Regenerative Architecture

The inspiration towards greater sustainability

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“*Be the change you wish to see in the world*”

- Mahatma Gandhi

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1. Introduction: current state

1.1 World situation

We are living in a period of big changes. World population reached 8 billion people on November 15th 2022 and keeps growing, with the part of urban population increasing exponentially[1]. More people means more needs, more consumption, more production, more impact on the planet and more pollution if we continue with our actual practices and habits. The climate is changing: the earth's global surface temperature has risen by more than 1°C since the pre-industrial period[2], the biodiversity is declining and more extreme weathers are to be awaited in the future. All these events are the result primarily of human actions linked with the overconsumption of natural resources, especially fossil fuels[3].

The good news is that there is an awareness of the impact of our actions on the environment and on people, as it has been documented and scientifically proven. Since we know the causes of the problem, we can now focus on solving them by changing our practices. Nature is our life supporting system, and if we harm it, it is like harming ourselves, which means self-destruction in the long term. Once we understand the scope of our actions and direct repercussions on ourselves, a mindset shift begins.

1.2 Buildings impact

In Europe, buildings, including the construction and operational phases, are responsible for around 40% of all energy consumption[4], 36% of all greenhouse gas emissions and 33% of all solid waste production[5]. These numbers show that the impact of buildings is far from being negligible and that big progresses are still needed if we want to decarbonise the sector and reach the target of net zero emissions by 2050 according to the Paris Climate Agreement[6].
The way we build today is still generating resources depletion, soils, air and water pollution, as well as biodiversity and natural surfaces loss. If we put the increase in the world's population and general urbanisation into perspective, we can predict that the demand for new constructions will grow as well. And if we link this prediction to the existing impacts of the building sector, we can anticipate an increase in overall consumption and thus energy, resources, pollution and greenhouse gas emissions, if practices remain as they are today.

1.3 Needs

Buildings are one of the foundations of human civilisation, because they meet two simple and essential needs: shelter and comfort. To ensure these needs, external inputs of materials and

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[1] United Nations, Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420)*, 2019, New York
[2] Lindsey R., Dahlmann L., *Climate Change: Global Temperature*, Climate.gov, June 2022, last visited 02.12.2022, www.climate.gov/news-features/understanding-climate/climate-change-global-temperature
[3] IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC , 2014, Geneva, Switzerland, 151 pp.
[4] European Commission, Department of Energy, *Energy efficiency in buildings*, Brussels, 2020
[5] Eurostat, *Key figures on Europe : 2016 Edition*, European Union, 2017, 202 pp.
[6] European Commission, *Paris Agreement*, Climate Action , last visited 02.12.2022, https://climate.ec.europa.eu/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en

energy are required for the construction and use of buildings. With human evolution and desire for more comfort, we have always increased the total use intensity of both energy and resources over history. Since it has been proven that we cannot continue endlessly with our accelerating consumption, because our planet has physical limits and works circularly within its own boundaries, humanity is looking for sustainable solutions to continue its activity and ensure its comfort while lessening its environmental impact. It is therefore imperative to change our relationship with the environment, because we depend on it and its limits for our existence and our comfort. Rapid and drastic changes must be made in the building sector to reduce its impact on the environment, as it is a major contributor to its degradation.

The overall challenge is to restore a healthy relationship with our planet: answering human's needs while letting other living systems do as well, without hindering their chances to do so, using natural resources without depleting them and engaging in practices that do not destroy the environment in any form. In the simple natural principles of our planet's functioning are many answers to our problems: limits and circularity. The positive aspect is that nature can be healed, it simply requires time and ongoing commitment with good practices.

1.4 Assumptions

Although architectural practices have made significant progress in terms of operational energy and carbon reduction, these efforts are still insufficient if we assess them from the point of view of total negative environmental impact. Many constructions and practices are called sustainable, but the fact is that they are often empty words. The way we build today still does harm the planet and does not represent a true sustainable way of constructing, as it still contributes to resources depletion and pollution.

The focus must be then shifted to other important aspects of buildings that are also responsible for significant environmental damages or that could help improve them, but also beyond the building itself. Impact reduction efforts to date in the building sector have not addressed all the "hidden" parts of the problem with the same attention as the operational side. Although the operational phase tends to weight more in term of percentage for the overall energy consumption and greenhouse gas emissions, it is wrong to assume that addressing only this issue will decarbonise the sector. For example, as building's performances increase and the operational impact decreases, the embodied part tends to become more important in percentage. In order to fully address a building's impact, it is necessary to address all sides of the problem, even the less obvious ones.

Architect can be a key figure in changing practices in the construction sector, as they are the initiator and reference person for each project. They have an overview and understanding of all problems and interests involved, which puts them in a central position to make significant suggestions and initiatives to make the profession evolve. By bringing awareness and promoting better practices, they could accelerate changes in the profession through their ongoing commitment and projects. Today's role of architects is to take part in this goal, by contributing to environmental problems resolution through architecture, as the design of a project has a big influence on its final environmental impact. Architects are those who envision and project, but also those who analyse, understand and dialogue with all actors of the profession. This makes our role even more important, given the number of people we interact with and thus the scope we can have.

2. Research questions and methodology

This theoretical statement aims to better understand what "*regenerative architecture"* really is, with the help of sustainable architecture comparison and related case studies. This work aims to answer the following questions:

- What does it mean for a building or project to be regenerative?
- What are the definitions, principles, actions, examples and subtilities?
- Where does it stand with respect to sustainable architecture?
- What are the conditions to reach this type of architecture?
- What are the benefits, limitations, dangers and difficulties?
- Why are some projects regenerative and others not?
- Which topics does it target?
- What can be learned from regenerative architecture?

The theoretical statement will first provide a concise definition of regenerative architecture and its precise contextualisation and comparison with sustainable architecture.

Next, regenerative and sustainable case studies will be presented and compared, in order to differentiate between both types of architecture.

Then, a critique of current sustainable architecture will be made, following the lessons that were learned from the case studies analysis.

Finally, a conclusion will be drawn concerning regenerative architecture, including its relevance, possibilities, opportunities and limitations.

3. Definitions

3.1 What is Sustainable Architecture?

To better understand the subject, it is necessary to understand the definition of the main term used throughout the work, so that it can be placed in its architectural context.

***Sustain** (verb):*
(1) to cause or allow something to continue for a period of time
(2) to keep alive
(3) to keep something in operation (maintain)[7]

a. Limit impact
Sustainable or ecological architecture is an umbrella term that defines architectural practices that aim to have a limited environmental impact through improved overall design and strategies, which reduce the amount of materials, energy or space needed for a project[8]. One of the initial guidelines was to ensure people's needs with available resources without depleting them, thus not hindering the possibility of future generations to respond to their own needs. In other words, to preserve our ecosystem while reducing our carbon footprint. The concept gained prominence in the 1970s, once awareness of sustainable practices was sufficiently raised by the retreat of modern architectural practices and the oil crisis[9]. Different types of architecture are grouped under this term, among others: autonomous, bioclimatic, biomimetic, biophilic, carbon neutral, energy conscious, energy plus, environmental, frugal, green, natural, net positive, net zero, organic, passive and solar[10].

b. Global approach
Through a global approach, every aspect of the project is targeted, from early design concepts, through material selection, energy efficiency and supply, technical solutions, landscaping, construction, and up to the end of life of the project. Each step is supposed to be carefully examined and implemented with the best available solution to limit its impact on the environment, if it is feasible, desired and asked by the client or suggested by the architect.

c. Evolving definition
There is no perfect definition of sustainable architecture, as the concepts and criteria are constantly evolving with the knowledge we acquire, the technologies we develop, the needs and problems we have to address. Also, many concepts claim to be sustainable in the same way as others, might they be more or less ambitious regarding environmental goals. Sustainability is a very complex idea that can be interpretated and assessed in many different ways that are not always comparable, because they address different criteria. Is the sustainability targeting the present or the future? Humans or animals? Materials or plants? Which is more important and for what reasons? Are these reasons valid everywhere and for everyone? Because of its complexity, there is no consensus for a clear and unique definition.

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[7] Cambridge Dictionary, *Meaning of **sustain** in English*, Cambridge University Press, last visited 18.12.2022, dictionary.cambridge.org/dictionary/english/regenerate
[8] Wikipedia, *Sustainable Architecture,* last visited 18.12.2022, en.wikipedia.org/wiki/Sustainable_architecture
[9] Hohenadel K., *What is Sustainable Architecture?*, The Spruce, 2022, www.thespruce.com/what-is-sustainable-architecture-4846497
[10] Attia S., Towards regenerative and positive impact architecture: A comparison of two net zero energy buildings, Sustainable Cities and Society, Elsevier, 2016

3.2 What is Regenerative Architecture?

To understand the difference in impact compared to sustainable architecture, starting from the definition of the term regenerative is essential.

***Regenerate** (verb):*
(1) to improve a place or system, especially by making it more active or successful
(2) to grow again[11]

a. Reverse damages

Regenerative architecture is a conscious practice that seeks to reverse the environmental damages[12] that have been done to the planet (such as excessive CO2 emissions, natural spaces destruction, biodiversity loss, intensive resources extraction and depletion, as well as air and water pollution), through the practice of architecture. Its main aim is to have a net positive impact[13] on the environment and on humans through projects that strive for biodiversity and health[14]. This type of architecture goes beyond actual concepts of sustainability: it wants to actively heal and give back more than it took[15] to realise a project, both socially and environmentally. Ideally, regenerative architecture would increase the carrying capacity of the planet and reverse our ecological footprint[16], allowing the recovery of lost features[17], such as natural and social capital, environmental stability and equilibrium between human and nature.

b. Whole systems approach

Regenerative architecture is based on whole systems and living thinking, which means recognising all living systems as equal shareholders of the environment, allowing all of them to have their needs answered and enough space for them dedicated. It pursues the reconnection of humans with nature by engaging in mutually beneficial relationships and co-evolution on site[18]. This practice is deeply linked to ecology and is therefore place based, well integrated, connected with the site, impact conscious and precautionary. This system wants to answer both side's needs locally (human and environment), while having the bigger picture in mind (global impact).

Short: regenerative architecture is an architecture that seeks to answer architectural, social and environmental problems at the same time, through deep systemic changes in principles and therefore, also in practices.

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[11] Cambridge Dictionary, *Meaning of **regenerate** in English*, Cambridge University Press, last visited 18.12.2022, dictionary.cambridge.org/dictionary/english/regenerate

[12] Busby P., Richter M., Driedger M., *Towards a New Relationship with Nature: Research and Regenerative Design in Architecture*, Architectural Design 81, n°6, November 2011, p.92-99. doi.org/10.1002/ad.1325.

[13] HMC Architects, *Regenerative Architecture Principles: A Departure From Modern Sustainable Design*, 2019, last visited 18.12.2022, hmcarchitects.com/news/regenerative-architecture-principles-a-departure-from-modern-sustainable-design-2019-04-12/

[14] Guenther R., *Regenerative Architecture: Redefining progress in the built environment*, Architecture and Health, 2019, 1st edition., p.280-95. New York, Routledge, doi.org/10.4324/9780429021169-20.

[15] Littman J. A., *Regenerative Architecture: A Pathway Beyond Sustainability*, University of Massachusetts Amherst, Department of Art Architecture and Art History, 2009

[16] Attia S., *Towards regenerative and positive impact architecture: A comparison of two net zero energy buildings*, Sustainable Cities and Society, Elsevier, 2016

[17] Rey E., Laprise M., Lufkin S., *Key Steps of a Regeneration Process*, Neighbourhoods in Transition, p.97-109, The Urban Book Series, Springer Cham, 2022, doi.org/10.1007/978-3-030-82208-8_6.

[18] Reed B., *Shifting from 'Sustainability' to Regeneration*, Building Research & Information 35, n° 6, November 2007, p.674-80, doi.org/10.1080/09613210701475753.

3.3 Where do they meet / diverge?

a. Goal

Both sustainable architecture and regenerative architecture are positioned within the framework of sustainability. The main difference is that sustainable architecture is a overall definition that encompasses many different ideas, which can be more or less ecological, but all aiming for an improvement in the profession through the reduction of the environmental impact. As shown in figure 1, regenerative architecture targets a more precise and demanding position in the sustainability dimension, by pushing the boundaries of current sustainable definitions and reinterpreting the "impact reduction" with "impact reversal" and "active healing".

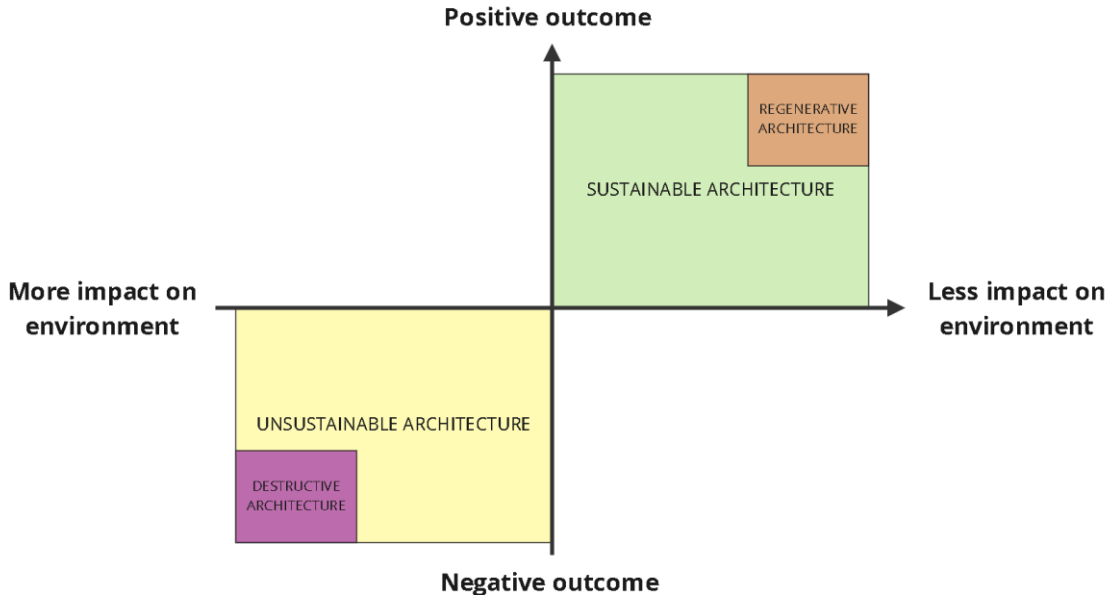


Figure 1: Place of different types of architectures, based on impact and outcome[19]

b. Principles

Sustainable architecture proposes a wide range of principles for every step of a project to help reducing the impact of construction practices on the environment. They can be sorted into different categories, regarding which part of the building or of the project they impact. A non-exhaustive list of sustainable characteristics could be established as follows[20,21]:

Energy

Reduce consumption, use clean energy, implement passive systems, create buildings that produce as much energy as they consume (net zero emissions)

Building

Flexible design, materials selection, well integrated into the landscape, quality of spaces

[19] All figures' sources can be found in the list of figures, at the end of the work in part 12

[20] Hohenadel K., *What is Sustainable Architecture?*, The Spruce, 2021, last visited 18.12.2022, www.thespruce.com/what-is-sustainable-architecture-4846497

[21] Capoferri, *Sustainable Architecture. Definition, principles and famous projects*, 2022, last visited 18.12.2022, www.capoferri.it/en/sustainable-architecture-definition-principles-and-famous-projects/

Impact on the environment
Reduce overall human carbon footprint, avoid waste, optimise water conservation systems, do not harm other ecosystems

Social/human
Improve happiness and well-being, positive experience, inspiration and education, community

All the above principles, but also others possibilities that are not mentioned, can be implemented in sustainable architecture, one by one or combined. As the definition and knowledge of sustainability evolves, more principles can be added to the list or adapted. Regarding regenerative principles, as their ideal is placed within a higher range of objectives, it can be said that only some principles of sustainable architecture are regenerative in their intentions, alone or combined, as represented in figure 2 below. For example, if we take the "energy reduction" principle, it is not regenerative per se, because a simple reduction of a building's energy consumption will not make a project regenerative. But if combined with "reduce carbon footprint", "education" and "flexible design", there is a higher chance that the outcome will be regenerative (blue combination).

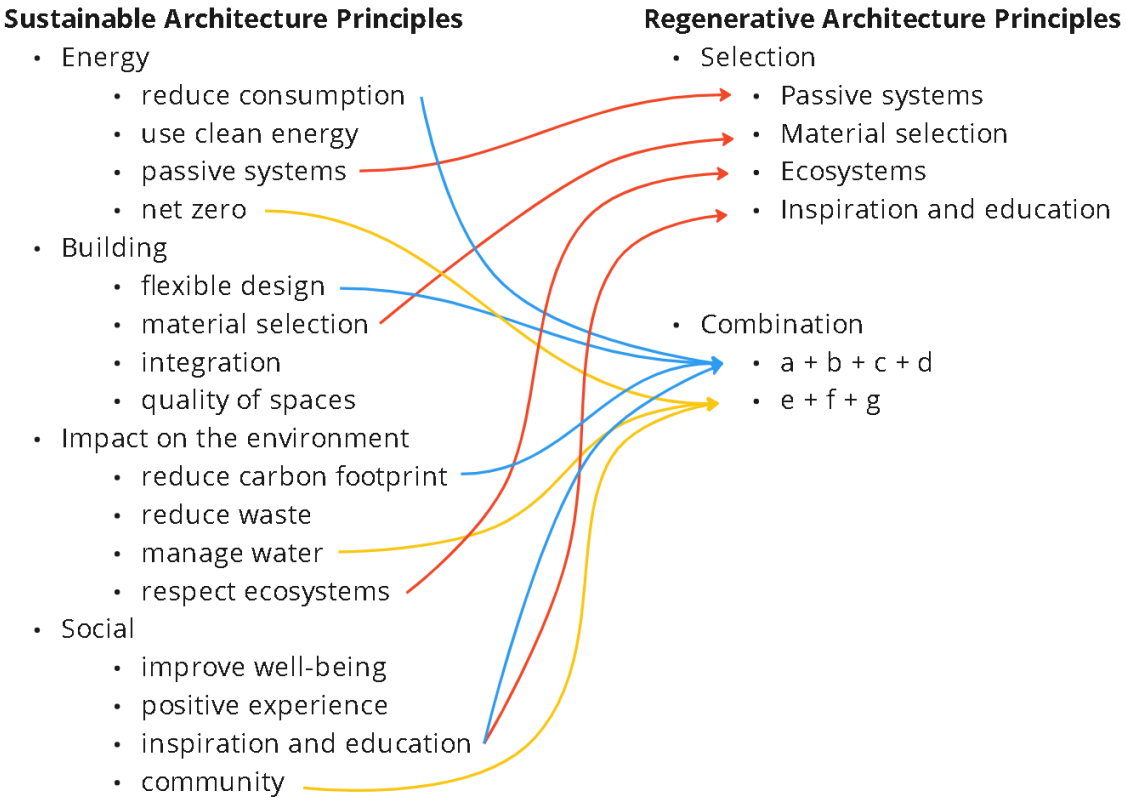


Figure 2: Sustainable and regenerative architecture principles correlation possibility

c. Practices

Similarly to sustainable architecture principles, sustainable architecture practices are various, numerous and can also be classified into different categories regarding which part of the building or project they impact. Practices respond to their related principles and are classified under the same sections (energy, building, impact on the environment, social). A non-exhaustive list of sustainable architecture practices could be represented as follows:

Energy
Use high efficiency appliances, teach and encourage sparing consumption, implement renewable energies (solar, wind, hydraulic), maximise natural lighting, install shading systems, install proper insulation, use thermal mass, natural ventilation, heat recovery

Building
Adaptable, modular, flexible, correct dimensions, made with local, renewable, reused, natural, non-toxic, low-processed materials, avoid and replace carbon intensive materials with better alternatives, adapted to the landscape and climate, healthy spaces, comfort, durability

Impact on environment
Reduce consumption of energy and materials, optimise water conservation systems, purify air, sequester carbon, incorporate vegetation, create spaces for biodiversity, go for circular economy principles (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover)[22]

Social/human
Thermal comfort, acoustic comfort, views inside and outside, circulation, easy access, connections and transitions, aesthetics, link with other users/occupants, social project

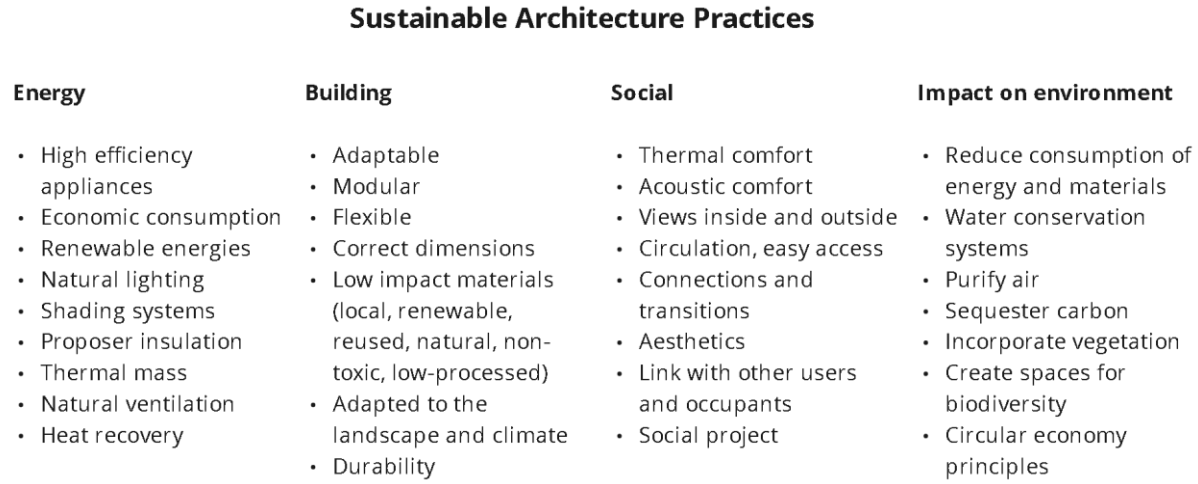


Figure 3: Sustainable architecture practices sorted by impact categories

The same observation as for the principles can be made for sustainable architecture practices: not all sustainable practices are regenerative, because they do not all aim for the same objective. Only a specific selection or combination of sustainable practices will eventually provide with a regenerative project.

Within sustainable architecture itself but also in other fields, there is a gap between theory and practice. In general, principles are often more demanding than current practices, as they set an ideal to reach that is still not the norm, like it is the case with sustainable architecture and even more for regenerative architecture. The discoveries we make in laboratories and on the field take time and efforts to be shared and then implemented in future projects, which explains why there is this temporal, knowledge and application gap between both.

[22] Potting J., Hekkert M., Worrell E., Hanemaaijer A., Circular Economy: Measuring innovation in product chains, PBL Netherlands Environmental Assessment Agency, 2016, The Hague, p.5

The way we assess progress and the achievement of objectives in sustainable architecture today is through sustainability labels and certifications. With the help of different lists of criteria, projects are examined on their environmental, social and economic aspects. The most popular sustainability labels in Switzerland are: LEED, BREEAM, Minergie and SNBS, but there are many more[23].

Concerning regenerative assessment, the only existing sustainability label that responds to the ideas of regenerative architecture and contains a significant number of regenerative projects is the Living Building Challenge (LBC). The International Living Future Institute offers different certifications, among which the last one that is of interest for regenerative assessment, due to its stricter and bigger list of criteria. Four out of the five proposed certifications are shown in figure 4, with the list of requirements that need to be achieved. The label "Living Certification" targets ideal results regarding sustainability and is an *"advocacy tool for projects to move beyond merely being less bad and to become truly regenerative"*[24].

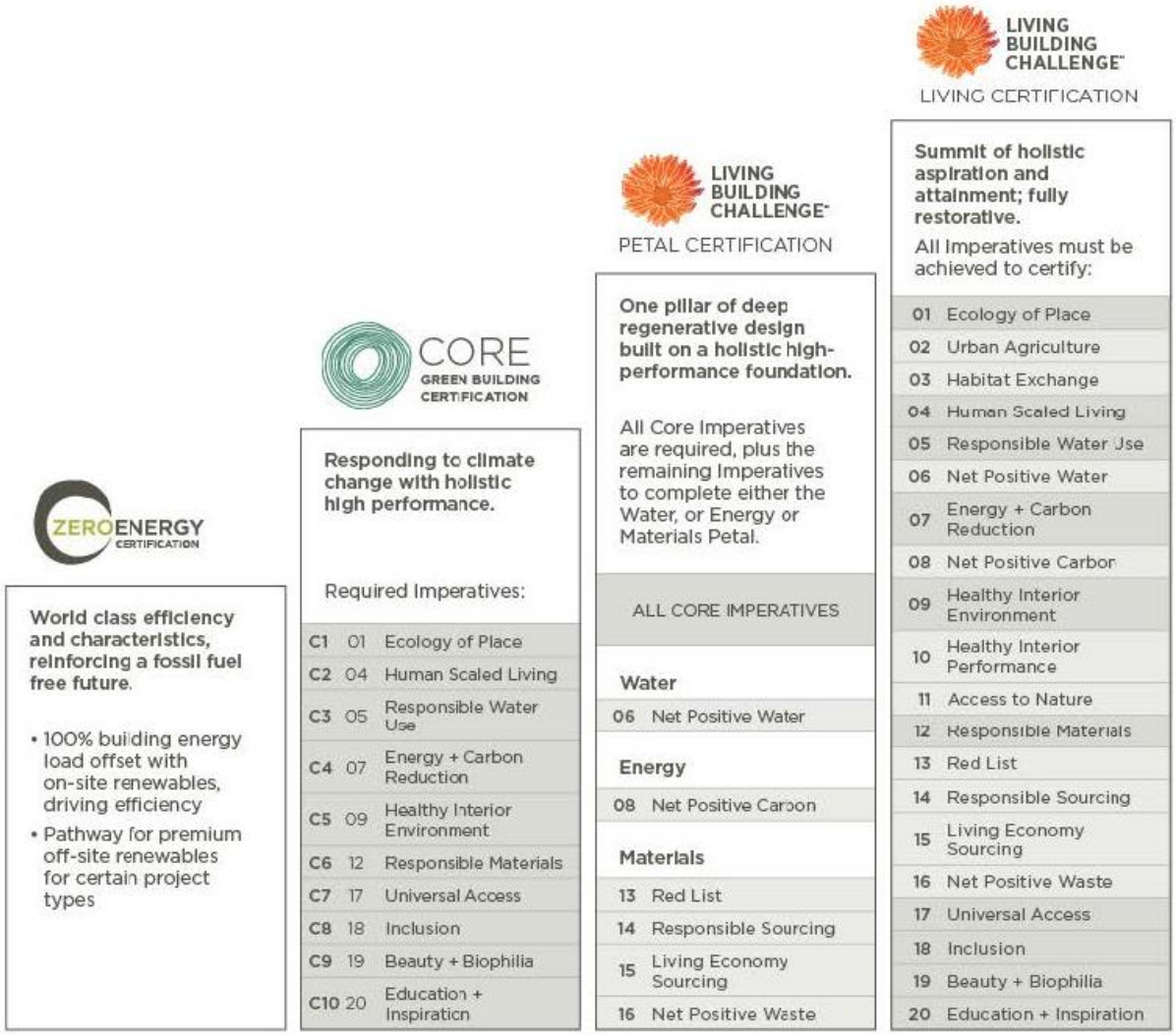


Figure 4: International Living Future Certifications (without "Zero Carbon")

[23] Mark K., Ackermann S., Zeifang H., Kastner F., Guide : Standards et labels de la construction durable en Suisse, NNBS, 2021

[24] International Living Future Institute (2019), *Living Building Challenge 4.0: A Visionary Path to a Regenerative Future*, United States of America

The full living certification is the most demanding label proposed by the International Living Future Institute, aiming and certifying projects that respond to all criteria, without exception, making them truly regenerative, and even restorative in the Institute's eyes. The twenty criteria are spread among seven themes (also called petals): place, water, energy, health and happiness, materials, equity and beauty. All these characteristics are part of the question: "what does good look like?", which is the question they asked in order to develop this new assessment list, for an improved design to answer the highest sustainability expectations. This evaluation system is one of the most advanced around the world, and offers in my eyes a very powerful potential for the future, as it may become the most relevant attestation method for regenerative projects[25].

d. Context of sustainability

Both sustainable and regenerative architecture recognise that environmental damage is caused by human activities and that the building sector is a significant contributor. The additional step in regenerative thinking is that it assumes that actual practices are not enough, because even if good intentions are translated into sustainable principles, actions taken today do not solve long-term problems. Regenerative architecture is a way to move forward and seek systemic and profound improvements in the profession to address and respond to real problems better than has been done to date.

A first step is to redefine sustainable architecture. From a regenerative perspective, the term can be misleading because of the multiple interpretations that can been made and the wide range of degrees of sustainability that can be aimed at (weaker and stronger). In this sense, there is a lack of clarity and precision in what can truly be named sustainable architecture. From a regenerative perspective, regarding the previous damages done to the environment, the current state of our world would require a replenishment instead of a stabilisation, which should be mentioned in the now obsolete definition of sustainability.

A second step would address the goals of sustainable architecture. Regenerative architecture sets very high goals regarding sustainability, because it assumes that the actual ones are not sufficient. One reason for this is that we rarely achieve 100% of the goals we set, like we often witness with sustainable architecture. The idea is that if we aim higher than requested, we have better chances to reach better sustainability and have a regenerative result. Goals are an important step, because they directly influence the ideas behind the principles we set, and therefore the solutions we put in place to attain these objectives. As represented in figure 5, goals are central, because they synthetise the knowledge we have from the past, they define the present of sustainable definition (which represents our current understanding of sustainability), and they have a direct impact on the future actions we take by orientating our principles and practices.

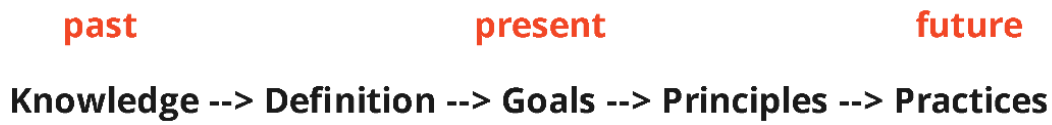


Figure 5: Impact chain timeline

[25] International Living Future Institute (2019), *Living Building Challenge 4.0: A Visionary Path to a Regenerative Future*, United States of America, p.3-11

4. Regenerative Architecture Case Studies Analysis

To grasp the ideas of regenerative architecture, it is important to have some good examples to illustrate what is behind all these principles and definitions. The concepts may be precise and motivated, but the representations are not always obvious and easy to find. From the case studies that are presented in this section, I would like to show their regenerative aspects, explain how they work, how they achieve a regenerative result and which parameters are responsible for the positive outcomes. I would like to expose the subtle way in which each project achieves regeneration and gives more back to humans and nature. All case studies were chosen based on my understanding of what regenerative architecture is, for their unique qualities and positive influence on environmental and social aspects. Whenever possible, the cases were chosen in Switzerland, except for one.

4.1 The Bird Island House

a. Description

The project, realised in 2021 by LOCALARCHITECTURE for the Lausanne Ornithological Circle in Préverenges (Switzerland), answered the need to create a new visitor centre dedicated to animation, information and education, as the previous one was in poor condition. The goal was to have an inviting space for raising awareness about the conservation of local bird species and to create new favourable biotopes for them to reproduce and migrate.

Figure 6: Front facade with main entrance to the pavilion
Figure 7: Drone image of the site with the protected and renatured bird's island

b. Materials

Particular care has been taken in the selection of materials: most of them are bio-based, locally found or produced, and non-toxic for humans and the environment. Different types of local wood essences were used for the structure, envelope and furniture (white fir and spruce), and applied as solid wood or cross laminated timber for the construction. The pedagogical house received the Lignum Prize in 2021, which rewards wood projects for their quality, originality, and innovative approach. Also, it possesses the Swiss Wood Label (Label Bois Suisse), ensuring that the product responds to a sustainable forest management, a quality control throughout the processing chain, the maintenance of regional workplaces and the reduction of transport distances. The almost 25m^3 of wood lock a significant amount of carbon inside them, as long as the material is not burned or degraded, making it a carbon sink that helps mitigate climate change. Not only did the material reduce the amount of CO2 in the atmosphere during the

tree's growth, but it also blocked the emissions of other carbon intensive materials, in case they would have been chosen for the pavilion. Outdoor wood was treated with a water-based solution instead of a chemical one.

The different types of insulations were also chosen to be as ecological as possible: sheep wool for thermal insulation (eliminating smell, pollutants and being naturally fire resistant), wood fibre boards against water infiltration (carbon storage and insulation) and gypsum fibre-boards instead of classical plasterboards (water resistant, fire proof, reduced CO2 impact). Regarding the foundations, the amount of concrete was highly reduced, as only parallel soles were poured instead of a whole base. Another even less invasive solution with buried feet was suggested but not implemented, due to the time and economical limitations (Laurent Saurer, personal communication, 7th December 2022).

c. Space for animals and nature

The main contribution made for biodiversity is the enlargement of the island that was created back in 2001-2002 and the addition of new spaces (a pond, a shoal and a cliff) to attract more species and diversify the possible habitats for migrating birds[26]. The island is located further away from the shore, to limit human presence and disturbance, but still close enough to be seen and birds to be heard.

On the construction site, existing trees were untouched by the interventions, as they were listed and precisely mapped on the plan. The building itself was designed to host birds and other animals. The elevated structure, shown in figure 8, allows rodents and small mammals to hide underneath, hunt or create a burrow, but also to avoid humidity problems for the building in times of flood. The wood trunnions in figure 9 do not only serve to hold the wooden pinched lamellas in place without glue, they also let birds perch on them occasionally. The holes in the outer façade are not just decorative, there is a reserved 5cm space behind it to shelter bats and allow them to reproduce. The house becomes a "reproduction place" for different species[27].

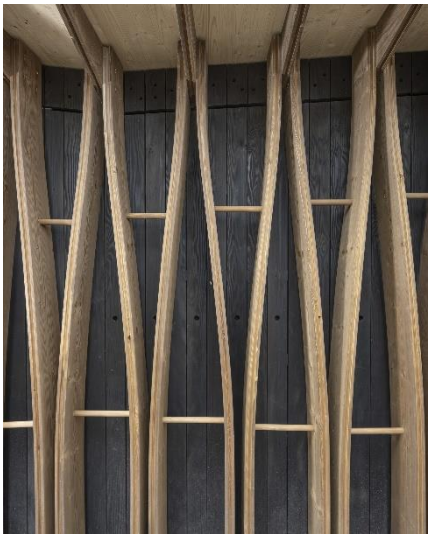


Figure 8: Back entrance of the pavilion, with shown gap underneath the construction
Figure 9: Wooden facade with perches and bat holes

[26] Cercle Ornithologique de Lausanne, *Maison de l'île aux oiseaux : dossier de recherche de fonds*, 2022, last visited 26.12.2022, ileauxoiseaux.ch/index.php?nav=dossier

[27] LOCALARCHITECTURE, La maison de l'île aux oiseaux : construction d'une cabane d'observation à Préverenges, Dossier de presse, 2021

d. Observation and education

As in shown in figures 10 and 11, the simple 49m^2 pavilion is located exactly in front of the bird's island, alongside the promenade leading to the beach of Préverenges. The house aims to raise awareness about the impact of human activities on the depletion of migratory stepover sites for birds. Through their collection exhibition, observation possibilities and educational spots and workshops, the Ornithological Circle of Lausanne plays an important role in raising awareness and teaching. People walking by are intrigued by the beauty of the pavilion and are attracted inside, where they can learn about birds and the project, and develop a sensitivity for the subject. School classes from the region are often invited on site and many activities linked with birdwatching are organised throughout the year, for individual or institutions, even when the weather is bad now that there is a dedicated space for such activities.

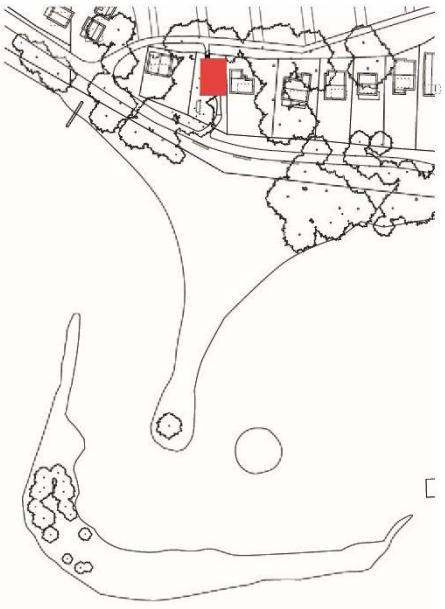


Figure 10: Situation plan with added red hatch for the house
Figure 11: Interior view of the entrance with the observational window

e. Regenerative Outcome

This example is certainly regenerative, first because there is a net positive human and environmental impact: people have a new place to gather and learn, and animals have more space to live, migrate and reproduce. Chosen materials reduce the carbon footprint of the construction and provide a healthy interior due to their natural characteristics, and biodiversity is improved by landscape interventions and maximum preservation of pre-existing vegetation on site.

Second, the integration of the project is well made, above existing traces of islands and among built cabins, and it makes the spot more attractive and dynamic. The place is liked, inspiring by its architecture and landscaping, and seen as exemplary: the overall situation is improved.

Third, the function of the building encourages interaction and connection with the local biodiversity. The pavilion is linked with the bird's island, through the observational window, the exhibition and other info-points present on site. The ideas of the Ornithological Circle of Lausanne can be felt and are well transmitted through the whole project.

A virtuous circle is created: people started a group of interest for birds, they learned more about the subject, understood its importance and decided to create an island dedicated to

them 20 years ago. As a result of this intervention, biodiversity has improved significantly and people have been able to enjoy it. The results motivated people to continue investing in this program and new renaturation sites were created, giving even more place for wildlife to thrive and occasions for people to learn about it and gather.

The last important point is the architecture that was created: the house was designed to serve not only people, but also wildlife. Without compromising construction requirements, elegant solutions were found to include other living beings into the house. A holistic thinking and opportunism were necessary to arrive to such a strong and effective project.

4.2 AQUA House

a. Description

The house, built in 2016-2017 by the bureau F. Jud Architektur AG for the architect herself in Zofingen (Switzerland), was a pilot project for water self-sufficiency. Franziska Jud, the architect, wanted to live in a house that reconnects her with nature and works in balance with natural systems. She wanted to feel in harmony with herself and the environment, by reducing her impact and improving her family's well-being, happiness and health.

Figure 12: Outside view of the single-family house
Figure 13: Interior view of the kitchen and living room

b. Materials

The project was realised with a Holz 100 natural structural construction system, using Swiss wood for walls, floor and roof. The architect wanted to reduce the environmental impact of the building as much as possible and have a healthy interior environment with natural materials. Environmental data gathering and analysis was pushed to its maximum, to show with numbers and facts that the house offered optimal living conditions while observing a minimal carbon impact. Swiss moon wood (harvested at a precise time of the year for improved quality) was used for the facade, thus having a positive impact on the quality, making it more resistant in its natural finished state for outdoor conditions[28].

[28] F. Jud Architektur AG, *EFH AQUA – das wasserautarke Holz 100 Haus*, 2017, last visited 27.12.2022, www.judag.ch/referenzen/efh-aqua/

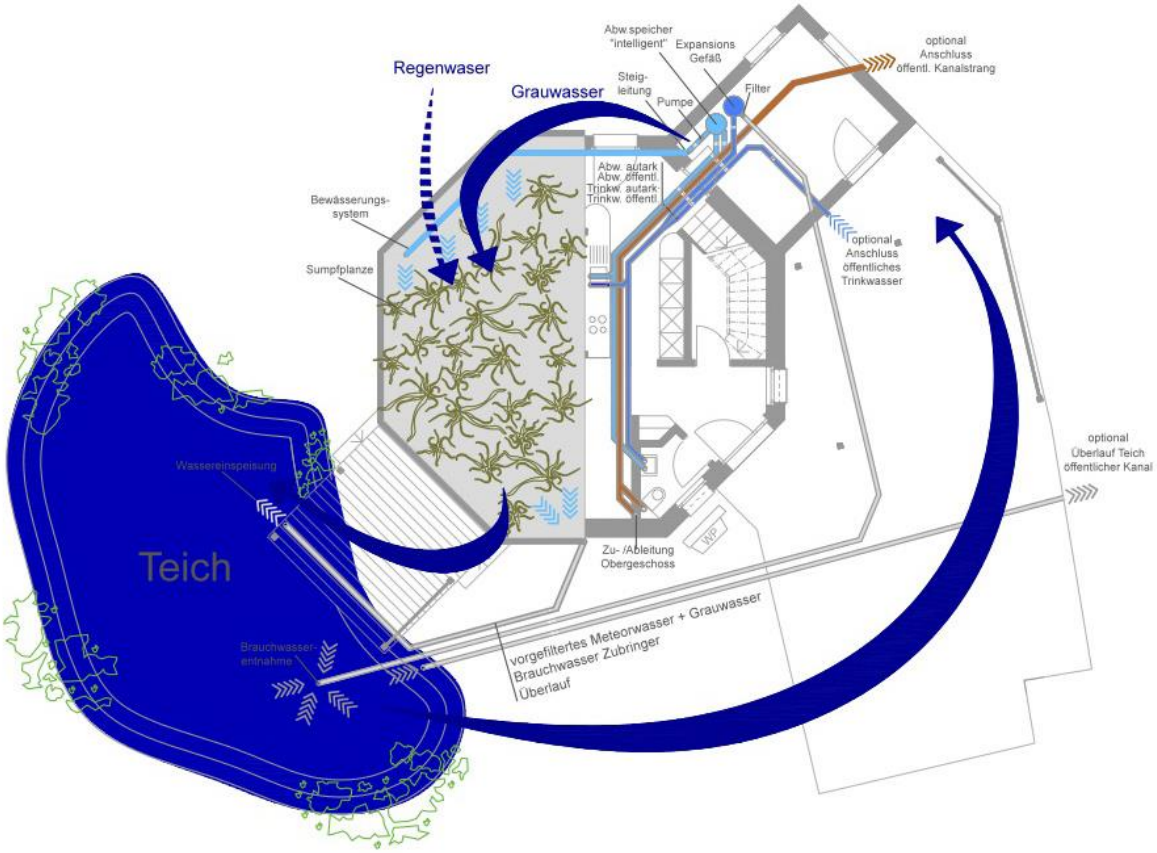


Figure 14: Technical scheme for water autarchy design

c. Water autarchy

The main wish of the architect was to have a self-sufficient house regarding water supply, completely autonomous and not connected to the national water network. Her desire was realised with the creation of a plant purification system on the roof, a 70m^2 pond to collect water and an additional filtering system. The whole system is represented in figure 14. Rainwater falls on swamp plants located on the roof, shown in figure 15, which purify water through their roots, before redirecting it to the pond next to the house. The latter does not only serve as a water collector: it is used as a pool during summer (figure 16) and serves as a reflecting surface in the winter to redirect low sunrays into the home to reduce the needs in heating. The final non-chemical technological filters get rid of remaining impurities and redistribute clean drinking water into the house. This whole system is designed to circularly treat grey water, which is the reason why toilets are not part of it and work separately with another method. The whole mechanism allowed reducing costs, sparing energy and resources, thus justifying its positive ecological impact and absolute feasibility[29].

[29] Sturm Johannes, *Das wasserautarke Haus,* Wohnwagon, 2018, last visited 27.12.2022, wohnwagon.at/mein-wasserautarkes-haus/

Figure 15: Roof with naturally purifying swamp plants
Figure 16: The water collection basin also serves as a swimming pool in summer

d. Reconnection to the forces of nature

The house was created to be linked with the powers of nature, to bring awareness and well-being in the daily aspects of the inhabitants. Francisca Jud said in the video of her project: "*With nature I feel good. I realised how I really felt when I spent time in nature: relaxed, happy and in harmony with myself*".[30] Her intense and spiritual relationship with the environment was the biggest motivation for this project and explains all further steps that were taken.

A precise ground investigation was undertaken with a dowsing rod, to know if the parcel had good energy levels and fit the well-being objectives of the future inhabitants. During the concept sketching, astrological and energetical properties of the house and parcel were analysed, which helped with the overall disposition of the rooms. The energetical sketch for the house is shown in figure 17. This assessment also influenced the final form of the house, which is an octagon, because it is the best form from an energetical point of view. Each facade is directed towards a precise cardinal point and gets specific advantages from each direction. To complete the design and methodology, a colour concept for each room and a careful disposition of furniture were developed[31].

[30] F. Jud Architektur AG (2017), *EFH AQUA – das wasserautarke Holz 100 Haus*, video «アクア ー 調和のとれた家 - Aqua - Haus im Einklang», 0m33sec, translated from Swiss German, https://www.judag.ch/referenzen/efh-aqua/

[31] Tschenett Fatima, *EFH AQUA, Zofingen, Entwurfs- und Planungsbegleitung, Farb- und Möblierungskonzept*, Atelier Sulai, 2018, last visited 27.12.2022, www.atelier-sulai.ch/2018/05/01/entwurfs-und-planungsbegleitung-efh-aqua/

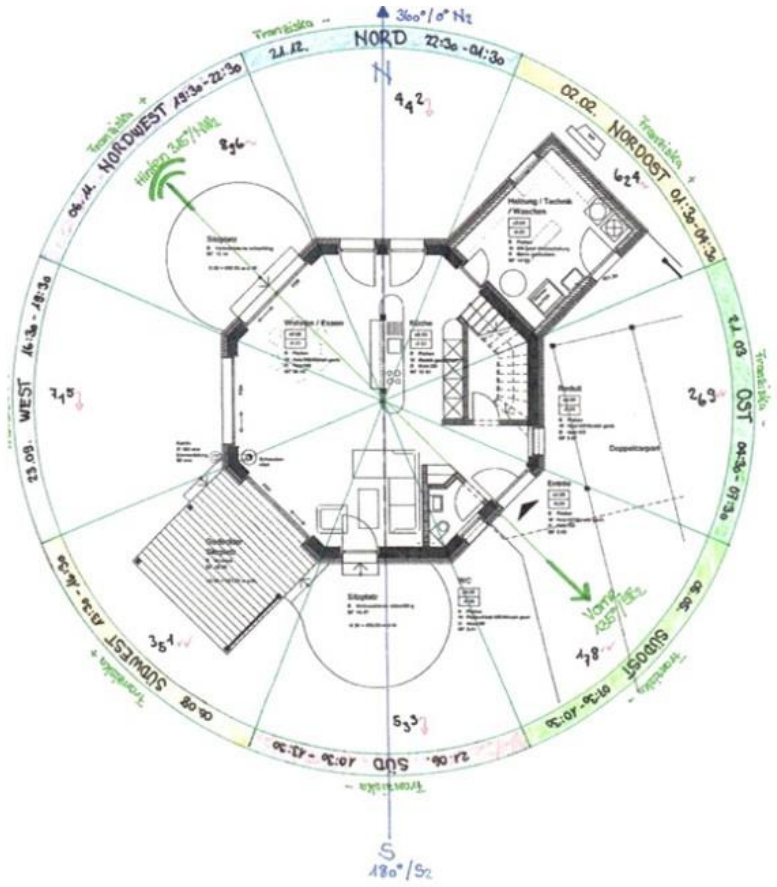


Figure 17: Astrological and energetical concept for room disposition in AQUA house.
The green arrows to the northwest and southeast represent the "Yin" zones, suitable for rest, sleep or bathrooms. The south and southeast are "Yang" zones and therefore perfect for being active. That is why the terrace, the living room and the pool are located there.

e. Regenerative Outcome

The project is definitely regenerative, starting with the overall concept or reconnecting people with their natural environment, its powers and cycles. The house supplies itself with drinking water all year round, thus respecting the natural cycles of water and directly influencing the behaviour of the occupants: they know the limits and must deal accordingly with what is available. They must develop some awareness of resources, as they depend on them to survive: with their water autonomy come different responsibilities. The circular thinking that is awaken in one discipline will likely influence other aspects of the inhabitants' life and push them to adapt certain behaviours towards more environmentally friendly ones[32]. A virtuous circle is then created, as this new acquired knowledge will possibly reduce the environmental impact of their actions, inspire other people and thus directly benefit the planet.

[32] Wolf Helmut, *Mein Haus verbindet mich mit der Natur*, Lebenskonzepte, 30.08.2017, last visited 27.12.2022, www.lebenskonzepte.org/artikellk/mein-haus-verbindet-mich-mit-der-natur

Next, the is a net benefit to both human and environmental sides: this family has new qualitative habitation to answer their housing need, and a reduced impact and the water cycle is achieved thanks to their autonomy. No new canalisations had to be built, a clear reduction of water consumption was achieved and micro-climate was created on site. The added vegetation purifies water but also air, provides oxygen and regulates the humidity level around the house. The soil bed on the roof provides insulation, and the plants around the pond retain water in the ground, thus preventing erosion and creating a fertile milieu for insects and other ground creatures. An ecosystem with the pond may encourage aquatic life to develop, as well as other microorganisms.

Also, a high quality of life was achieved with this project. People living here enjoy the same comfort as in an any standard construction, with the additional benefit of having more natural materials, potential health benefits from the energetical design and the satisfaction of having their own water. They feel a certain freedom from current conventions, because they had the courage to attempt a pilot autonomous project, and were glad to embrace a happy sobriety. The proposal was a success and improved the overall situation for all involved actors. It will serve as an example and motivation for future autarchic projects to take place and go towards more sustainable practices and lifestyles.

4.3 Gundeldingerfeld

a. Description

Gundeldingerfeld is a large-scale transformation project located in Basel (Switzerland), with the purpose to change the site of a former machine factory into a lively neighbourhood meeting place. The different interventions are planned since 2000 by Baubüro In Situ, an architectural office known for its reuse practices. It is a pilot project for the 2000 Watts Society program, with the goal to achieve zero net emissions for the whole site before 2050.

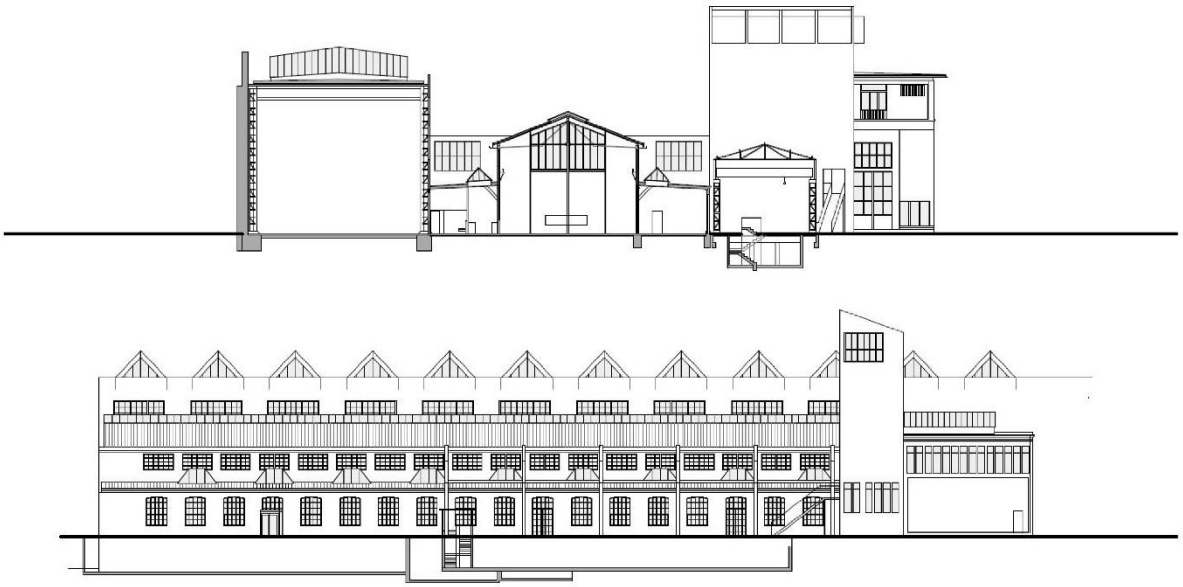


Figure 18: Sections and facades of the Gundeldingerfeld site

b. Reuse

The large-scale operation on 12'700m^2 suggested customised solutions into the 8 existing buildings for all new functions of the site. The motto of the office is "*We plan on site. With the people, with the existing, with the environment*."[33] Professionals working there are aware of the impact the building industry has on the environment and want to replace current practices with more circular ones. They are convinced that architects can have a positive impact on what is built and planned today, by bringing awareness and finding solutions within what is already there, be it materials, structures or furniture. Some of their reuse ideas are shown in figures 19 and 20. All their projects are based on opportunism, but also on a deep network of people with the construction industry.

The first task for the reuse of existing buildings was a deep analysis, redrawing and inventory of all the things on the site, to get an idea of what is worth keeping in place or moving to a more useful location. This work was also done in parallel with the search for construction materials to reuse from other demolition sites. This way of approaching their mandates has already proven successful, as explained in their publication *Bauteile wiederverwenden: ein Kompendium zum zirkulären Bauen* (Baubüro in situ AG, Zirkular GmbH, Park Books, 344p). They showed that reusing a building or constructing a new one with reclaimed components can save up to 70% of CO2 emissions, compared to an entirely new building constructed using current best practices.

[33] Baubüro In Situ AG, Homepage, 2022, https://www.insitu.ch/


Figure 19: Previous coal silo and terrace inside a previous structure
Figure 20: Transformed interior with remaining overhead crane and recovered ski seat

c. Reactivation

The mission was to revive the prior industry zone into a multifunctional site for culture, education, workspaces and leisure, but not at the expenses of tranquillity and quality of life. The guidelines were inclusion and diversity, as well as specific criteria for tenants' selection (relevance, integration and sustainability). The idea of this project was to offer low rents due to the unusual type of buildings but to reduce tenants' changes to a minimum, because the goal was to a have a lasting and functioning community.

Plurality was the key to the success of this project, something that made the site come alive every day and all year long. Created functions were related to: children (kindergarten, family centre), food (bistro, restaurant, trucks), leisure (climbing hall, theatre, circus, hostel, bar, gym, other health practices, library), work (offices, workshops, brewery) and sustainability (Pro Natura, WWF, solar power station)[34]. Biodiversity was also a focus, as different renaturation and reintegration projects were accomplished: bee hives, urban gardens, trees, green roofs etc. More than 70 tenants got involved in the project and the group keeps growing and expanding every year. Inhabitants from the district became regular visitors as the location gained in attractiveness. The unique aesthetics of the place reflects a certain aura and charm of its own, that the population seems to appreciate for its authenticity and singularity.


Figure 21: Entrance of the site with the restaurant's terrace
Figure 22: Beekeeper harvesting honey on a roof on site

[34] Baubüro In Situ AG, *Gundeldingerfeld Basel 2015*, www.insitu.ch/projekte/191-gundeldingerfeld

d. Ongoing commitment

The project was financed by the Kantensprung AG Foundation, which in fact was created by the architects that took care of the development of the site. This self-financing and support was beneficial for them, but also for the project. Not only were they able to hinder the possible destruction of the patrimony, but they were also able to lower rental prices and gain more freedom for their operations. They show a real commitment to reduce energy consumption on the site by investing 20'000 CHF every year (almost 50% of the foundations' income) for energy-saving measures, such as the installation of PV panels or proper insulation. They are gradually optimising their building stock over the years and intend to continue doing so[35].

Through their actions, they also involve their community and other related citizens, spreading information and ideas about the place and attracting more people. They also share and exchange a lot with the architectural world, inviting and presenting their work, discussing today's uses and involving the state and the city in their projects.

Figure 23: Visit of the result of solar panels implementation on the former coal silo
Figure 24: Local gathering in front of the small theatre and climbing hall

e. Regenerative Outcome

The result of the widespread interventions over the years is remarkably regenerative to me. The architects managed to significantly improve the situation and attractiveness of the site with a minimum of procedures but with a lot of commitment. Their way of imagining architecture reconnected people to the site and its existing qualities, and motivated them to stay, invest and improve the whole. The urban site was revived instead of rebuilt, which significantly reduced the environmental impact as compared to any other conventional project.

The impact is a positive for both humans and nature: people have a pleasant and unique place to spent time, live, exchange and learn, and the reintroduction of biodiversity has taken place and continues to expand. Almost all actors of society have been integrated into the site or at least openly invited, creating an inclusive and equitable space. Alternative practices and lifestyles are put forward and encouraged, as long as they strive for health, circularity and sustainability. The beauty of the place shows a possible happy sobriety, an exemplarity of practices and another subtle face of regenerative architecture, within a bigger context.

[35] Kantensprung Stiftung, *Hintergrund*, Basel, www.kantensprung-stiftung.ch/hintergrund/

4.4 The House of the Environment

a. Description

The laureate project of the competition for the General Administration for the Environment of the State of Vaud was won by Ferrari Architectes. The building was finished in 2021 and hosts all collaborators of this sector under one roof in Lausanne (Switzerland). The innovative project received the highest SméO label (energy and environment), as well as the Minergie P-ECO certification, an attestation of its performances and reduced environmental impact.

Figure 25: Building with covered front entrance and roof terrace at the back
Figure 26: Interior view of a loggia

b. Passive systems

The House of the Environment was thought as a passive building, wanting to answer today's needs and ecological challenges by creating an exemplary case in the region to be inspired by. It was given a compact shape with a natural ventilation system, provided by two green patios, making the system work physically thanks to the chimney effect. The atriums do not only serve as aeration and interior climate regulation, but also as a special meeting, circulation and contemplative space, with a dimmed and relaxing atmosphere. The construction, mainly made of wood and rammed earth, works in a passive combination of light and heavy materials: one carrying the building and enclosing it, the other working as thermal mass and regulating humidity level. Natural light is optimised, low consumption appliances were incorporated, and high-performance insulation reduces the heating and cooling needs of the building. Solar photovoltaic panels are installed on the roof and provide the building with clean electricity[36].

[36] Ferrari Architectes SA, *La Maison de l'Environnement*, 2021, last visited 03.01.2022, www.ferrari-architectes.ch/portfolio/maison-de-lenvironnement

Figure 27: Longitudinal section of the building

c. Materials

Local, bio-based and low carbon impact materials were used in the 4'600m^2 building, in order to reduce the project's embodied energy as much as possible, also with the distance reduction for their transportation. The use of wood for the structure was imposed by the competition, but the idea of rammed earth rediscovery came from the architects. 4500m^3 of wood from the region were set into the four-storey building, making it a significant carbon stock locked in the construction for climate mitigation. Concrete was only used for the foundations and basement spaces. Nearby excavation earth was compressed in blocs by a local company and implemented around the inner patios. This ancestral material is very low in CO2 emissions and allows to naturally regulate the inside climate of the building, thus ensuring thermal comfort and good humidity levels throughout the year, thus considerably reducing the need for external mechanical regulation[37].

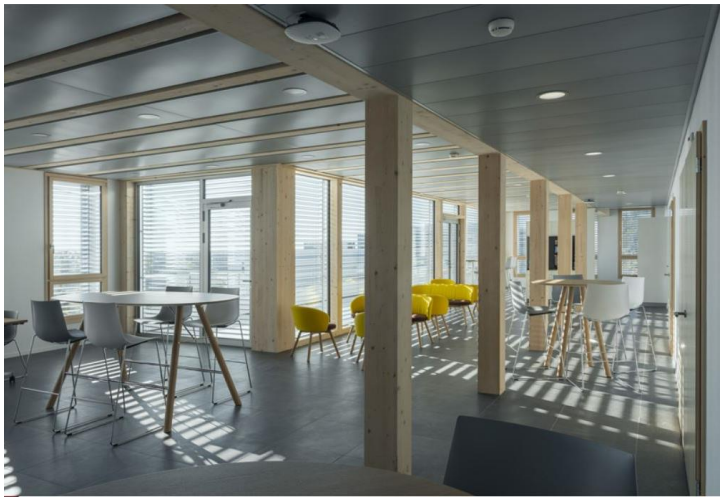


Figure 28: Interior view of a patio with a planted tree
Figure 29: Interior view of the cafeteria

d. Environmental commitment

Being the new headquarters of the Environmental Department of Lausanne, integration into the landscape, respect of nature and space for biodiversity were essential aspects to consider in the project. The roof was vegetalised and driftwood from Lake Geneva was put there to promote the reproduction of insects and birds. An orchard was planted next to the building and

[37] Chantiers Magazine, *Maison de l'environnement, Lausanne – De bois et de terre*, 15.03.2021, last visited 03.01.2022, www.chantiersmagazine.ch/?s=maison+environnement

a small valley with a biotope was shaped to allow recovery water to naturally flow back to the nearby river. The construction has been deliberately placed at the edge of the parcel to allow either future built extensions or natural public spaces to be made[38].

Furthermore, the function of the building itself invites to actively participate in environmental preservation and enhancement. People working at the department contribute directly to actions that benefit wildlife. They can now work in a beautiful building, where they are even more connected with the sphere that they are engaged for. Direct views on the orchard, valley, forest and Alps create a link with their work and motivate them further.

Figure 30: Rendered image of the building in its context

e. Outcome

This contribution is distinctly regenerative and inspirational. The intervention is not only a working space, and tool, for direct positive decisions regarding the environment to be taken: it is the emblem of the State's desire to act as a concerned actor of sustainability. The will to improve the built stock with exemplary cases and actively participate in the empowerment of alternative and more responsible construction methods can be felt in this project.

There is a positive impact on people and the environment: a pleasant place to work and spend time, added and improved spaces for on-plot and remote living systems. There is a visual reconnection with the environment inside and outside the building, and the work done on a daily basis is also a way to have a positive physical impact on local fauna and flora, which in turn also has a positive impact on the population.

The intervention had a strongly reduced carbon footprint compared to other similar buildings, mainly due to the materials and construction methods. This was possible because of the clear imposition of the state in the competition, but also because the architects played along and went beyond what was demanded. An environmental conscience has awakened the will to improve practices and to try out techniques that are still not widespread. The fact that, for example here, having a wooden elevator shaft has been accepted in a public building will probably help the regulations to evolve towards alternative practices, which are also valid and guarantee safety standards. Such positive examples encourage strongly practices to change for the better, as they are proof that better choices are possible and desirable.

[38] Direction Générale des immeubles et du patrimoine, *Maison de l'environnement, bâtiment administratif*, Septembre 2021, Canton de Vaud, PCL Presses Centrales SA

4.5 Perkins SEED Classroom

a. Description

The last scrutinised regenerative project is located in the United States and was the 4th certified living building by the Living Building Challenge. It was created by the SEED Collaborative (Stacey Smedley and Ric Cochrane) and built in 2014 for the Perkins School in Seattle. The acronym stands for Sustainable Education Every Day and represents the goal of this project: teach children about sustainability, how things work and how much resources we consume. The SEED organisation no longer exists (information from Barry Wright, head of school, personal communication via mail) but many other SEED classrooms were built in the US.

Figure 31: Welcome sign next to the science building

b. Building

The initial design wanted to address America's need for healthy classrooms with a prototype based on modular units that could be used temporarily or permanently. It had to be flexible, sustainable, reusable and easily implementable. The Seattle campus was convinced by the project and bought it to install its definitive science building there. It was placed on the campus' parking lot, a place that was easily accessible but also visible for the public.

The building integrated the most demanding principles regarding sustainability: being net positive regarding energy (production via PV panels), respecting net zero water (collecting rainwater from the roof, storing it into cisterns, filtering and using it before returning it to the garden), using only non-toxic materials (respect of a red list), providing maximum natural daylight (position of openings and skylights), having a high efficiency envelope and appliances (reduce heating and energy demand) and providing natural fresh air through natural ventilation only. All these methods ensured the best human comfort possible with simple and most low-tech systems possible. The carbon footprint of the building was minimised, carbon offsets were purchased to compensate for the impact, certified materials were used (wood structure, cork boards, gypsum boards, natural fibres carpets) and production waste was cut to 5%.

Inside the classroom, every material and functioning system was left exposed and commented with an explanation panel for students to understand how the building was constructed and how it works. The construction itself becomes a visual tool for learning and easy understanding, where children can see, touch and interact with every part of the building[39].

Figure 32: Interior view of the classroom
Figure 33: Sample of the building's wall made with corn-based Styrofoam insulation

c. Education and inspiration

The teaching method promotes a hands-on approach, by interacting directly with the buildings and its physical systems, including water, air and electricity, designed to be as pedagogical as possible, easy and fun to use. The scientific education purpose is perfect for the building, as children can learn about the water cycle, how it is filtered on site with charcoal and UV light, how sustainable design works, what holistic thinking is etc. The school intends to "*educate and motivate our students about greener, smarter possibilities that benefit and enhance our own lives and the broader world […] to deeply evaluate, assess and question*"[40].

The cursus wants to celebrate everyday aspect by exposing it to the eyes, reconnecting people to natural and constructive systems and to their tools, and inspire students to be stewards of their environment. The architects created learning opportunities wherever they could. By applying a wide range of patterns, forms, materials, colours and textures, they wanted to awaken children's curiosity and invite them to interact with their surroundings through exploration and discovery. Figures 34 and 35 show two educational systems related to the water system of the classroom. Students learn what happens inside and outside the building, they have to follow the path of water to understand how it is impacted at every step of its cycle.

[39] International Living Building Institute, *Perkins Seed Classroom*, 2015, last visited 28.12.2022, https://living-future.org/case-studies/perkins-seed-classroom/
[40] The Perkins School early K-5th grade, last visited 28.12.2022, www.theperkinsschool.org/sustainability

Figure 34: Handwashing zone with roof filtered water and plants irrigation system
Figure 35: Outside water cistern with pedagogical evacuation ramp

d. Biophilic environment and access to nature

The project aims to reconnect with the natural environment and better understand how it works and why humans depend on it. Through practical activities, children take care of plants and learn about them in different ways. A living wall inside the classroom, shown in figure 34, purifies air and produces edible greens, a food garden designed for the whole school is located on the campus and students must take care of it and a bamboo garden as well as a 20m^2 rain garden were installed to reuse grey and excess water.

A further connection is made between the school and natural protected habitats, as the educational program is linked with Shadowlands Nature Preserve, which organises tours and activities linked with nature preservation, restoration and education[41]. Also, the whole plan (curriculum and building) is a metaphor of a flower, as it teaches about all required elements for a plant to grow: air, water, soil and sun.

Figure 36: Bamboo Garden for the disposal of greywater
Figure 37: Children interacting with the green wall

e. Regenerative Outcome

This project is distinctly regenerative for the inspiration and qualitative education it brings. Every lesson that takes place in the classroom reconnects people a little more to the environment, thanks to the personal involvement that is emphasised with the practical exercises. Children get to understand how nature and systems work, how much energy and resources are necessary for their own needs and those of plants, and what must be done to

[41] SHADOW Lake Nature Preserve, 2021, last visited 28.12.2022, shadowhabitat.org/what-we-do/

keep the whole in a healthy state, so that both sides can benefit from it and thrive over time. Students realise that people, buildings and the environment work together and cannot be separated, as there are dependencies involved, particularly from humans on natural resources. What they learn on site is then brought home and shared with family and friends, which can have a positive influence on others and motivate positive changes to happen in their homes.

This reconnection then has a positive impact on the human and environmental aspects, as quality education can be provided in a healthy and inclusive environment, bringing happiness, understanding and care, and the impact on the environment is reduced via the building and the practices it induces (energy and water reduction, vegetation, cyclic use, compensation). The implementation of flora and urban agriculture is also a net benefit to nature, which finds more space in an urban area. Biodiversity is then naturally invited, as the soil quality is improved and more types of plants are present on site for pollination, nutriments or shelter.

The overall situation is improved for all sides, the location is more active and successful. The project was often spotlighted and gained popularity, prompting other schools to purchase the pavilion as well, spreading similar practices across the US and ultimately benefitting more people. The ideas behind this classroom sought to be exemplary and healthy, which eventually made the project a model to follow. A certain beauty is also created with this project, as people tend to appreciate more something that they are connected to and involved with, that they understand and recognise for precise and valid reasons.

5. Outcome: what do we learn from these case studies?

5.1 Regenerative aspects

a. Common criteria

The four projects presented above achieved regenerative architecture status by different means and for different reasons. However, when put side by side and compared, common criteria were met in each regenerative intervention.

First, regarding the building, every project had a conscious approach regarding the impact of the building linked to the materials used and energetical consumption induced. The first two examples focused on choosing low impact and bio-based materials (mainly wood and natural fibres for carbon sequestration) and renewable energy supply, with the Bird Island House not being heated at all, and the AQUA house being in water autarchy, without depending on the national network. Gundeldingerfeld chose the path of reuse and new materials use reduction, by using what was available on site or nearby, also installing photovoltaic panels and storage systems to ensure autonomous and clean energy supply on site. The Perkins School followed a red list, opting only for nontoxic materials and as durable as possible, leaving them exposed. It also created a closed loop water cycle, collection and treatment around the classroom, linked with UV light and solar electricity generation.

Second, all projects contributed positively to human well-being, satisfaction and activities, with the creation of qualitative spaces for education, leisure, housing or work. In every case, the program was respected, and a certain link to the environment was pursued; through the observation of wildlife, information display on panels or in exhibitions, reconnection via direct interaction, active commitment in renaturation and contributions and spaces reactivation.

Third, the needs of other natural systems and living beings were considered and integrated into each project. Spaces for fauna were specially created for the Bird Island House, inside, around and next to the building (island, pond, interstices), low tech water collecting and filtering systems were implemented in the AQUA House and at the Perkins School, reducing their dependency on external provision through autonomy but also discipline. An awareness of consumption has been brought about by these self-sufficient systems: people are dependent on natural resources and are directly in charge of their management, which also induces a reduction of waste and use in general. In Gundeldingerfeld, revitalised green zones were created and insects were reintroduced on site, which had a positive impact on floor permeability and plants growth in the district, and especially in urban gardens.

To summarise, based on the definition of regenerative architecture given in Chapter 3, all of the above projects met the following criteria: improved overall situation (active and successful), actions to improve biodiversity, reconnection to natural environment, inspiration for future projects, positive impact on humans and on the environment, and reduced environmental impact.

b. Specific points

Other elements included in the definition of regenerative architecture were applied in some cases only. The Bird Island House managed to integrate remarkably well to the existing web of cabins, but with an attention to seasonal changes (sea level, animals) and with a certain exemplarity of practices regarding the construction methods and their social and environmental impact. AQUA House and Perkins School both sought to improve interior health

and quality via the influence of energy or the choice of materials, respectively. Gundeldingerfeld had the particularity to participate in the recovery of lost features of the site, especially of plants, biodiversity and inclusion of other functions and people on the previously industrial parcel. The projects made environment grow and people thrive again. These facts show that not all points of the regenerative architecture definition must be fulfilled in order to achieve a regenerative result. But the more points implemented, the greater the scope of sustainability and the greater the regeneration potential achieved.

5.2 Function and scale

a. Activity as a vector of regeneration

All projects presented were favourable to sustainable practices implementation and nature reconnection, which is an important factor to achieve regenerative architecture. The function of a building or of a space will influence and give room to certain repetitive behaviours, which will induce the development of habits and norms. If these places are intended to improve the relationship of humans with their natural environment, they will encourage users to be more respectful and aware of resources, other living beings and natural systems.

An appealing visitor centre to observe, interact and understand local wildlife will raise awareness of the importance and needs of biodiversity. The qualitative architecture and the direct link it establishes with the topic studied on site will allow people to remember the place, as well as the information provided and the reasons why it was created. It will serve as a means to connect knowledge, people, nature and practices with each other, and at the same time be a place to make these positive things possible.

A pilot family home built for nature enthusiasts that works in autarchy will have a big resonance among the region and even the country, showing that different models of living are possible, comfortable and desirable. It is said that we spend most of our life in our homes, which means that it is the place that resembles us the most and that has the biggest impact on our habits. If environmental reconnection and awareness happen at home, it might have the most effective impact on the family living here and on all the people that know the house or the project, eventually leading to positive changes in behaviour and architectural practices.

A sustainable urban district, aiming for long-term improvements regarding practices, people, environment and energy, is an inspiration for other cases to act similarly. Involving people by creating a strong community and acting together towards a better vision of the world is what regeneration is also about, especially in complex environments like large cities.

A passive administrative building, made with sustainable materials and alternative practices, will show that the state is willing to invest in such constructions and will motivate people and professionals to shift towards more sustainable architecture.

A school is an essential and powerful place, because it is a crucial location that shapes the life and mind of every child. An important part of our education, social interactions and self-development takes place there, making it a sort of compass that will help us find future directions and take important decisions in our lives. It is a place of exchange, joy, learning and understanding, where people try to find a common ground and evolve together and where sustainable practices and concepts are the most important to be implement and shared.

Many other functions can be implemented with regenerative architecture, as long as their intention is to reach a mutually beneficial state for people and the environment they live in, a

relationship of positive co-evolution and healthy interdependency. A touch of philanthropy and biophilia are also essential ingredients for a regenerative result, as positive actions made locally have a global impact, as they influence future behaviours.

b. Size of project

Three of the four projects presented are small-scale projects and were completed within one year. Gundeldingerfeld is a long-term urban project, which has been ongoing for already 20 years and is still developing. The exposed projects showed that smaller new projects could fulfil their regenerative potential faster than large-scale ones under specific conditions.

More modest size interventions are generally cheaper than bigger ones and can be more easily financed by individuals who have a stronger motivation for a regenerative project to take place, as they directly benefit from it. Urban-scale interventions not only take more time to be implemented, because of their dimensions, but also because stricter regulations are applied in city centres and similar areas. Also, the total cost is generally more important and cannot be afforded by some regular incomes alone. It necessary that a larger group or community contribute, or that donations via institutions are invested. The other possibility is to spread the operations over time to make it economically affordable for smaller groups, like it is the case in Basel. Being the owner and the actor on site is also beneficial for the architects of Baubüro In Situ, as it lowers the expenses, reduces the number of intermediaries, partly because the project was not financed by a third party, which might have desired a certain return on investment above a positive outcome of the project.

5.3 Goal

All of the above projects shared a similar goal: create places that address today's needs while seeking for more, regarding human and environmental aspects. In all cases, an attempt to make things differently than current norms was pursued, with innovative construction methods, the materials used or the systems that were implemented. Every architect involved took the challenge seriously and bypassed certain conventions: building also for animals, disconnect from the national network, initiate a different approach to teaching, imagine another way of living and of investing in existing buildings. All these small actions show a certain courage to go beyond a comfort zone regarding well-established practices, but also an awareness and involvement in current environmental and construction habits. More in-depth architectural work was carried out, done by people for people and not for outsiders, with significant involvement from all parties. All protagonists were sincerely committed to each project, with an ideal in mind, and succeeded in achieving it.

5.4 Positive feedback loop system creation

The central aspect of every presented example, the core reason for a regenerative outcome to be possible, was the creation of a beneficial system on site, involving people, nature, building and ideas together. The sensitivity to environmental problems, raised by the understanding of the direct impact it has on humanity, encouraged a will to create places to notify, mitigate and help solve these issues. Created edifices and landscapes give room to both human and non-human, letting them act in a hopefully improved manner regarding the ecological impact they can have. It is hoped that architecture can be the vessel to improved relationships with the environment, through the beneficial practices that it hosts.

Linked with the impact chain timeline proposed at the end of chapter 3 in figure 5, each project sets precise goals regarding the needs of its assigned program, but also with an understanding

for all systems involved in its development, might they be related to the building techniques, social processes involved, or natural and other living systems impacted. The goals were set thanks to the global understanding that was acquired over time, experience and mistakes, and which was accordingly adapted. New principles were set, such as they contribute to restore what has been lost or damaged previously, also because there was a recognition towards systems that support us since the beginning, and on which humans depend. And again, principles derived from ambitious goals will influence practices, which will evolve and bring better results due to the whole adaptation of the chain of thoughts.

In these five regenerative cases studies, the architecture is the result of this thinking process, derived from the understanding of the world and of human impact as a society. This insight allowed to adapt design processes, which are directly derived from the understanding of the environment and of people, in order to adapt the built environment and practices to contemporary needs. In this sense, these cases of regenerative architecture are the end, but also the beginning of this evolutive improvement process. Such architecture symbolises the understanding of a place at a very precise moment, and the essence of the intention that was set to respond to a specific context. But it is also a moment of truth and revelation, to see if the ideas that were proposed do work, or not. The building becomes a moment of reflection and of improvement seeking, starting the whole process anew, with new lessons learned and new objectives developed. Figure38 on the next page shows the four criteria and steps which impact each other and make every type of architecture evolve over time. The environment gives the conditions and means for people to live at the precise moment in time, which impacts the design based on this previous knowledge. This is synthesised in a building in a specific location, which incorporates all this process and inspire future projects.

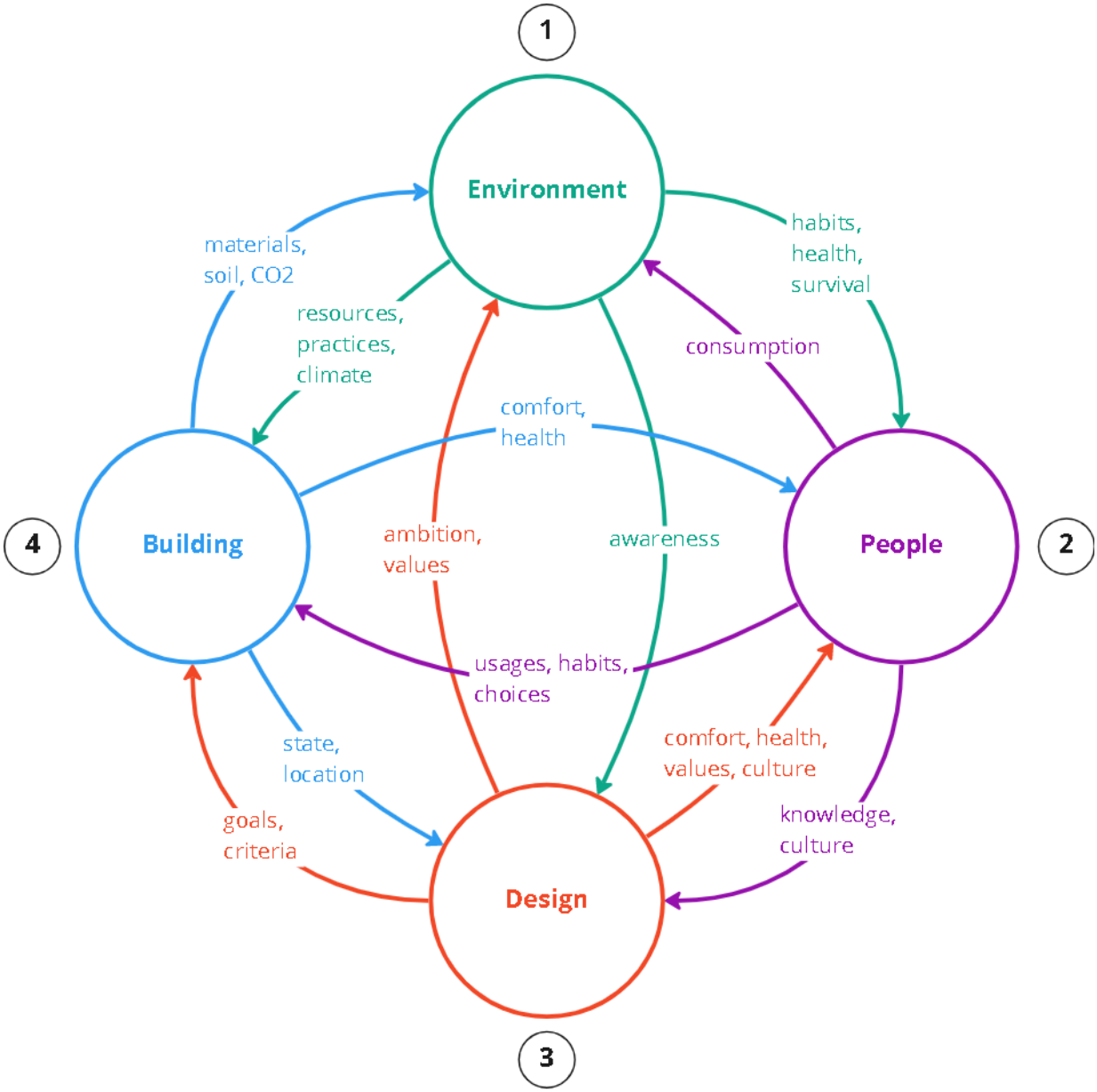


Figure 38: Evolutive interactional diagram for architectural development

6. Sustainable Architecture Case Studies

The best way to understand the differences between regenerative and sustainable architecture is to present examples of both categories and compare their respective aspects. The idea is to see the differences and subtilities of these buildings and understand why they could not be called regenerative, and for which reasons. The following three examples were chosen based on the best sustainability labels they received: SNBS, LEED and BREEAM. All case studies are in Switzerland and are seen as examples to follow to attain the highest sustainability goals set in the country but also worldwide.

6.1 Administrative Building FOITT

a. Description

The project to realise a new administrative building for the Swiss Federal Office of Information Technology, Systems and Telecommunications (FOITT) was carried out by the architectural office Bauart Architekten und Planer AG. The construction lasted from 2018 to 2021 and received the label SNBS Platinum in 2022, a certification for respecting Swiss construction sustainability norms. It is part of an architectural complex of three adjacent buildings, with the goal of relocating the federal IT section and other departments as well, all in one single place, in Zollikofen.

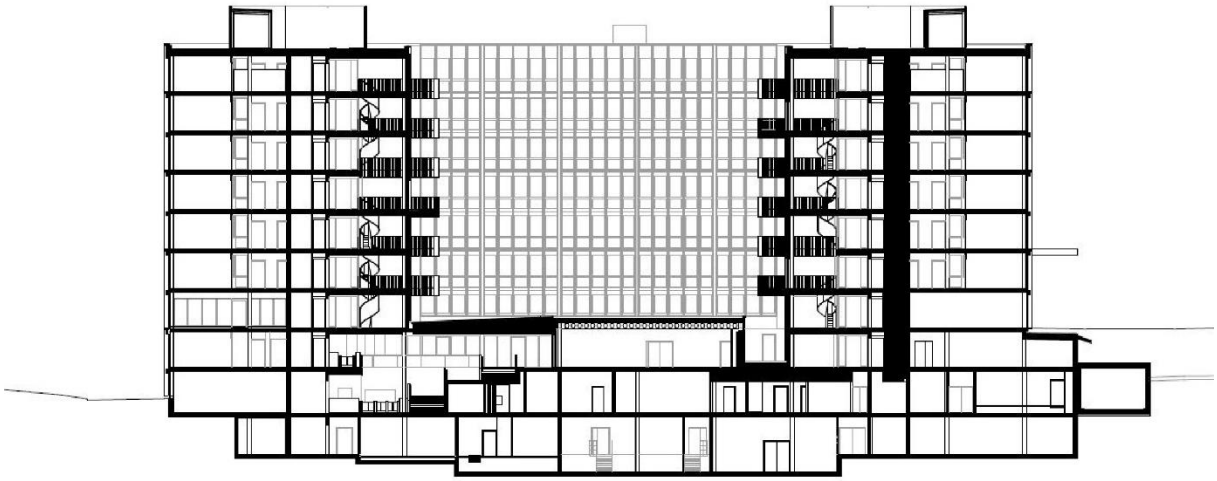


Figure 39: Longitudinal section of the building

b. Architectural concepts

From the very beginning, the building had to respond to sustainability objectives, set by the Swiss Confederation. The main idea was to offer a flexible building to respond to actual needs, with the possibility for future distribution and spatial changes to take place, with minimum impact on the structure and image of the building. To summarise, the construction had to be easily adaptable and designed for the long-term. Its physical durability was crucial, because of the state-related function it has and the related public founding, which requires to make useful and robust buildings that will stay for a long time and not waste public money.

The FOITTBIT also had to respond to the urban context and dialogue with the existing built stock that forms a whole. It defines the access on site by linking the building to the topography,

offering entrances on two levels. The architectural diversity of the building offers many possibilities for further development, changes and users in the future[42].

c. Strategies

To develop the 33'000m^2 building following sustainability principles given by the SNBS, the architects decided to give it a compact shape, implement active thermal storage mass materials, solar protections and high insulation components to reduce the overall energy consumption. Solar photovoltaic panels were installed on the roof to provide clean energy supply and 49 geothermal probes assure the cooling of the building in summer. The design reduced the amount of excavation required for the project and materials were used sparingly to reduce the embodied energy of the construction. The conception was thought to be cost-effective for operation and maintenance. These measures allowed the access to the SNBS label, as well as to Minergie P-ECO and Gutes Innenraumklima certifications, attesting that the building respected high sustainability standards, was made with non-toxic materials and offered good interior conditions[43]. Figure 40 shows the criteria of the SNBS certification which define what a sustainable building is for them.

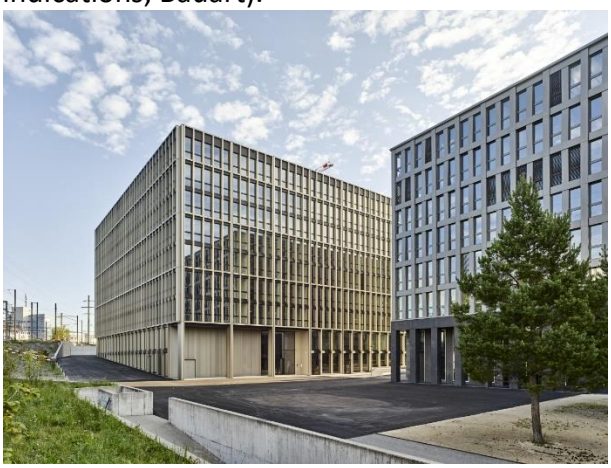
[42] Bauart Architekten und Planer AG, *Verwaltungsgebäude Etappe 2 Zollikofen*, 2021, bauart.ch/projekte/verwaltungsgebaeude-bit-zollikofen

[43] NNBS, *Gute Beispiele: Verwaltungsgebäude Eichenweg 3*, SNBS, last visited 02.01.2023, www.nnbs.ch/-/verwaltungsgebaude-eichenweg-3

Figure 40: SNBS Sustainability construction criteria. The three sectors of sustainable construction, society (red), economy (blue) and environment (green), each have four themes with criteria (25 in total). Those are assigned indicators that can be scored (45 in total).

d. Materials

Materials were chosen according to their resistance, durability, aesthetics and compliance with norms, but also for their economic advantages, as there was an overall surge in construction prices during the time of realisation, during the Covid-19 pandemic. The main substance used for structural elements and thermal mass was concrete. Many types were selected depending on the place of implementation (cast, prefabricated, mono) with different finishings (raw, polished). Some lime sandstone, porcelain stoneware and tiles were used in more visible or utility spaces (bathrooms). Lightweight wall systems out of gypsum boards were implemented in flexible space areas and sometimes carpets were laid in certain rooms for noise reduction. Outside, mainly asphalt had been poured on the ground, mixes of gravel were also implemented and some vegetation socles with substrates were created on the ground floor level and on the roof (Benjamin Schütz, provided plans and sections with materialisation indications, Bauart).



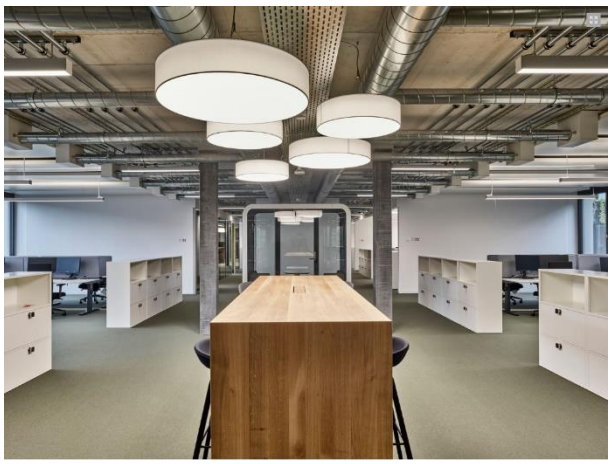


Figure 41: Entrance of the building (OFFIT)
Figure 42: Interior view of working spaces

e. Outcome

The result is seen as sustainable, but not regenerative. The concepts for the design were justified and allowed a good integration of the building in its context and most sustainability principles helped to reduce the impact of the building, compared to other conventional construction methods. However, some weaker points and neglected aspects are responsible for the distance from a regenerative outcome.

First, the materiality of the building is quite questionable from an environmental sustainability point of view. The main material is reinforced concrete, which is a very controversial material because of its carbon intensity for its production and transport. Cement alone is responsible for 10% of CO2 emissions in Switzerland, due to its fabrication process requiring heating to approximately 2000°C, with rarely renewable energy sources. The extraction and transportation of its raw materials and finished product are also responsible for greenhouse gas emissions (trucks with diesel), which questions even the point of the SNBS label claiming that the construction is resource and environmentally friendly. I see missed opportunities regarding bio-based materials, which are not present apart from furniture, which could have lowered the carbon impact of the building way more effectively. For example, excavation earth could have been implemented for thermal mass and humidity regulation.

Second, some passive solutions may have been more thoroughly investigated, in relation to geothermal probes, which require carbon intensive machines to insert pipes in the ground, or the ventilation mechanisms, which are quite numerous and visible in most working spaces, and a part of it could have been replaced with natural and automatised ventilation systems. The House of the Environment, built in the same period, has a very similar shape and function, but working completely differently, which shows that alternatives are possible.

Third, vegetation and biodiversity have very little space allocated on site. Few shy receptacles for trees, bushes and flowers were installed but do not grant enough space for a generous root system to develop, leading to a reduced growth possibility for trees, impacting the total carbon storage, shade possibility and oxygen provision. Although it is an urban space, no intentions for wildlife integration are visible.

In short, the project responds well to the defined program, allows changes over time to occur without big works needed, has a physical durability guaranteed over time, offers qualitative and healthy spaces for the users, easy access on site and good integration in the urban context. But regarding regenerative criteria, there is no tangible reconnection to nature, biodiversity is weakly implemented on site and cannot fully thrive, there is therefore a bigger positive impact for humans but not for other living systems. Last, the project cannot be called exemplary, as many alternative practices or materials have been skipped, which could have granted a better sustainability outcome. In a way, it is a missed opportunity to have a model for sustainability, which could have shown the involvement of the architects and of the state, regarding climate change and its related actions.

6.2 The Olympic House

a. Description

The iconic project of 3XN Architects was realised in 2019 for the International Olympic Committee (IOC), to be the new Headquarters where all 500 collaborators could be regrouped in one single building in Lausanne (Switzerland). The project received the highest LEED v4 grade ever given, making it "*one of the most sustainable buildings in the world*" according to the label and IOC. Five key objectives were set for the project: movement, transparency, flexibility, sustainability and collaboration. All similar values to the core Olympic Movement ones, inspiring the design to create a highly efficient and sustainable workspace[44].

Figure 43: New Olympic building (right) next to the Chateau de Vidy (left)

b. Site Integration and image

The new 22'000m^2 office building replaced the previous one on the same location, which was three times smaller in terms of total surface. 95% of the previous building components have been either reused or recycled. Nested in a unique historical site, the architects tried to respect the protected context of the parc with the 18th century Château de Vidy, while at the same time creating a highly symbolic edifice. Half of the parcel area is dedicated to green surfaces (compensation on roofs and terraces) and fifty new local essences of trees were planted on site. An emphasis on access and fluidity was brought, as a direct connection with the castle was made, entries on all four sides of the building were created and direct paths with views lead to the parc and lake.

The facade tries to mimic the graceful movement of an athlete through transparency, flow and visibility, just as a human body in movement would be perceived. This organic architecture wants to shape behaviour and make people take specific paths, encouraging interactions, communication and knowledge exchange between all collaborators. It also seeks to provoke strong feelings and emotions with the form of the building[45].

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[44] International Olympic Committee, *Olympic House becomes one of the most sustainable buildings in the world*, June 2019, Press Release, last visited 03.01.2023, olympics.com/ioc/news/olympic-house-becomes-one-of-the-most-sustainable-buildings-in-the-world

[45] 3XN, *Olympic House – IOC Headquarters*, 2019, last visited 03.01.2023, 3xn.com/project/ioc-headquarters

c. Building systems

Sustainable principles and innovative features were put forward to minimise the building's environmental footprint and overall consumption. A green roof and terraces help the building to integration into the site and preserve a part of biodiversity on site, a rainwater collection system reduces the water consumption by supplying all low flow taps and toilets, thermal active slabs regulate the inner temperature with a lake water heating and cooling pipe system, the double façade allows proper daylight, temperature and noise control, and 1000m^2 of photovoltaic panels provide renewable energy to the building. All these measures reduced the energy consumption of the building by 40%, compared to similar new buildings[46].

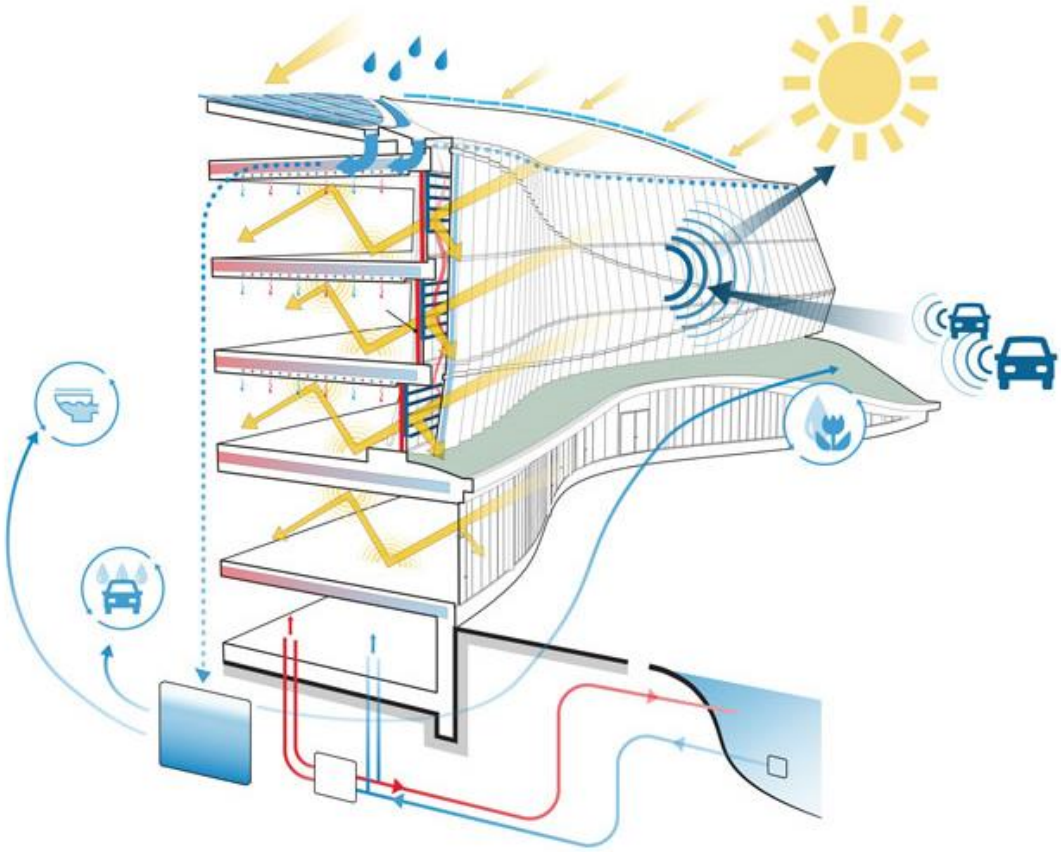

Figure 44: Olympic House building systems diagram

d. Materials

To allow the existence of such a large free space, a reinforced concrete structure was created, which also allowed the good storage of the thermal mass. The facade is fully glazed on all sides and covered by metallic profiles. It is doubled to improve thermal and noise insulation. Materials in the building were chosen, such as they limit the pollutants inside the space, to improve the indoor air quality and people's comfort. As mentioned, a consideration for circularity was present, as the previous building was reused and recycled to 95%. The central monumental oak staircase links all floors of the buildings and symbolised the five rings of the Olympic logo.

[46] 3XN, Itten Brechbühl, *Olympic House – Focus on sustainability*, 3XN Olympic House Sustainability chapter, Archilovers, www.archilovers.com/projects/164997/olympic-house.html#resources


Figure 45: Oak tree monumental staircase
Figure 46: View of the green terrace with the double facade

e. Outcome

This emblematic architecture answered the mission of the International Olympic Committee to create a space for cooperation, transparency and sustainability, even receiving the best grade from a prestigious label. Even if this construction is named as "*one of the most sustainable buildings in the world*", its regenerative potential is still quite far from achieved.

First, its implantation into an already artificial site (manmade parc) does not bring much more qualitative green spaces, as the total area has been at most preserved. Certainly, many trees have been planted and other plants have been added, which is already better than having simple cut grass, but the amount of excavation required to extend the basement has strongly depleted the soil from its nutriments and living systems. The newly created green terrasses contain a relatively thin layer of substrate for the vegetation to survive, requiring extended gardening and fertilisation to be maintained, before the ground revives on day. In this sense, not much place for autonomous and rich biodiversity has been given.

Second, a strong focus on energy and water efficiency was put in this project, which highly improved its operational performances. Most systems rely on innovative technology, but there is no mention of many passive systems, such as natural ventilation for example. The size of the building might have made it too complicated or expensive to implement, or the will to do so was simply not there. The systems put in place mainly focused on prestige, visual qualities and respect of concepts, to show the best international image possible and demonstrate the organisation's power and wealth.

The will to reduce the building's consumption and impact is strongly supported in the speech given, but the question is: on which level and at what cost? Regarding materials for example, mainly high carbon ones have been used: concrete, steel, metals and glass. These were justified for the building's durability in time and architectural expression, allowing to reduce the operational energy, but making the less visible and publicly understandable part increase: the embodied energy. Moreover, it was declared that almost all buildings elements were unique, because they were designed through computational architecture. The will was to make the design seem as simple and pure as possible, but this made the whole construction mode

complex, even inducing more than 30'000 different drawings for execution![47] The sold image of beautiful sustainability is in fact not so accurate if we look at the whole process and total environmental impact, which in fact tends more towards greenwashing than truth. This project might have received the best sustainability label, but there are many other buildings, without labels, that are way more respectful of resources, energy and of emissions.

Regarding regenerative criteria, the Olympic House doesn't invite to a real reconnection with the environment, as the means put on site do not benefit so much the local fauna and flora. There is a net human benefit regarding activities, work and quality of spaces, but a more debatable benefit to the environment. Also, the behaviour on site does not directly encourage to take positive actions for the environment. The created architecture is more a treat to the eyes, a nice experience to live and a jewel placed on the lake side to be exposed.

[47] The Plan, *Olympic House, Movement's values into built form*, 2020, www.theplan.it/award-2020-officebusiness/olympic-house-movements-values-into-built-form-3xn

6.3 Skylab PCR

a. Description

Skylab is a multipurpose complex hosting different relocated industries and functions, such as biotechnology, IT, the watch industry, restaurants, shops, but also public services (kindergarten and fire station). It was designed by Bassicarella Architectes SA for different public and private investors, and inaugurated in Plan-les-Ouates in 2015. The finished project received the final BREEAM certification with the highest grade (excellent) given in Switzerland at that time, as well as the Minergie-P label. The intervention ambitioned to answer the need for workplaces following the strong demographic expansion from the previous decades in Geneva[48].

Figure 47: Exterior view of the building

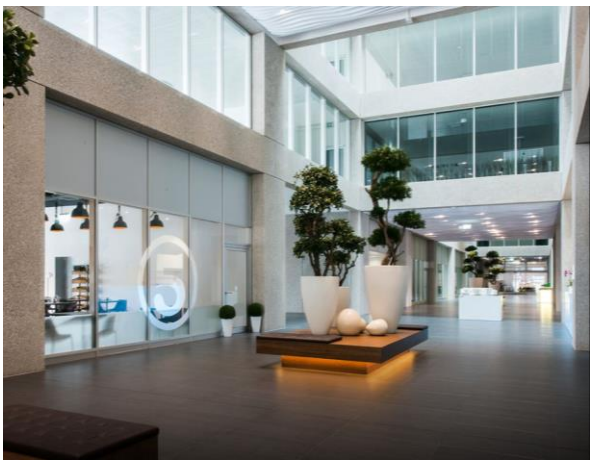

Figure 48: Interior view of the main entrance

b. Site

A previous project has been started in the same location but was quickly abandoned after the excavations started. The brownfield has been left in this state for more than twenty years and was named "the pool", as the dug hole filled with water after every rainfall, due to bad soil permeability. Further soil investigations made by the new project team revealed that the composition contained mainly clay, which made the ground difficult for projects of such size. A groundwater source prevented the use of piles, because of water contamination prevention, which caused the additional excavation of 35'000m^3 of earth over five meters and the realisation of a massive watertight concrete base[49].

During the realisation phase, adaptations were brought to the project, such as the creation of a water retention tank due to the clay soil and an adaptation of the vegetation on site. A population of toads had to be moved from the site, as it had probably settled there while the area was left untouched for a long time and the humidity level was adequate for their habitat[50].

c. Building systems

The two accorded labels attest that the building was designed to respond to their energetical and environmental requirements. Regarding the BREEAM certification, ten points had to be considered in the project: global management, health and well-being, energy, transport, water,

[48] Guillemin P., *Skylab*, Architecture et Construction, August 2016, Induni & Cie SA, pfd on : induni.ch/portfolio-items/skylab/

[49] Guillemin P., *Skylab*, Architecture et Construction, August 2016, Induni & Cie SA, pfd found on : induni.ch/portfolio-items/skylab/

[50] Stein Véronique, *Certificat BREEAM pour Skylab à Plan-les-Ouates*, Tout l'immobilier, n°962, Construction, 30th Septembre 2019, p.20

materials, waste, soil and ecology, pollution and innovation. To respond to these points, architects made the edifice flexible enough to respond to actual needs, but also future ones, considering eventual users and program changes during the next 50 years.

Prefabricated modules set the rhythm of the facade, water consumption is reduced through rainwater collection and redistribution into the sanitary network, and energy needs are also lowered thanks to high insulation, high-efficiency appliances, remote heating system and double flow ventilation with energy recovery. Natural daylight is provided where possible, also through the skylights placed at the centre of the roof. A waste management plan has been set and material recycling was planned for the end of use of the building.

Figure 49: Building with access to the parking
Figure 50: Finished interior with dividable surface

d. Materials

The 25'000m^2 centre is mainly made out of reinforced concrete: the large foundation slab, the three underground parking levels, the structure and the "*herculean reinforced concrete beams with an 80 x 130 cm cross-section*" (Guillemin P., *Skylab*, 2016, Induni & Cie SA) express the impressive amount poured on site. There was even a personal concrete batching station, allowing to cast 300m^3 per session. Metallic window frames were used for the industrial and elegant aspect they give, and recycled concrete-glass cladding was chosen for the envelope. Prefabricated and glued sandwich walls required the use of one of the biggest cranes ever used in the Swiss Romandie to put them into place.[51]

e. Outcome

A very similar critique as for the two previous examples can be made: the project respects the label's requirements and is seen as a very sustainable building; however, it does not fit a regenerative description. A few weaker points regarding the environment make the project stay away from a regenerative potential. But it is important to say that the human side benefits from the construction, as many new functions and needed workplaces were created, making the place more alive and successful, as well as compatible with the existing built stock.

[51] Batimag, *Au fond de « La Piscine », nouveau pôle d'affaires high-tech*, 26.05.2014, Docu Media Suisse Sàrl, last visited 04.01.2023 www.batimag.ch/architecture/au-fond-de-la-piscine-nouveau-pole-daffaires-high-tech-2092

First, the very modest amount of vegetation and the non-integration of broader biodiversity on site can be criticised. As it is visible in figure 49, a rather thin green band runs along the walkway with some planted trees and bushes, leaving more space for grass. A more dense and diverse choice of plants could have been figured out, which could have created more opportunities for smaller mammals to hide and nest, and for supportive root systems to develop. This lack of nature presence does not invite the users of the building to an environmental reconnection and does not help to fight the heat island effect that is present in dense, mineral urban areas.

Second, almost no passive systems have been implemented in the building, making it rely purely on technical means and electricity. There is no local production of electricity on the roof or facades, but this can always be implemented at a later stage. The spaces around the skylights could have been slightly changed to create a chimney effect and help to naturally ventilate the building. Such simple design adaptations could have further reduced the carbon footprint and energy consumption of the building and made it environmentally more friendly.

Then, the very important question of material consumption arises. Like the two previous examples, the most used materials are highly carbon-intensive ones (concrete and metals). The design might have thought about future changes and the recycling of materials, but the impact minimisation is quite questionable. In the case of concrete, over dimensioning of beams was caused by an irregular static distribution near the skylights, which could have been quite easily avoided, especially since a modular and repetitive system has been created. The three underground parking levels could have also been reduced, knowing that a big public transport offer has been developed for the sector, therefore potentially reducing the amount of concrete and the need for excavation.

Unfortunately, many aspects contribute to the non-exemplarity of the building, regarding ecological criteria, even if the label attests that such considerations were considered in the design. Technological innovations were put forward in this project, and a good attempt was made for the end-of-use phase, but the means put into the realisation weighed a lot on the embodied energy side.

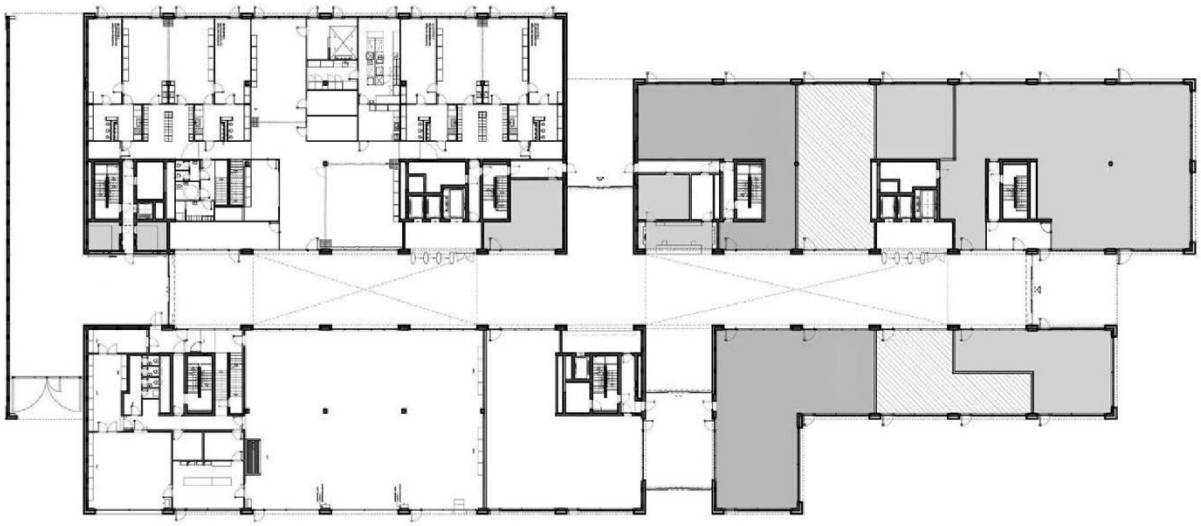

Figure 51: Ground floor plan of the building

7. Outcome: why are these examples not regenerative?

7.1 Environmental aspect

The main lacking element in these examples is a deeper consideration for the environmental aspect and a reasonable amount of space dedicated to it. One of the key aspects for a project to be regenerative is to consider other living systems as important and legitimate shareholders of the space. Biodiversity has the same rights as humans to exist and to have enough space allocated. More importantly, having natural elements in our built environment is also beneficial to us, as it helps to overcome issues related to artificialised contexts, such as the heat island effect (shading, evapotranspiration), air quality (oxygen production, particle filtering) and water management (soil permeability, filtering, flood regulation).

Another goal of regenerative architecture is to reconnect humans with their natural environment, from which they directly depend, and even more in urban areas, where organic systems are much less present and sometimes totally absent. A growing part of the urban population is disconnected from nature in their daily life, which slowly leads to forgetfulness of how things physically work: how natural systems operate, how humans depend on them, how the food is produced, how much effort and energy it requires to arrive in cities, the role of biodiversity in our food chain, etc. A distanciation from our life-bearing systems, added to the power of abstract thinking that people possess, has for several decades made certain groups of people treat the environment as a separate entity,[52] from which we could extract resources without consequences and exploit at will. This way of thinking has thankfully changed since the repercussions of human actions have been made visible and tangible with climate change and resources depletion. Although this has been cleared conceptually, practices do not change as easily and as quickly as ideas in our minds. Without this environmental aspect, the three projects do not meet the core commitment necessary to reach a regenerative grade of sustainability.

[52] Reed B., 2007, *Shifting from 'sustainability' to regeneration*, Building Research & Information, 35:6, 674-680, DOI: 10.1080/09613210701475753

7.2 Materialisation

The second and most decisive aspect that supports the idea that these projects are not regenerative is their materialisation, the moment when the ideas take shape. The choices that have been made regarding materiality in the before-mentioned examples are already better than many standard constructions over the world regarding their carbon footprint, but they are still far from being exemplary.

The previously mentioned fact, that practices do not change as quickly as our ideas, is quite tangible in the architectural field, where high inertia in practices and construction methods remains, partly because of the complexity and quantity of interests involved. In the three cases that were cited before, the choice of materials for the execution is debatable concerning the negative environmental impact it had, especially since alternative and less carbon-intensive solutions exist, such as bio-based or reused materials. It is not the idea to totally stop using materials that have a high carbon footprint, it is more the will to reconsider a more appropriate, justified and reasonable use of those, considering the knowledge that is accessible about their environmental impact, but also about their availability and possible future depletion.

Population growth pushes towards more construction, which increases resources consumption but also innovation for more sparing methods, which are developed in parallel but only implemented later, creating a dephasing between knowledge and present actions. At the same time, already accepted projects get built following standard methods, which since the adjudication have evolved and could be seen as outdated by the time a project is finished. And when the newly completed edifice is open to use, the impression that nothing goes forward, or way too slowly, is given to the group of professionals that are involved in the improvement and decarbonation of architectural practices. Such projects exhibit an image of an ideal of sustainability to the public, which is rarely instructed about the topic, and which then may think that this is the model to follow and ask architects to realise similar buildings, impacting the transition of practice even more, in a negative way.

In addition, economical and lobbying reasons “justify” why some practices, like full concrete constructions, are kept in place because the prices are lower, businesses want to keep going and find attractive ways to sell their products, and simply because a solid infrastructure backs them up, assuring price stability and quick execution. This comfort and existing system simplify the job of professionals, which could get used to it and wouldn’t necessarily feel the need nor the will to change something that has worked for so long, and that still so many contractors do in their projects, so why would they have to make things differently?

This step is very important, as it will set the definitive outcome of the project: the concepts can be based on the best intentions, but if the way that the building is realised did not consider the full impact of the intervention, and especially the embodied energy of the materials and related methods of construction with enormous machines, then it is impossible for a project to be regenerative, and maybe even not sustainable. Reducing the carbon footprint of the building is also important for the embodied part, not only the operational one. It is crucial to integrate this preoccupation at the very beginning of the design, to have a globally improved and positive impact regarding all aspects of the building.

A project of the groups *Builders for Climate Action* analysed four methods of constructing a four-storey building in Canada, from the most conventional way with standard materials (business as usual), to the most sustainable manner they could imagine with mostly bio-based materials. Their results showed that the best building could work as a carbon sink, due to the nature of materials that were chosen. Vegetal materials absorbed carbon during their growth through photosynthesis and stored it in their structure, locking it as long as they are not burned or disintegrated, meaning that carbon was temporarily removed from the atmosphere. Conventional materials such as concrete or metals do not provide such environmental mitigation benefit, as their production requires more energy and produces more carbon emissions than they could store themselves, making them not environmentally friendly and even harmful if used in large quantities like it is the case today.[53]

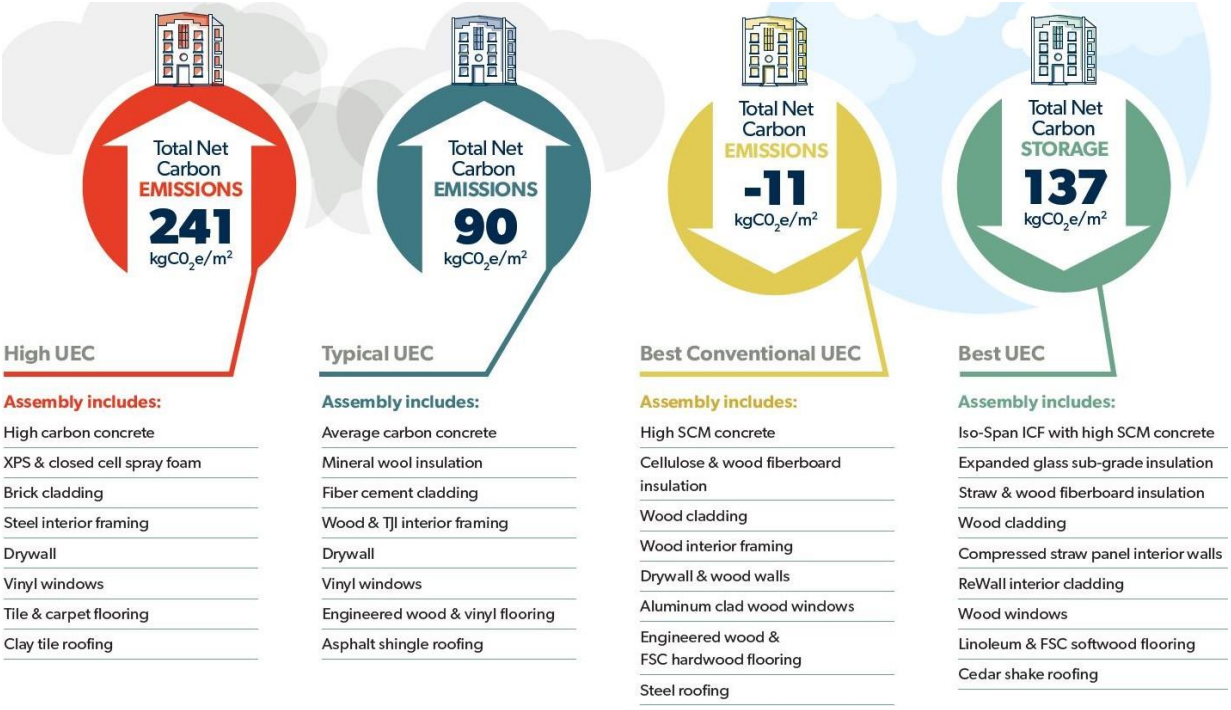

Figure 52: Four examples of materialisation for a same building, with their related up-front embodied carbon emissions (UEC), depending on the choice of materials

[53] Builders for Climate Action, *Low-rise Buildings as a Climate Change Solution*, 2019

7.3 Goal setting

Two main objectives were set for the three case studies: answer the needs of the program and respond to the criteria to obtain the wanted label. To do so, building systems were thought in depth to optimise every possible part from a technical point of view. They all respected common sustainable design principles: giving a compact shape to the building, using high-performance insulation, providing natural lighting, and allowing thermal mass storage. Skylab and the Olympic House have an integrated rainwater collection and redistribution system, the latter having an additional innovative lake water heating/cooling system as well. BIT and the Olympic House have a renewable energy source production on site via PV panels.

All these measures and some complementary ones allowed them to fit in the sustainable architecture category and to receive certifications regarding their energetical performances. However, the criteria that were followed for the design of each project were mainly focused on the operational side and the impact reduction, and not a holistic approach regarding also other natural and living systems. This is the reason why, for example, landscape integration and renaturation were not really pushed themes, and were implemented towards the end of the conception, giving them the minimum remaining space.

A possible explanation as to why these projects are not regenerative could also be given by the label factor. Current assessment criteria mainly put their attention on energy and performance, because it is something that can be calculated and which represents the biggest impact of the building over its lifetime. So, if the goal is to make a sustainable building obtain a label, efforts will be first put on the already given aspects that must be considered in the requirements, and less on those that could create a positive impact system on site. If the real goal is prestige through certification, then the means allocated to its achievement will be much bigger than those given for other “secondary” objectives, like increasing biodiversity or choosing materials carefully based on their impact. As long as there is no clear intention from the label, the authorities, the function, the client or even the architect, there is almost no chance for a project to be regenerative, as the idea to create a virtuous system will not be put forward and not sufficiently supported, may it be financially or ideologically.

To resume, the presented projects, which received the best sustainability labels in Switzerland, are not regenerative, mainly for design reasons. The way the projects were technically thought is defendable and allowed to strongly reduce the energy consumption of those buildings over their lifetime, but other living systems were poorly considered. Further opportunities for carbon footprint reduction were not systematically taken (passive systems and alternative materials) and the integration of biodiversity was put in the second plan, limiting the beneficial interactions and reconnection of humans and nature on site.

8. Critique of sustainable architecture through regenerative glasses

8.1 Sustainability

a. Range

Sustainable architecture, as explained in chapter 3, is a broad definition that encompasses different types of architecture, which aim to have a limited impact on the environment. This broad definition leads to diverse interpretations and sometimes confusion among the public, but also among professionals. The reason for this is that sustainability has a large range of possible performances, which go from low to high, depending on: the resource or practice concerned, the time frame imposed, and the rate of exploitation or execution. For example, a natural resource can be sustainably managed for the duration of the producer's activity, the land's carrying capacity, the law's decision, or an infinite horizon, with slow, normal or quick harvesting. It also depends if other practices are involved, which increase, stabilise or decrease the system's output. This is also present in architecture, which could be sustainable at different scales (unique building, district, city, country), time frames (years, decades, centuries) and rates (slow, normal, fast). The architecture can also be sustainable in certain aspects but not others: sustainable energy management, heating solutions, water consumption, materials, construction techniques, etc. This was to illustrate that there is no consensus regarding sustainable architecture, as it can mean many different things, because it has many possible parameters, inside a too wide and unprecise definition. The sustainable architecture range allows one to "choose" freely what type of impact the building will have, may it be passive and very low in carbon, or super-efficient but realised with controversial materials, as in the end, it will still be possible to call the result "sustainable architecture".

b. Misuse of the word

This state of incoherence and lack of harmony brings a real weakness to the word, which can be then used in diverged and not always honest ways. With this "open to interpretation" notion, people can play with words and make some practices seem sustainable, in situations where there are not. Greenwashing is a big phenomenon impacting all spheres related to human consumption, making harmful and dubious activities continue as long as possible, to save businesses that have things to be ashamed of. It has become a term of justification to legitimise methods and designs, but also of manipulation and branding, making certain things desirable and believable, even if it is just a mask. It is also the case for green or sustainable architecture, where buildings are called or labelled as sustainable, but are in fact still very harmful to the environment and absolutely not bearable or reproducible in the long term.

8.2 Principles and practices

a. Principles

As it has been shown in chapter 6, many examples of labelled sustainable architecture, which integrate many sustainable principles, do not always achieve excellence on all levels. The concepts of sustainability and sustainable architecture evolve over time, and the more we learn and develop these definitions, the more exigent the principles get. In general, principles are more demanding than current practices, because they represent goals to achieve, as they are not yet the norm. For instance, the respect and revalorisation of ecosystems are already present in ecological architecture for over 50 years, but it still is not a norm and the practices are still not focused enough on this aspect. The knowledge exists, but it was not widely spread in the academic cursus and made mandatory until recently, and not in every school. This is also

visible with the generational gap, where younger generations of architects are way more sensible towards this topic than older ones, but the latter have a bigger impact on practices, as they are already in the field for many years.

b. Practices

Innovative ideas try to be implemented with current or recent means to respond to sustainable architecture criteria, such as net zero energy or carbon, water autonomy, self-sufficiency, etc. The results are not always as good as expected, but they are learning opportunities to improve building designs further, and they generally have a more positive outcome than standard ways of building. It is important to note that not all sustainable principles can be implemented at once in every single project, as there are physical, conceptual and economical limitations to each situation. It is not necessary, nor feasible, to make constructions that are flawless in every aspect. What is important is to have balance and coherence, systems that work well together and implement each other, in the most beneficial and durable way possible. In the case of regenerative architecture, the subtle assembly of principles and conceptual ideas allows a sort of symbiosis to happen on site, where human and natural living systems interact at ease, and work in a beneficial way for both sides. It is the high goals that are set at the beginning that shape the ideas for the design and allow to find the best ways to achieve them with current means.

c. Labels

Sustainability labels are the current way to assess buildings on their energetical and environmental performances. They are based on acknowledged criteria (environmental, economic, social) that are defined by private or institutional groups, which lets a window for interpretation. They are a tool to indicate if specific aspects of a project respond to actual norms or future expectations. They help to attest a certain quality of design and spread a desirable image of better practices.

The main issue of most existing labels is that they focus mainly on the building itself and its operational aspect. Performance and energy were the first topics to gain in popularity, as they were directly linked with the energy crisis that appeared as a threat in the 1970s, and to which they were the obvious aspect to reconsider. Lessening the carbon footprint of a building is very important nowadays, but it might not be enough to focus only on this, within the context of population growth and the increase in construction demand that we face. Although labels incentive to design better and more economically, the fact remains that every construction does have an impact on the environment and that every construction means a reduction in natural available surfaces, which is a growing problem that also requires attention.

With this in mind, the next step for architecture to limit its impact is to consider the lost surfaces and biodiversity with each project, and to include solutions to counter and compensate for these losses, in every single project. Regenerative architecture integrates such reflexions, as there is a non-negotiable criterion, which focuses on giving biodiversity a space to exist in the long term, via the reconnection with humans and engaged interaction towards co-evolution. This aspect helps to create a mutually beneficial system, which could be the missing key to the current definition of sustainable architecture.

Labels help a lot to motivate contractors to make efforts regarding sustainability, because there are sometimes rewards and compensations that are given, and a positive image of the project and its designers is then spread among the community, which can raise interest for the office and bring many benefits. They also give important guidelines to respect, in order not to forget

aspects in this multi-attribute complexity that is sustainable architecture, especially for people who do not have the broad knowledge required to understand interactions with other domains. However, I believe that actual labels' criteria can still be improved, as many do still not address very important aspects like positive biodiversity cycle creation and virtuous interactional systems creations (between humans and nature). Certifications are a widely spread system that is already accepted and sought for, which gives a certain prestige and acknowledgment to this method. Improving an existing and growing method is easier than trying to find another fully different system of evaluation, which would require more time and thus delay the result of possible positive actions.

The absent feature of most today's rating systems is the creation of a positive system on site for both humans and the environment, which works in interaction between the occupants, the building, its function, and natural/living systems around and inside the building. This element cannot be numerically attested, like other measurable criteria are, because this is a question of process implementation and not just of numbers. This element would strongly encourage designers to change the way they think and integrate the building and its occupants into their environment, how new relations are thought and behaviours shaped. The Living Building Challenge which was introduced in chapter 3, is the perfect example to show a label improvement, which works on actual sustainability performance assessment, but also other important aspects, which are crucial for a regenerative outcome to be possible.

The last aspect regarding labels is the lack of unity among all of them, nationally and globally. Every label is different and targets different aspects more in depth than others. Private, professional and public representatives can decide which criteria are more important regarding sustainability, and thus influence the rating and practices, which if they want to answer to the given requirements, will have to adapt accordingly. This comes back to the issue of sustainability definition, which is still too open to interpretation, and in a way blocks definite guidelines and actions to be taken. This broad freedom of choice that is given do not help practices to evolve faster, because gaps in the label system can be exploited to avoid taking effective measures regarding sustainability.

8.3 Approach

a. Goal and ambition

In my opinion, the way that sustainable architecture was approached until now is not enough to resolve the core problem of the negative environmental impact of our practices, which are partly derived from the relationship we have with it. Until now, sustainable architecture has addressed only the built side of the problem, the direct repercussion it has on humans via extraction, pollution and construction methods. For me, the problem is that other natural systems are not enough included in the design, may it be natural cycles like water, or rich biodiversity inclusion (animals, plants, insects). The current focus is to sustain ourselves first, by diminishing our impact on the planet, from which we get all our resources, by striving for net zero.

The United Nations define the net zero strategy as: "*cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance*".[54] With this definition, they recognise the need to drastically

[54] United Nations, *For a liveable climate: Net-zero commitments must be backed by credible action*, Climate Action, last visited 08.01.2023, https://www.un.org/en/climatechange/net-zero-coalition

reduce our greenhouse gas emissions, but they do not consider dealing with the previous damages that have been done (CO2 emissions, deforestation, ocean pollution, etc.), nor compensating it, assuming that natural systems will deal with the remaining emissions. The problem with this statement is that it does not consider the fact that natural systems have a maximum absorption rate per year and that it may take many years or even decades to compensate for the previous emissions and the new ones that will be produced and will remain. Also, it is not just a question of emissions, but also of total concentration in the atmosphere and the time that these molecules stay there, because of their natural cycle. Carbon, as an example, is naturally reabsorbed by natural systems like forests, soils and oceans, but the emissions we produce from the burning of fossil fuels cannot be all reabsorbed, and the remaining amount can stay up to thousand years in the atmosphere[55].

If we continue with our actual paradigm of simple reduction without any form of compensation or restoration, natural floor surfaces will continue decreasing with all the new constructions predicted, and in consequence the total environmental absorption rate will diminish as well, which is already considered as a problem. Other harmful practices, often linked with the construction sector, destroy natural balancing systems of the planet such as forests or oceans, by illegal tropical wood cutting leading to deforestation and increased fires, or even deep ocean sand extraction for concrete mixes due to other sources shortage.

The high-tech solutions that are often put forward and implemented in many sustainable architecture projects also raise questions regarding our actual context of resources shortage. Precious metals are getting scarcer, but are an essential part of many technical systems that are implemented in our daily occidental lives and buildings. The current and future situation of materials shortage will probably not allow us to continue implementing these kinds of high-tech systems in every new project that we make, simply because the necessary matter will not be available or will be too expensive to purchase. Brilliant innovations will be made for sure in the future, but it is not certain at what time it will happen, will it take months, years or decades? In this perspective, it is not the best option to focus only on such energy and resources intensive solutions, when other more passive ones are also available. I agree that technology can be very useful and beneficial, especially in larger scale construction, where for example automatisation of window opening for natural ventilation is clearly profitable and reduces the electrical charge a mechanical solution would have required and the effort on people as well, who would all have needed to open every single window in the building by themselves. But, the known phenomenon of the rebound effect is also important to take into consideration. The more a solution seems energy efficient, the more people will want to use it, because it will seem attractive and smart, and they will not have a bad feeling about it.

b. Mindset

For me, there is a better way of approaching the problem from an architectural point of view, and it is through a comprehensive and reconnected way of designing everything we do. For this to be possible, there is a need for a mindset shift to be undergone, which is already being made within the academic field and a more conscious generation of architects. The main change, or realignment, that needs to be done, is to integrate whole systems thinking in every design. To date, most designs focused only on building systems alone, so that the way they operate within their own structure is efficient and impacts as little as possible the “exterior” environment. The

[55] Riebeek H. (16.06.2011), *The Carbon Cycle – Effects of Changing the Carbon Cycle*, NASA Earth Observatory, last visited 08.01.2033, https://earthobservatory.nasa.gov/features/CarbonCycle

separation that is made between the building system and other natural systems, is for me one of the reasons why we do not reach more sustainable projects.

Understanding, reconnecting and working with exterior systems and living beings is for me crucial, if we want to improve our designs, living spaces, overall well-being and environment. By not addressing only the building and its main occupants' requirements, we might reach projects that really do good to all parts involved, I understand human and environmental aspects. By putting a higher goal than emission and consumption reduction, and addressing other involved systems' needs, we might create positive impact projects. The vision we have influences the goals we set, and therefore the design solutions we implement for the result we strive for. Being more ambitious than current norms is what makes humanity go forward, and this mindset should be put to good use to improve the way we design and build. Shaping the places we inhabit, with the knowledge we have from the world and from other living systems, should strive for intelligent and integrated architectural spaces within their environment, working in cooperation and partnership with other living systems, benefiting both and not at the detriment of one side. Part of the answer is, for me, within regenerative architecture.

c. Concepts and strategies to improve

According to the critique that has been made so far, the two main considerations regarding sustainable architecture that need to be addressed are the principles and the related strategies, as they both influence the final outcome of a project.

Concerning the principles, instead of focusing only on the building and its principal occupants, with as little impact on the environment as possible, they should directly include other environmental and living systems' preoccupations and needs. Instead of saying: the project should achieve net zero carbon emissions, energy consumption, be passive or other similar aspects, it should be described as: the project should reach a state where it does benefit the users and the environment in which it is implanted, bringing people and nature together, letting them cohabit and thrive, without negatively impacting each other, but co-evolving in symbiosis, for a better and more sustainable world. Targeting this goal means raising the expectation bar higher, making greater design efforts, but also having a potentially greater result.

As for strategies, they should meet these ambitions as best they can, but with a bigger focus on the overall outcome than on individual performance. Indeed, the building should respect the highest standards in energy consumption, insulation performance, and ensure the best indoor quality and comfort possible, but all systems and techniques put in place should first strive towards a global positive result, and not just the target amount of kWh/year. All tactics should bring a positive effect on both humans and the environment, may it be for example indoors with natural ventilation (bringing fresh air without the need for energy consumption) or outside with a permaculture garden (food for the inhabitants, space for biodiversity and soil improvement). Proposed solutions should be holistic and target durable results, optimising the chosen systems energetically and materialistically, for the benefit of all.

9. What does it mean to be regenerative?

After the exploration of the definitions, reasons, principles, and examples of sustainable and regenerative architecture, I will combine all of my most important findings and lessons in this chapter, to best illustrate what it means and what involves creating regenerative architecture.

9.1 Approach

a. Goal setting

The very first step to be taken is the correct goal determination for each concerned project, as this will influence the whole chain of actions for its development, as explained at the end of chapter 3 and illustrated in figure 5. This first step is very important, because it will guide the architect(s) during the whole design process and help take important decisions for the advancement of the project. This is the moment to be ambitious enough to reach beyond current norms and convince all involved actors to take this path instead of another one, to look for improved conditions compared to current ones, to design a project that gives back, in the long term, more to people and the environment than it took from it, and which positively influences all impacted actors and systems around and within itself.

b. Interdisciplinary approach

A holistic and interdisciplinary approach is required for a regenerative project to take place. Similarly to sustainable architecture, many complex and interactive aspects must be taken into account, so that the whole building system works in harmony. In a regenerative case, this must be pushed even further, as new actors are considered in the design: animals, other biodiversity and natural systems. The building, its human factor and environmental impact reduction are not sufficient anymore, we need to take into account the interactions that happen between all involved parties: human, non-human, wild-life, flora, natural cycles, and the building. The whole must work coherently and for the benefit of all, in a mutually beneficial relationship, achieved with the creation of a positive feedback loop system.

c. Mindset

As already mentioned, the conventional mindset must be shifted towards whole living systems thinking, considering all actors of the environment taking part in the established architecture. The focus must be put beyond existing conventions and strive for the best possible solution, creating unique and inspirational projects, which work positively for a brighter and more responsible future. The process is vital, as it will ensure that until the end, the core idea will be kept and accordingly executed, for a regenerative outcome to be possible.

Regenerative design focuses more on environmental and social aspects, as it seeks to give back more to these sustainability sides, which benefited less than the economical one for the last decades. The design wants to find solutions for actual problems and needs, while always having the future in mind. By accepting responsibility[56] for the result of the project, precautionary principles[57] are implemented, in order to avoid all possible and predictable negative outcomes.

[56] Guenther R., *Regenerative Architecture: Redefining progress in the built environment*, Architecture and Health, 1st edition., Routledge, New York, 2019, p.280-295, doi.org/10.4324/9780429021169-20.

[57] Busby P., Richter M., Driedger M., *Towards a New Relationship with Nature: Research and Regenerative Design in Architecture*, Architectural Design 81, n°6, November 2011, p.92-99. doi.org/10.1002/ad.1325.

9.2 Found guidelines

Based on the given definitions and the analysis of case studies, I identified four main guidelines that occurred in every single regenerative project. They are: the environment, people, design, and the building (or project). They are the most relevant aspects that have to be considered, in my opinion, to achieve a regenerative result or any architectural project. These four points were already mentioned at the end of chapter 5, in figure 38, which showed the interaction occurring between them, inside an evolutional iterative process for architectural improvement.

These criteria are relevant for regenerative architecture, because they are all part of a complex interactional scheme that directly and indirectly influences architectural practices, inside an infinite cycle. All require a certain degree of reassessment and requestioning, regarding present environmental, social, or architecture profession-related conditions, which is exactly what regenerative architecture is focusing on. The goal that is sought by regenerative architecture, which is to improve and solve environmental, social and architectural issues, is clearly represented in these four aspects, with architecture being split into design (process) and building (result). These four guidelines have special requirements that need to be fulfilled, in order to achieve a regenerative state. Each point states three specific demands, which help orient the design for a regenerative outcome to happen, because each of them looks for the creation of a virtuous system, and can therefore be seen as possible assessment criteria. Such a positive feedback loop system engages both humans and nature to coevolve in a mutually beneficial way, bringing a conscious reconnection and understanding to people, to bring them to act more positively towards the environment and towards themselves, because doing good to nature will impact us positively now, and in the future, because all systems are connected and the impact chain comes back to us one day, in one way or another.

The four regenerative guidelines are listed below, and each point explains how the three requirements act towards the creation of a virtuous and mutually beneficial system, in other words: what is brought to this criterion from a regenerative perspective. They do not say what has to be precisely done, like creating a pond or insulating the building to achieve a wanted U value. They do not want to impose practices, they want to inspire and guide, to help designers take correct decisions, without limiting their creativity.

a. Environment

- Recognition of human dependency on natural systems and resources, leading to a deeper understanding of the environment and bigger respect for its integrity
- End and prevention of harm toward the environment (education and actions)
- Increasing the carrying capacity of the planet and working towards ecological footprint reversal via restoration, replantation, creation of biotopes, etc.

To benefit the environment, the three above mentioned points want to induce a chain reaction of beneficial actions. The human dependency recognition through education will bring knowledge and awareness which, if well assimilated, will cause an improvement of human actions towards positive and unharmful practices, and even replenishing ones.

b. People

- Creation of healthy, qualitative and nature-connecting spaces
- Education bringing knowledge, awareness and the will to spread it
- Continuous engagement and collaboration, which bring sense

To benefit people, shaping qualitative spaces and environments is the role of architecture, which can work as a reconnector to the place that is invested. The created place seeks to bring awareness via education, visibility, and induced actions thanks to the appropriate design. The goal is to give room, inspiration and motivation for a continuous engagement toward the environment to be taken.

c. Design

- Paradigm shift: striving for health, quality, abundance, long-term, giving back more
- Whole systems thinking: integration and reconnection to other natural systems
- Interdisciplinarity: many actors and many factors, which interact with each other

As mentioned by Shady Attia in his work, a paradigm shift needs to be taken in the design crisis, from a mere impact reductionist one towards an impact reversal and positive outcome one.[58] The approach of whole systems thinking works towards this deep environmental reconnection and paradigm shift, by including a broader interdisciplinarity in the process.

d. Building

- Energy needs minimisation and renewable production
- Carbon minimisation and sequestration via bio-based materials
- Reconnection with the site, the people, the environment, and the function

The building must seek not only an environmental impact reduction via energy and carbon reduction, but it also has to be a place of reconnection between humans and their natural environment. All actors need dedicated spaces to act on their own, but also interact with each other. The final construction must be a place of regeneration of its own, for people and for the planet.

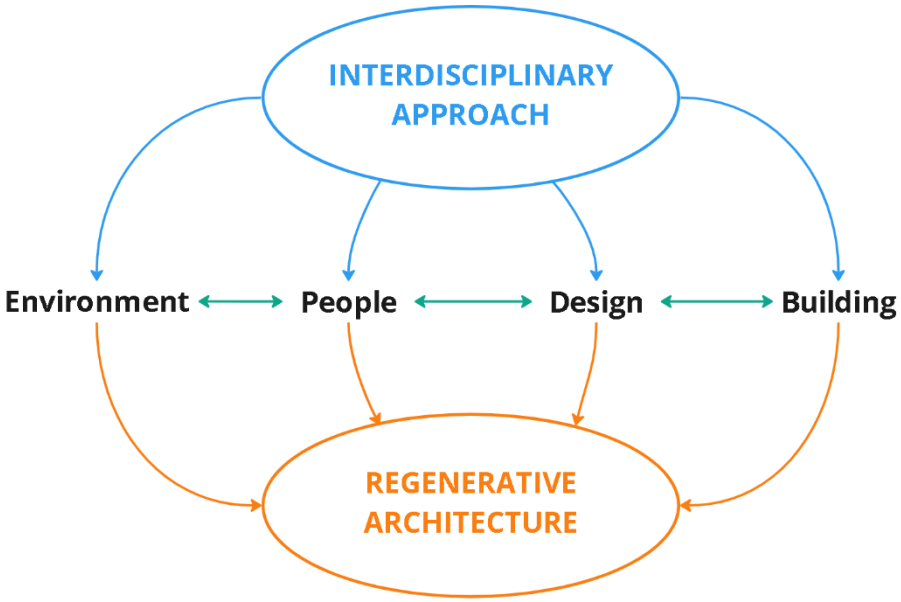

Figure 53: Found Guidelines for Regenerative Architecture

The figure above represents the four regenerative guidelines, interacting with each other to produce the aimed positive feedback loop system, also called regenerative architecture. The environment is the starting point of the chain, representing the given state of the world on

[58] Attia S. (2016), *Towards regenerative and positive impact architecture: A comparison of two net zero energy buildings*, Sustainable Cities and Society, Elsevier

which we will act as architects, in order to answer human needs while respecting natural ones as well. People's understanding of the world will accordingly influence the design and adapt it over time, which will be seen in the final result with the final building. The combination of those criteria will give regenerative architecture, if all requirements are fulfilled and the virtuous system is working for the benefit of all parts involved. But the result is not the end of the story: the construction will be a new case from which we can learn and improve the architectural design, to improve people's well-being and environmental impact, which makes the whole cycle begin once again, going virtually back and forth until infinity, hopefully improving the whole system every single time. Humans are the main actors and cause for changes to happen, and in consequence environmental impacts to be made or avoided. The environment is a given state, but it also reacts accordingly to our actions and adapts itself, which gives us new conditions to live upon and adapt as well. In the end, all the things we do come back to us one day, showing that we have the power to create the world we want. This means that we have the opportunity and the responsibility to provide ourselves with the means to create the best possible living environment: the choice is up to us.

9.3 Implementation

a. Specific conditions

Each regenerative project is unique and responds therefore to specific conditions and needs of a place, which cannot be identically executed somewhere else or at a different time. Like in every architectural project, premises change in every situation and a pertinent approach and design must be developed accordingly. Also, even if the wish is to have the best and most sustainable project possible, not everything can be done at once, because there are always limitations to every project, might they be financial, geographical, political or physical. There is an equilibrium to be found in every case, because deploying extra means for just a slight gain that does not significantly benefit the whole system is also not the correct way to go. Solutions must be reasonably feasible within given conditions, with the appropriate amount of input, limiting the environmental impact, for the best achievable output.

b. Easier aspects

Regenerative architecture does not have to be difficult to implement. It indeed seeks a higher range of sustainability than current and standard practices in the architectural field, but it applies similar solutions to its design, with just a slightly different approach though.

The main change to happen concerns design adaptation, such as setting the right goal, being more ambitious, striving for health and quality, and most importantly: creating a virtuous system. A certain rigour must indeed be respected during the process, always keeping in mind the final goal and striving for the best, being cautious and pertinent in every step that is made, but it is also already the case in many architectural projects, like for example big scale ones, where every technical aspect must be on point and not interfering with other parts. Tools such as BIM (Building Information Modelling) are already in use and help solve such issues, even before they become critical. Other similar technologies and processes are being developed, so the fear of the difficulty is a rather emotional one, which can be overcome with external support.

The step of materialisation is also a manageable aspect regarding the development of the project. Opting for local, bio-sources, non-toxic and lower-impact materials is a choice that can be made early on in the project, which can also lower the final cost if decided during the initial stages of the design. Alternatives do exist and are available on the market. They do sometimes

cost more, but the initial cost is not the only decisive factor, as it can be compensated in the long-term through energy expenses diminution. Informing clients about health and environmental benefits is also an important step of the process, and it could convince them to invest a bit more if they see the true potential. Furthermore, state subsidies are sometimes available and help to take the final decision, and the more such solutions are put forward and implemented, the better the probability for prices to drop, as they will be much more spread among professionals[59].

Regenerative materials, called so because of their carbon-storing property, could help mitigate climate change, because they would lock certain amounts of carbon within their structure, as long as the building is standing, or its components continue being used within a circular network. In the best case, the total amount of absorbed carbon would be bigger than the one that was emitted for the manufacture, use and elimination of the product, which theoretically would mean that carbon was removed from the atmosphere.

Examples of regenerative bio-based materials include: sustainably harvested timber, bamboo, vegetal fibres (wood, cellulose, flax, hemp, straw, rice hulls, nettle, etc.), cork, mycelium, algae, sheep wool, earth, clay.[60]

The last easier step to implement in every design to be more regenerative is the consideration of other living beings and biodiversity. Simple yet effective solutions such as more greening and more space dedication for nature and wildlife are aspects that can change the outcome and image of a project. Integrating more vegetation will benefit all inhabitants of the site, make it more visually appealing, and have a positive impact on the environment.

c. Limitations and challenges

The biggest challenge that regenerative architecture is facing right now is the one concerning the mindset and design shift, as well as current practices change. This problem of the global vision of architecture concerns professionals, but also the rest of the population. It is the scale of the necessary change that makes it a real challenge. Not only do many architects have to adapt their design methods, but also the whole following chain of practitioners and actors have to reinvent themselves, which can cause fear and discomfort.[61]

The engineers and constructors have to modify and adapt their practices or take part in less common ones, accepting the "risk" they expose compared to current standards. As already pointed out earlier, the construction sector faces high inertia of practices, because of the time involved from the early design until the final realisation on site, the number of different actors on a single project, and the big economical and lobbying pressure that is put on practices. The way we build right now is backed up by a whole structure and even partly by the state. Changing the whole machine requires a lot of time and engagement, and is a difficult operation to achieve. After all, the purpose of sustainability is not always the top priority of those people

[59] Varriale Fabrizio, *Are biobased materials the key to a more sustainable construction industry?,* World Built Environment Forum, 6th September 2021, https://www.rics.org/fr/wbef/megatrends/natural-environment/are-biobased-materials-the-key-to-a-more-sustainable-construction-industry/

[60] Builders for Climate Action, *Low-rise Buildings as a Climate Change Solution*, 2019, p.14

[61] HMC Architects, *Regenerative Architecture Principles: A Departure From Modern Sustainable Design*, 2019, last visited 18.12.2022, hmcarchitects.com/news/regenerative-architecture-principles-a-departure-from-modern-sustainable-design-2019-04-12/

who have to power and money to make things happen quickly, because the return on investment is not as interesting as continuing with a more lucrative model.

Clients and investors have to agree with the vision that is proposed and the necessary means that it implies, and the slightly higher investment involved. Of course, a project can be realised in more phases than one, spreading the financing over a longer period of time, which makes it more bearable, but sometimes it is just not possible, especially for smaller or individual budgets. The long-term thinking is definitely worth it and most people understand it, but if the capital is not available, the bank does not want to give a loan, the state does not give enough subsidies and at the top, there is a risk for subsistence with a bigger investment, it will simply not be done, even if the best intentions are present.

The second tricky and large-scale constraint addresses the cultural problem of abstract thinking and disconnection from the natural environment[62]. The emergence of fossil fuels and the culmination of their power with the modern movement made many people forget the real and external conditions of the world we live in. Everything seemed possible and affordable, making architecture "limitless" and ultra-technologically controlled. With hindsight and the information acquired, it is clear that it is no longer possible to do and live as before. More and more people are realising some of the weaknesses of our current lifestyles, and are questioning them, daring to try other things more in line with their beliefs. Here lies the opportunity and at the same time difficulty of the problem: awareness is rising among the population, but at the same time we are so used to the modern lifestyle and habits that it is difficult to go for something that seems less convenient. The reconnection with nature is wanted, but not at the detriment of the gained comfort and prosperity, in most cases. So, we need to create a system that is desirable, comfortable, attractive and cost-effective, so that it is widely accepted, but at the same time create something that engages people in more sustainable, conscious and environmentally friendly practices. People want something sexy but ecologically irreproachable, the best of both worlds, a utopia.

The third obstacle is the famous greenwashing one, linked with the blind trust that can be given. Many people and industries are ready to do many things to achieve their goals, even if it means lying, using questionable means, or sowing the seeds of doubt within the population, exactly as it has been made with climate change by giant oil companies and their henchmen[63]. Energy, environment and construction are very complex topics combining many aspects, people and interests, which makes them “easy” targets to criticise or requestion, in order to make the public doubt, because it generally does not have the whole knowledge about the topic which is discussed, but will still have an opinion depending on the information he gets. This is a real threat to the smooth advancement of sustainable practices, even if big data helps to prove the facts, because the use of manipulation is a very effective tool and regenerative architecture could be used as the next marketing tool, repeating the same mistake again.

Then, a lack of governmental support, supporting policies and adequate labels will limit the deployment of regenerative architecture. Law incentives take time to be implemented and

[62] Littman J. A., Regenerative Architecture: A Pathway Beyond Sustainability, University of Massachusetts Amherst, Department of Art Architecture and Art History, 2009

[63] Weilhammer F., Mach P., *Climat, les gros mensonges des géants du pétrole*, Temps Présent, 29th September 2022, https://pages.rts.ch/emissions/temps-present/13308072-climat-les-gros-mensonges-des-geants-du-petrole-29-09-2022.html?anchor=13426426

allow additional adaptation time before the regulation concretely starts working. It can be a really strong tool if implemented quickly, but the reality is unfortunately the opposite.

The last difficulty is the paradox of the need for quick and radical solutions for environmental impact reduction to be made, and the time it takes for change to operate, mindset to evolve, priorities to be shifted, design to be adapted, practices to evolve and the trend to follow. The frustration that can arise is understandable, but the only way to dissipate it is to continue acting for the better, involving always more people, spreading the knowledge, engaging in positive practices, and seeing the change operate over time. It is better than doing nothing, because each action has a repercussion, and who knows which one will be the decisive element to have a bigger impact on the whole construction chain.

d. Benefits of regenerative architecture

Regenerative architecture looks to improve all sides related to architectural practice, which mainly means benefitting the people and the environment to the best of its availability. Five main benefits could be found in the ecological practice.

The first benefit of a regenerative practice would be that it appears as a possible solution, or at least a greater improvement, to the negative impact that buildings and the construction sector have on the environment. Nowadays, most projects have a heavy environmental footprint and do not bring anything back to the environment for what they have taken from it. Regenerative architecture seeks improvement for all sides, but especially for the neglected one: nature. The pertinent idea of autoregulation is mentioned in the work of Chidinma U. and Omoyeni F. (2019), where they say that: "*just as plants and vegetation adapt to their environment and are involved in the process of preserving the ecosystem, buildings should contribute and regenerate their environments rather than deplete it*".[64] This concept is exactly what regenerative architecture is trying to accomplish, by making buildings and projects active contributors to the climate crisis solution.

The second one is the pursuit of life quality enhancement, with the will to bring more comfort with high-quality spaces, stimulate both physical and mental health with safe environments and natural features, as well as create unique opportunities and activities on site, inside and outside of the building, inducing sustainable and resilient practices.

Next comes the will to raise awareness and consciousness about the world we live in, and all the interactions that take place between humans and their environment. Providing knowledge through education and reconnection to nature and other living systems can re-establish a healthy relationship between people and the natural world, making them cohabit in a beneficial way, full of respect, consideration and positive actions. It wants to restore a balance between both sides, to enable a brighter future to be possible.

Then, another benefit would be that regenerative architecture could work as an inspirational model, making it valued and praised for its exceptional design, which could guarantee its duration in time and direct influence on practices and mindsets. Its alignment with circular economy and permaculture practices could make a global shift happen faster, because it will act as a positive working example.

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[64] Chidinma U., Omoyeni F., Assessment of Regenerative Architecture Principles in Nigeria; A Case Study of Selected Research Institutes in Nigeria, Journal of Physics: Conference Series 1378, no 4 (1st December 2019): 042074. https://doi.org/10.1088/1742-6596/1378/4/042074., p.2

The last benefit would be to see it as an opportunity for experimentation and data gathering. Regenerative architecture could be the premisses for an architectural revolution and understanding of what true sustainability could look like. Testing alternative processes that conventional ones for water treatment, air purification, heating methods and so on could be tested and then analysed, to see what can be done with other, more environmentally friendly methods, and see if they work for current comfort standards.

e. Why are some projects more regenerative than others?

As sustainability can be described as a range, where actions can be continued over a certain period of time, and which more or less impact its sources, it can be assumed that it applies also to regeneration, which can be more or less pushed. There are some reasons which could justify, why a project would be more regenerative, or more sustainable than another one.

The first one would be the number of positive systems that were implemented in a project. If two visually identical buildings exist, but one integrates many passive strategies and a big proportion of revitalised and biodiverse land, and the other only some passive strategies, almost no space for vegetation and has a worse building energy performance, then it could be reasonably said that the first is more sustainable than the other. In real-life situations, it is not as simple as in this example, but the more a building can function without any input of external energy or system, the better and more sustainable it is. A building that dedicated various spaces for biodiversity will be definitely more sustainable than a similar one, where the effort was not made. It is not just the number of systems that is important, but also the final result: maybe fewer systems can have the same output as many.

A second aspect would be the function implemented inside the architecture. The creation of a school, natural reserve, environmental research centre or environmental administration will probably have more benefit to people and the environment than the creation of a gas station, cheap fashion boutique or fast-food restauration. Extremes are taken as examples, but it is to easily understand that the function that a building hosts may influence on the broader impact of the building, and thus its sustainability. Architecture creates places for people to act, and the dedicated space for each activity has an impact on common behaviour. If there is no fast food in a certain location, people will find alternatives, or just go further to find one. But if we eradicate all of them, then there will be no choice but to eat somewhere else or to cook. Architecture shapes behaviour, so the function directly impacts us and the environment.

A third factor could be the inspiration a project can bring, influencing more strongly practice and creating a will to create similar situations elsewhere or engage in the same practices as those. The power of an example is intangible, because it can provoke drastic changes to happen on a large scale, and have a more positive impact than many years of improved practices, because beauty, exemplarity and ideology are strong catalysts for progress and innovation.

f. Attitude

Implementing regenerative architecture today is not easy and obvious, as it is not a conventional type of architecture. It requires courage and will to go against mainstream conventions and practices, and the guts to say no to ideas or acts that are problematic but still widely spread in society. Going against the majority can be frightening, but no big change in history has ever happened while being passive and staying in the comfort zone. To start taking action when we are conscious of existing problems is essential, and it is already a step forward, because not doing anything also has consequences, and often negative ones in the context of climatic change and architectural practices.

There is no need to be perfect to be regenerative, just careful enough to bring the project to a state that is beneficial for all involved parts, that makes sense, that reconnects and that makes things personal. It is not just about implementing a green roof or storing water, regenerative architecture is about creating a system where all parts are connected and work together, where functions respond to needs, displays reconnect, people are engaged, and the building inspires. A place to live, learn, understand, evolve, and act.

10. Conclusions

This journey through regenerative architecture has been a passionate one and has brought me many valuable lessons and inspirations for the future. With its subtle and unique approach, it showed me other possible ways to improve the sustainability of a project, by not only focusing on the building itself, its performances or construction methods, but by looking at the bigger picture and other impacted systems on site. The moment we try to deeply cohabit with the environment in a given place and invest ourselves for a positive change to happen, then the will for regenerative architecture arises.

The proposed regenerative case studies attest that better architectural practices are possible and that the question of architectural responsibility towards the environment is being addressed more seriously than before among professionals. These are still exceptions among other standard harming practices, but they are a ray of hope and show that people are being more conscious about their impact and that they want to act. I link them with the famous readapted quote of Mahatma Gandhi: "*Be the change you wish to see in the world*", as they are examples of possible alternatives, that bring more architectural, environmental and human qualities than most generic constructions of today.

For me, regenerative architecture is the best way to approach sustainability today, from an architectural point of view, considering the environmental crisis we are experiencing. The holistic and multi-systemic thinking induced in the design perfectly crystallises all the implications of our environmental impact at all levels. The architectural concept wants to involve us directly in our practices and relationship with our environment, in order to influence and change our behaviour at the very source, in the places we spend most of our lives: the buildings. In this perspective, I think that the way that sustainability is addressed today should totally embrace the regenerative paradigm, as the same goal is pursued, but more comprehensive and integrative approaches are taken. All the good intentions are present within sustainable principles, at least in the way that they are taught in the academic field, but the final goal should be more explicitly expressed. The best intention, which is regeneration, should be pursued.

I also see potential in regenerative architecture to be the next architectural movement, that deals with the issues created by the detachment from the natural world, induced by the intensive use of fossil fuels, materialised by modern architecture, and unanswered by the postmodern movement. Regenerative architecture could achieve to understand and address the core of the problem and provide better solutions than current sustainable ones. If it would achieve this goal, then it would be the symbol and manifest of a new architectural era.

For such a big change to happen, it requires a strong commitment from the architectural community. Every project is a contribution to our world, and it is the role of the architect to do everything in his/her power to make it a positive one. We do have a responsibility to answer people's needs, but also to guide choices to achieve them. We need to regain our "educational" power back, to persuade and help clients understand the scope of the decisions that are made, might they be economic, environmental, social, comfort and health-related, etc. Making things personal impacts people the most, and sharing our knowledge can only be beneficial if we want things to change more quickly in the construction world.

Regenerative architecture helped me ask new questions, and consider new aspects to lead my own regenerative design, such as:

- What new relationships could the project enable?
- What actions will be taken regularly for regeneration?
- How to create a system that is mutually beneficial for humans and nature?
- How to deeply integrate human and non-human?
- What does it architecturally mean?
- Is it an opportunity to redefine new ways of living?
- Wake curiosity with a visible or hidden element: make people ask questions and understand new things about the building and the world

Regenerative architecture offers many positive hopes for the future, but had still a long way to go to be widely accepted and implemented. It faces many challenges, especially educational, conceptual, design and execution ones, but the presented regenerative examples prove that they are possible and desirable. They serve as examples to wake awareness about alternative practices that respond to current environmental issues and show that greater sustainability is achievable, comfortable, useful and beautiful. The more such projects will be made and put forward, the bigger the demand for them will raise, and the bigger the incentives will be provided, which could lead to systemic changes in the construction system and make it a new affordable architectural norm.

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