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REGENERATIVE DESIGN - GENERAL PRINCIPLES AND IMPLEMENTATION STRATEGIES IN BUILDING DESIGN

BY

LAURA DUMITRESCU[1,*], IRINA BLIUC[2], IRINA BARAN[1], RADU-AUREL PESCARU[1] and PAUL-DORIAN PARINCU[2]

“Gheorghe Asachi” Technical University of Iași,
[1]Faculty of Civil Engineering and Building Services
[2]“G.M. Cantacuzino” Architecture Faculty

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Abstract. The built environment, through the consumption of energy from non-renewable sources and the associated CO_2 emissions, as well as through the production of waste throughout its life cycle and the effects of soil and water degradation, contributes significantly not only to the phenomenon of climate change, but also to the irreversible degradation of the natural environment. The concept of regenerative design provides a framework for a holistic approach to these issues in order to identify the most effective remedies, proposing the restoration and regeneration of the global socio-ecological environment through a system of engineering practices suitable to the specific context. The defining aspects of the regeneration applied in the buildings sector refer to the architecture and inserting in the natural environment ensuring a healthy and well-being indoor environment, reducing to zero the consumption of energy from non-renewable sources and promoting renewable energy sources, minimizing carbon footprint by rational use of materials and waste management throughout the life cycle.

Keywords: regenerative design; natural environment; sustainability; buildings.

[*]Corresponding author: *e-mail*: laura.dumitrescu@academic.tuiasi.ro
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1. Introduction

In the modern era, the relationship between the built environment and the natural environment has been deteriorated significantly due to industrialization, urbanization and population growth. These causes have led to the imminence of depletion of material and energy resources, reduction of land covered with vegetation, pollution of soil, water and air. As a corollary, there is a worrying increase in the volume of greenhouse gases responsible for climate change that the planet is currently facing.

But while the built environment is an important contributor to amplifying the causes of climate change, it also offers significant potential for improving this situation. The exploitation of this potential depends on the extent of the awareness of the negative impact that the built environment has on the natural environment within the permanent relationship of interaction.

The emergence and development of the concept of sustainability/ sustainable development, with real measures and applications on the socio-economic environment and implicitly on the building sector, were important steps in this awareness effort to find viable solutions to stop the processes that favour climate change (WCED, 1987). However, it has reached a point where the paradigm shifts in addressing the natural environment. It is determined by the imminent climate change and appears to be strictly necessary, in the sense of moving from a vision focused almost exclusively on meeting human needs with minimal implications on the environment, to a new vision, aimed at ensuring the prosperity of all living systems. This vision corresponds to regenerative development associated with the regenerative design concept, which is based on a holistic approach integrating the recent achievements of science and practice and the development of new possibilities of knowledge with the internal and external dimensions of sustainability (Gibbons, 2020).

Synthesising the results obtained by introducing the principles of sustainability and the associated measures in the European and national legislation of the member countries, it is found that important steps have been taken primarily to reduce energy consumption for the operation of buildings, the evolution of the specific annual consumption requirements being obviously in this respect, Fig. 1.

As a result of the application of these measures, it is found that, although in the period 2010-2017 the built-up area increased by 17%, the energy consumed increased by only 6%, and a quarter of the global amount of electricity was produced from renewable sources in 2017 (Gielen *et al.*, 2019). At the same time, the increase in the quality of the indoor environment has been significant.

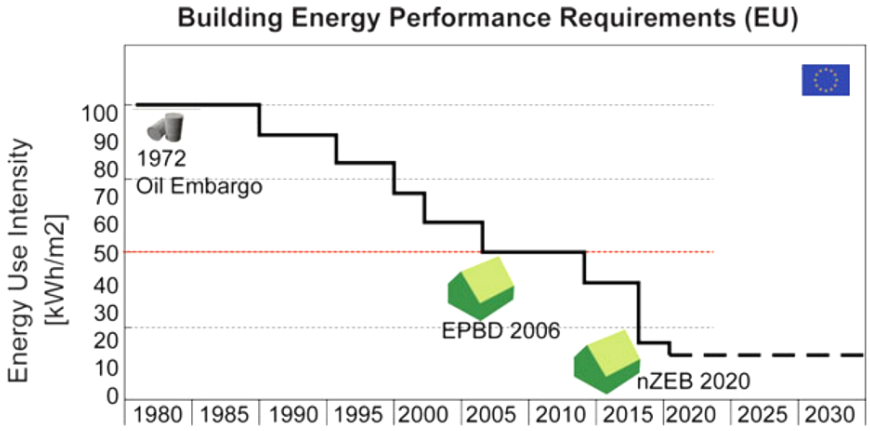


Fig. 1 – Evolution of the EU energy performance requirements for buildings (Attia, 2018).

Forecasts for the coming years are a cause for concern, given that in 2030, 60% of the population is expected to live in cities, and the number of people over 60 years old will be doubled - the forecast appeared before the pandemic period (UN, 2015).

All of these are arguments in favour of the new wave of sustainability, called *Regenerative Sustainability / Regenerative Development*. This concept integrates the principles of conventional and contemporary sustainability, the main feature being a holistic view of the world, Fig. 2.

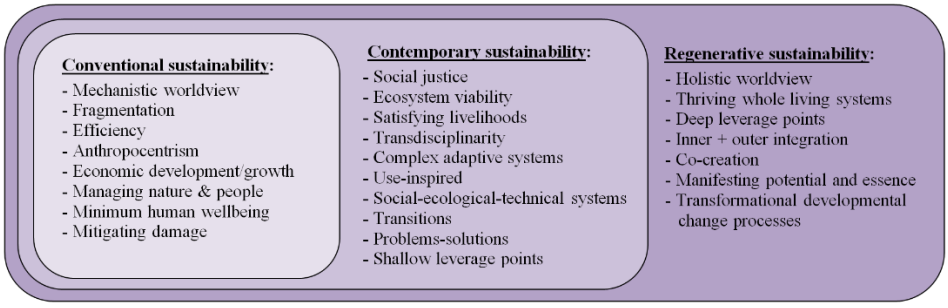


Fig. 2 – Evolution of the sustainability concept (Gibbons, 2020).

The regenerative-sustainable paradigm addresses the dysfunctional human-nature relationship, entering into a co-creative partnership with nature, in order to restore and regenerate the global socio-ecological system through a local set of ecological regulations and engineering practices integrated into this context (Littman, 2009).

2. The concept of regenerative design; general principles

Regenerative design is the tool through which the principles of regenerative development are applied to the built environment through the evolution of new methods, explicitly formulated in the concept of the sustainable - regenerative paradigm.

The objectives of regenerative design are: to improve the quality of housing and life, architectural and urban modernization, to reduce energy consumption and pollutant emissions, improve the social climate, increase security, increase the sense of social responsibility, reduce segregation/isolation, to reduce suburbanization.

The term “regenerative” refers to the processes that restore, renew or revitalize energy and material sources, creating systems that integrate the needs of society with those of the natural environment (Hes and Du Plessis, 2015; Du Plessis, 2012). The concept derives from ecological systems of the closed-loop type, a model in which outputs exceed or are equal to inputs. The ecosystems and regeneratively designed systems aim to create (absolutely) waste-free systems. This concept is in line with the European Commission's new action plan for the circular economy, proposed in March 2020, focused on waste prevention and management. Circularity and sustainability must be introduced at all stages of the value chain, from design to production and, finally, to the consumer (EC, 2020).

Current norms, commonly used in design and execution, disconnect the human being from the natural environment, multiplying the mental model in which humans are above nature. This mental model generates structures and infrastructures that degrade the environment, the understanding of this aspect being the first step towards regeneration.

It can be said about the architecture that it is regenerative when the production generated by the system is higher than necessary. Such an ideal structure can produce energy, food, capture and purify water, produce oxygen and absorb carbon dioxide.

Sustainable systems tend to meet the basic needs of today's man without compromising the ability of future generations to meet their own needs. In addition, the ultimate goal of regenerative design is to modernize systems with absolute efficiency, which allows the co-evolution of the human species with other species. In essence, the difference between "regenerative" and "sustainable" is that, in a sustainable system, environmental losses do not return to the system. In the regenerative system, these losses regenerate and return to the system.

Representing on an axis the degenerative-regenerative evolution, the level of sustainability is located in the neutral point, the transition point from degenerative systems to regenerative systems (Plaut *et al.*, 2012; Craft *et al.*, 2017), Fig. 3.

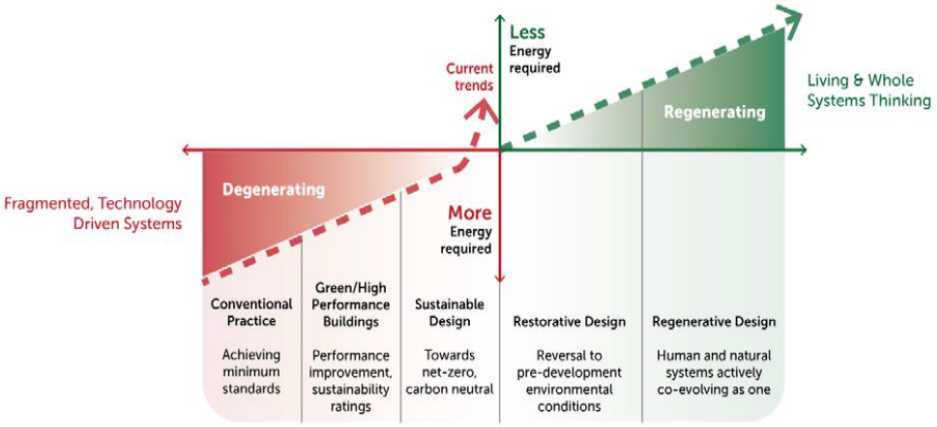


Fig. 3 – The evolution of the relationship between built environment and natural environment (Craft *et al.*, 2017).

The regenerative design promotes the site of placement, as the primary starting point, and the connection of people with the spirit of the place. Modernists have replaced the meaning of place with a more abstract notion "*all-encompassing framework of each particular circumstance, an unlimited container of all possible contents*" (Leatherbarrow, 2009).

The 1960s and 1970s brought the notion of bioclimatic design and bioregionalism (Cole, 2012). Bioregionalism can be defined as the attempt to develop the community by integrating it into the surrounding ecosystems - understanding the place, the specifics of the place where we live. Regionalism emphasizes the specificity of the place in an architectural sense, as a remedy for homogeneity and mediocrity in the existing built environment. Critical regionalism has as its strategy to mediate the impact of universal civilization with elements indirectly derived from local particularities.

Respect for the place is the distinguishing key between green design and regenerative design. While green design tools tend to level regional and cultural distinctions, the regenerative design seeks to understand the system as a whole. The regenerative design builds the regenerative and self-renewal capabilities of natural and designed systems, creates the conditions for sustainable and positive evolution (Gibbons *et al.*, 2018).

The concept of regenerative architecture determines a growing interest among specialists. To capitalize on its scientific and professional potential, it is necessary to establish an organized framework capable of providing designers and builders with effective guidelines in project development and execution monitoring.

3. Integration of regenerative principles in the building design process

The implementation of the principles of regenerative design is gradually achieved, starting from the architectural and structural systems, construction elements and materials. The process is presented in the flow chart presented in Fig. 4.

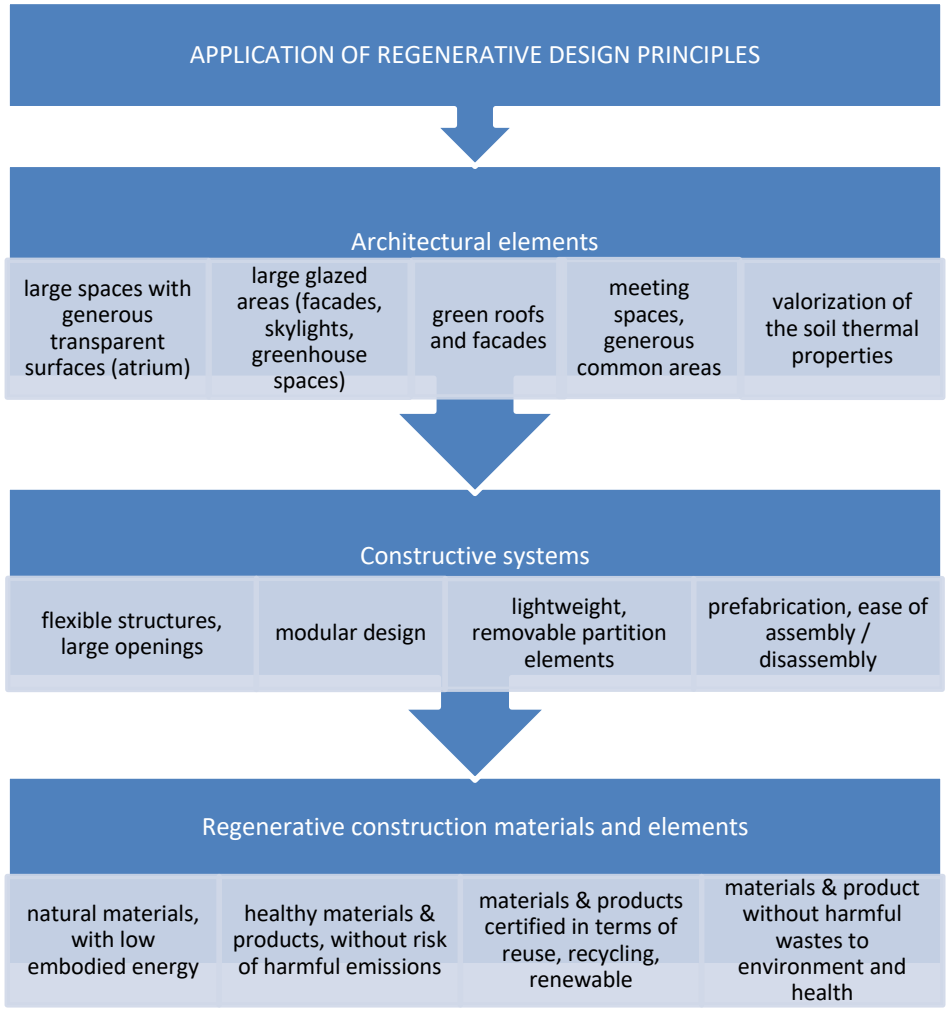


Fig. 4 – Application of regenerative design principles.

By implementing the principles of regenerative design can be relied on the following effects:

- *Architecture*

- providing natural lighting for a long time during the day,
- solar gains by using passive systems,
- ensuring a relationship with nature and balancing biodiversity,
- opportunities for socialization and collaboration in the community interest;

- *Constructive systems*

- adaptability to changing functions and activities by varying the distribution of spaces,
- the possibility of easy assembly and reuse of materials,
- ease transport and assembly;

- *Regenerative construction materials and elements*

- healthy indoor environment,
- positive impact on the natural environment,
- recycling, circularity,
- reduction of investment and operating costs during the life cycle of the building.

The implementation of the decisions taken in the design phase of the building in close correlation with the site requires appropriate strategies, able to meet the objectives of regenerative development, Fig. 5.

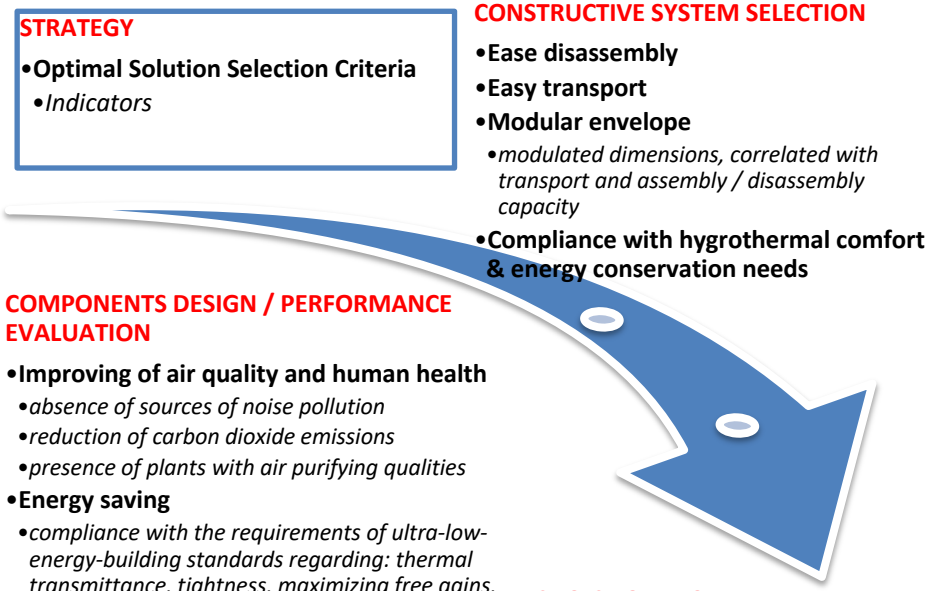


Fig. 5 – Strategies for implementing the regenerative design principles.

One of the buildings that integrate the regenerative design principles is the City Hall of Venlo, The Netherland, Fig. 6. It was designed and built between 2010 and 2016 following the Cradle-to-Cradle design, based on four principles (Attia, 2018):

• Increasing the purity of indoor and outdoor air by creating a living green facade;

• Integration of renewable energy sources that produce more energy than is necessary for the operation of the building;

• Use of recyclable materials;

• Improving water quality and valorising the entire amount of wastewater.

The shape of the building is compact, and the orientation ensures a maximum level of natural lighting.



Fig. 6 – The City Hall of Venlo – North façade (C2CPII, 2017).

4. Evaluation of the regenerative design principles implementation

A rigorous assessment of the extent to which the principles of sustainability and regenerative design have been implemented in a project and especially of the positive effects found during the building operation is a complicated process, which requires knowledge of a large number of parameters and the development of high complexity algorithms. A life cycle analysis, complemented by the carbon and energy content of materials, can be a tool for comparative analysis of some projects or buildings in operation.

4.1. Life cycle analysis

Buildings need to be seen in a much broader perspective than they do today, not only as short-term projects but also considering how they look, interact

with the environment and respond to users' needs, while also examining the long-term effects of the taken decisions. For this reason, the building must be considered throughout its life cycle, from conception to demolition, and in terms of the impact of the life cycle, it extends beyond the physical existence of the building, to the processes involved in the extraction of materials and also to the post-demolition work, Fig. 7.

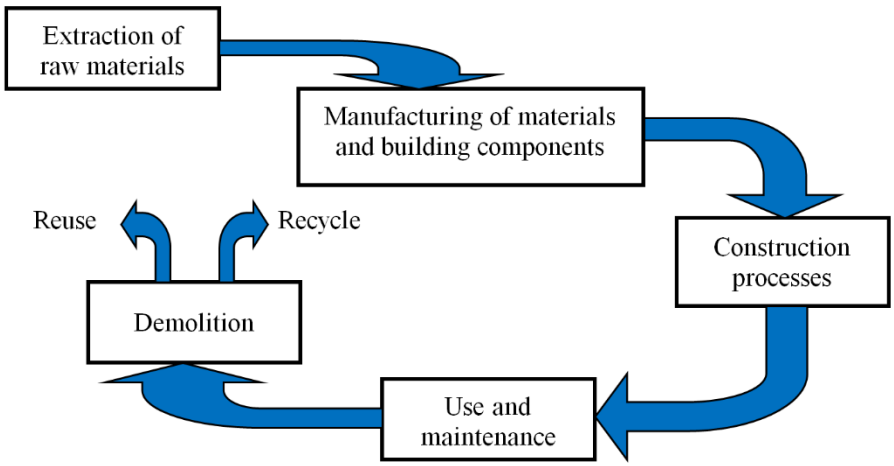


Fig. 7 – The life cycle of a building.

Life Cycle Assessment (LCA) is an increasingly used method of quantifying the environmental impact of construction materials and products. LCA involves the systematic collection of data at different stages of a product's life cycle to measure its impact in terms of pollutants generated. LCA involves a complex and slow process, which requires a lot of data for each product.

LCA methodologies can provide useful information about a large number of building components that can guide options for building materials and design choices. For example, a poorly insulated building could have a low impact on the environment during the construction phase (low requirement of materials), but it will certainly have a much higher impact during the operation phase, due to the energy consumption for ensuring interior comfort. A material can have a significant impact on the environment during its production (e.g., high energy consumption), but afterwards a very reduced one during use (low maintenance and recyclability) or vice versa.

The lifespan of the building is not only an economic factor but also has a significant influence on the creation of sustainable construction, as ensuring the necessary lifespan of the building, materials and products, reduces the amount of waste that can cause environmental pollution. Also, lifespan is linked to the results of renovations, modernization and demolition of buildings and the

possibility of recycling materials. The short life of buildings is unacceptable because they require the extraction and use of new materials unless demolition leads to large-scale reuse of materials.

4.2. Embodied energy

Most research confirm that the impact on the environment is as much reduced as the processing level and energy consumption required for the production of materials are lower. This energy is called *embodied energy*, including the total energy consumed in obtaining raw materials, manufacturing components and constructing the building on site. Obtaining accurate and reliable databases on embodied energy and CO_2 emissions for all materials used in buildings is a difficult task and a necessity to make detailed comparisons of materials. Embodied energy can vary between 6% and 20% of the energy consumption during the operation lifetime for conventional buildings, between 26% and 57% for low energy buildings and between 74% and 100% for NZEB (net-zero energy buildings) (Chastas *et al.*, 2016).

As buildings become more energy efficient in use, the share of embodied energy becomes higher and, in the same way, that of energy involved in demolition, and the importance of recycling materials increases. However, at present, the greatest energy savings are achieved by reducing the energy consumption in use.

5. Conclusions

The awareness of the negative impact of human activity on the natural environment, with the worrying effects on biodiversity, water and soil quality, air purity, and climate change, is a constant concern of international and European organizations, national governments, academic and economic fields.

The built environment, consuming materials and energy resources and, at the same time, an active contributor to greenhouse gas emissions, harms the natural environment by reducing the areas covered with vegetation, by amplifying the heat island phenomenon in large urban agglomerations and the large volume of waste resulting during the use and post-use stages.

In architecture, the attempt to harmonize the relationship between building and natural environment was expressed through different paradigms such as bioclimatic architecture, ecological architecture, green buildings, and sustainable architecture. The application of these concepts has led to notable advances in energy saving, rational use of resources and reduction of greenhouse gas emissions, but not to a sufficient extent to stop the phenomenon of climate changes and the trend of degradation of the natural environment.

Under these conditions, the development of a new paradigm that establishes full equality between man and the natural environment appears to be

necessary. This is the *regenerative development* with correspondence in the construction field, the *regenerative design*, a concept that incorporates the building in the natural environment, based on the principle that all living systems have the right to be treated with the same care and understanding as the human society, the final objective being to achieve buildings and urban agglomerations that are at least neutral in terms of energy consumption and carbon dioxide emissions. Practical achievements based on the principles of regenerative design provide reasons for optimism about the future.

REFERENCES

Attia S., *Regenerative and Positive Impact Architecture. Learning from Case Studies*, Springer International Publishing AG, 2018.

Chastas P., Theodosiou T., Bikas D., *Embodied energy in residential buildings-towards the nearly zero energy building: A literature review*, Building and Environment, **105**, 267-282 (2016).

Cole R.J., *Regenerative design and development: current theory and practice*, Building Research & Information, **40** (**1**), 1-6 (2012).

Craft W., Ding L., Prasad D., Partridge L., Else D., *Development of a regenerative design model for building retrofits*, Procedia Engineering 180 - 658 – 66, (2017).

Du Plessis C., *Towards a regenerative paradigm for the built environment*, Building Research & Information, **40** (**1**), 7-22 (2012).

Gibbons L.V., *Regenerative - The New Sustainable?* Sustainability, **12** (**13**), 5483 (2020).

Gibbons L.V., Cloutier S.A., Coseo P.J., Barakat A., *Regenerative Development as an Integrative Paradigm and Methodology for Landscape Sustainability*, Sustainability, **10**, 1910 (2018).

Gielen D., Boshell F., Saygin D., Bazilian M.D., Wagner N., Gorini R., *The role of renewable energy in the global energy transformation*, Energy Strategy Reviews, **24**, 38-50 (2019).

Hes D., Du Plessis C., *Designing for hope: pathways to regenerative sustainability*, Routledge, New York, 2015.

Leatherbarrow D., *Architecture Oriented Otherwise*, Princeton, NJ: Princeton Architectural Press, 2009.

Littman J.A., *Regenerative Architecture: A Pathway Beyond Sustainability*, Master Theses, Paper 303, University of Massachuttes Amherst, 2009.

Plaut J.M., Dunbar B., Wackerman A., Hodgin S., *Regenerative design: the LENSES Framework for buildings and communities*, Building Research & Information, **40** (**1**), 112-122 (2012).

*** C2CPII, *Built Positive Principles Play Key Role in Venlo City Hall's Sustainable Design Mission* (2017), https://www.c2ccertified.org/news/article/built-positive-principles-play-key-role-in-venlo-city-halls-sustainable-des.

*** Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the

Committee of the Regions – *A new Circular Economy Action Plan. For a cleaner and more competitive Europe* (COM (2020) 98 final, 11.03.2020).

[*] United Nations, Department of Economic and Social Affairs, Population Division (2015), Population 2030: *Demographic challenges and opportunities for sustainable development planning* (ST/ESA/SER.A/389).

[*] World Commission on Environment and Development, *Our common future*, Oxford University Press, Oxford, 1987.

PROIECTAREA REGENERATIVĂ - PRINCIPII GENERALE ȘI STRATEGII DE IMPLEMENTARE ÎN PROIECTAREA CLĂDIRILOR

(Rezumat)

Mediul construit, prin consumul de energie din surse neregenerabile și emisiile de CO_2 asociate, ca și prin producția de deșeuri pe întreg ciclul de viață și prin efectele de degradare a solului și apei, contribuie esențial nu numai la fenomenul modificărilor climatice, ci și la degradarea ireversibilă a mediului natural. Conceptul de proiectare regenerativă oferă un cadru de abordare holistică a acestor aspecte în scopul identificării celor mai eficiente căi de remediere, propunând restaurarea și regenerarea sistemului socio-ecologic global printr-un sistem de practici inginerești adecvate contextului.

Aspectele definitorii ale regenerabilității aplicate în domeniul clădirilor se referă la arhitectura și încadrarea în mediul natural, asigurarea unui mediu interior sănătos și a stării de bine, reducerea la zero a consumului de energie din surse neregenerabile și promovarea surselor regenerabile, minimizarea amprentei de carbon prin utilizarea rațională a materialelor și gestionarea deșeurilor pe durata ciclului de viață.