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Uloga reciklirane arhitekture u ublažavanju klimatskih promjena i provedbi kružnog gospodarstva

The role of upcycling architecture in mitigating climate change and implementing a circular economy

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Abstract

The article addresses the issue of implementing circular economy principles in architecture as a response to the escalating climate and resource crisis. Particular attention is given to the concept of generative upcycling, understood as the process of reusing building resources in a way that enhances their functional and environmental value, while simultaneously initiating further circular activities. The text analyzes the phenomena of urban mining, adaptive reuse, and material recovery, highlighting both their potential for reducing greenhouse gas emissions and their capacity to activate local communities. The author compares two models of circularity—an analytical, systemic model, characteristic for developed countries and an organic one, rooted in the economic conditions of developing regions—emphasizing the potential for mutual inspiration. A case study from the author's practice demonstrates how the practical implementation of generative upcycling within the design process can initiate multiple reuse cycles of building components. The findings indicate that circular architecture, perceived as an ongoing process rather than a final product, may serve as an effective tool for climate change mitigation, reducing demand for non-renewable resources, and strengthening urban resilience in an increasingly unstable climate.

Keywords

Circular architecture, climate change, upcycling

Introduction

The year 2015 went down in modern history with the signing of the Paris Agreement - an agreement for a common fight for the climate. The signatories represented almost all countries. At the time, the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) seemed to be a milestone achievement that brings us closer to achieving climate neutrality; at that time, the European Union presented a long-term strategy to reduce emissions, in which it committed to reduce EU emissions by at least 55% by 2030[1] compared to 1990 levels. Care should be taken to ensure that it is no more than 2°C (the best below 1,5°C) above pre-industrial times (Adoption of The Paris Agreement, 2015, p.26), (IPCC, 2021). Meanwhile, there are 5 years left until 2030; the global window of climate action is closing very quickly; The level of warming by 1.5°C was already exceeded at the end of 2023[2,3] and emissions continue to rise.

For the future of cities, which are a kind of lens and catalyst, climate change may have a huge regional impact (Seneviratne et al., 2018), which is quite a challenge for the global economy and the global community (Lewko & Felski, 2023, p.13-34). This was confirmed by The World Heritage Committee during the 29. 2005 session (Colette, 2007, p7). The European Climate Risk Assessment (EUCRA) report on the assessment of climate-related risks for the European Union[4] leaves no doubt in this matter; out of the 36 identified climate risks more than half require urgent action, and eight of them require immediate response.[5]

One cannot resist the impression that in the aspect of the global review of the activities carried out so far under the Paris Agreement, which has already been announced for 2028, the actions taken have rather a formal than a factual effect.

In a situation where non-renewable resources are gradually depleted, their prices are rising; the transition to a circular economy model is becoming necessary to guarantee sustainable economic development and better environmental protection. We should be aware that the process of spatial development is tightly connected with a huge consumption of raw resources. The implementation of construction projects has an impact on the environment already at the stage of production of the necessary raw materials, during the construction process, the operation of the facility, and at the stage of its future demolition (Felski, 2021, p.18). Each of these stages contributes to the depletion of non-renewable resources and generates waste. Moreover, the more modern the investment, the greater the demand for rare minerals and critical raw resources, and the generated waste are more difficult to dispose of (Bartosz, Kowalski, 2022, p.29).

Researches clearly indicates a close relationship between the advancing climate crisis and the decline in GDP; studies show that by the end of this century, there is more than a 75% chance that limiting warming to 1.5°C could reduce economic losses relative to 2°C. Moreover, 71% of countries – representing 90% of the world's population – have more than a 75% chance of reducing economic damage at 1.5°C, with poor communities benefiting the most. (Burke, Alampay Davis & Diffenbaugh, 2018, p.549-553).

1. From downcycling to upcycling. Implementing recycling on Geels' model

The definition of downcycling was first used by Reiner Priz (Kay, 1994, p.11-14), (Sodje et al., 2025) in 1994 in an architectural context: "*I call recycling downcycling. They break bricks, they break everything. What we need is upcycling, where old products are given more value, not less.*"

Although *downcycling* is generally the simplest form of reintroducing resources into the life cycle, it is important to remember that although products after the downcycling phase can be recycled, this possibility is limited. Downcycling resources are reused only once or several times before they become waste that cannot be recycled, or it is financially and organizationally unprofitable. It is curious that there are practically no known examples of the transition from downcycling to upcycling, and in the case of the construction industry, this is particularly rare. It is even rarer to consciously combine several cycles between different investments, where the investment is then treated as a kind of "spare parts warehouse"[6]

1 https://www.europarl.europa.eu/news/en/press-room/20230414IPR80120/fit-for-55-parliament-adopts-key-laws-to-reach-2030-climate-target [accessed 29.07.2025]
2 https://climate.copernicus.eu/copernicus-2023-hottest-year-record, [accessed 20.07.2025]
3 https://berkeleyearth.org/global-temperature-report-for-2023/, [accessed 20.07.2025].
4 https://www.eea.europa.eu/publications/european-climate-risk-assessment [dostęp 03.08.2025]
5Ibid.
6 In the literature on the subject and in design practice, this phenomenon is referred to as *BAMB* (Building As Material Banks).

Upcycling as a process of transforming waste or unused resources (including building resources, furniture, raw materials) into products of higher value or better – more adequate functionality is an innovative approach that goes beyond the traditional understanding of recycling.

Its innovation is due to several aspects:

1. Increase the value of end products while minimizing waste generation.
2. It supports the idea of a circular economy by reducing the need for the extraction of new raw materials; It is also an action to strengthen the security of raw materials in the context of crisis situations, such as conflicts, extraordinary events, natural disasters.
3. It affects the development of craft creativity due to the fact that upcycling generally outputs the framework of mass production.

According to the author, the implementation of upcycling construction would also be an effective action towards the activation of local communities. Urban mining, due to the specificity of diagnosing anthropogenic resources and the technology of material recovery, requires a large share of unskilled workers. However, in order to effectively implement upcycling based on urban mining elements on a large scale, it is necessary to find out an efficient model for scaling such activities.

According to the author, this is best described by Geels' theory of three technological levels (Geels, 2002, 1257-1274). Three levels of action are required to emerge simultaneously to implement it successfully – a broadly understood context, which Geel calls the "*technological landscape*", legislation called the "*technological regime*", and technological *niches*, which are specific precedents for action.

The Global Risks Report 2025 (Elsner, Atkinson & Zahidi, 2025) prepared for the World Economic Forum shows that the existence of climate risks is understandable among the surveyed communities and is one of the most important diagnosed problems over the next 10 years. Also, the objectives of the 7th Synthesis Report IPCC (Meinshausen et al., 2024) in the field of building adaptation plans are inextricably linked to cross-sectoral integration with the Sustainable Development Goals and moving away from a linear economy towards circularity for a sustainable future. This builds the aforementioned context (technological landscape). The technological regime, on the other hand, is the implementation of regulations at the international and national level (The European Parliament and the Council of the EU, 2021), (European Commission, 2021) conditioning the effectiveness of activities at the systemic level, because new technologies have difficulties in dissemination due to inadequate regulations, infrastructure or even user practices. (Freeman & Perez, 1988, 38-66). This is somewhat of the situation we are currently in, because on the one hand, the need to reduce the environmental and climate burden requires a radical transition from a linear to a circular economy, while existing regulations, such as environmental protection and waste management regulations, effectively discourage the implementation of large-scale upcycling.

The last element remains, which, according to the author, is the weakest element so far. Individual "architectural precedents" – catalysts for changes in thinking that arise in various places and times give rise to changes – are technological niches (Geels, 2002, p. 5-6). As mentioned, without these peculiar "startups" (technological niches), the process of changing thinking would not be activated. Many of these projects are experimental and implementation-focused, as described below (Chapter 2). Additionally, Chapter 4 presents the author's experiment involving the implementation of generative upcycling in a real construction project aimed at engaging local communities, alongside verifying the possibility of using components from demolition and disassembly.

2. Organic and analitycal approach of upcycling architecture

In countries whose economies are the aftermath of the legacy of the post-socialist transformation, degraded historical buildings lost the interest of investors, thus only increasing the sub-standard city substance, and in terms of carbon footprint – a kind of "emission grey market". The main driver of change in the city is (unfortunately) economic calculation, while it should be the desire to ensure safety and comfort for its residents; non-functional and expensive buildings will be eliminated from the spatial structure of cities in future. Therefore, it is important to ensure in advance that they do not become an unwanted legacy, but rather a kind of resource to be recovered as part of *urban mining*. On the one hand, this will help solve some of the raw material problems, and on the other hand, it creates the potential to activate local communities.

Analyzing the balance of greenhouse gas emissions, in the author's opinion, that contemporary architecture first uses carbon by transforming it into carbon dioxide, generating a carbon footprint, and only secondarily, as a kind of residual product, it manifests itself in the form of an architectural work. After all, most of the modern facilities are investments, almost impossible to rationally recycle.[7] The inbuilt carbon footprint is a true size in the carbon budget of the investment; It will be released into the atmosphere during the demolition and disposal phase and additionally multiplied when another building will be built in the same place. The author's research shows that modern energy-efficient buildings are environmentally and climate-friendly only in the *use phase*, while the inbuilt carbon footprint resulting from the specialized technologies (heat pumps, HVAC, highly effective insulation materials) significantly exceeds the carbon footprint of traditional building materials. Moreover, , it should be borne in mind that in the context of historical buildings and *urban mining* used in them, their carbon footprint has already been partially neutralized due to time.

According to the author, it is the "doughnut" model promoted by Raworth (Raworth, 2017), and in the context of architecture – the perception of architecture as a process, not a target could be a catalyst for changes in thinking about problems of contemporary cities (Felski, 2023, p.25-47). The implementation of the principles of circular economy in spatial development can significantly increase the resilience of both individual communities and entire cities to the effects of climate change. Examples include recycling and reusing building materials that reduce CO_2 emissions and reduce stress on natural resources, which is crucial for ecological and energy stability. In addition, supporting local economic initiatives based on the circular economy model helps to strengthen economic and social resilience.

In architecture, circularity can transfer from the reuse of materials to the reuse of complex structures called "*adaptive reuse*". This approach allows to redefine thinking about both the structure and the entire building. Work on this type of transformation of building structures is currently being implemented in various research projects across Europe[8].

The common approach to waste perceived only as a side effect of the production and exploitation process (Janiak, 2017, p.27), contributes to concerns related to the creation of space using "garbage" (patchwork space)[9]. However, are these legitimate fears and the right trend in the interpretation of architecture?

In contemporary architecture, a paradox related to *reuse* can be seen – regardless of whether we are talking about *adaptive reuse* or rebuilding of recycled elements. The examples described in the literature are often an artistic or ideological manifesto of authors aware of their actions; These are very often works characterized by the idea of promoting and popularizing the idea of circularity (Fig. 1). This analytical approach is far from the organic approach, where circularity and recovery are an example of mitigation of poverty, social and economic marginalization; it provides the existence of residents, without the interest of critics and the construction industry. Moreover, providing the basic necessities of life for the majority of the world's poor communities is often a taboo subject, both for users and decision-makers.

According to the United Nations data cited by the Polish Economic Institute, in 2020 the number of people living in slums in the world was 1.06 billion, an increase of 165 million compared to the beginning of the 21st century.[10] It is a paradox showing two faces of circularity in architecture and in economy – organic and analytical, systemic ones.

FIGURE 1. ANALITICAL APPROACH TO UPCYCLING AS AN ARCHITECTURAL MANIFESTO. LE PAVILLON CIRCULAIRE IN PARIS BUILT WITH USED DOORS

Source: https://encoreheureux.org/fr/projets/pavillon-circulaire,

7 Nour Fakharany. "MVRDV "Carbon Confessions" Exhibition in Germany Reveals the Realities of Sustainable Construction" ArchDaily. https://www.archdaily.com/1026050/mvrdv-carbon-confessions-exhibition-reveals-the-realities-of-sustainable-construction> ISSN 0719-8884, [accessed: 23.01.2025]

8 Due to the Non-Disclosure Agreement with the Agencies of the European Commission, they cannot be discussed at this stage.

9 TEDx Talks: https://youtu.be/yQBngJqDhz0?si=rHhEth7VeOoaPdl6 [accessed: 23.08.2025]

10 The majority of these people, as many as 85%, live in Asia and sub-Saharan Africa. India had the highest slum population at 237 million, while the highest proportion of urban slum dwellers was found in Chad, where it stands at 82%. UN forecasts indicate that by 2050, the number of people living in slums could rise to three billion, which would be about 45% of the world's urban population. Countries such as Nigeria, the Philippines, Ethiopia, Tanzania, India, the Democratic Republic of Congo, Egypt, Pakistan are expected to be responsible for half of this increase, source: https://forsal.pl/swiat/aktualnosci/artykuly/9460978,wedlug-danych-onz-ponad-miliard-ludzi-na-swiecie-zyje-w-slumsach.html, [accessed: 25.07.2025]

Summarizing, there are two scenarios for the implementation of upcycling in the construction space – a conscious, resource-efficient, environmentally-oriented circular economy model that is the domain of developed countries (analitical upcycling), and a bottom-up form of circular economy aimed at the reuse of building components and materials, closely related to the low economic potential and relatively weak economy of poor countries (organic upcycling). Both of these circular models of construction, developing in parallel and simultaneously, can be a collection of many interesting inspirations for each other (Fig. 2).

FIGURE 2. ORGANIC APPROACH TO UPCYCLING AS AN EVERYDAY ARCHITECTURAL REALITY. A BUILDING IN DAR-ES-SALAAM BUILT FROM FORMWORK WASTE

Source: private photo of the author

Most importantly, both approaches can be easily implemented for generative upcycling, which could be scaled as a tool for both mitigating climate change and engaging degraded communities.

3. Upcycling as a circular tool for strengthening raw material efficiency

Traditionally, weight minimization under constraints related to performance aspects and strength parameters has always been a factor determining the effectiveness of structures. And what if these products of engineering paradigms of the time are just reaching the end of their life cycle or the individual elements lose their strength parameters due to their condition? According to a publication by the European Commission's Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (European Commission et al., 2018), 30% of all waste generated is construction and demolition waste, making it the largest waste stream in the European Union in terms of volume.

There are many reasons why the reuse of building materials should be treated positively. According to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on Resource Efficiency Opportunities in the Construction Sector, the construction and use of buildings account for around 50% of all resource extraction and energy consumption and around a third of total water consumption.[11]: In Europe, the construction industry produces more than 385 million tons of waste per year, while building materials account for 10-20% of a building's life-cycle carbon footprint (Geerts et al., 2024).

In a world where the linear model of economics has been stimulating the economy to intensive exploitation of resources and mineral resources for years, it is worth mantion at alternative strategies.

The primary goal of circular construction is a paradigm shift in the context of resource exploitation and waste production, consisting in delaying the obsolescence of manufactured structural elements (Fivet & Brütting, 2020, p.74-81). The task facing architects is therefore to ensure that components can be used for as long as possible, both in the initial context for which they were designed and, in the future, in unforeseen contexts (European Commission, 2015). This strategy is considered key to achieving a circular industrial economy.

Architecture is considered to be a field of activity close to art, i.e. the aesthetic sphere, and is not always treated as an instrument for regulating resources. Architects can have a real impact on the budget of material resources and the dynamics of natural resource consumption through conscious programming of scenarios for the use of components (Fig.3). This can be achieved by designing a new component and assembling it for future reuse or by reusing the component for a different purpose than originally envisaged. This other way of managing a construction component can be used to reduce its use value, i.e. using it in a new investment in a way that brings the life cycle closer to the role of waste (downcycling) or makes its reuse increase its value by obtaining a new functionality of the component – even if it would mean changing its basic function (upcycling).

However, in order to increase the effectiveness of such activities, the aforementioned reuse should be implemented after the designed period of use of the

11 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0445 [accessed 8.07.2025]

building (moral death), and after the functional cycle of the component (technical death) has ended.

FIGURE 3. ANALITICAL APPROACH TO UPCYCLING AS A TOOL OF THE CIRCULAR ECONOMY. A BUILDING BUILT FROM USED LETTERBOXES IN AARHUS

Source: private photo of the author

This other way of managing a construction component can be used to reduce its use value, i.e. using it in a new investment in a way that brings the life cycle closer to the role of waste (downcycling) or makes its reuse increase its value by obtaining a new functionality of the component – even if it would mean changing its basic function (upcycling).

While technological development and the search for a way to extend the life cycle of a building element is fundamental to the technological transformation of architecture, the trend at the "other end" (although not in opposite) cannot be overlooked. After all, there are ideas that are based on the assumption that the transition to circular construction is actually less technologically advanced; this is in fact a return to the known in history pragmatic use of materials already produced locally. As we read in the summary of the ReCreate scientific project[12], the construction sector is maturing to the fact that the production of building materials (although sustainable and circular) is also carbon-intensive, as mentioned at the beginning. Reusing components helps to reduce the inbuilt carbon footprint, as no new material needs to be produced in this case, and construction waste does not need to be disposed of. You can simply collect existing elements from buildings that have been designated for demolition. It has great potential to reduce embodied emissions. What we need is, above all, a re-evaluation of the approach to anthropogenic resources and a re-evaluation of knowledge, a redefinition of competences in the field of approach to architecture, a method of obtaining raw materials from anthropogenic resources, not natural ones.

Interestingly, the circular economy and the reuse of raw materials as part of downcycling and upcycling are not a new doctrine and are not only the domain of communities aware of the importance of the complementary climate and raw material crises. This use of existing structures has been popular for centuries; The author many times comes across with relics of the reuse of existing elements from earlier buildings, also using them further (Felski, 2024, p. 1008-1014). The use of existing materials allows us to maintain the aesthetic consistency of the newly designed elements with the historical substance, which can often be crucial in making investment decisions in the historical urban substance. According to the author, historical and recovered materials play a key role in the decarbonization of construction and minimizing the burden on the natural environment in the context of the exploitation of non-renewable (human-time) raw material resources.

4. Case study on implementing generative upcycling

The research objective of the experiment was to determine the extent to which upcycling can be effectively implemented in architectural practice in a way that enables its generative (autonomous) scaling, while simultaneously preserving the historical value of the building and minimizing its impact on CO2 budget. The study also aimed to assess whether such an approach would gain social acceptance and, consequently, whether the tools and methods developed through this process would be organically adopted and sustained by the local community.

The investment is an example of a complex process of mapping resources for recovery and reuse, which was also aimed at initiating further investments, also using the recovered resources. In addition, it was decided to transform it into upcycling instead of downcycling; is an attempt to knock resources off the path of permanent degradation to put them on the path of circular use.

12 https://recreate-project.eu, [accessed:14.07.2025]

The first of the mentioned building is a structure erected in the post-war period, which was dismantled in the next phase and moved to another town (reuse) by the new owners. It was the 90s of the twentieth century. In this condition and in this set, the building is used to this day and there would be nothing special about it if it were not for the fact that some of its elements were dismantled once again at the beginning of the 21st century and reinstalled in another building (window and shutters); these elements appeared in the next phase of reuse in the historical (XIXc.) building in Ostroróg (Felski 2024, p.209). The existing PVC windows, and other elements from the second building (installed by owners in the 90s of XXc.) were also again used in next investment (initiation of the next reuse phase). It allowed us to define a model of several independent reuse workflows in different buildings, causing each of them to gain in quality, aesthetics and value.

The author's research on the use of architecture as a tool for mitigating climate change has led to the concretization of activities in the field of recycling in architecture and the definition of the hypothesis that appropriate work on the revitalization of the architectural substance can serve as a factor initiating generative recycling, i.e. recycling that will stimulate the emergence of further independent activities in the field of circularity. In other words, based on the example from the author's work, establishing cooperation in the field of obtaining elements from an existing building resulted in the initiation of independent processes of reuse of other building elements in the architectural and construction context (Fig. 4, 5); it also activated promotion of circular economy activities in the field of education.

Popularization of such activities in which the reuse of materials will not be just an individual action but will activate further steps in the field of generating closed material cycles in the construction industry, will significantly reduce the demand for obtaining natural resources. It can also reduce the burden of waste on the environment and, what is more important, give us the opportunity to use historical resources, i.e., those in which the carbon footprint has already been neutralized (Pic.1).

FIGURE 4. HISTORICAL BUILDING BEFORE RETROFITTING

Source: private photo of M. Okła

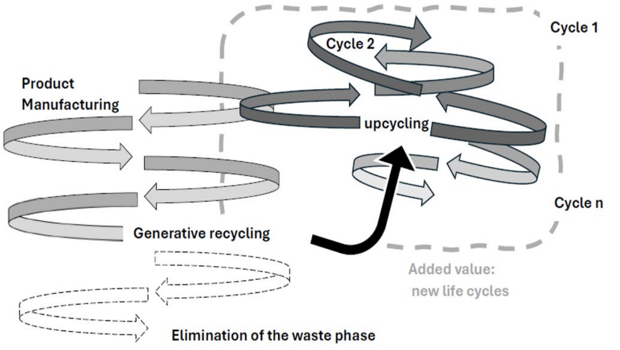
FIGURE 4. HISTORICAL BUILDING REBUILT AS PART OF GENERATIVE UPCYCLING FROM RECOVERED RESOURCES

Source: private photo of author.

5. Conclusion

The process of shaping architectural space described in the article is associated with a huge demand for materials, and thus with a serious burden on the natural environment. Architectural projects have a negative impact on nature at all stages of their life cycle – from the production of materials, through implementation and operation, to potential demolition, and are not without impact on the climate and the related crisis. Each of these phases leads to the depletion of non-renewable resources and the generation of waste, with modern investments often requiring even larger amounts of scarce and critical raw materials and the resulting waste being more difficult to neutralize. Natural resources, formed in geological processes over millions of years, are intensively exploited in a short period of time, which makes it impossible to recreate them in the dimension of "human life". Although their extraction and use contribute to economic development, it also generates environmental problems that cannot be fully solved in the short term, and their scale is already a real threat, according to the latest research (Elsner, Atkinson & Zahidi, 2025). In this context, upcycling can be, according to the author, an effective tool for mitigating climate change – by reducing greenhouse gas emissions and reducing the demand for natural resources; generative upcycling, on the other hand, can be an effective tool for activating local communities that can engage in construction and revitalization processes.

PICTURE 1. GENERATIVE UPCYCLING SCHEME. INSTRUMENT FOR THE ACTIVATION OF LOCAL COMMUNITIES



Source: author.

In a broader perspective, these activities support the development of the circular economy, resulting in an increase in both urban resilience, urban resilience and, consequently, also positively influencing the economy of local communities exposed to the effects of climate change.

Further research indicates that focus should be placed on the development of effective tools for addressing resources to potential future users and skillful programming of building use scenarios, treating them as material resources and not only as an end in themselves.

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