



DRIVE 0

Driving decarbonization of the EU building stock by enhancing a consumer-centred and locally-based circular renovation process

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Summary

The **Circular and Consumer Centered (CCC) business model** as developed by the University of Bologna (UNIBO) in T5.1 “Circular Business Models for a circular economy in the renovation market” and T5.2 “Consumer Centered Business Model” has been promoted and implemented by the three European umbrella organisations involved in the DRIVE 0 project, i.e., Architects’ Council of Europe (ACE), Housing Europe (HE), and International Union of Property Owners (UIPI).

The presentation and promotion of the outcomes from the above-mentioned activities conducted in the economic field were supported by the running of **three webinars** (one for each organisation), tailor-made for the specific target groups, i.e., respectively architects and professionals in the construction sector, social housing providers and private property owners. The three webinars took place online between March and April 2023.

Furthermore, a collateral capacity building event was implemented to offer an opportunity for participants to explore the aspects of energy efficiency, decarbonization, and deep circular renovation of the existing building stock further. The capacity building took place in Bologna on 25 May 2023 and was developed in two main sessions. The first part was about the presentation of the Italian demonstration building from the design to the completion phase. The second part was more practical as the participants exchanged design project ideas for developing circular local solutions and discussed them in relation to the local barriers (legislative, economic, and social), based on the lessons learnt during the first part of the event. The technical solutions were analysed in terms of opportunities of the CCC business model, as well as circularity and environmental impact in relation to the local climate, building typologies, and driving factors. Finally, a **special training session** was organised for the DRIVE 0 partners on the deployment of the CCC business model in conjunction with the 8th DRIVE 0 consortium meeting held on 10-11 May 2023 in Dublin (Ireland).

The outcomes of all these activities developed have been collected and analysed in order to elaborate the report D5.4 “Three webinars for ACE, HE, and UIPI for a further market uptake of the business model and one collateral capacity event on the application of the business model” and the related deliverable **D5.5 “Booklet with policy recommendations”**.

As explained in this report, the following policy recommendations result not only from the lesson learned during the activities developed in the framework of T5.4 but also from the data collected during other important DRIVE 0 meetings, events, and activities organized with the aim of **creating a dialogue between different target groups** of stakeholders involved in the process of renovation of the built heritage.

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1 Introduction

DRIVE 0 is a four-year-long project funded in the framework of the Horizon2020 Programme designed to implement efficient and effective **circular solutions** for deep renovating the existing built heritage. The **efficacy and effectiveness** of the proposed circular strategy must be referred to both performances and costs. The purpose of the DRIVE 0 project is to spread awareness, build confidence, and demonstrate to all the stakeholders involved in the renovation processes the attractiveness – in terms of opportunities and benefits – of a **holistic approach** based on the implementation of circular materials, products, and components.

One core concept of DRIVE 0 is the importance of making a transition from a linear to a circular economy model in all productive sectors. This also needs to happen more than ever in the **construction sector**, which, according to analysis by the European Commission, is responsible for 40% of primary energy demand in the European Union and 36% of greenhouse gas emissions¹. Green Building Council estimates² mention how more than 50% of the total carbon emissions from all new global construction between 2020 and 2050 will be precisely due to embodied carbon and thus emissions related to materials and the construction or renovation phase of buildings.

Therefore, accelerating the **decarbonization of the built environment** in all phases and components assumes a key role in achieving the energy and climate targets imposed by the European Commission to be met by 2050.



Figure 1. Estonian pilot: residential building located in Saue. General view after the deep renovation intervention based on the implementation of a circular strategy: extension of net area by closing balconies for enlarged living spaces and implementing façade additions for new balconies; energy refurbishment of the envelope through prefabricated modules with reused and recycled materials and bio-based material, and building integrated renewable energy technologies. (Source: TalTech and TIMBECO, 2023)

¹ The Construction Sector Towards a New Challenge: Decarbonizing Construction, (ed.) Gabriele Nanni, Legambiente Science Office, “Embodied Carbon Emissions” Project funded by European Climate Foundation. November 2022. Available online: https://www.legambiente.it/wp-content/uploads/2022/11/La-decarbonizzazione-delle-costruzioni_report-2022.pdf

² World Green Building Council. Available online: <https://worldgbc.org/buildinglife/>

The implementation of the **circularity concept in practice** is highly challenging. A deep renovation project based on the adoption of a circular approach, that is the use of materials, products, and components with a low environmental impact, assembled through low carbon emissions processes (Figure 1) must tackle a significant number of constraints and obstacles. These barriers are of a **varied nature: technical, regulatory, financial, social, and societal**.

The implementation of circular strategies could even extremely complicate the deep renovation process of the existing heritage, thus affecting it in terms of increase in economic expense, technical-construction difficulty, the hardship of finding materials, the duration of the permitting process to meet regulatory requirements, and - not least - the challenge of social acceptance of the intervention by individuals involved in the process.

Aware of those possible barriers and willing to find viable solutions to overcome them, the DRIVE 0 consortium organized several meetings and events during the project's whole course to create dialogue and discussion among all the **stakeholders involved in the renovation processes**, with **different profiles and perspectives**.

An accurate evaluation of those barriers is the basis for elaborating possible solutions for mitigating the obstacles to the implementation of the circular strategy in the construction sector. Even if the DRIVE 0 partners have always demonstrated awareness regarding the impossibility of identifying a unique solution to be adopted generically in all the contexts examined, the analysis of the barriers represents the first fundamental step in breaking down the problem and identifying specific customised solutions tailored to the nature of the building, its intended use, and its typological-construction characteristics.

Analysing those challenges from different target groups' perspectives and at different national and international levels guaranteed a complex overview of the framework and a **holistic approach**. Indeed, the DRIVE 0 consortium comprises research institutions (universities and institutes), companies and industries, architectural design firms, and umbrella associations active in the construction field. Furthermore, other local and European stakeholders active in governance and strategy-making for the transition to decarbonization of the built environment have been involved in several meetings and events organized. During these events, the collection and debate among the **key actors** on the barriers to circularity implementation in the construction field always represented the key factor. They thus made it possible to achieve a general framework that includes technical, legal, and financial aspects.

The identification of the main barriers to the circularity in the building sector has been tackled and included in other reports of the DRIVE 0 project (e.g., **D3.2 "Report with a description of the boundary conditions of an enhanced circular renovation process"**³) and other results consisting of scientific publications. For instance, another important document tackling the issue related to the constraints is the positioning paper⁴ drafted by some DRIVE 0 partners (HYA and ZUYD, together with ABT) reporting on the results of a workshop held at the Sustainable Places 2021 Conference by six Horizon 2020

³ "DRIVE 0" Horizon 2020 EU Project, D3.2 Report with a description of the boundary conditions of an enhanced circular renovation process. Available online: <https://www.drive0.eu/wp-content/uploads/2022/07/Report-with-a-description-of-the-boundary-conditions.pdf>

⁴ J. van Oorschot, M. S. Di Maggio, P. Op 't Veld, A. Tisov, *Boosting the Renovation Wave with Modular Industrialized Renovation Kits: mapping challenges, barriers and solution strategies. A common positioning paper by six H2020 projects on deep renovation*. 2022. Available online: https://www.drive0.eu/wp-content/uploads/2022/10/SP2021-Positioning-Paper_Boosting-the-renovation-wave-with-Modular-Industrialized-Renovation-Kits.pdf

projects. As a result, several technological, market, financial, legal, and institutional challenges and barriers to the adoption and/or implementation of Zero Energy Renovation Kits were identified, assessing the challenges and barriers to development.

The above-mentioned documents were aimed at giving a general overview; on the contrary, this report intends to give a more detailed picture of the barriers and challenges, providing precise classification matches as well as identifying suggestions for possible mitigation/elimination measures.

Therefore, the purpose of this report is not to reiterate data already highlighted but to capitalize on the work already done during the DRIVE 0 project, making a final synthesis that can contextualize the results that have already emerged, clarify and dissect the barriers and opportunities of implementing circularity in the construction sector.

With that in mind, distinguishing obstacles and incentives for specific circular interventions from those related to deep energy refurbishment is challenging at times and would not necessarily be meaningful since, from the investor's point of view, the renovation project would be seen as a single project with related and common conditions.

Taking all these elements into account, this report aims to:

- Propose a meaningful yet non-exhaustive list of challenges that key stakeholders face or expect to face during the conceptualization, design, implementation, planning, and execution phases of a circular deep renovation intervention;
- Suggest potential solutions and best practices for facing the barriers identified;
- Propose possible policy recommendations on how the key stakeholders can overcome these barriers and related challenges.

2 Target groups addressed by the report

The DRIVE 0 project is addressed to the whole construction sector by considering different use categories, with a particular focus on the residential sector. Indeed, the pilot cases selected as demonstrator buildings representative of different local contexts are almost all residential buildings (single-family houses, family houses, or condominiums) except for the Spanish pilot, which is an office and showroom building.

Consequently, the project is focused on the different target groups involved in the renovation process of buildings in different ways and phases, with different perspectives. In this report, the main stakeholders considered – both private and public – have been divided into three broad categories based on the similarities in background, interests, and scope for action that these parties generally have:

1. Private sector;
2. Public, social, and cooperative housing sector;
3. Experts in the construction sector.

2.1 Private sector

Within the category called “Private sector”, the following actors are meant to be included: private owners and co-owners (occupiers and non-occupiers), tenants, landlords, managers, investors, Energy Service Companies (ESCOs), banks, and financial institutions.

For this target group, the contribution of the **International Union of Property Owners (UIPI)** has been crucial to understanding the private property owners’ perspective. The term “private property owners” is extremely broad and potentially encompasses a range of real estate actors: from large listed or non-listed real estate companies with a portfolio composed solely of large commercial buildings to individual owner-occupiers. UIPI focused especially on the part of the sector they mainly represent and know best: mainly small private landlords and owners’ occupiers in the residential sector, corresponding to the 70% of the population living in a household owning their home or rent a certain number of residential dwellings on a non-professional basis or as small businesses.

2.2 Public, social, and cooperative housing sector

The following actors are included within the category “Public, social, and cooperative housing sector”: non-for-profit housing providers at the local level (social housing, public housing providers, and cooperatives) and national and regional housing federations. For this target group, the support provided by **Housing Europe (HE)**, as a European Federation of Public, Cooperative & Social Housing. Since 1988, it’s a network of 46 national & regional federations gathering 43.000 housing providers in 25 countries. Together, they manage around 25 million homes, about 11% of existing dwellings in Europe⁵. The social and public housing sector manages large estates and must constantly make decisions regarding extraordinary maintenance and deep renovation of the ones they manage. Therefore, their voice is very important to understand the obstacles they face in implementing a circular approach.

2.3 Experts in the construction sector

The “Experts in the construction sector” category includes the following actors: professionals (engineers and architects), academics, construction companies, and industries. It is therefore a very broad category, including individuals working as freelancers and individuals employed as employees of private or public entities. These are always people who have received specific training in construction and who deal with the issue of deep renovation on a daily basis in their profession, with particular reference to issues of a technical-constructive profile.

⁵ Housing Europe. Available online: <https://www.housingeurope.eu/>

In this context, the experience of the **Architects' Council of Europe (ACE)** played a crucial role in understanding for a real understanding of the experts' perspective on the obstacles encountered during the analysis and feasibility study phases of the interventions, their design, and implementation.

3 Methodological approach

During the DRIVE 0 project, several project meetings, technical workshops, conferences, and webinars were organized (Figure 2).

Below are listed the main events performed with the aim of **sharing opinions and generating a valuable and fruitful discussion** about the opportunities and benefits of the adoption of a circular strategy:

- DRIVE 0 Consortium meetings throughout the entire four-year duration of the project;
- Two physical technical meetings and workshops (one in Ljubljana in January 2020 and one in Barcelona on March 2022);
- Online working session in June 2020;
- “Accelerating Deep Energy Retrofit in Housing through Modular and Circular Solutions” Conference, organised by HE and TU Dublin, held on 11 May 2023 in Athlone (Dublin);
- “Circular Talks” series of three webinars held online on March-April 2023;
- Building capacity event in the framework of the “Renovation Tour” held on 25 May 2023 in Bologna;
- Several dissemination activities organised by partners during the project;
- “Fostering experiences from EU innovation projects to accelerate a sustainable built environment” DRIVE 0 Final Symposium & Clustering Workshop, organised by Huygen Installatie Adviseurs, HE, and ACE, held on 15 November 2023 in Brussels.

Furthermore, a specific contribution was made by HE, which carried out collateral activities useful for deepening knowledge and understanding of the barriers to the development of circularity in the construction sector, with a focus on the social, public, and cooperative housing perspective:

- International training for social, public, and cooperative housing providers on circular housing renovation, as part of the International Social Housing Festival in Helsinki, organised by HE (15 June 2022);
- Semi-structured interviews to Westmeath County Council and EKYL (Estonian Union of Co-operative Housing Associations), conducted by HE (29 September 2023 and 9 October 2023);
- Webinar on “Reducing carbon footprint without reducing the delivery of social & affordable homes” organised by HE (30 November 2023).

Critical barriers and threats emerged from these debates at both local/national and international/European levels. These **obstacles** are **of technical, regulatory, financial, social, and societal nature**. For instance, the implementation of circular solutions in a deep renovation process could affect the feasibility of the project from a technical and economic point of view.

To collect and compile the information contained in this report, the following sources have been used:

1. Grassroot and field experience, as well as knowledge coming from UNIBO and the umbrella associations (UIPI, HE, and ACE) partner in the DRIVE 0 project;
2. Desk research (including information from other European projects);
3. Data collected during DRIVE 0;
4. Input and comments collected during all the events above-mentioned.

From all these sources, a check about the different target groups' perceptions was done to reflect real concerns and obstacles to implementing a circularity strategy and even to decide to activate a deep renovation process according to a circular approach. The collected data was proven valuable for developing the DRIVE 0 suggestions and policy recommendations, ensuring that the project results have real potential to increase awareness and promote the adoption of circular measures for energy-efficient retrofitting of the existing built heritage.



Figure 2. Consortium picture (Source: <https://www.drive0.eu/about-us/>)

4 Obstacles and barriers to the implementation of circularity

This chapter brings together the challenges and possible solutions for accelerating circularity in the construction and renovation sector, considering the comments, observations, and outcomes of the discussions held during the events organized during DRIVE 0 (see chapter “Methodological Approach”). To classify these challenges, the afferent spheres of the issues that emerged were identified, namely the following spheres: technical, regulatory, and financial.

However, it is essential to emphasise that some of these aspects are strongly interconnected. For example, a deep renovation intervention on a protected historic building must comply with certain regulatory requirements that imply precise technical-constructive choices unavoidably linked to economic-financial aspects. Here, then, is how a barrier considered regulatory in nature can be closely related to financial and technical obstacles.

Moreover, social and societal parameters are a central and cross-cutting element of this analytical approach: a lack of social awareness and empathy with users who have to make upgrading choices could lead to adopting behavioural patterns incompatible with users' financial and legal interests. For this reason, behavioural aspects, social norms, or reference prejudices have been treated as a permeable cross-cutting factor with all categories and not a category on its own.

Figure 3 depicts the interconnections that exist between the three main fields covered by the barriers to the development of a circular approach, which are in turn influenced transversally by the factors belonging to the social and societal evening.

Finally, it should be pointed out that the observations derive from a comparison between EU countries with very diverse economic, legislative, and socio-cultural situations and that, therefore, the reported analyses must always be related to the different local contexts under analysis.

However, although conditions vary, there are common patterns in how stakeholders involved in the renovation process decide to invest in such projects by adopting a circular approach. Therefore, the objective of this report is not to present universal “pre-packaged” solutions to be adopted indiscriminately in all European contexts but rather to present suggestions and policy recommendations that can enrich the discussion regarding the implementation of circularity in the construction sector.

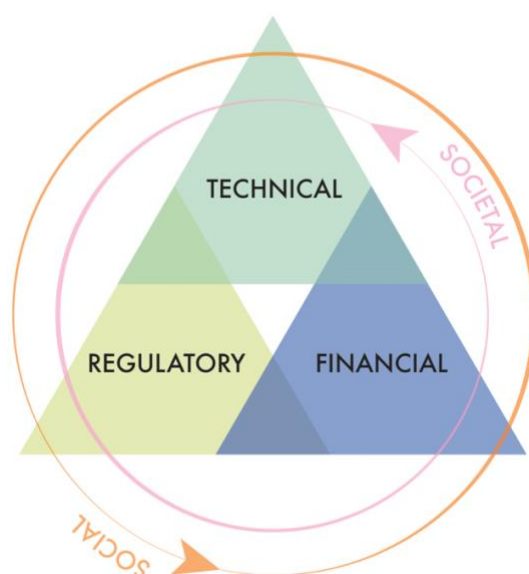


Figure 3. Scheme representing the different fields considered for the analyses of the obstacles and barriers to the implementations of circularity in the building sector. (Source: C. Mazzoli, 2023)

4.1 Technical issues



Figure 4. Technical issues. (Source: C. Mazzoli, 2023)

The definition and evaluation of indicators related to the mainly technical-constructive aspects of circular actions (Figure 4) have been the main aspects investigated within the DRIVE 0 project since the first months of work (e.g., see D6.1 “Report on benchmarking on circularity and its potentials on the demo sites”⁶).

The technical viability of the implementation of circular solutions was assessed through technical feasibility studies of the demonstrator buildings selected by the project. In particular, the study of specific circular 2D (see **D2.2 “A set of circular prefab 2D building envelope elements with case specific solutions”**⁷) and 3D (see **D2.3 “A set of circular prefab 3D case specific solutions”**⁸) solutions was investigated.

Technical feasibility is, of course, of great importance for all stakeholders. However, the aim of this chapter is not to evaluate what is feasible or technically most suitable in specific cases. Rather, it is to better understand the most technically relevant aspects and how the relevant stakeholders involved in the deep renovation processes perceive the innovative and technological changes in terms of expected benefits and potential risks. The analysis of technical feasibility is the first step towards designing appropriate circular strategies that are efficient and attractive.

i. Lack of knowledge of the potential and relevant benefits offered by the available solutions, possibly customisable

Barrier

The lack of knowledge among all stakeholders about possible circular strategies for deep renovation of buildings is a major obstacle. Adopting a circular approach involves many aspects, including using materials with a low environmental impact and adopting reversible products and systems, i.e., easily assembled and disassembled, with a high degree of reuse and recycling. Often, circular solutions are not considered in energy refurbishment processes as they imply technical difficulties with economic consequences. This aspect was mentioned several times during the DRIVE 0 Project Meetings and during the “Circular Talks” webinar series. Therefore, if planners and professionals, in general, do not propose solutions based on circularity principles to tackle the deep renovation of buildings, it is unlikely that owners/operators will consider this option.

⁶ “DRIVE 0” Horizon 2020 EU Project, D6.1 Report on benchmarking on circularity and its potentials on the demo sites. Available online: https://www.drive0.eu/wp-content/uploads/2020/08/DRIVE0_D6.1.pdf

⁷ “DRIVE 0” Horizon 2020 EU Project, D2.2 A set of circular prefab 2D building envelope elements with case specific solutions. Available online: https://www.drive0.eu/wp-content/uploads/2023/02/DRIVE-0_D2.2-Improved.pdf

⁸ “DRIVE 0” Horizon 2020 EU Project, D2.3 A set of circular prefab 3D case specific solutions. Available online: <https://www.drive0.eu/wp-content/uploads/2022/07/Set-of-circular-prefab-3D-case-specific-solutions.pdf>

For this reason, it is crucial to disseminate information among communities of owners on the advantages, benefits, and technical specificities of circular solutions. In particular, it is necessary to leverage the benefits linked not only to the reduction of environmental impact for the entire planet in terms of decarbonisation but also to the benefits that circular products have directly on those who own/administer and inhabit buildings in terms of healthier environments (thanks to more natural, less toxic, even bio-based materials) and ease of maintenance during the building's lifetime. The latter aspects, directly impacting the final users, can be better understood and thus have more weight on decisions.

Suggestions

Raising awareness and training on circular solutions is crucial to ensure that the existence of these options reaches owners through reliable and independent sources. All identified target groups (private sector, public sector, experts in the construction sector) should be directly involved in training and information on circular solutions.

Transparent and user-friendly information on the subject, easily accessible to all final users, should be provided. It should also be comprehensive enough to include all relevant details on customization, possible obstacles, and hidden costs to be considered valid by the consumer.

The circularity tool “Circular Homes”⁹ promoted within the framework of DRIVE 0 allows the evaluation of single-family houses or single dwellings in multi-family buildings or buildings with more than one dwelling, proposing a series of measures to be more circular: measures and products, DIY (Do It Yourself) solutions, and habits.

Another valuable tool to assess the level of circularity of a building before and after the interventions is the EASY (Express ASsessing tool for CircularitY) method, developed by UNIBO in the framework of DRIVE 0¹⁰. Such tools are essential to allow visualization and evaluation of the benefits of proposed solutions to guide decisions.

Finally, research institutes at the local level play a key role in assisting and advising social, public, and cooperative housing providers in identifying the most appropriate renovation strategies following a circular approach. This is the only way to help the social and affordable housing sector in one of its main challenges: reducing its carbon footprint without reducing the supply of affordable housing.

ii. Lack of trust in professionals and experts in the field of construction

Barrier

The hidden mistrust of building professionals and experts, coupled with the lack of specialised expertise in energy efficiency through the adoption of a circular approach, can heavily influence the final decision made regarding the type of deep renovation intervention to be implemented.

Especially private property owners and landlords do not know where to turn to find reliable experts and professionals from whom they can receive advice and assistance on what to do. Indeed, for these individuals, making a decision as important as a deep renovation through the adoption of circular strategies is often the second most important investment after the purchase of the property.

⁹ Circular Homes. Available online: <https://www.circularhomes.eu/>

¹⁰ Cecilia Mazzoli, Rachele Corticelli, Lorna Dragonetti, Annarita Ferrante, Johannes van Oorschot, Michiel Ritzen (2022). *Assessing and Developing Circular Deep Renovation Interventions towards Decarbonisation: The Italian Pilot Case of “Corte Palazzo” in Argelato*. In: SUSTAINABILITY, 14, p. 1–34, ISSN: 2071-1050. Available online: <https://doi.org/10.3390/su142013150>

Therefore, they seek an assistance service capable of identifying and suggesting the most suitable economically and practically feasible solutions that guarantee a satisfactory and long-lasting outcome.

Suggestions

Lists of certified building professionals and experts could be supplied by third parties such as public authorities, homeowners’ or consumers’ associations, or “One-Stop-Shop” facilities. In order to address the lack of transparency in the market, these lists should provide a sufficient choice of professionals and a fairly wide price range for the services offered. In particular, each of the identified target groups should work together to develop an independent and reliable guide, which would serve as a comprehensive "service package" with information on the most efficient and environmentally friendly circular solutions, available financing instruments and tax measures, as well as lists of certified construction professionals experienced in this field.

iii. Consumer acceptance of innovative circular technologies and solutions for deep renovation

Barrier

As emerged during dialogues and debates during DRIVE 0, associations of property owners, social housing, and professionals often report a certain level of uncertainty towards the adoption of innovative technologies among their individual members.

This phenomenon, known as “consumer acceptance”, corresponds to a bias in favour of the adoption of technological solutions that are available on the market and have already been tried and tested. The feeling of uncertainty towards the use of innovative products, components, and circular construction techniques is mainly due to the lack of knowledge on the subject. This negative feeling of discomfort leads final consumers to the willingness to exclude any risk related to the implementation of an innovative circular solution to conduct their deep renovation and energy refurbishment.

Suggestions

Dissemination, awareness-raising, and training activities in the field of circular strategies for energy refurbishment of buildings are essential to spreading knowledge and thus acceptance of new technologies. Conducting sensitisation campaigns involving all the main stakeholders committed to the renovation processes is the first essential step to providing knowledge on the importance of improving the energy efficiency of buildings through the implementation of decarbonisation processes based on circular strategies, often innovative in terms of the use of materials, products and building systems. Parallel to these campaigns, it is crucial to carry out information campaigns aimed at providing more specific and technical insights to fill knowledge gaps regarding the characteristics, potential, and costs of implementing these innovative solutions.

It should be noted that correct information and education for acquiring such expertise must necessarily be accompanied by valid assistance from professionals and technical experts in the field to promote their proper and effective application. Indeed, also in the social and affordable housing sector, the key to scaling up innovative solutions lies in running a feasibility assessment. Some innovative solutions are more adaptable to larger volumes. Housing providers, together with industries, should put focus on suitable variants. More importantly, circularity is not the only priority

for social housing providers, but other issues come into play when investing in renovation, such as liveability, energy poverty, social cohesion or employment. From moment one, the feasibility perspective must come into practice, and where other priorities exist, an integrated renovation strategy should be considered.

In general, it is important to boost the concept that renovation goes beyond materials and energy and includes people and local socio-economic needs, which is an important step toward market uptake of circularity methods.

iv. Difficulties in certifying and supplying circular materials, products, and systems

Barrier

The industrial partners of the DRIVE 0 consortium reported that one of the technical (and legislative) barriers in their business that hinders the implementation of circular solutions concerns the difficulty in finding certified circular materials and thus in realising more complex systems obtained by assembling different components that are certifiable.

During DRIVE 0, from the testimony of the industrial partners involved during the Technical Meetings and Workshops, it emerged that the product certification is both complex and resource intensive and can take over 2-3 years. In particular, the affordability of time-consuming certification procedures can hinder construction Small and Medium-sized Enterprises (SMEs) to invest in this type of technology innovation for deep-renovation processes.

This issue is more evident for prefabricated and modular technologies, which, despite having well-known advantages in terms of time reduction, are not yet so widespread. Innovative compound systems are often not CE-certified as product systems and depend on the individual CE certificates of the integrated components. This factor hinders the full integration of the individual components into the modular product system and consequently prevents the achievable potential in terms of overall modular system performance from being fully utilised.

This barrier also concerns the re-certification needed to allow the use of secondary materials, which is expensive and risky for social/public housing providers, and liability (initial cost and failure of certification). Indeed, insuring and tracing secondary materials is difficult for social and affordable housing providers. Their lack of certification makes them less reliable to building inspectors than traditional construction products, resulting in additional costs and responsibilities for housing providers, which discourages their use. Building inspectors, who ultimately give access to building insurance, are unfamiliar with some of the products and techniques used in the circular projects, which can put most insurers outside their “comfort zone”. At present, it takes significantly more effort to secure these assessments than for a “traditional” building, and many housing providers either can’t or won’t tolerate that.

In general, building product certifications are extremely tied to national schemes, which blocks the exchange of sustainable regional construction products across national borders and thus market uptake. Consequently, retrofitting solutions from one country are not insured in another country.

Suggestions

It is necessary to raise awareness among policy-makers and agencies involved in the product certification process about the importance of using circular modular solutions for energy

refurbishment and decarbonisation of the built heritage. Indeed, on a national and European level, obtaining certifications for modular building systems would allow modular product suppliers to assure customers of the quality of their products, demonstrating that they meet the guidelines and thus comply with legislation.

Consequently, with the increase in circular solutions, familiarity with the insurance sector will also increase. The revision of the Construction Products Regulation (CPR) should help with this too, by putting in place harmonised rules for secondary materials, so that they are insurable in the same way as new materials.

The EU should consider making material passports mandatory or, at the very least, find ways to vastly upscale their use for new buildings. Doing so could be an essential part of developing a secondary market with the right scale to satisfy the need for products and offer real competition to producers of new products, which too often are very carbon and resource intensive. The CPR could help create some convergence and increase comparability for material passports.

v. Limits and interruptions in the use of spaces of services

Barrier

This factor, also called the “disruption factor”, refers to all the problems that renovation work could generate for the occupants of the buildings being renovated. This factor plays a key role mainly when intervening in the built heritage by means of deep renovation works, which may have a long duration and may involve somewhat invasive work. This factor can therefore influence the final decision regarding the realisation of the renovation.

This aspect, which emerged during several events held by DRIVE 0, is confirmed by a large body of literature and research that underlines that one of the main obstacles to energy retrofits is the inconvenience caused to users.

In particular, disturbances can be of various nature: disturbance and limits in the use of the indoor living environment caused by the promiscuity between living areas and construction site areas occupied by workers, which creates dust, dirt, noise, and other nuisances; interruption of the supply of services (e.g., gas, water, electricity); disruption of traffic in the streets delimiting the lot where the building under construction is located (e.g., road closures, changes to the road system and access).

Suggestions

The “disruption factor” can be significantly reduced by adopting circular Plug&Play solutions, which allow for intervention from outside the building and even, if well designed, do not require the mobilisation of the inhabitants.

In addition, reversible and dry-assembly solutions make it possible to limit the generation of dirt and dust and to limit the time required to carry out the work, with considerable benefits both on indoor comfort and on the environmental and economic impact of the site.

Proper planning of interventions by means of a timetable, which adequately informs occupants and landlords and brings out the advantages in terms of time reduction, can be decisive for promoting and implementing deep renovation interventions.

The DRIVE 0 consortium addressed this issue during the whole duration of the project, also thanks to the crucial contribution of industrial partners who designed and implemented specific 2D and 3D circular solutions for the deep renovation of the pilot cases selected by the project.

vi. Absence of a unified method to measure embodied emissions

Barrier
At the European level, there is a lack of a unified definition and calculation method for embodied emissions, which makes it difficult for social and affordable housing providers to integrate Life Cycle Assessment analyses into their projects.
Suggestions
The EU definitions of ZEB and nZEB buildings must include the embodied carbon during the development and construction phases, but also mobility in the use phase and production of decentralised energy. A life cycle sustainability assessment system is mandated. Mandating carbon accounting would stimulate retrofitting while encouraging modern construction methods to accelerate delivery. It would penalise projects that are not sustainable.

vii. Difficulties in the management of secondary materials and end-of-waste status

Barrier
Social and affordable housing providers experience logistical issues related to the storage of reused materials, careful removal, and transportation of materials from existing buildings. When components become free, they are expensive to store and must be transferred to the new site directly. The storage of secondary materials has been recognised as an area where local authorities should intervene. Furthermore, the “Products As A Service” approach by which the building owner rents certain building components is not well adapted to buildings with a long lifetime. It might be the case that a housing provider is renting certain building components from a company that may not operate in the future. If the component needs replacement, housing providers are left with no options. Regarding waste in the construction sector, the percentage of building waste that is allowed is often limited by legislation, depending on the type of materials.
Suggestions
Online sharing platforms help to increase and improve connections between suppliers and customers. Materials platforms offer a wide range of building products (including windows, doors, and other components and household fixtures) to users, such as social housing providers, at affordable prices. It would be important for existing buildings to require a materials audit to identify the condition of the materials and an assessment of their potential for disassembly and reuse/recycle. If this step is taken first, architects, engineers, and others involved in the design phase can work with this inventory to maximise the reuse of materials.

4.2 Regulatory issues



Figure 5. Regulatory issues. (Source: C. Mazzoli, 2023)

In most cases, the technical issues can be resolved if a sufficient budget is available and if those involved in the process have reached a good level of awareness of the potential of adopting circular strategies for deep renovation interventions. On the contrary, several legislative aspects (Figure 5) can hinder this process and are more difficult to overcome as they depend on higher-level governmental and legislative factors. They relate to the nature of the building being renovated but also to the general regulatory framework that governs the context in which it is located.

These aspects were addressed and discussed during all the DRIVE 0 Project Meetings, from which it emerged that the situation varies in different local and national contexts. Therefore, it is important to emphasise that most of these regulatory barriers are not uniformly regulated at the level of European directives but are of national competence. Consequently, the application of the circular solutions identified during DRIVE 0 may respond to different degrees of legislative feasibility and, in some cases, may prove not to be applicable.

i. Lack of knowledge and legal inconsistency and uncertainty among the different regulatory frameworks

Barrier
<p>Among the most evident barriers that stakeholders in the construction and real estate sector encounter in relation to the adoption of circular strategies for deep renovation of the built heritage are those of a legal and regulatory nature. First of all, there is a general lack of knowledge of the regulatory framework on circularity, which, in all countries, is very fragmented and unclear. This legal uncertainty is one of the main reasons for the low uptake of circular solutions in construction. The implementation of circular solutions, which are still not widely disseminated and tested, also creates a potential legal/legal risk (e.g., the need for legal action by neighbours, co-owners, companies, or other stakeholders) that some owners and investors are often unwilling to face. In addition, the heterogeneous and highly diverse legal and regulatory frameworks, not only between EU Member States (MS), but also at regional and local levels, increase the complexity level of carrying out such actions. The lack of a clear legislative knowledge framework is one of the most frequently cited obstacles in the literature and is one of the most recurring factors during the meetings held during DRIVE 0.</p> <p>Furthermore, at the local and European levels, no general mandatory prescriptions impose the adoption of specific low environmental impact solutions for certain general cases. On the contrary, each country prescribes the respect of certain requirements only for particular cases and for particular solutions (e.g., in Italy, the respect of the Minimum Environmental Criteria - CAM must be</p>

respected only for public buildings, but not for private ones). The lack of a homogeneous and general regulatory framework for MS constitutes an element of uncertainty and mistrust toward the effectiveness of circular solutions.

Suggestions

A large part of the legal uncertainty can be mitigated or even eliminated if investors and managing entities are aware of the regulatory framework governing the adoption of circular deep renovation solutions. The most effective way to achieve an adequate level of information among stakeholders would be the creation of OSS models at the regional or local level, as this would ensure that local and regional specificities related to the regulatory framework are addressed in detail at the local level. In addition, greater knowledge and awareness of the obligations and legal implications of circular actions would lead to the development of a sense of confidence and trust among stakeholders, who would be more comfortable investing in a circular approach.

First, legislative information could be provided by the relevant administrations through informative campaigns based on easily accessible and understandable information materials available (e.g., printed materials such as booklets and brochures or online resources on dedicated websites).

In addition, umbrella associations that gather the identified target groups (public agencies, private entities, and professionals and experts) could play a key role in providing assistance and decision support in identifying suitable and feasible circular solutions and their legal implications, thus helping to increase the sense of trust and acceptance.

In addition, the definition of some precise general requirements and criteria, adoptable for all MS, could contribute to the establishment of a clear regulatory framework for the development of such strategies.

ii. Barriers in the decision-making process for multi-property owners and other multi-user realities

Barrier

Due to a significant proportion of the existing building stock in many Member States being multi-apartment buildings, thus administered by multi-property owners or other multi-user bodies, decision rules on required majorities may acquire additional complexities during the decision-making and authorization process. For example, making a decision on energy upgrades in apartment buildings requires a majority of more than 50% in some European countries, while in others, consensus must exceed 75% or may even require unanimity.

Owners of housing units included within a condominium or multi-property buildings are the main decision-makers in energy refurbishment. They may be supported by other third parties, including building management agencies, external experts such as municipal functionaries, or professionals providing technical advisory services. The final decision and financial responsibility for the investment and overall maintenance of the building belongs to the owners themselves, who must reach an agreement regarding the intervention to be undertaken. The decision-making process therefore can become complicated and prolonged considerably, especially if there is a discrepancy between different building units, in terms of different upgrading needs and extent of intervention.

Suggestions

To facilitate the complex decision-making process and create consensus in multi-property settings, the provision of easily available, understandable, and accessible information about the implications of circular solutions for deep renovation and energy refurbishment of the buildings.

Therefore, it becomes essential to envisage adequate, comprehensive, and clear information about possible intervention solutions to achieve energy efficiency through environmentally friendly solutions. This information should be focused not only on the achievable benefits in terms of techniques for energy efficiency and comfort indoor, but also of legal and financial implications that the interventions would have (e.g., regarding the installation of photovoltaic panels or other systems for renewable energy production, as well as the creation of extra spaces to increase the surface area of the building units through the installation of 3D circular components). A clear information framework would help to avoid the occurrence of legal uncertainties and possible complications during the process.

Another potential effective solution could be the simplification and streamlining of general rules to facilitate decision-making while respecting the rights and interests of individual owners within a multi-property context.

iv. Obstacles in urban planning legislation and bureaucratic procedures

Barrier

Rigid planning legislation and bureaucratic procedures can pose a severe challenge to the potential implementation of circular solutions, especially if these involve innovative 2D/3D components that could significantly alter the building's original morphology and construction characteristics.

This issue becomes particularly delicate if the heritage asset on which action is being taken is a historic and protected asset, subject to regulatory constraints that aim to protect its architectural and historical-testimonial value (as was the case, for example, with the DRIVE 0 pilot located in Italy). Indeed, planning and approval procedures often involve considerable bureaucracy and time-consuming procedures requiring, for instance, the need to obtain special permits and derogations. In addition, building and land use regulations are often too restrictive or inappropriate to include circular solutions.

These technical barriers emerged during the various dialogues held in DRIVE 0, especially during the Project Meetings and Technical Meetings and Workshops, where the different Local Pilot Leaders for the pilot cases selected by the project recounted the difficulties they encountered.

Suggestions

Regarding severe land-use planning laws and related regulatory obligations, one solution could be to raise awareness among national, regional, and local authorities of the importance of adopting circular solutions, even if they are novel or have a greater impact on the final design of buildings, in order to achieve the heritage decarbonization goals that Europe must strive for by 2050. Raising awareness of the benefits achievable through implementing circular strategies could make obtaining waivers/derogations and special permits easier.

In addition, it would be important for local legislative bodies to initiate a process of reviewing regulations to bring them up to date with current European regulatory trends on circularity and

decarbonization, as well as streamlining and simplifying administrative and bureaucratic procedures.

v. Constraints for the protected cultural and historical built heritage

Barrier
<p>Buildings or urban areas subject to specific legal requirements concerning the preservation of particular architectural value or of historical-testimonial value represent particularly critical cases in terms of constraints and lack of flexibility in the interventions that can be implemented.</p> <p>Obstacles may concern regulatory constraints that impose the use of specific materials while respecting the original ones, the use of the same construction techniques as those originally used, and the impossibility of heavily intervening on the building envelope (external walls and roofing) through innovative and circular components, including integrated photovoltaic panels (which are often perceived as a factor that degrades the aesthetic value of a building on listed historical heritage). This aspect was particularly highlighted by the experience of the deep renovation of the Italian pilot, consisting of an early 20th century villa protected by a historical-documentary constraint.</p>
Suggestions
<p>The review of existing local legislation could represent a potential solution for tackling this obstacle. Furthermore, simplifying and streamlining authorization procedures to obtain the required permits and derogations could play a key role in facilitating the uptake of specific novel circular solutions for energy refurbishment for the protected built heritage.</p> <p>Furthermore, information should be provided on possible solutions for deep renovating historical buildings through specific solutions based on a circular approach, including dry-assembly and reversible construction Plug&Play solutions.</p>

vi. Lack of circularity criteria in public procurement

Barrier
<p>Current public procurement rules, to which many housing providers are held, often reward price over sustainability. This poses major obstacles to the upscaling and replication of successful innovative renovation practices.</p>
Suggestions
<p>EU-wide circularity criteria and guidelines should be embedded in green public procurement. Among the various criteria that could be introduced are the use of minimum percentages of recycled and/or bio-based materials, the implementation of solutions to contain CO₂ emissions throughout the life cycle, and a minimum percentage of conservation and reuse of existing materials.</p> <p>Furthermore, it is important to stimulate a critical mass of demand for more sustainable goods, services, and processes, for example, through the establishment of local platforms of social and affordable housing providers to enable group purchasing and increase scale.</p>

4.3 Financial issues



Figure 6. Financial issues. (Source: C. Mazzoli, 2023)

The financial issue (Figure 6) is the main obstacle for owners and investors during a deep renovation and energy refurbishment process. The available budget is an objective constraint for the definition of feasible strategies on the existing heritage, and often, the implementation of circular materials, products, and systems implies higher costs than traditional solutions. During the DRIVE 0 project, in particular within the framework of WP5 “Consumer centred Business models and Financing”, the different business models that industrial companies can adopt were investigated in order to understand which economic-financial barriers hinder their transition towards circular business models. During DRIVE 0, UNIBO developed a Circular and Consumer Centered (CCC) business model. In particular, the aim of its actions was to deepen the concept of business model innovation and illustrate the types of circular business models that are particularly relevant for the three different target groups considered in the project as well as in this report. The term *circular business innovation* is used for innovation in value proposition, creation, and delivery and in value captured by a company. It refers to technological innovations, but also social innovations, encompassing new solutions and processes that determine new products and service opportunities while simultaneously changing behaviours and consumers’ attitudes and leading to new capabilities and network relations to better use of resources. The analysis of the circular business model innovations implemented by the DRIVE 0 partner industries was developed, together with a method to assess their degree of adoption of circularity (see **D5.1 “Report on the business models employed in each case study”¹¹**, **D5.2 “Report on the experimental/lab results on consumers/users behaviour and social responsibility”¹²**, and **D5.3 “Numerical code for the construction of the Circular Readiness Indicator”¹³**).

i. Difficulties in the investment and need for upfront financing

Barrier

Initial investment costs can be high, especially for more ambitious renovations, and this is a major obstacle to consumers' investment decisions. This factor goes together with the possibility that the payback time of investments made to realise a renovation may be very high. In fact, many property owners and investors do not consider investments that are not essential and do not pay for themselves within 3-7 years.

¹¹ “DRIVE 0” Horizon 2020 EU Project, D5.1 Report on the business models employed in each case study. Available online: <https://www.drive0.eu/wp-content/uploads/2022/07/Report-on-the-business-models-employed-in-each-case-study.pdf>

¹² “DRIVE 0” Horizon 2020 EU Project, D5.2 Report on the experimental/lab results on consumers/users behaviour and social responsibility. Available online: https://www.drive0.eu/wp-content/uploads/2023/05/Drive-0_D5.2.pdf

¹³ “DRIVE 0” Horizon 2020 EU Project, D5.3 Numerical code for the construction of the Circular Readiness Indicator. Available online: https://www.drive0.eu/wp-content/uploads/2023/09/Drive-0-WP5_D5.3-1.pdf

A major challenge of the DRIVE 0 project concerns the definition of efficient circular solutions to reduce the payback period of renovation costs.

Suggestions

The definition of a Circular Readiness Indicator (CRI) is useful for assessing the readiness of circularity for companies in the construction sector and supporting them in the transition towards circular business models. In particular, the CRI defined in D5.3 “Numerical code for the construction of the Circular Readiness Indicator”¹⁴ aims at assessing: readiness, flexibility, and capacity to adjust and progress to circular economy; dimensions beyond environmental variables; interrelations among variables and network of variables relevant for circularity. The CRI provides a taxonomy of companies based on their readiness for circularity and allows to understand which dimensions have to be improved to become top-performers. Furthermore, CRI can be used in a dynamic perspective to track the progress of industrial companies toward circularity.

The 2D and 3D solutions developed under DRIVE 0 were analysed according to this approach in order to support industrial partners in understanding how to improve the developed systems. Specifically, in D2.3 “A set of circular prefab 3D case specific solutions”¹⁵, several circular 3D solutions (volumetric additions) were investigated that would allow for an increase in housing floor area and energy performance level while increasing the real estate value of the building. If properly designed, such solutions would allow for intervention with reduced environmental impact solutions that would respond to financial schemes capable of limiting initial investment.

Based on the experience gained during the EU Horizon2020 project “ABRACADABRA - Assistant Buildings' additions to Retrofit, Adopt, Cure And Develop the Actual Buildings up to zeRo energy, Activating a market for deep renovation”¹⁶, on which the idea of Add-ons is based, this would be possible in the following ways: through the sale of the right to build; through the "selling off-plans" of the building additions before the actual execution of the works; through their sale before the entire completion of the renovation works. The first two modes are the only ones that can ensure sufficient cash flow before the renovation. On the other hand, the third mode involves high risk and uncertainty and is highly dependent on the local real estate market and the selling price demanded for the expansion.

The development of design scenarios with short payback periods, to be presented to owners and investors in a clear and comprehensive manner, could definitely promote the implementation of circular energy efficiency interventions. The analysis of design scenarios in terms of the cost-effectiveness of a retrofit must necessarily include factors that highlight costs throughout the building's life cycle and raise awareness of possible long-term maintenance costs that can be avoided through energy retrofits.

¹⁴ “DRIVE 0” Horizon 2020 EU Project, D5.3 Numerical code for the construction of the Circular Readiness Indicator. Available online: https://www.drive0.eu/wp-content/uploads/2023/09/Drive-0-WP5_D5.3-1.pdf

¹⁵ “DRIVE 0” Horizon 2020 EU Project, D2.3 A set of circular prefab 3D case specific solutions. Available online: <https://www.drive0.eu/wp-content/uploads/2022/07/Set-of-circular-prefab-3D-case-specific-solutions.pdf>

¹⁶ “ABRACADABRA” H2020 EU Project. Available online: <https://cordis.europa.eu/project/id/696126/it>

ii. Lack of funding opportunities

Barrier
<p>Lack of financing opportunities and/or the inability to obtain financing on acceptable terms is generally one of the most frequently cited barriers to investment in energy efficiency measures under a circular approach. In fact, subsidies for energy efficiency renovations and installation of renewable energy sources are often the only sources of financing available for the real estate sector. However, there are no specific tax incentives for the implementation of specific circular actions related to the choice of materials with low environmental impact or the adoption of reversible systems that are easily removable to be repaired, recycled, or reused.</p> <p>Lack of funding opportunities and inability to secure financing on acceptable terms is generally one of the most cited barriers to investing in energy efficiency measures. This applies at the level of the individual householder, as well as large or small landlords. This issue is exacerbated in the case of AdoRES for which specific funding sources remain almost nonexistent. Therefore, most of the time, the only available sources of funding for the private real estate sector are subsidies for energy efficiency renovation and the installation of renewable energy sources.</p> <p>As public spending has been reduced, these funding opportunities have become limited, and the uncertainty and volatility of proposed programs have increased. Policy-makers, particularly at the European level, are increasingly encouraging the reduction of subsidies and instead promoting revolving financial support that combines public and private resources. However, subsidies remain an important argument for incentivizing property owners to renovate. It is therefore believed that, apart from areas with high property value, the cost-benefit equation for deep energy and circular renovations cannot work without supporting public subsidies.</p> <p>Furthermore, the activities carried out with the social housing sector revealed that public/social rent models based on income allow for sinking/reserve funds for planned maintenance but not for new retrofitting standards.</p>
Suggestions
<p>Continuously informing owners and investor entities adequately about funding and co-financing opportunities at the local level and providing them with an advisory service (e.g., through OSS mechanisms) can significantly facilitate the promotion of circular strategies for deep renovation of the built heritage. The support and advisory service should provide a comprehensive overview of all the funding that can be obtained for different co-related categories of intervention (energy performance improvement, structural improvements in seismic/non-seismic risk contexts, volumetric additions, installation of renewable energy generation facilities, and so on), which may be cumulative with each other and thus providing multi-benefit synergic efficiency.</p> <p>Finally, with particular regard to the social housing sector, delegated Acts to the EU Taxonomy to include a broad range of circular activities so that institutions like the European Investment Bank (EIB), which align their lending activities with the Taxonomy, lend for the construction of new social and affordable housing, with a much greater focus on circularity. This would open new funding opportunities for social providers.</p>

iii. Lack of fiscal incentives (tax advantages, reductions, and deductions)

Barrier

Among the main factors encouraging the development of circular deep renovation projects are tax advantages and the deductibility of investments, as well as the reduction of VAT for renovation works (especially in countries with high labour costs). In addition, these factors are compounded by the lack of specific tax policies to balance property taxation and incentives for energy refurbishment interventions through the implementation of circular actions.

With a particular focus on the social housing sector, the processes surrounding circular renovation and construction, such as the set-up of resource inventories and material banks or certifying local bio-based products, is a financial burden for social and affordable housing providers that is not adequately compensated for by cost savings or financial incentives.

Suggestions

The regulatory framework of taxation and fiscal incentives should be reviewed at the local level to increase legal certainty on the real applicability of specific circular solutions. A general legal framework that is clear and accessible to all, defining all the different possibilities for implementation, would help to increase legal certainty and the diffusion of energy refurbishment interventions according to circular strategies, facilitating their financial planning and thus their actual implementation.

Furthermore, it is crucial to foresee more fiscal or monetary compensation at the local level, especially for social and affordable housing providers to use secondary materials/elements/components or reduce waste. Such improved fiscal incentives could also help to extend the lifespan of products and encourage after-sales/after-use services.

iv. Split-incentive and financial investment**Barrier**

In the particular case of buildings inhabited by tenants that do not coincide with the owners/co-owners of the same, the so-called “split-incentive dilemma” is revealed. In these cases, in fact, the circular and energy efficiency interventions become less attractive for the owners, as the resulting benefits, in terms of bill savings and increased indoor comfort, fall on the tenants, who do not participate in the expense. This factor strongly influences the investor's willingness to undertake deep renovation, especially when the associated risks are considered high, for example, in relation to the use of innovative solutions based on the use of circular materials, products, and systems.

Suggestions

The implementation of circular 3D solutions (Add-ons) that increase the area of the single building units allows owners/tenants to have a direct benefit in the form of financial income generated from the sale or rental of additional units.

In this regard, a revision of rental, condominium, and lease laws could help to create a legal framework that encourages energy refurbishment investments by allowing voluntary agreements between landlords and tenants (e.g., “green leases”¹⁷).

¹⁷ Duquesne, B.: Latest developments on the use of green leases in Europe, in: Castellazzi et. al. European Commission's Joint Research Centre Technical Report: Overcoming the split incentive barrier in the building sector (2017), p. 16. Available online: <http://publications.jrc.ec.europa.eu/repository/bitstream/JRC101251/ldna28058enn.pdf>

v. Imperfect mortgage market for circular deep renovation and energy efficiency actions and difficult loan eligibility

Barrier
<p>Banks and credit institutions are still reticent to grant loans for the realisation of energy efficiency projects and require certain guarantees. This does not incentivise investors to decide to contract a loan to invest in an energy efficient deep renovation, even though this would be profitable and could increase the real estate value of the property.</p> <p>This imperfection of the mortgage markets is a major obstacle to the adoption of circular and energy refurbishment, especially if this type of intervention is carried out using a circular approach based on the use of circular materials and circular, often innovative, solutions.</p> <p>The tightening of loan regulations in most EU countries has considerably increased the administrative requirements for the credit application process, contributing to discouraging homeowners from applying for bank loans. Usually, households without mortgages are older and often find it difficult to obtain a second mortgage in the current regulatory environment, so this factor represents a significant barrier.</p>
Suggestions
<p>The general loan conditions should be revised to allow owners/co-owners and, in general, all investors to obtain loans to carry out energy retrofits. They should be made more flexible, with more convenient and thus stimulating conditions, especially in multi-owner buildings, where the authorisation process becomes even more complex. Furthermore, for associations, co-operatives, and bodies representing the interests of different investor stakeholders, it would be important that the possibilities to take out loans are disclosed at an early stage to inform users about the different options, create financial certainty, and facilitate the decision-making process.</p> <p>In the particular perspective of social, public and cooperative housing providers, changes in the financing conditions are needed to exponentially increase renovation investments.</p>

vi. High maintenance costs during the lifespan of buildings

Barrier
<p>In general, it can be said that retrofitting projects have plenty of contingencies that are not foreseen in the grants' budget. There is a lack of contingency funds within the budget for renovation projects, and therefore, additional budget needs tend to come from own resources.</p> <p>Another aspect to consider from the point of view of the economic impact of deep renovation interventions concerns the long-term maintenance costs related to the components integrated or introduced by replacement during the retrofit. These maintenance costs, in the case of interventions based on circular actions, can be particularly incisive and varied in nature: related to heating and cooling systems installed for energy efficiency and decarbonization of the building; related to renewable energy production systems; related to specific circular, prefabricated, and dry-assembly building components (i.e., Plug&Play systems).</p>

In particular, the use of innovative technologies and products can involve quite significant costs due to the still small number of qualified service providers.

Suggestions

Regarding the financial support for the development of renovation projects, a contingency fund of 5% is recommended.

To build confidence and enable proper financial planning, maintenance costs should be assessed from the early design stage and should be provided from the start to the property owner and manager, who acts as an investor.

One factor to highlight regarding the maintenance costs of circular building components concerns whether they can be contained through suitable design choices, such as meeting Design for Disassembly (DfD) criteria (see **D6.1 “Report on benchmarking on circularity and its potentials on the demo sites”¹⁸** and **D2.2 “A set of circular prefab 2D building envelope elements with case specific solutions”¹⁹**). In fact, if 2D or 3D components are designed according to the criteria of reversibility, ease of assembly/disassembly, and accessibility of the elements, maintenance operations for local repair and/or replacement of parts should present reduced time and cost, both in terms of parts supply and labour. Therefore, the high expense initially incurred could be amortized over the life of the building.

vii. Additional costs for vacancy and relocation of inhabitants

Barrier

In the case of deep renovation interventions, given the possible level of disruption, the physical relocation of inhabitant tenants during the works is often necessary, and the negative impact this would have on people's lives often leads the investor parties not to allow the works to be carried out. In fact, in such a case, in addition to the renovation costs, the property owners would have to incur additional costs for relocating the tenants (e.g., to a hotel or other facilities) or, in the case of vacant apartments, extend the planning of the "empty" months for longer periods until the work is completed.

Suggestions

Within the business plan and estimation of the cost-benefit ratio of the deep renovation intervention for energy refurbishment, possible relocation and vacancy costs should also be taken into account, and these should be communicated to the investor from the very beginning.

With this in mind, the use of prefabricated Plug&Play circular solutions, which allow the interventions to be carried out while greatly reducing the time required and, sometimes, to intervene from the outside without disturbing tenants, is an effective strategy to mitigate this barrier. The experiences conducted for the DRIVE 0 pilots demonstrated this factor.

¹⁸ “DRIVE 0” Horizon 2020 EU Project, D6.1 Report on benchmarking on circularity and its potentials on the demo sites. Available online: https://www.drive0.eu/wp-content/uploads/2020/08/DRIVE0_D6.1.pdf

¹⁹ “DRIVE 0” Horizon 2020 EU Project, D2.2 A set of circular prefab 2D building envelope elements with case specific solutions. Available online: https://www.drive0.eu/wp-content/uploads/2023/02/DRIVE-0_D2.2-Improved.pdf

5 Policy recommendations

These policy recommendations aim to address barriers and obstacles to the spread of circular strategies in the field of construction for the deep renovation of the built heritage aimed at achieving the decarbonisation and energy efficiency standard imposed by the European Commission. Starting from the suggestions proposed in this report for each barrier identified for leveraging technical issues, regulatory requirements, and financial incentives - according to a holistic approach that also deals with social and societal aspects – a list of top policy recommendations has been drafted.

- 1. Establishment of circular One Stop Shops to raise awareness and improve knowledge:** Local centres (at the regional or municipal level) should be established to offer consultancy services for the development and selection of innovative circular technologies based on the One-Stop-Shop model. These services would represent fundamental support for all key stakeholders involved in the deep renovation process, from non-expert investors to professionals. Furthermore, local authorities should develop comprehensive awareness-raising campaigns to adequately inform all stakeholders involved in the renovation processes (in particular architects/engineers, social/public housing providers, and homeowners) about the advantages of circular practices in the construction sector. It is important that all actors are educated about circular principles in the construction sector through specific courses and training programmes focused on the benefits that can be achieved through the adoption of circular practices in terms of environmental and economic impact.
- 2. Circular training and certification for workers:** The legislation should oblige all Member States to develop a clear strategy at the national level to ensure that key workers in the construction sector receive appropriate circular training. This should include both the training of new workers as well as the re-skilling of existing workers. To this end, it is crucial that Member States cooperate with national representative bodies to co-design accessible, attractive, and affordable training modules and tools for key workers in the built environment, e.g., architects, engineers, and construction workers.
- 3. Provision of support for research and development:** Private and public financing subjects should invest in research and development to address challenges related to circular construction. This innovative research must be done in cooperation between the academic and the industrial sectors and should be focused on product and service innovation, increasing knowledge levels, and changing habits and attitudes within the industry. Even if progress has been made towards a circular economy, there is still room for improvement, so it is crucial to continuously support and foster initiatives to drive further advancements in circularity in the construction sector.
- 4. Creation and promotion of sharing networks:** The creation of sharing networks at the local and European level must be promoted in order to facilitate the dissemination of knowledge in the field of construction materials/products/components/systems and strategies according to a circular approach. These networks, derived from the close cooperation between professionals and industries, can encourage the adoption of a more circular approach to construction and renovation projects. For example, these networks could involve the collection of information on a wide range of construction projects based on the adoption of a circular approach, providing details on materials, products, components, and building systems in an easily accessible manner.

5. **Establishing EU Recovered Materials Agency:** The European Union should seek to establish a new public agency to better understand the possibilities and potential of recycling and reuse of certain building materials and help create a healthy secondary market for materials. Furthermore, it is crucial to support the development of mature markets for recycled products and services, including by providing incentives for the creation and adoption of recycled building materials and products. Cooperation between building investors, the recycling industry, and local authorities for more effective waste management, recycling, and resource recovery is a necessary precondition for the success of this measure.
6. **Application of the sufficiency principle to urban development.** In general, a shift towards renovations rather than demolition in the building sector must be encouraged. However, it is important to sensitize professionals on the importance of conducting specific analyses for assessing the environmental and economic impacts of both intervention scenarios to evaluate the most effective option. The boost of deep renovation interventions can be achieved by providing incentives, technical support, and guidance for renovating existing structures with circular and energy-efficient materials and technologies. Where deep renovation is not affordable (from an economic and environmental point of view), setting limits to average carbon emissions to construction companies in newly built projects (portfolios) could contribute significantly in this regard. This could be addressed through the Emissions Trading Scheme (for the cement industry, for instance) and the Corporate Sustainability Reporting Directive.
7. **Alignment with regulations:** Regulations and laws at the local and European level, including procurement and certification requirements, should be aligned in supporting circular construction practices. The industries should be encouraged to comply with these regulations and use economic incentives to promote the adoption of circular strategies for deep renovation of existing assets, with a focus on materials and products. Furthermore, the Energy Performance of Buildings Directive and CEN should refer to a unified European definition and calculation method for measuring embodied carbon. In general, Member States should make building codes more open to innovation through Communication or Recommendation provided by the European Commission. In this context, it becomes important to contribute (also through research) to the alignment of building codes in Europe to build innovative, affordable housing.
8. **Enhancement of financial incentives and improvement of access to financing schemes:** Financial incentives for the adoption of circular practices should be strengthened at the local and European levels. These can include loans, grants, subsidies, tax incentives, and deductions for using recycled materials, improving energy efficiency, or embracing circularity in renovations and retrofits. Furthermore, it is important to develop a clear framework, at the local level, of all available financing schemes for the implementation of circular strategies available to individuals and SMEs. Each Member State should establish, on the basis of a common structure, databases and digital tools: (preferably open source) and national funding agencies to help investors make more informed choices on the adoption of circular solutions. These tools could provide users with benchmarks against some particularly successful European cases of circular strategy implementation (which could be considered “lighthouse projects”).
9. **Provision of support for maintenance costs:** Public funding should be made available to help meet the costs of installing innovative circular systems and the costs of maintenance

throughout the buildings' life cycle. Indeed, these circular solutions are often more expensive than traditional systems because they are more complex and require monitoring over time, which in turn entails additional costs in the medium to long term. The development of reversible, prefabricated, and modular “Plug&Play” solutions should be promoted to reduce the maintenance interventions during the lifespan of the building and to maximise the possibility of locally repairing and replacing the single damaged portions of the building systems and recycling and reusing them.

10. **Provision of pre-financing of projects:** In cases where public fundings are available for the realization of circular projects, local governments should consider providing pre-financing. This economic support could encourage the investors to undertake circular solutions, even technologically innovative, that may be more expensive during the implementation phase as well as during the whole use phase and the related maintenance interventions.
11. **Tax reform:** Taxation policies should be reformed to incentivise circularity and energy efficiency in property renovations and retrofits. Policy-makers should reduce or waive altogether charges, taxes, and levies related to the development of construction and renovation projects that meet defined environmental and resource efficiency criteria. Nowadays, in many EU regions, local building taxes and levies to be paid do not consider the circularity or overall sustainability of the building.
12. **Recasting of construction products regulation:** The proposed recast of the regulation on construction products should be pursued and implemented in both the private and public building sectors. This regulation can help address existing technical and regulatory barriers by setting standards for the use of circular materials and products in the building and energy sectors. One possible action for policy-makers could consist of requiring mandatory building material passports for all new buildings above a certain size to increase the traceability of materials, thus helping to improve confidence in their reuse. This recast process could be facilitated by the establishment of national agencies in charge of developing clear and up-to-date guidelines for green procurement and digital procurement tools.
13. **Inclusion of EU-wide circularity criteria and guidelines in green public procurement:** Especially in the public construction sector, circularity requirements, and guidelines should be included in procurement regulations in order to promote economies of scale and the overall capacity to implement circular solutions. Among the various criteria that could be introduced are the use of minimum percentages of recycled and/or bio-based materials, the implementation of solutions to contain CO₂ emissions throughout the life cycle, and a minimum percentage of conservation and reuse of existing materials.
14. **Reduction of the bureaucracy:** Each Member State should conduct a holistic review of its authorisation processes within its public administration in relation to achieving the objectives within the EU renovation wave. It would become crucial to streamline the bureaucratic processes that hinder the authorisation and implementation process for building renovation by simplifying administrative procedures and reducing the associated bureaucracy.
15. **Alignment with EU Taxonomy for sustainable activities:** Local regulations should align with European ones, promoting the use of a European Union-wide reference taxonomy, which encourages rather than hinders the adoption of circular practices by property owners and investor entities in general. This process can be facilitated by the adoption of a European-wide reference framework, such as Level(s), which could help local governments align to certain

standards, improve knowledge and the transfer of best practices in terms of circularity and sustainability of buildings, and provide a common language and evaluation method for sustainable building.

16. **Revision of the CE markings:** Work is needed on the CE marking front to try to streamline and accelerate the certification process for circular construction products that companies must carry out. The provision of a database of certified circular materials, products, components, and systems with reduced environmental impact, sustainability, and reversibility according to Design for Disassembly criteria (i.e., ease of replacement, repair, and recycling) would help all stakeholders involved in the deep renovation process in the decision-making procedure. In this context, the Construction Products Regulation (CPR) should provide a simpler certification procedure and tax incentives for low-carbon construction products to improve their competitiveness compared to traditional products.
17. **Development of circular loan conditions:** The general loan conditions of banks and credit institutions should be revised to enable investors to obtain loans for energy upgrades based on the use of circular strategies. Especially in the context of multi-owners or multi-users, they should be made more flexible, with more convenient and thus stimulating conditions. For example, loans granted by public or ethical banks could be recast and provide for reimbursement based on savings generated by using and implementing circular solutions (e.g., reductions in water, gas, and electricity bills).
18. **Recognising renovation as social projects:** Acknowledging that renovation goes beyond materials and energy but also includes people and local socio-economic needs is an important step forward toward market uptake of circularity methods. More funding is needed to invest in the social engagement of tenants during renovation. This could be addressed by the European Investment Bank (EIB) in its lending policy (i.e., linking a part of the loan or providing non repayable grant).
19. **Easier mutual recognition of the validity of local materials in the building codes:** Reduce the administrative burden to get the CE marking for secondary material. The affixing of the CE marking is regulated by the Construction Products Regulation, but the level of performance to be achieved to receive the marking is set by technical bodies and CEN. CEN could therefore develop a standard for secondary material.
20. **Mandating carbon accounting:** Incorporating life cycle sustainability assessment in renovation projects to stimulate retrofitting while encouraging modern methods of construction to accelerate delivery. This is addressed for new buildings through the Energy Performance of Buildings Directive.

6 Conclusions

The barriers and suggestions in this booklet represent an effective synthesis of the dialogues and discussions that took place during the meetings, technical workshops, and round tables held during the four years of the DRIVE 0 project. Indeed, it contains a summary of the best suggestions for solving or at least mitigating the barriers that arose from all the activities developed. The final objective is to make a synthesis and draft a list of policy recommendations embracing the technical, regulatory, financial, social, and societal issues. In particular, social and societal aspects are factors that affect all technical, regulatory, and financial obstacles crosswise, varying according to geographical and cultural context.

The concept of "policy recommendation" refers to a written policy advice/suggestion prepared for a group that has the authority to make decisions. In effect, the policy recommendations listed in bullet points aim to provide concrete solutions to overcome obstacles to the widespread adoption of a circular approach in the construction sector. These policies suggest precise actions to spread the principles of circularity and increase their adoption among all key stakeholders involved in the process of deep renovation of the built environment. They also provide concrete examples of viable initiatives and solutions.

In conclusion, these policy recommendations aim to find ways to finance energy efficiency deep renovation interventions in the public and private building stock through a circular approach to try to achieve the European Green Deal goals of no net greenhouse gas emissions by 2050.