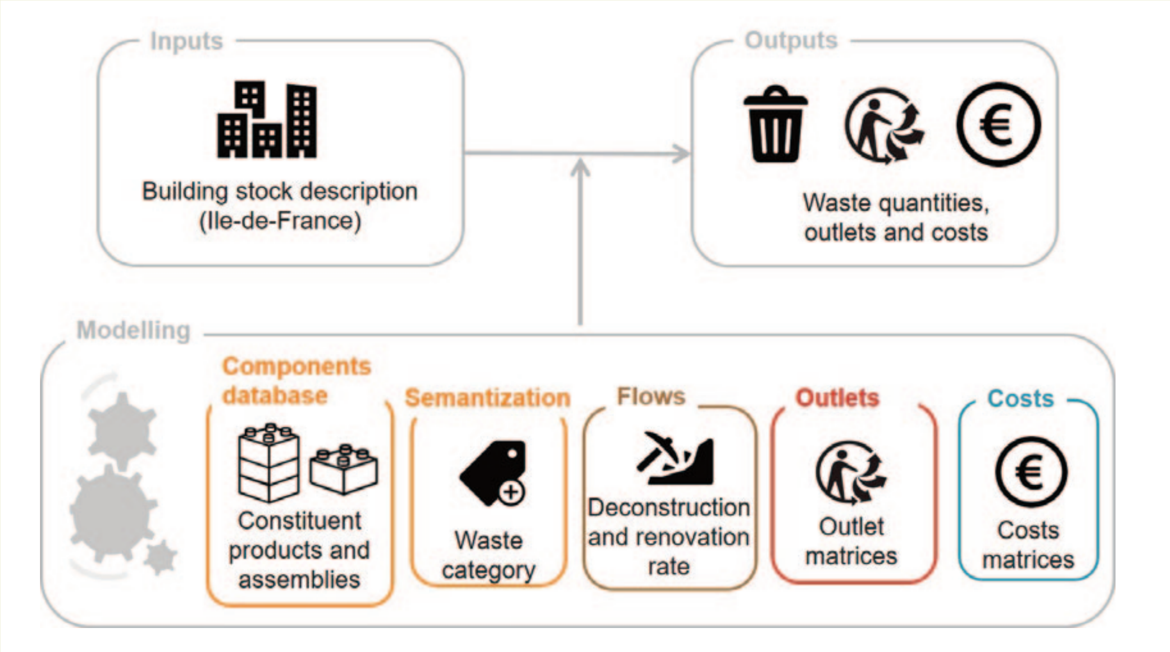

Figure 9: Key results of BTP Flux study (source: CSTB, 2021)

CONTEXT

BTPFLUX is a bottom-up methodology to assess material stocks and flows applied in a first experimental geographic scale: in the Ile de France region. The model covers five uses (single-family house, collective housing, offices, education and industrial) as well as the waste streams linked to renovation and deconstruction. For the study case, 101,352 buildings were modelled. Buildings geometry stems from geographical information, and material buildings characteristics stem from a macro-component and assemblies database (117 existent types). Each building is therefore a combination of more than ten macro-components, which provides great flexibility in building descriptions.Renovation and demolition scenarios have been developed to estimate the waste generated by category (e.g. concrete and stone, plaster, plates and tiles, ceramics). Wastes were distributed in various outlets (e.g. recycling / reuse, quarry filling, storage) according to scenarios distinguishing the waste sorted at the foot of the site and treated as a mixture. Induced environmental impacts and treatment costs of each category of waste in the different outlets were also estimated. A price range was used to reflect the heterogeneity of situations. Finally, territorial results are obtained by extrapolation. The key results are depicted in Figure 9.

WHAT WERE THE STUDY OUTCOMES?

The developed method can be applied in other territories and at different scales: (1) to anticipate the waste flows that will be generated by land-use planning operations, (2) to estimate the average recovery of this waste (recovery rate, type of recovery, environmental and economic impacts), (3) to be able to compare, for a specific territory, the flows and waste generated and the future needs for materials, (4) to identify future material flows for the development of new reuse or recycling solutions.

STUDY FEATURES: Bottom-up, Macro-component description, Stock & Flow, Prospective. Reuse scenarios are included in this study.

Comparative Methodologies

This section is based mainly on several scientific articles already referenced in the brief overview of this booklet[22]. For more information, do not hesitate to consult them.

1. Approaches

Different methods and approaches are developed to evaluate material flows and stocks. These methods focus on flows and/or stocks and estimate them considering a reference year (static) or a longer time scale (dynamic) retrospectively or prospectively [9]. They are represented below. These can be used separately, but can also be combined, which is one way of dealing with uncertainty. For example, six major combined methods are identified by V. Augiseau in 31 existing articles materials flows and stocks [9]: static BU or TD flow analysis, BU stock analysis, dynamic (retrospective or prospective) flow analysis using flow-driven or stock-driven models, TD (retrospective or prospective) stock analysis using a flow-driven model.

The choice of approach depends on the objective pursued, but also on the quality and accessibility of the data, which vary greatly from one country, region or even city to another [7]. As a consequence, the results can vary considerably between approaches. A standardised method therefore seems difficult to envisage at this stage, although unification in terms of definition, indicators and methodological approach is to be recommended [9]. The different approaches are explained below, with the exception of the static and dynamic, prospective and retrospective approaches, which have already been discussed above.

Regarding reuse, the use of archetypes in a bottom-up approach could represent the most suitable method for evaluating certain deposits with a view to their potential reuse. The complementary use of a GIS tool could also be useful to spatialise the distribution of potentially reusable elements in a territory. The demand-driven or flow-driven modelling approach is also a possibility as it uses socio-economic indicators to model future demand, and thus can suggest sustainable pathways through the analysis of intervention strategies.

22. [7] [3] [9] [10]

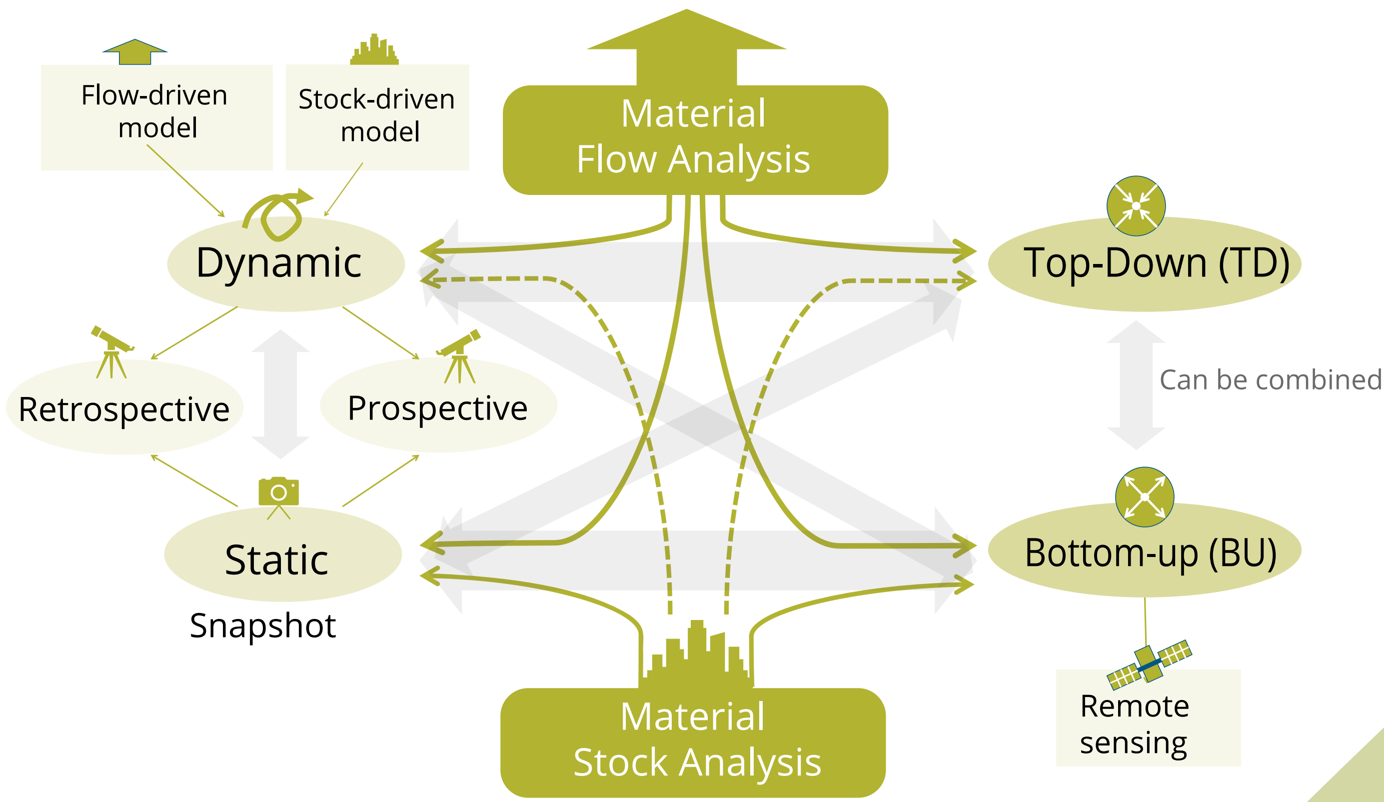

Figure 10: Different approaches for the analysis of material stocks and flows:combination are possible

(Based on [7] and [9])

Top-down Approach (TD):

This kind of approach is mainly implemented through a flow-driven method and based on macroeconomic or aggregated data. Information on inflows is easier to obtain than data on outflows, which often rely on estimates. Statistics are mostly available on national or global levels, resulting in a lack of precision as to the quality and exact location of stocks by material, at the urban level. The top-down approach is the method most commonly used in urban metabolism studies which account for in- and out-flows. Definitions of the top-down approach to MFA have been given by Eurostat (2001). Existing top-down approaches applied to stock analysis are essentially dynamic studies. Half of these are retrospective, 10% are focused on a prospective approach, while the remainder combine retrospective and prospective approaches [7].

Bottom-up Approach (BU):

This kind of approach is driven by information collected from stock inventory. The collection of data is therefore relatively detailed and labour-intensive, but allows for greater accuracy in results, in terms of composition, intensity and geographic distribution. However, this type of approach also tends to reduce the scale and/or time frame of the analysis and does not eliminate uncertainty, notably when applied to large areas. The majority of bottom-up studies (69%) focus on a rather static characterisation of stocks [7]. The remainder (31%) opt for a dynamic approach and analyse the change in stocks over time by compiling results over a number of years. In these dynamic BU studies, 50% are retrospective, 30% are prospective, and 20% combine retrospective with prospective approaches [7]. BU approaches generally use several ways to respond to data gaps in terms of inventory of materials and intensity of use:

Building Archetypes classify buildings according to their type and age and are often based on building samples. As long as the sample is representative, they enable more detailed and accurate results to be obtained, particularly with regard to composition (constituent materials and elements) and the building system. However, the more detailed the archetypes are, the more representative data and information will be required. This increases the intensity of the work required to collect and process the data, while some degree of uncertainty may persist[23].

Geographic Information System (GIS) is a tool that uses geospatial data, which allows for greater precision in the location of buildings stocks. The type (use), footprint, levels (or sometimes height) and year of construction are the main characteristics used in GIS-based bottom-up analysis. These are fairly easy to set up, although material intensity and the specific composition of buildings and infrastructures are not currently included in GIS databases. To address this, the definition and analysis of building archetypes are used to produce an average of material intensity coefficients. However, this usually results in uncertainties associated with the geometrical properties of each building[24].

Geometric specifications (height, depth, width) related to buildings are therefore important and necessary to complete GIS databases. They would provide information on the morphology, composition and location of the constituent materials of the constructions [13]. Furthermore, *developing a systematic bill of materials for each building within a country would be commendable in order to facilitate detailed studies of built environment material stock composition* [7, p.18].

The bottom-up approach is usually based on assumptions such as the homogeneity of material composition and service life within groups of built works. Case studies and crossed top-down and bottom-up approaches would improve the reliability of estimates [9].

23. Some sources of uncertainties are: the manner in which material intensity (MI) coefficients are defined. Then, there are uncertainties related to how to use the archetypes (only material characteristics applied to geometric characteristics of a real park or weighted material building's quantity based on MI coefficients and the percentage of constructed surface based for every building stock segment).

24. Uncertainties stem from different steps in a MFA model.

Flow-driven or Stock-driven modelling

Dynamic analysis can be based either on input flows or on stocks. Models generally referred to as 'flow-driven' or 'demand-driven modelling' [14] can be either bottom-up or top-down. This combines monetary data with physical data on products and materials. For example, models are based on an extrapolation of flow data to an annual average. So, demand-driven modelling uses socioeconomic indicators and includes population to model the built environment stock instead of historical data [3].

The other approach to dynamic analysis uses stock-driven models. The assumption of these models is that the stock and 'service units' are the driving force behind material flows. In this context, several parameters can be used to estimate the stock: 'development model' [...], 'rate of stock expansion' [...], population and lifestyle [15].

Remote sensing approach

There is an additional approach which uses remote measurement techniques to estimate material stocks. Generally combined with the GIS tool, this approach is used in territories which lack a vast quantity of available data. In China, for example, several studies have been carried out using this approach to identify the stock of metal used in civil engineering works and buildings [16] [17]. It can be associated with a bottom-up approach since it is based on modelled data such as a sample of buildings [3].

2. Data collection and processing

Data collection

The lack of data is often the main obstacle to the study of built environment stocks. Statistical and macro-economic data is usually used in a top-down approach. Concerning bottom-up studies, data sources are multiple and often cross-referenced (land register, building permit, plans, measurements, specifications, geospatial information, and others). Data relating to the building's age, the location, the use and the footprint of the building, sometimes its height or the number of levels is usually the main information gathered. This is generally used to define archetypes of buildings, i.e. 'families' of buildings with the same characteristics in terms of morphology and composition. Nevertheless, a lack of precise data persists regarding the characterisation of the material composition of built environment stocks and its potential to be circularised. Providing this type of information (material types and assemblies, lifespan, wastage rate, etc.) requires architectural knowledge that is currently lacking in existing studies [7]. In Europe, countries and cities do not compile systematic statistics on reuse, which makes it difficult to exploit such data and may explain the relative absence of reuse in existing UM studies. In addition, some useful data for the study of reuse on a larger scale could be exploited if their inventory[25] was integrated into the administrative

25. For example, see https://ec.europa.eu/growth/content/eu-construction-and-demolition-waste-protocol-0_en and the Guide for the identification of the reuse potential of construction products produced in the Interreg FCRBE project.

Table 1: Tools used in UM studies to process data (based on [3] and [7])

MFA	**Material Flow Analysis**	MFA aims to account for all incoming and outgoing flows of a specific geographical area defined as a system[26] (cities, urban areas, region, country, etc.) and follows the principles of mass conservation. It is a useful tool to model spatially dynamic material flows [3] [18].
MSA	**Material Stock Analysis**	MSA aims to account for the accumulation (and composition) of the material stock (including buildings and infrastructure) of a specific geographical area defined as a system.
LCA	**Life Cycle Assessment**	LCA is used to assess the environmental impacts of products, processes, buildings, cities, etc. It can be conducted at various scales and commonly considers 'cradle to grave' phases [3]. GIS is a tool that is increasingly used in the evaluation of material stocks. As it can process and map a significant amount of data (including life cycle impacts) at different levels it represents a key instrument to better understand the composition of the stocks. GIS is needed to include spatial dynamics of stocks and flows [3].
GIS	**Geographical Information System**	GIS is a tool that is increasingly used in the evaluation of material stocks. As it can process and map a significant amount of data (including life cycle impacts) at different levels it represents a key instrument to better understand the composition of the stocks. GIS is needed to include spatial dynamics of stocks and flows [3].
NTL	**Night-Time Lights**	This tool produces images that are available worldwide, over many years. It can be useful to analyse stock-intensive areas or other uses, like the copper or infrastructure stock. Nevertheless, this technique does not provide robust information about the stock (results are static) and is inherently limited (due to night-time light saturation and scale effect). It should be interpreted with care [7].

26. It can also be conducted at the level of companies, industries or industrial zoning, but this is not covered by this booklet.

procedures linked to a project and their method of accounting could be harmonised.

Data processing

There are several types of tools for processing data. These tools can be used separately or combined. The main tools used in UM studies are as follows:

However, it is important to underline that stock analyses tend to rely on a bottom-up approach, particularly through the definition of archetypes. The collection and processing of data in this case requires significant work prior to understanding the composition of these stocks and how they have been built up over time. In the absence of consolidated statistical data, working on reuse in the analysis of urban stocks will most likely require this type of approach.

3. Geographical boundaries

The geographical and territorial scope of built environment stock studies varies. They can be conducted at a district level, but also at the level of a city, a region, a country or larger geopolitical/geographical entities. Currently, the majority of existing studies[27] focus on a national scale. About one-third are conducted at an urban scale, and more than one-tenth are carried out at a larger scale (multinational). Built environment stock studies at a regional level are fewer. The least represented scales are typically the district and building scales [7]. Usually, studies show higher mass intensity of construction material stock (kt/km²) at the urban level than at national or regional scale. This is explained by the population and construction density of cities, which are significantly higher than in rural areas. Likewise, levels are also higher in developed economies than in developing economies at both national and urban levels. Depending on the geographical scope, data availability and quality, the studies can present different levels of resolution [7].

4. Analysis scales

As for the overall modelling approach, the scale of analysis is also variable. The focus can be on material or even a substance as well as products, components, elements, up to an entire building or infrastructure. These scales can also be combined. As far as reuse is concerned, the studies must take into account at least the scale of the products or construction elements (the study of substances is not really relevant in this case).

27. More than half according to the 250 studies reviewed by Lanau et.al. [7].

Table 2: Urban Metabolism in a linear pattern (based on [7])

National Level	City Level	Material stock per square km [kt/km²]	Material stock per Capita [t/cap]
Austria		20	
	Vienna	1000–1200	200–300
Japan		100	
	Wakayama	+/- 1000	200–300
U.S.		10	
	Philadelphia (on 2.6km²)	1400	
China	Average for cities studied (for 2012/2013)		< 50

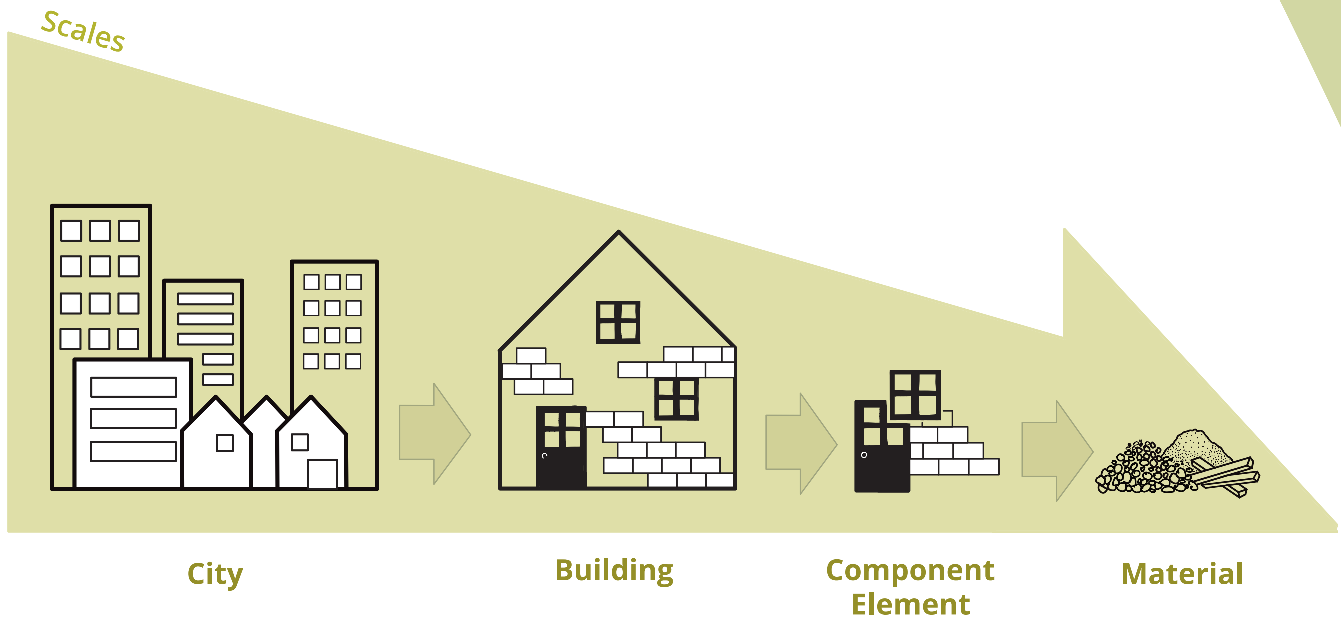

Figure 11: Analysis scale

Concerning the **building scale**, some bottom-up studies analyse the distribution of different building types across urban zones to characterise their material composition [19] [13]. The latter is sometimes difficult to establish precisely. It generally requires increased working time and technical knowledge of the building and its components (materials and construction techniques depending on the construction periods). Residential buildings feature more commonly in bottom-up studies than non-residential buildings. Indeed, non-residential buildings are more diversified in terms of their functions and composition, making data collection more complex [7]. But the turnover in the residential sector is often lower than in office or commercial buildings. Therefore, the type of function and use would influence the dynamics of flows and their occurrence over time. Concerning the **infrastructure**, it is generally linked to the urban spatial organisation. The proportion of infrastructure in relation to the built environment stock will be lower in densely built-up areas, these areas generally having a higher built proportion per m² of land use. The share of underground material stocks is also not negligible (foundations, underground parking, transport infrastructure, networks, etc.) [7].

Building elements and the scale of components are less discussed and analysed in existing studies [19] [13]. Quantification is more often carried out for materials of a specific nature, or grouped by type. However, construction elements can be composed of different types of materials, such as windows, doors, sanitary facilities, etc., which can make their accounting more complex in UM studies. However, it is precisely the scale of the building elements that makes the framework of recovery through reuse most interesting. Some existing studies already focus on certain specific building elements that would present opportunities for reuse either because of their rarity (historical character, heritage, limited edition, design) or their relative abundance, as well as the existence of a market and/or demand[28]. For example, a study in Toronto examines the stocks of clay bricks in single-family homes to generate information that can be used for city-wide reuse and recycling of materials. The study shows that an average of 2,523–4,542 m³ of bricks would be available for reuse each year, representing 20–36% of the volume of virgin bricks consumed in the construction of new houses in

28. Concerning the reuse market, it may be useful to refer to the online catalogue developed within the framework of the FCRBE project, which presents a selection of recovered products widely available in the reuse sector and adapted to large-scale projects. This catalogue already makes it possible to identify recovered elements widely used on the market, as well as their main technical characteristics. The Opalis business directory is also a useful source of information (https://opalis.eu/en), as is the salvoweb site (https://www.salvoweb.com/).

2012. The estimated reuse potential is lower than the recycling potential (6,187 m³), mainly due to the use of cement mortar, which makes the recovery of bricks harder [20].

Built environment stocks studies can focus their analyses on **specific materials or products**, on a set of defined and differentiated materials or aggregated results for a set of materials such as 'metallic' and 'non-metallic' materials, 'minerals' and 'non-minerals' materials, or more generally 'construction materials'. This approach is best suited to recovery through recycling. As previously mentioned, studies focusing on metals are well represented, and then studies on mineral resources. The most frequently analysed materials include steel, copper and aluminium, but also concrete and timber. Single material studies are rarer. In addition to the most commonly studied materials already mentioned, some focus, for example, on plastics, cement, clay or other types of metals such as zinc, lead and iron. [7]. Other types of materials are not represented as consistently. Studies tend to combine several materials in the same analysis.

Units

The stock can be quantified considering different units. These are also influenced by the scale of analysis, the type of data available, the object and the purpose of the study. With regard to reuse, an accounting by construction elements seems more appropriate. As the latter may be a juxtaposition of different materials assembled to form a single entity (for example, a window has a wooden, aluminium or PVC frame and a glass pane), the units used will preferably relate to surface area, number of pieces, linear metres or even volume. At present, however, existing UM studies tend to consider almost only mass as a unit of measurement (including mass/capita, mass/m², etc.). This allows easier comparison between studies [7] but it is not the most suitable for reuse aspects. It can also lead to an under-representation of key fractions such as insulation, which has a low weight but represents large volumes since it is increasingly implemented in energy-efficient buildings [4] [19]. Finally, socio-economic value is rarely addressed in existing studies. This is despite it being particularly useful when studying the implementation of urban mining and a more circular economy. In addition, with regard to reuse, certain socio-economic indicators (number of jobs created, economic resale value, etc.) should be considered in a complementary way to the unit of weight more commonly used in built environment stock studies. In order to link the analysis to an environmental impact assessment, the unit of weight will be necessary.

Table 3: Different units related to the scale analysis

	Mass (kg, tons)	Linear (m)	Surface (m²)	Volume (m³)	Numbers (#)
Material	X			(X)	
Products		X	X		X
Component/ Elements		X	X		X
Buildings			X	(X)	X
Derived unit / Indicators	mass/m²			m³/m²	
(larger scale of analysis)	mass/capita		m²/capita	m³/capita	

4.

Limits and opportunities

UM studies are valuable for improving resource management through a better understanding of the built environment stock. For public authorities, they help support strategic and regulatory decisions: improving waste management policies, promoting reuse practices, anticipating urban operations, etc. For economic stakeholders, particularly in the construction sector, they make development opportunities visible: developing recovery channels (by third parties or by the producers themselves), implementing new selective demolition practices (for demolishers), opting for construction choices that facilitate the subsequent recovery of buildings (for investors and designers), etc. However, UM studies also have limitations.

An emerging research field

The field of research is still relatively young and requires further harmonisation of terminology and standardised methods. In addition, despite the increasing popularity of UM studies, few of them seem to have resulted in concrete policies[29], especially regarding reuse at a larger scale, as well as their influence and integration into urban planning. The study of reuse on an urban scale may therefore seem difficult or not obvious at first glance. The fact that it is a practice which is still under-exploited and is often carried out on a project scale in an ad hoc and non-systematic manner may also explain this lack of uptake. The principal gaps to integrate reuse of construction materials in UM studies are the lack of knowledge of the built environment composition. This knowledge needs to be focused on the nature, quantity and availability of materials and components, and not on the outgoing waste fractions. In addition, the status of materials is also essential (like the inherent resistance characteristics materials) because of technical requirements and standards (security, comfort, thermal or structural resistance). This information is not easy to obtain; laboratory tests to obtain these characteristics are sometimes needed; and they are often conducted on specific elements and at project scale. Nevertheless, as it is a significant component of EC strategies, it would be beneficial to develop more UM studies integrating reuse. In this sense, the bottom-up approach may be more adapted to the specificities of reclaimed construction elements: starting from the constructed archetypes and their characterisation with regard to reuse (types of materials and construction techniques, etc.), or by approaching it through the question of mono-flows assessment (specific products presents on reuse market such as clay bricks, for example). Crossing the method with a top-down approach could decrease uncertainties. However, the growth of circular economy strategies should encourage and stimulate the implementation of new studies aimed at addressing the challenges and obstacles encountered by current methods, and reuse has a key role to play in this context.[30]

A data-intensive research field

UM studies are fundamentally dependent on data that are often difficult to obtain (in terms of accessibility, reliability, quality). In particular because some important flows are not monitored in a systematic and harmonised manner. This is particularly the case for reuse channels. With the exception of a few initiatives such as BigREc conducted by Salvo in the UK[31] and the statistical work carried out by the FCRBE project[32], Member States in Europe do not compile systematic statistics on reuse. Having access to centralised data is essential to facilitate

29. Although some studies, mainly of urban metabolism and industrial ecology commissioned in particular by the public authorities, have resulted in the concrete implementation of measures (such as those presented in section 3. Existing studies talking about stocks).

30. Refer to *How to build a roadmap The do's and don'ts of reuse in the construction sector* of the futuREuse booklet series (by Emilie Gobbo for Brussels Environment, 2021).

31. The BigREc survey is a business survey conducted by Salvo on the reclaimed building materials sector.

32. Refer to the statistical analysis carried out within the Interreg FCRBE projet.

the recovery of construction elements through reuse (and to a lesser extent recycling). In practice, materials are already documented (technical data sheets, performance declarations for materials submitted to the CPR[33], producers' catalogues, etc.) and this documentation is already collected (in particular via as-built plans and post-intervention files, land register, building permits, etc.). The use of these existing data sources could be improved in order to facilitate data collection and processing (possibly restructuring). However, issues relating to confidentiality and security may also arise with regard to the management and accessibility of this data (wider access to very precise information on the nature of the waste that is going to be generated).

Alongside this, the development and encouragement of 'new' tools such as pre-demolition or reuse inventories, building passports or material passports, and others are also relevant. The difficulty therefore lies rather in optimising the documentation process, systematising and centralising the information. Whether it is necessary to go as far as providing a passport to identify materials is another question. While the basic intention of the material passports is to ensure the transmission of up-to-date information, the risk is that they could lead to the development of a certain duality in the materials market: on the one hand, materials that have a passport – and can therefore circulate freely – and on the other hand those that do not, and which are simply excluded or overlooked. The use of reusable materials could therefore be undermined, which is not what is intended in the aim of optimising the use of resources. Moreover, the non-homogeneity of the deposits, their diffuse nature combined with the unpredictability of demand and access to these deposits (different owners, need for consolidation) are challenges to be taken up by the development and prospection supporting the reusable construction elements market.

A need to integrate actors

However, it is important to note that the accounting of flows is not sufficient to ensure the optimisation of resource management on an urban scale. Territorial organisations and decision-makers at different levels (government, companies, associations, citizens) make the decisions that actually drive the circulation of flows. A complementary study of the actors who manage and consume these flows is therefore essential to ensure the transition of cities towards greater circularity. It seems essential to mobilise these actors around the issue of resource efficiency, in particular by informing them of the usefulness (and limits) of stock studies (such as those mentioned in this report) and by making them aware of the opportunities that reuse represents in this context. The benefits of better understanding the composition of urban stocks are multiple and affect many actors in the value chain. In this context, governance seems essential to implementing CE strategies.

Finally, it is clear that UM studies can inspire methods and approaches that can be used to quantify and characterise batches of materials likely to be encountered today and in the near future. However, while these tools are necessary, they are not sufficient on their own. For a sound evaluation of the reuse potential, whether at the level of a building or, a fortiori, of a city, these approaches must be coupled with notions of art and architecture history, evolution of construction techniques, economics, understanding of the specificities of the market and reuse practices, etc. It is also important to identify the parameters that can influence the urban stocks (economic, technical, regulatory levers, etc.), the interrelations within the stock, the links with other energy (energy efficiency, embodied energy) and their environmental implications. Ultimately, these built environment stock studies could lead to the development of sustainability/circularity indicators and actively participate in the implementation of sustainable urban development policy, circular and resource efficient [7].

33. See more on https://ec.europa.eu/growth/sectors/construction/product-regulation_en

5.

Reusing urban stocks?

If we refer to the concept of UM, the city can be regarded as an accumulation of resources, arranged and assembled together to form various buildings, roads and networks. This 'accumulation' can be seen as a series of layers resulting from successive construction, destruction and reconstruction, some of the remains of which are preserved. In itself, the idea is not new[34]. The term 'palimpsest' was introduced into the fields of architecture and town planning in the late 1970s to illustrate this process: as towns and buildings are modified and redesigned, traces of their past lives remain (in watermark or visible manner). Nevertheless, this analogy to parchment being 'scraped' to be reused as a writing support does not consider the possibility of recovering the constituent elements of the layers removed.

In practice, UM studies aim to analyse the dynamic nature of the evolution of cities, including their buildings. But the idea supported by the city as a reservoir of materials implies the fact that the layers and constituent elements of a building that are removed retain and carry a certain value, allowing them to be reused or reintroduced into a new cycle. It is undoubtedly this notion that differentiates the concept from what was proposed and believed in pre-existing theories and analogies. The challenge is, therefore, on the one hand, to learn how buildings and their constituent parts can be maintained as long as possible and used in practice during successive transformations over time and, on the other hand, to prevent them from being devalued. Indeed, *a reduction of material use would be most easily achieved through a stabilisation of existing stocks and an effort to prolong lifetimes of standing infrastructure and buildings. Preliminary results for European roads suggest that these stocks are a major driver of resource use, and their maintenance and net expansion need to be considered critically* [12, p.12].

In this sense, the reference system proposed by the circular economy, and which is generally underlying in the field of UM, is promising. Indeed, it proposes a shift towards an economy where care, maintenance, repair practices and efforts to extend the life of existing resources generate value (rather than their consumption and early obsolescence). From this perspective, because it involves a transformation of materials and not an extension of the life of building components, recycling should be considered rather as a 'second choice' compared to reuse. In spite of the ambitious objectives of the circular model, initiatives in this direction are increasing. For example, there are already actors who are succeeding in extending the life of building materials by putting them back into circulation during demolition or conversion work. By analogy, they correspond in some way to 'prospectors' of the 'urban mine'. Their practices can already teach us a great deal about the way in which certain 'deposits' are identified and exploited.

However, although reuse practices are encouraged by the circular model, it must be noted that:

- many reusable items escape the control of these 'prospectors' for reasons such as lack of systematic identification, on-site performance requirements (time and budget), the use of largely mechanised processes (which defy any comparative competition in terms of labour costs), the loss of a culture of reuse, etc.
- not all fractions of the 'urban repository' identified as reusable will lead to effective reuse. Various explanations can be given to justify this phenomenon, the issue of profitability obviously being predominant (dismantling too costly, new equivalent materials inexpensive by comparison, significant preparation work, etc.) as well as more technical considerations (risks of contamination, destructive implementation – and dismantling, etc.).

34. Léon Krier defended the idea of 'accumulation' in cities in the 1970s. In urban planning, André Corboz proposed the metaphor of the palimpsest in his text 'The territory as palimpsest' in 1983. The term is also used in architecture and landscape analysis.

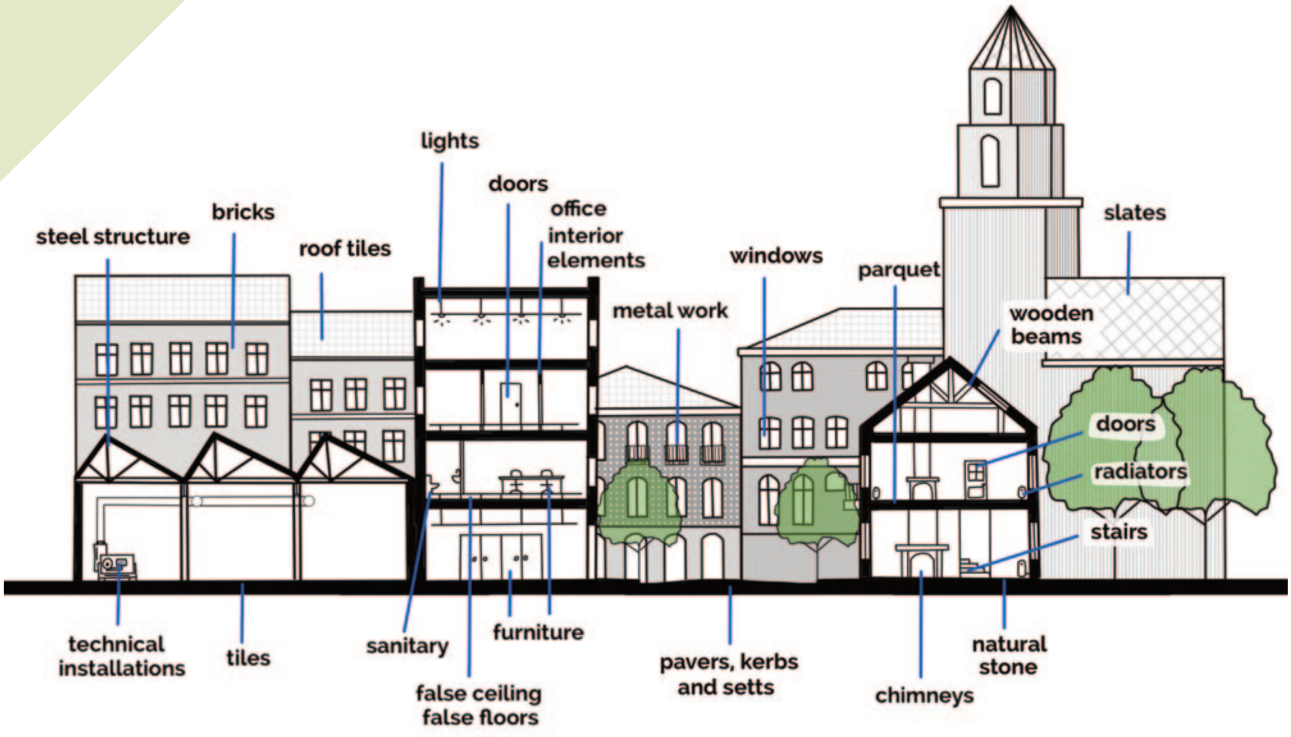

Figure 12: Prospecting for reusable materials in the city

Reuse practices involve local material resources, which are 'abundant' and already manufactured, and whose recovery requires human resources that cannot be relocated. Given the opportunities it represents in terms of circularity, the potential is therefore clearly underestimated and under-exploited. Moreover, it can easily be combined with other recovery approaches such as recycling. In this sense, UM studies could help identify new opportunities and support ambitious public policies to promote reuse, including the definition of reuse targets and the monitoring of efforts and achievements in this direction (and feed statistical data). In a way, this could revive a culture of reuse and support the transition effort.

Finally, this is in line with the ambitions of the European Commission, which intends to review the material recovery objectives set by European legislation for demolition and construction waste by 2024. The implementation of measures to support and develop reuse and recycling platforms to boost the internal market for secondary raw materials is also one of the focus areas pursued by the Commission in its renovation wave strategy. As well as aiming to double the rate of renewal, this strategy makes the link with the integration of circular economy principles in building design and the EU Construction and Demolition Waste Management Protocol [6].

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