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MASTER'S THESIS

Title of the thesis: Eco-tech complementary architecture in historic city centre. Reflexion on the direction of architectural development in the XXI century on the example of Virtual Reality Research Centre in Irun, Basque Country, Spain. Centrum Badań Wirtualnej Rzeczywistości w Irun, Kraju Basków, Hiszpanii.

Title of the thesis (in Polish): Uzupełniająca architektura eco-tech w historycznym centrum miasta. Refleksje nad kierunkiem rozwoju architektury XXI wieku na przykładzie Centrum Badań Wirtualnej Rzeczywistości w Irun, Kraj Basków, Hiszpania.

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ABSTRACT

The future of how we live, work and spend free time, influencing the architecture around us, is the consequence of layers of changes and events of the past.
This thesis aims to research the issue of contmeporary architecture and society, by searching through its sources and examples of behaviour. It tries to find the answer to the question what it means to design in the first quarter of the century, which tendencies and trends dictate the hand of the architect of the year 2025. It contains considerations on possible further development and searches for space in which we could prepare for that future.
The considerations realise themselves through the project of Virtual Reality Research Centre, located in the historic centre of Irun, Basque Country, Spain. The concept touches on the isses of complementary architecture in urban tissue, constructing within the exisiting structures and designining with assumption of openess towards the future needs. The project assumes a multifunctional layout, combining the functions of a virtual reality center, office, gastronomy, the third-places and co-working spaces. In line with current interests, in which we are largely invested in as a society, the project examines the relationship and cooperation between the development of ecological awareness and sustainable development and the dynamic development of technology. It tries to find solutions on the borderline that will fulfill the assumed programme. The project does not aim to evaluate the solutions currently used, it functions as a freeze frame of trends in the field of architecture of today.

Keywords: architecture of the XXI century, the future of architecture, virtual reality, ecotechnology, complementary architecture, adaptable architecture, recycling

STRESZCZENIE
Przyszłość tego jak żyjemy, pracujemy i spędzamy czas wolny, a więc także architektury, która nas otacza, jest konsekwencją nawarstwaijacych się zmian i zdarzeń z przeszłości.
Niniejsza praca dąży do zbadania zagadnienia społeczeństwa i architektury współczesnej, poprzez wyszukanie jej źródeł i przykładów zachowań. Stara się znaleźć odpowiedź na pytanie co to znaczy projektować w pierwszym ćwierćwieczu XXI wieku, jakie tendencje i trendy kierują ręką architekta w 2025 roku. Zawiera w sobie rozważania nad możliwym dalszym rozwojem i szuka przestrzeni, w której moglibyśmy się na tę przyszłość przygotować.
Rozważania realizują się poprzez projekt Centrum Badań nad Wirtualną Rzeczywistością, zlokalizowanym w historycznym centrum Irun, w Kraju Bsaków, Hiszpanii. Koncepcja zahacza o zagadnienia architektury uzupełniającej tkankę miejską, budowania w kontekście istniejących struktur oraz projektowania z założeniem otwartości zabudowy na przyszłe potrzeby. Projekt zakłada wielofunkcyjność założenia, łączącego w sumie funkcje centrum wirtualnej rzeczywistości, biurowej, gastronomicznej oraz przestrzeni miejsc trzecich i co-workingu. Zgodnie z obecnymi zainteresowaniami, w które w dużym stopniu inwestujemy jako społeczeństwo, projekt bada zależności i współprace między rozwojem świadomości ekologicznej i zrównoważonego rozwoju z dynamicznym rozwojem technologii. Stara się znaleźć rozwiązania na pograniczu, które spełnią założony program. Projekt nie ma na celu oceny stosowanych obecnie rozwiązań, funkcjonuje jako stop klatka tendencji z dziedziny architektury z dnia dzisiejszego.

Słowa kluczowe: architektura XXI wieku, architectura przyszłości, wirtaulna rzeczywistość, ekotechnologia, architektura uzupełniająca, architektura adaptacyjna, recykling.

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I. INTRODUCTION

1. Introduction

Each building, quite like any other piece of artistic and social value is a marker of its time. The human-made environment is a subject to constant change and redefinishion as our values, abilities and changes over time. Even the spaces that answer to needs constant thorough history: health, knowledge, living, the interpretation of those spaces is dictated by the trends and technological possibilies of construction.

The current times stem from the experiences of the past centuries, and were greatly defined by various factors. For the sake of this reaserch the main focus on determining the character of the times we live in in 2025 is based on the technological progress and growing ecological distress. Those two factors combine in the field of ecotechnology (ECT), which, in short, is a science and practice focused on "strategic application of technology in ecosystem management, aiming to minimise intervention costs and reduce the negative impact on the global environment"[1]. That definition suggests few areas of interest. Firstly, the use of technology. Secondly the relation to ecosystems, which can refer to interrelationship between organisms and their environments, such as corporate workplace, urban space etc. Thirdly the definition established the purpose that leads the decisions to implicate ecotechnological solutions, which is the minimisation of the cost and lowering the disruption of the planetar environment.

Through the lenses of that definition ECT can be viewed as a philosophy implicted on the design, that individualises its needs by researching its ecosystem, and implicating the solutions that aim to be as undisturptive as possible while relying on the human technological progress. In its main principles it touches the relationship between nature and technology. This tension has been a point of interest of scientists and artists for centuries, only intensifing after the Industrial Revolution and resulted in a fascinating dialogue refering to human nature, our past and our future, very much progressing even now.

The understanding of the philosophy of ECT for the built environment comes from the understanding of its two main components, nature and technology, and the impact they have had on the way we design that resulted in the current trends. With nature, the focus is placed on the ecology and, more importantly, on its preservation or, at the very least, designing with respect to the local environment and with protection of the global one in mind. Therefore the discussion has to relate to the change of climate, as it has been the driving factor of our understanding of what the environment is and what is our place in it. While the environment is the way, the technology is the mean, so understanding our relation of the state of art of human technological is important to recognise the decision we undertake now to reach out goals.

[1] M. Straškraba, "Ecotechnology as a New Means for Environmental Management," Ecological Engineering 2, no. 4 (December 1, 1993): 311–31, https://doi.org/10.1016/0925-8574(93)90001-v. As in Ricardo Ruiz-Sánchez et al., 'Exploring Research on Ecotechnology through Artificial Intelligence and Bibliometric Maps', Environmental Science and Ecotechnology 21 (4 January 2024): 100386, https://doi.org/10.1016/j.ese.2023.100386.

2. Research approach

Project theory is developed through researching exisiting published works related to adjecent issues, case studies and observations. The project is not meant to provide one answer to the question of how do we or should we design our cities and buildings, it is rater an exploration of the current situation for academic purposes.

The general nature of the study relies on the Europocentric and Western perspective to present the main areas of the change of thought.

The conclusions on current development and future predictions are based on the overview of current narratives and observations on the focuses of the general public.

3. Project idea source

The idea for the design part of the thesis, a concept of the Virtual Reality Centre, is in line with the 6th chapter of the Report of the Planning Guidelines for the Basque Country (Directrices de Ordenación Territorial) from 2019[2], which presents enclaves of strong identity such as singular architecture coastal spaces or historic city centres, as a perfect space for implementation of structures related to cutting-edge technology, art and design.[3] This idea uses the strong character of those spaces and their organic development of needed utilities and facilities as a starting point for integration and creation of a dialogue with the new direction of social, cultural and technological development. Through various urban renewal programmes and with the respect towards the historic identity of the space such implementation creates an opportunity for reshaping the existing structures and creating the image of traditional centres as a driver for the future. It narrates that respect towards identity can go hand in hand with the future-focused vision, and work as a mean to achieve other environmental goals stated in the Strategy, such as reuse, densification, urban regeneration, developing new uses and drivers of economy and social life.

4. Art inspiration

The tension between humans, environment and technology dates back centuries, but its current picture can be attributed mostly to social changes achieved through the Industrial Revolution. Its expansive side can be captured in futurism[4]. As a concept futurims evolved at the beginning of the XX century. It was a largely italian movement started with the Manifesto of futurism[5] by an Italian poet Flippo Tommaso Marinetti, as a celebration of modernity through agression, speed, machine and rejection of morality and the oppresive, in their view, frames of the past.[6] Futurism has influenced the art of its time and later evolved throughout the century into Neo-Futurism, a manifestation of faith in the technological advancement in a more socially aware manner than its predecessor. Futuristic ideas have deep roots in rapid development and glorification of science, which are still the backbone of Western societies. Its manifestations and similar train of thought can be found in different means of art, from manga to cyberpunk, and in architecture from high-tech buildings to their reintroductions through the designs of Zaha Hadid or Santiago Calatrava.

Examples of art below (figure 1-2) reflect both a more dystopian and a more utopian vision of the relations between technology, nature and humans. It drives reflections: what does the future hold in place for us? What will the collaboration between artificial intelligence and natural intelligence (human, animals and nature) look like in the future? Where will we end up on that scale of mutual influence?

Fig. 1 Jakub Różalski, „1920-fields of usonia", 2021, digital art, https://www.artstation.com/artwork/aYerRk

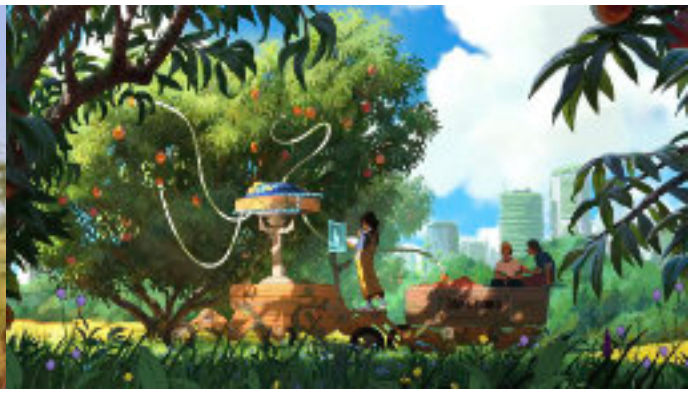

Fig. 2 The Line for Chobani, by Bjørn-Erik Aschim et al., Dear Alice, 2021, animated commercial https://www.youtube.com/watch?v=z-Ng5ZvrDm4

[2] Gobierno Vaso, REGIONAL PLANNING GUIDELINES OF THE BASQUE COUNTRY DECREE 128/2019 of 30 July, DIRECTRICES DE ORDENACIÓN TERRITORIAL DEL PAÍS VASCO Decreto 128/2019, de 30 de julio, (Edita, 2020), transl. Bitez S.L., https://www.euskadi.eus/contenidos/informacion/rpg_dot_ingles/es_def/adjuntos/DOT_EN_BOOK.pdf

[3] Gobierno Vaso, Report in REGIONAL PLANNING GUIDELINES OF THE BASQUE COUNTRY DECREE 128/2019 of 30 July, DIRECTRICES DE ORDENACIÓN TERRITORIAL DEL PAÍS VASCO Decreto 128/2019, de 30 de julio, (Edita, 2020), transl. Bitez S.L., page 2010, https://www.euskadi.eus/contenidos/informacion/rpg_dot_ingles/es_def/adjuntos/DOT_EN_BOOK.pdf

[4] Wikipedia, keyword: Futurism, https://en.wikipedia.org/wiki/Futurism#Legacy, accessed 14.03.2025

[5] Filippo Tommaso Marinetti, Futurist Manifesto in Gazzetta dell'Emilia, (Bolognna, 1909)

[6] 'The Founding and Manifesto of Futurism', accessed 14 March 2025, https://www.unknown.nu/futurism/manifesto.html.

THEORETICAL PART

1. Ecology

1.1 Term definition and relation to architecture

Ecology is a science branch that studies the relations between individual organisms and their environment[7]. While research on species has existed as far back asin the 4th century ancient Greece[8], its significance as science has began to be recognised with the publication of Darwin's "Origin of species"[9] as a struggle to exist. The term ecology was introduced few years later by Ernst Haeckel[10] and the science as we know it, focusing on the categorisations, classifications and relations between components of the ecosystem gained track by the end of the XIX century. Most are in agreement that ecological research consists of three units of interest and methods: populations, communities and ecosystems[11], with some areas, like landscape ecology[12], falling under more than one unit. There is no definite consensus on the concept of either of those and for the purpose of this paper the ontological status is to be kept undefined, focusing more on the results of these classifications and discussions used in architecture and urbanism. For ecosystems that would mean taking into account the influence of abiotic[13] factors on other organisms and the transfer of energy, that in ecology is researched along the trophic levels[14] and in construction can be used to analyse the embodied energy[15] of the used materials and design solutions. Research regarding communities in ecology focuses on the interations of the populations within a community[16] in aspects of competition, predation, mutualism and parasitism, which interpretation can be found in built environment in the research field of symbiotic architecture, a relation of the new structure to the existing ones[17]. Methods used in the population unit, the eldest researched in ecology due to its more individualistic nature, in science branches related to architecture and urbanism can be reimagined for researching migration and demographic changes in the field of human ecology.

1.2 Anthropocene - human place in ecology

Human ecology is a transdisciplinary study researching the relationship between humans and their environment, either natural, social or built[18] and addresses the issues of human activity in different cultures, sustainability or technological development, among many more antropocentric matters.[19] Due to its very wide and varied scope of interest, and an undefined scope at that, the term human ecology can relate to most if not all disciplines researching human behaviour and relations to environment, but with the history of focusing on human impact on biotic factors[20]. The branches of most interest for the purpose of this paper include mostly urban ecology and environmental ecology.

Human ecology research on the human impact on the Earth's ecosystem falls under the Anthropocene interval[21] proposed as an successor of the Holocene epoch[22] (figure 3), but existing nowadays as such without the formal status.[23] If the anthropocene were to be fully recognised the general consensus indicates that the human collective impact on the Earth's ecosystems was small up until the Industrial Revolution of the mid XVIII century. Deciding on the starting point of the new epoch is therefore related to that period of technological advancement. Some of the possible starting points supported by the scientists included the 1784 invention of steam engine by James Watt[24] or the 1945- the year of the testing of the first nuclear weapons and the atomic bombing of Hiroshima and Nagasaki as well as the beginning of the so called "The Great Acceleration",[25] the period of significant post-war growth. The Anthropocene Working Group proposed the 1950s as the beginning of Anthropocene epoch during the International Geological Congress in 2016 as the year concluding all of those changes.[26] The proposal of the formalisation of the Anthropocene Epoch was turned down in May 2024, due to too insignificant change in rock strata, an indicator usually used when determining the Earth's new geological time,[27] but the term and its implications will remain to be used by the scientists until further research.

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[7] Alkistis Elliott-Graves, 'Ecology', in The Stanford Encyclopedia of Philosophy, ed. Edward N. Zalta and Uri Nodelman, Spring 2024 (Metaphysics Research Lab, Stanford University, 2024), https://plato.stanford.edu/archives/spr2024/entries/ecology/.
[8] Wikipedia contributors. "History of Ecology." Wikipedia, December 16, 2024. https://en.wikipedia.org/wiki/History_of_ecology#20th_century_transition_to_modern_ecology.
[9] 'Darwin, Charles, and Leonard Kebler. On the origin of species by means of natural selection, or, The preservation of favoured races in the struggle for life. London: J. Murray, 1859. Pdf. https://www.loc.gov/item/06017473/.
[10] Cooper, Gregory J., The Science of the Struggle for Existence: On the Foundations of Ecology, (Cambridge/New York: Cambridge University Press, 2003). doi:10.1017/CBO9780511720154 as cited in Alkistis Elliott-Graves, 'Ecology', 2024
[11] Kurt Jax, "Ecological Units: Definitions and Application," The Quarterly Review of Biology 81, no. 3 (September 1, 2006): 237–58, https://doi.org/10.1086/506237 as cited in . Alkistis Elliott-Graves, 'Ecology', 2024
[12] Turner, Monica G., and Robert H. Gardner. Landscape Ecology in Theory and Practice. Springer eBooks, 2015. https://doi.org/10.1007/978-1-4939-2794-4 as cited in . Alkistis Elliott-Graves, 'Ecology', 2024
[13] Abiotic - anthonim to biotic; non-living part of the system that shapes it, in the context of ecology can relate to factors like temperature, light, water, oxygen, altiude or solar radiation (Cambridge distionary) relating to the things in the environment that are not living, "Abiotic," March 12, 2025, https://dictionary.cambridge.org/dictionary/english/abiotic.
[14] Trophic level - the position of the organism on the 5-level food chain from primary consumers to detrivores (Cambridge dictionary) Any of the layers of an ecosystem with the same position in the food chain "Trophic Level," March 12, 2025. https://dictionary.cambridge.org/dictionary/english/trophic-level.
[15] Embodied energy - (European Commission) the total energy required for the extraction, processing, manufacturing, and delivery of buildings; European Commission, "Embodied", (pdf, September 2021) in "Pdfs Topics EU Buildings Factsheets," Energy, n.d., https://energy.ec.europa.eu/publications/pdfs-topics-eu-buildings-factsheets_en.
[16] Alkistis Elliott-Graves, 'Ecology', 2024
[17] Milan Šijaković and Ana Perić, 'Symbiotic Architecture: Redefinition of Recycling Design Principles', Frontiers of Architectural Research 7, no. 1 (1 March 2018): 67–79, https://doi.org/10.1016/j.foar.2017.12.002.
[18] Wikipedia contributors, "Human Ecology," Wikipedia, January 23, 2025, https://en.wikipedia.org/wiki/Human_ecology#.
[19] The Department of Human Geography. "Human Ecology," n.d. https://www.keg.lu.se/en/education/subjects/human-ecology#:~:text=Human%20Ecology%20is%20the%20study,biology%2C%20economic%20history%20and%20archeology.
[20] Wikipedia contributors, "Human Ecology."
[21] Anthropocene- (National Geographic definition) period of time during which human activities have impacted the environment enough to constitute a distinct geological change; "Anthropocene," n.d. https://education.nationalgeographic.org/resource/anthropocene/.
[22] Holocene epoch (Merriam Webster dictionary) - of, relating to, or being the present or post-Pleistocene geologic epoch; "Holocene." In Merriam-Webster Dictionary, n.d. https://www.merriam-webster.com/dictionary/Holocene.
[23] Rafferty, and John P. "Anthropocene Epoch | Definition & Evidence." Encyclopedia Britannica, February 23, 2009. https://www.britannica.com/science/Anthropocene-Epoch.
[24] Kingsford, and Peter W. "James Watt | Biography, Inventions, Steam Engine, Significance, & Facts." Encyclopedia Britannica, February 11, 2025. https://www.britannica.com/biography/James-Watt.
[25] Globaïa. "The Great Acceleration — Globaïa," n.d. https://globaia.org/acceleration#:~:text=The%20Great%20Acceleration%20is%20a,around%20the%20mid-20th%20century.
[26] Rafferty and P, "Anthropocene Epoch | Definition & Evidence," February 23, 2009.
[27] Wikipedia contributors, "Anthropocene," Wikipedia, March 13, 2025, https://en.wikipedia.org/wiki/Anthropocene#.

Undetermined status of the Anthropocen does not stand in the way of further research relating to human impact on Earth. The human-made niches of Anthropoce called Novel Ecosystems[28] come from either human activities or their effects. Anthromes[29] also called anthropogenic biomes[30] define human-altered environments with specific characteristics.

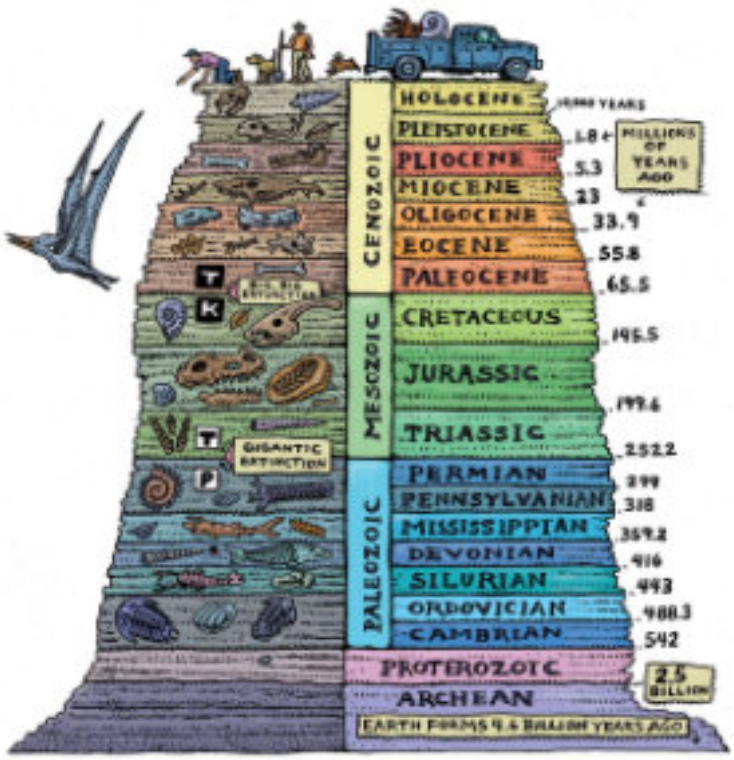


Fig 3 Epochs of the Earth, image source: https://geologylearn.blogspot.com/2017/03/anthropocene.html

[28] A novel ecosystem - "a system of abiotic, biotic and social components (and their interactions) that, by virtue of human influence, differ from those that prevailed historically, having a tendency to self-organize, and manifest novel qualities without intensive human management" ; Richard J. Hobbs, Eric S. Higgs, and Carol Hall, Novel Ecosystems: Intervening in the New Ecological World Order (John Wiley & Sons, 2013).as cited in British Ecological Society. "Novel Ecosystems: The New Normal? - British Ecological Society," December 16, 2024. https://www.britishecologicalsociety.org/content/novel-ecosystems-the-new-normal/.

[29] Anthromes -(Wikipedia) anthropogenic biomes are a way of classifying lands in their human-altered form using global ecosystem units; Wikipedia contributors, "Anthropogenic Biome," Wikipedia, February 15, 2025, https://en.wikipedia.org/wiki/Anthropogenic_biome.

[30] Biome- distinct geographical region, characterised by its climate, flora and fauna, currently used type of ecosystems classification is the Goodall typse from 1974; Wikipedia contributors, "Biome," Wikipedia, February 17, 2025, https://en.wikipedia.org/wiki/Biome#cite_note-1.

1.3 Built environment- urban ecology

Defining ecology as a study of relations between organisms and their environment determines viewing urban ecology within the same scope of interest. As a concept its beginnings can be traced through publications up to 1970s[31] but urban research as a whole is a science that evolved in XX cenury. The term "urban ecology" gained track in scientific world by 1990s, and key concepts by the 2000s, with the popularisation of research regarding climate change and urbanisation. Most up-to-date researches on the scope of interest of urban ecology[32] as a science point out a shift in current conceptualisations of the term. Firstly, the influence of the urban tissue is not limited to the city, as urban effects spread along its region. This idea is captured in the concept of the "greater city", which expands the area of the considered city to the borders of its influence in regards to communication, infrastructre, population or density. That change in perception allows us to understand the urbanisation processes and needs better.[33] Secondly, in the recognition of regional differences around the world, with some regions experiencing urban growth and dealing with suburbanisation, while others with urban shrinkage[34]. Thirdly, in the dedicated research for the heterogenious nature of the cities, casting light on the different experiences and needs of various social groups[35] with growing research on gentrification and revitalisations. Fourthly, in inviting nature into the city, or natural processes, with various solutions being implemented and researched nowadays surrounding nature-based solutions[36] like city water retention, urban green spaces or pedestrian-only zones. Fifthly, in transdisciplinary understanding of the problem and search of solutions, based on collaborations of various sectors to determine to right approach to implement for the cities to respond to emerging needs.[37] The frontieer of current urban ecology research is therefore correlated with vast change, captured in the UN 17 sustainability goals[38], making the social equality and environmental security supreme values to all interdisciplinary processes and research regarding directions of development of the resilient cities of XXI century.

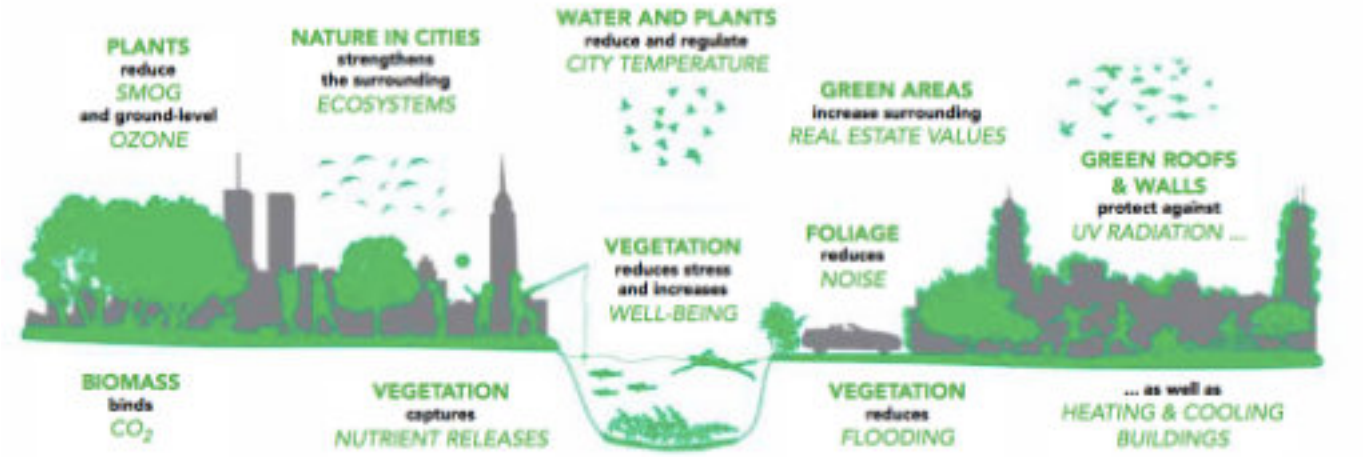


Fig 4 Factors of the urban ecosystem, all existing elements influence one another and the balance between them determines the living conditions and the characteristics of living beings withing the city. Image source: https://www.cocity.se/om-oss/urban-ecosystem-services/

[31] Silvia Flaminio, Joelle Salomon Cavin, and Guillaume Guex, 'The Urban in Ecology: A Quantitative Textual Analysis of the Scientific Literature over a Century', Urban Ecosystems 27 (6 September 2024): 2531–42, https://doi.org/10.1007/s11252-024-01603-4.

[32] Steward T. A. Pickett et al., 'Shifting Forward: Urban Ecology in Perspective', Ambio 53, no. 6 (June 2024): 890–97, https://doi.org/10.1007/s13280-024-02007-6.
[33] Lewis Dijkstra and Hugo Poelman, 'CITIES IN EUROPE THE NEW OECD-EC DEFINITION', n.d.
[34] Erik Andersson, Timon McPhearson, and Steward T. A. Pickett, 'From Urban Ecology to Urban Enquiry: How to Build Cumulative and Context-Sensitive Understandings', Ambio 53, no. 6 (June 2024): 813–25, https://doi.org/10.1007/s13280-023-01959-5. as in Pickett et al., "Shifting Forward: Urban Ecology in Perspective."
[35] Andersson et al., 'From Urban Ecology to Urban Enquiry: How to Build Cumulative and Context-Sensitive Understandings' as in Pickett et al., "Shifting Forward: Urban Ecology in Perspective."
[36] Bonnie L. Keeler et al., "Social-ecological and Technological Factors Moderate the Value of Urban Nature," Nature Sustainability 2, no. 1 (January 3, 2019): 29–38, https://doi.org/10.1038/s41893-018-0202-1. as in Pickett et al., "Shifting Forward: Urban Ecology in Perspective."
[37] Pickett et al., "Shifting Forward: Urban Ecology in Perspective."
[38] "THE 17 GOALS | Sustainable Development," n.d., https://sdgs.un.org/goals.

1.4 Ecology and its significance in built environment

Ecology in regards to the built environment, on a building's scale, refers to the relation between the nature and technology, human and technology and human and nature in regards to human comfort especially. The growing awareness of climate sensitivity is reflected in the approach of designing a building, a process which nowadays is obligated to take into consideration environmental aspects to the extent it didn't have to in the previous century. The context is a direct consequence of climate changes that have been observed in the previous decades.

1.4.1 Climate change - brief background

Climate change[39] describes both general changes in Earth's climate through its existence, and beside that, since the 1980s, the ongoing increase in global temperature, known as global warming, with weather patterns, air pollution or land modifications, that are a result of human activity since the Industrial Revolution.

The main parameters that determine the conditions on Earth are based on three energies- the energy incoming from the Sun, its reflection from Earth's clouds and surface through albedo effect and the energy transmitted back into space through Earth's radiating heat or long-wave radiation. All of those conditions have been undergoing constant changes in Earth's 5 billion years long history, either in the incoming solar radiation, planet's albedo or atmosphere's conditions. These changes were the causes of Earth's various warmings and coolings, spanning millions of years each, finally reaching a sinusoidic, regular timeframe of glacial and interglacial periods, starting around 1,5 million years ago.[40]

The cyclical nature of the present Ice Age period is attributed to the movement of the Earth around the Sun visualised on Milankovitch cycles graph.[41] Main contributor of these cycles is assumed to be carbon dioxide, which amount in the atmosphere reflect the interchangable periods of warmer and colder climate. CO2 in natural conditions is dependent on factors such as vulcanic activity and amount of snow-covered surfaces.[42] The human civilisation developed during the last ice-age cycle stabilisation. Apart from some regional climate declines leading to the end of some ancient socities, the current age is the first in human history to experience world-wide climate change. A distinguishable feature of current climate change is its speed, an acceleration caused by human activity resulting in addtional CO2 emission. Our assurance that the climate decline can be attributed to humans may be achieved thanks to various researches and simulations showcasing that without the significant additional human-activity-based CO2 emmissions, our climate wouldn't be leading into the warming period yet.[43]

[39] United Nations, "What Is Climate Change? | United Nations," n.d., https://www.un.org/en/climatechange/what-is-climate-change.
[40] Dirk Notz, 'A Short History of Climate Change', The European Physical Journal Conferences, January 2020, https://doi.org/10.1051/epjconf/202024600002.
[41] "Milankovitch Cycles and Glaciation," n.d., https://geol105.sitehost.iu.edu/images/gaia_chapter_4/milankovitch.htm.
[42] Notz, "A Short History of Climate Change."
[43] Notz, "A Short History of Climate Change."

1.4.2 Anthropogenic climate change

Human activity contributing to climate change is related to all aspects of human behaviour and needs. Many of the climate change consequences can be observed on a year to year basis with the rises in temperatures, summer forest fires and radicalised weather being observable worldwide, among various other negative results of human activities, which stem primarily from carbon dioxide emission and secondarily from the emission of other greenhouse gases, aerosols and changes in Earth's surface (*table 1*) (figure 5).

Greenhouse gases (GHGs)[44] are all gases in the atmosphere, that rise the planet's surface temperature, through absorbing radiative heat emitted by Earth and trapping it within the atmosphere (greenhouse effect). Lack of GHGs would result in dropping of av. temperature from 15°C to -18°C, making it inhabitable. The issue stands with the human contribution to GHGs, since the Industrial Revolution, that increased the amount of gases, such as CO2 or methane by respectively 50% and 150%, mostly from burning of fossil fuels as well as contributions from agriculture and industry. The action to limit the greenhouse gases in the atmosphere is climate change mitigation.[45]

Sulfate aerosols are atmospheric particulate matter, components to air pollution, that cause global dimming, the decline in amount of sunlight reaching the Earth surface. Lower amount of sunlight influences water cycles. It is speculated that the rise in aerosols in the atmosphere lend a hand to reduction of rainfall in some regions, as it diminished evaporation. Additionally, they have a cooling effect, that masks the effects of global warming, so while reducing pollution for the health of the population is necessary, it is predicted that with the reduction of aerosols and their cooling effect, the average global temperature could rise up by an additional 0.5°C.

The research on the extends of climate change is based on the climate models[46], which are mathematical simulations of relations between the drivers of the climate, and allow to make projections on the future climate changes. They can, generally, predict to some extend the future environment regarding water or seasonal cycles, changes in average temperature etc., based on variables from climate footprints and human activity, more so on the global level, not regional.

Table 1 Sources and causes of current climate change, simplified, own summary

Source	Result contributing to climate change	Climate change effect	
industry, agriculture, fossil fuels	greenhouse gases	ice melt, retreating of glaciers, rising global sea level, ocean acidification, ocean deoxygenation, urban flooding, island flooding	droughts, heat waves, weather radicalisation, animal migration, spread of diseases, pest propagation, food insecurity, increased death among the impoverished societies, agricultural changes
agriculture, logging for wood, wildfires	land surface change - deforestation	lowering carbon sink, higher local temperature in tropic and lower in polar regions, higher surface reflection	
combustion of fossil fuels	sulfate aerosols	air pollution, global dimming, reduced rainfall (leading to famines)	

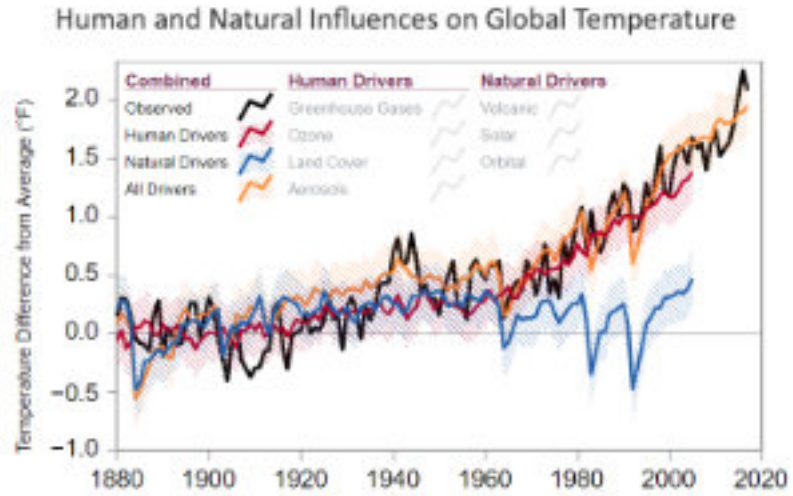


Fig 5 Causes of the anthropogenic climate change chart, image source: https://www.epa.gov/climatechange-science/causes-climate-change

[44] Wikipedia contributors, "Greenhouse Gas," Wikipedia, February 1, 2002, https://en.wikipedia.org/wiki/Greenhouse_gas.
[45] Wikipedia contributors, "Climate Change Mitigation - Wikipedia," March 27, 2025, https://en.wikipedia.org/wiki/Climate_change_mitigation.
[46] Wikipedia contributors, "Climate Model - Wikipedia," December 13, 2024, https://en.wikipedia.org/wiki/Climate_model.

1.4.3. History of anthropogenic climate change research, policy and tools.

Current times, due to growing public discussions and first-hand experiences of climate stress present the increasing number of publications that respond to the need for exploration of this planetary occurance. However interest in climate, with various scope and understanding of what the term includes, had been part of the human history as long as there have been societies. Public discourse saw the emergence of environmental thought as early as in the IVth century BCE, in more social terms, with environments meaning no more than regions, that influences the character of the societies that inhabit it.[47] If viewed from that perspective, climate emerges as a ever-exisiting background to all human activity. This approach is reviewed in Sorlin and Lane's research on historising the climate change[48], which explores numerous publications adjacent to the concept of climate, that treat it either as a driver for human decisions or a determing factor for change. In their words "At some point anthropogenic climate change enters the discussions of a community of hunters in the Arctic, a community of political economists or philosophers thinking about the future, or the intellectual and political leadership of a nation state."[49] That approach allows to view climate through various lenses, from anthropology, through history, till geography and therefore presents a wide scope of influence that the changing climate can introduce into human societies.

Apart from the holistic, societal view on climate issue and climate change, interpretation of the research available in the modern history stems from observations made on anthropogenic climate change. By the time the Industrial Revolution was changing the everyday life of the societies, the climate research had been a well established science as a part of research on the environment.

Scientists as far back as in the XIX century have began to predict the possible consequences of the hightened emission of greenhouse gases, most importantly CO2[50], basing their knowledge on then emerging concept of greenhouse effect. The general consensus points to three main contributors to the research of the phenomena. Firstly, to Joseph Fourier, whose 1820s research on the Earth's excessive heat in comparison to theoritical physical calculations showed to possible importance of the Earths atmosphere, suggesting that it may work as a form of insulator.[51] It was followed by John Tyndall 1850s further research on CO2, and by Svante Arrhenius, who is attributed with the discovery of the greenhouse effect in 1896, through his identification of connection between CO2 emission and climate change.[52] With the exception of some researchers[53] the issue has been abandoned for the majority of the first half of the XX century. It emerged back after the wars, supported by new carbon-detecting technology and resulting in Hans Suess research on oceans acting as carbon sink. He later started vouching, together with Roger Revelle, for carbon dioxide emission monitorings.[54]

The growing concern regarding the state of the environment in the 50s, is also visible in Gilbert Pass 1959 article, with predictions of global temperature rise thorough the XX century[55] and resulted in the creation of the World Meteorological Organisation (WMO). However it was the 60s and the 70s that saw both the growing climate anxiety in the media and the intensification of the environmental movement (figure 6), especially due to publications, such as Racher Carsons' "Silent Spring". The public dispute most probably have played a significant role in the increase of the collaboration between scientists and policymakers,[56] with the first high-profile conference on global environment policies and protection being the UN Conference on the Human Environment (UNCHE), which took place in Stockhol in 1972. The 70s energy crisis was also an important argument for promoting energy efficiency and use of the renewable energy.[57] With the tight collaboration between the science and politics the difference between the two in regards to climate change issues began to blur[58], which, together with common source for climate research being government funding, increased the existing scepticism or denial of the gravity of the climate emergency, with multiple sceptics to this day turning down the government-funded experiments for their seeming unreliability.[59] Nevertheless the final global recognision of climate change threat happened in the 80s[60], through the first World Climate Conference of 1979 which resulted in the creation of the World Climate Programme and political heads of the countries making adresses on its importance (Margaret Thatcher's UN adress of 1989).[61]

[47] Sverker Sörlin and Melissa Lane, 'Historicizing Climate Change—Engaging New Approaches to Climate and History', Climatic Change 151 (1), November 2018, https://doi.org/10.1007/s10584-018-2285-0.
[48] Sörlin and Lane, "Historicizing Climate Change—Engaging New Approaches to Climate and History."
[49] Sörlin and Lane, "Historicizing Climate Change—Engaging New Approaches to Climate and History." p. 9
[50] Chris Johnson et al., '15.5: Anthropogenic Causes of Climate Change', in An Introduction to Geology (Salt Lake Community Collage, 2017), https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/15%3A_Global_Climate_Change/15.05%3A_Anthropogenic_Causes_of_Climate_Change.
[51] Joseph Postma, 'A Note on Fourier and the Greenhouse Effect', 8 October 2015.
[52] Jan Corfee-Morlot, Mark Maslin, and Jacquelin Burgess, 'Global Warming in the Public Sphere', Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences 365 (30 July 2007): 2741–76, https://doi.org/10.1098/rsta.2007.2084.
[53] Papers and research of Guy Steward Callendar, Royal Meteorologcal Society as in Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere'
[54] David M. Hart and David G. Victor, "Scientific Elites and the Making of US Policy for Climate Change Research, 1957-74," Social Studies of Science 23, no. 4 (November 1, 1993): 643–80, https://doi.org/10.1177/030631293023004002. As in Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere'
[55] Gilbert N. Plass, 'Carbon Dioxide and Climate', Scientific American 201, no. 1 (1959): 41–47. As in Mark Andrew Maslin, John Lang, and Fiona Harvey, 'A Short History of the Successes and Failures of the International Climate Change Negotiations', UCL Open Environment, July 2023, https://doi.org/10.14324/111.444/ucloe.000059.
[56] Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere', p. 8
[57] Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere', p. 13
[58] Agrawala, Shardul. Science advisory mechanisms in mutilateral decisionmaking: three models from the global climate change regime. Woodrow Wilson School of Public and International Affairs, 398. Princeton, NJ: Princeton University. 1999 as in Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere', p. 14
[59] James E. Potzick, 'A Short History of Climate Change on Planet Earth', December 2022, https://doi.org/10.13140/RG.2.2.21301.58088.
[60] Maslin MA. Climate change: a very short introduction. Oxford: Oxford University Press; 2021. As in Mark Andrew Maslin et al. 'A Short History of the Successes and Failures of the International Climate Change Negotiations'
[61] Alan D. Hecht and Dennis Tirpak, "Framework Agreement on Climate Change: A Scientific and Policy History," Climatic Change 29, no. 4 (April 1, 1995): 371–402, https://doi.org/10.1007/bf01092424. As in Jan Corfee-Morlot et al. 'Global Warming in the Public Sphere', p. 14

Figure 6 First waves of the environmentalists movements of the 1960s and 1970s. Image source: https://www.herinst.org/BusinessManagedDemocracy/environment/environmentalists/index.html

The cooperative character of the second half of the XX century in regards to climate change, economy and other fields opened the doors to a wider perspective on collaboration for the common good. After the tumulous beginning of the century, its later stages provided a framework of international work not only in the aspects of climate change, but also in addressing other emergencies. The beginning is often attributed to Brundtland Report of the 1987. It was submitted as a culmination of the 900 days process of documenting the views on the scope of need for international cooperation from conferences speeches and meetings and notably defined the term of sustainablitiy as "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[62]

The introduction of the umbrella term of sustainability was significant due to drawing attention to variety of interlocked issues, that humanity should address, from the limits of growth and development, food insecurity to global economy and industries. Its popularity and digestability among many parties stands from the general nature of the document, as it usually is with the majority of strategies on a global or even country scale.[63] However vague, it works as a conclusion in the train of thought on the shared approach towards gloabal stability of its moment in time. What "Our Common Future" has showed is the implication of connection between different issues and therefore the possibility to create approaches that take into account the varied effect they may bring in all field of interest.

Since the 80s, moving forward the main tools for international collaboration regarding the climate change have been conferences, strategic documents and certifications. The *table 2* shows and overview of some of the most important conferences and their effects. The primary focus on the collaborations of the 70s and 80 resulted in the establishment of the organisations both researching the climate change and making recommendations for policies, as well as working as panels for international discussions. With thats the current approach to climate change has been established to be heavily dependent on legislative changes. On one hands such approach is intrinsic to the way the human sociaties have always worked, as changes coming from the top are more easily mandated. Additionally, in the age of corporations and emergence of the oligarichal tendencies on the West, it can work as a protection of public interest in preserving the sustainable life of its inhabitants. On the other hand the centrialised obligations to fulfil can feel limiting and are suseptible to corruption through imposing government's views over scientific dicourses. However much like with democracy, the exisiting system is possibly the best option we have for now.

Apart from the governmnet-issued panels, conferences or researches and reports, a common tool for the eco-friendliness have been certifications. Certifications are non-obligatory frameworks that the designers can strive to obtain, that systemise the most important, in their view, parameters of designing the environment concious solutions. In architecture most popular include Leadership in Energy and Environmental Design (LEED) established in 1993[64], focusing on variety of different metrics, such as building's site water and energy efficiency and more, Passivhaus, that originated in 1990s[65], a more ridig alternative that reaches for high values of energy efficiency or WELL Building Standar launched for the first time in 2014, with the system od concept-based parameters, like air, waterm light, etc.[66]

[62] Gro H. Brundtland, Our Common Future: Report of the World Commission on Environment and Development. Geneva, UN-Dokument A/42/427, 1987, page 41
[63] Thomas Zeroual, 'Sustainable Development: Why Is the Brundtland Report so Popular?', 21 May 2012.
[64] Ariana Nieves, "Looking Back: LEED History," Sustainable Investment Group, December 21, 2021, https://sigearth.com/leed-history/.
[65] Admin, "A Brief History of Passive House (Passivhaus) - Jane Cameron Architects," Jane Cameron Architects, January 12, 2024, https://janecameronarchitects.com/blog/brief-history-passive-house-passivhaus.
[66] "International WELL Building Institute," n.d., https://resources.wellcertified.com/articles/the-international-well-building-institute-launches-the-well-building-standard-version-1-0/.

The most up to date[67] framework for sustainable development, and through that view also the environmentally concious development are the 17 UN Sustainable Development Goals, established during the 2015 UN Sustainable Development Summit in New York. The three dimentions of sustainability that it captures refer to the society, biosphere and the economy. The social issus focus on equality in life opportunities and health, environmental on water and land management, as well as climate change prevention actions and economic goals refer to protection of decent labour and equity, consumption, production and innovation.[68] The Sustainable Development Goals and Targets, do not provide specific solutions, rather the ground for common understanding, as specific solution have to be related to the context. While SDGs work as a general map, the important aspect comes into play within their interactions. A guide provided in 2017[69] explores detailed interconnections between different goals with goals related more directly to construction industry like SDG 7, 9 or 11 functioning as a tool towards the imporvement of superior, in this relation goals, such as health (SDG 3.11) or resilient infrastructure (SDG 7.9).

[67] As on September 2024
[68] Annik Fet, 'Linking Sustainable Good Health and Well-Being to the Sustainable Development Goals: An Historical Perspective', 2024, 3–20, https://doi.org/10.1007/978-3-031-61810-9_1. Page 8-9
[69] 'A Guide to SDG Interactions: From Science to Implementation' (International Council for Science (ICSU), 12 May 2017), https://doi.org/10.24948/2017.01. As referenced in Annik Fet, 'Linking Sustainable Good Health and Well-Being to the Sustainable Development Goals: An Historical Perspective

Table 2 Overview of some of the most important international conferences regarding climate change and their objectives, own summary
Based on [1] Mark Andrew Maslin et al., 'A Short History of the Successes and Failures of the International Climate Change Negotiations' and [2] Jan Corfee-Morlot et al., "Convergence and contestation in climate science" in 'Global Warming in the Public Sphere'. [3] Annik Fet, 'Linking Sustainable Good Health and Well-Being to the Sustainable Development Goals: An Historical Perspective', 2024, 3–20, https://doi.org/10.1007/978-3-031-61810-9_1.

Structure	Characteristics
1972 UN Conference on Human Environment (UNCHE) in Stockholm	- Local and regional environment - Adressing the problem of pollution and pesticides for the first time - First such high profile conference with both scientists and policymakers - Resulting in the recognision of the climate change as a potential public threat and first promises on establishing systems of government funding its research _Resulting in the establishment of the United Nations Environmental Programme (UNEP)
1979 conference in Geneva	- Establishing of the World Climate Programme, and with that the international collaboration regarding gathering and collecting data
1980-87 series of conferences in Villach, Austria and 1987 in Belagio, Italy	- Debates regarding climate change policies
1987 conferenc ein Montreal	- Establishment of the Montreal Protocol - phasing out production of numerous substances that cause ozone layer depletion
1988 "Changing Atmosphere..." conference in Toronto, Canada	- Political recognision of global warming - Non-binding statement of reduction of CO2 emission by 20%, declaration made by the participating governments, recognised as a first call for restriction policies
1992 "Earth's Summit" conference in Rio de Janeiro	- Discussion under the three pillars: environment, economy and society, esteblished in the Brundtland Report - Establishement of the 27 principles for sustainable future - Led to entablishment of the United Nations Framework Convention on Climate Change (UNFCCC) or Agenda 21
1997 conference in Kyoto	- Led to Kioto Protocol, in which governments pledge commitment to control the anthropogenic greenhouse gases emissions - Discussions on taking into account underlying differences between parties
2009 conference in Copenhagen	- Resulting in the Copenhagen Accord, a political agreement for reduction of emission and financial support for the developing countries in reaching the Sustainability Goals - Establishment of the maximum of 2°C global temperature rise till 2015
2015 UN Sustainable Development Summit in New York	- Establishment of the current 17 Sustainable Development Goals (SDGs) [UN 17] with specified 169 targets under the 2030 Agenda for Sustainable Development
2016 Paris Agreement	- reducing vulnerability to climate change -improving capacity for adaptation - strengthening resilience Achieved through: -keeping global temperature of this century at less than 2°C below the pre-industrial average -pursuing efforts to limit it to 1,5°C below pre-industrial average - fundings for more vulnerable regions, where adaptive capacity to climate change is lower
2016 conference in Kigali	- Amendment to Montreal Protocol, increasing the restriciton of HFC greenhosue fas emission
2018 conference in Katowice	- Finalisation of the Paris Agreement Rulebook
2021 conference in Glasgow	- Glasgow climate pact regarding the 1,5°C temperature rise reestablishment

1.4.3 Future scenarios

The global warming, one of the contributors to climate change is measured in 20-year periods due to yearly temperature flactuation (*fig.* 9) The 20-year average is therefore a more realistic value to show us the changes in climate that we are experiencing. The current estimated from World Meteorological Organisation and Intergovernmental Panel on Climate Change (IPCCC)[70] estimates few scenarios for global warming (*fig.* 8). The IPCC Sixth Assessment Report from 2023 drew three main scenarios, that may take place by 2100:

(1) low emission scenario resulting in a 1-1,8°C global temperature increase;
(2) intermediate emission scenario resulting in a 2.1-3.5°C global temperature increase;
(3) very high emission scenario resulting in a 3.3-5.7°C global temperature increase.

To put the numbers in perspective, they could be compared with the temperature records experienced by Earth prior to current global warming. In the Earth's history, its global temperature has flactuated between 5°C less[71] compared to a Industrial Revolution average to up to 14°C degrees more around 50 million years ago[72], but with no more than a 1°C flactuation up or down the termometer metric in the last 11 000 years from the XX century average.[73]

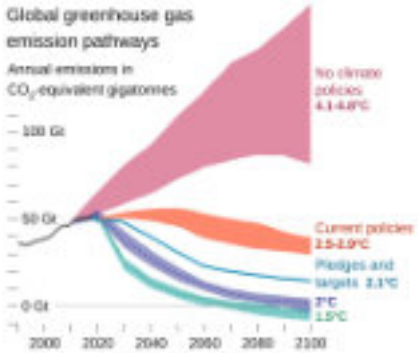


Fig. 7 Global greenhouse gas emission amounts based on the different global temperature rise scenarios, image source: https://en.wikipedia.org/wiki/File:Greenhouse_gas_emission_scenarios_01.svg

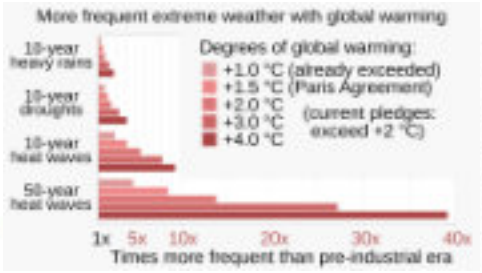


Fig. 8 Graph showing the rise in the frequency of the extreme weather conditions, dependent on the spenario that happend, image source: https://en.wikipedia.org/wiki/File:20211109_Frequency_of_extreme_weather_for_different_degrees_of_global_warming_-_bar_chart_IPCC_AR6_WG1_SPM.svg

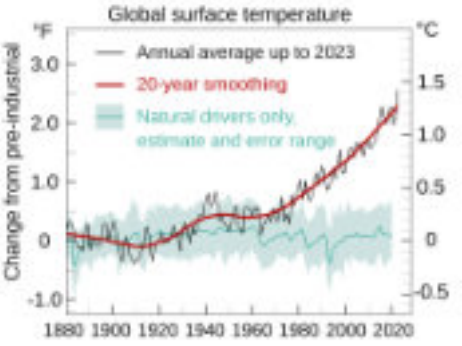


Fig. 9 Global surface temperature 20-year smoothing method grapg, allowing for more precise estimation of change, image source: https://en.wikipedia.org/wiki/File:Global_Temperature_And_Forces_With_Fahrenheit.svg

Due to the fact, that the anthropogenic climate change affects various districts of the industry, the estimations of the possible futures don't derive just from the scientific, international governmnet-funded researchers, but are a point of interest of various independent researchers as a way to grapple with the uncertainty and motivate action. Besides that, the issue of uncertain future has always been an inspiration for thinkers from different fields. In architecture and urbanism as well, there have been different researches and publications, both more scientific or populist in nature, not to mention legislations, that attempted to predict the possible outcomes and scenarios for the future.

ARUP's representation of possible scenarios for the year 2050 (figure 10), prepared in 2019, is based on the two objectives and their improvement or decline in the future. The objectives provide a possible area of focus of human action in the next 25 years and relate to societal and environmental focuses.[74] The four introduced scenarios vary in terms of global temperature increase and total population, among other factors. The post-anthropocene scenario is one that focused on planet-friendly solutions, achieving the Paris Agreement low-emission scenario through the introduction of circular economy and banning of virgin plastic, as well as paying attention to social issues with the vision of a sustainable society. The Greentocracy is the scenario, that achieves the Paris Agreement with the introduction of synthetic food and varied planet-friendly solutions but overlooks the society's needs. The Extintion Express is the scenario achieved though the continuation of the exploitation of the planet with the growing class differences and conflicts. The Human Inc scenario showcases the possible future of actions focused on protecting humans from the climate change effects and addressing social issues but without the sufficient attention to actual restrictions to lower the emissions of GHGs and the global temperature rise. The proposition adresses also how all of the scenarios could have addressed the UN17 SDGs as an indicator for taking actions. While simplified, the research functions as a thought exercise to visualise the inevitability of the future to come, with the open-end but clear message, the the type of future that would be in dependent solely on the decision of the people now.

[70] Wikipedia contributors, "Intergovernmental Panel on Climate Change - Wikipedia," April 11, 2025, https://en.wikipedia.org/wiki/Intergovernmental_Panel_on_Climate_Change.
[71] "What's the Coldest the Earth's Ever Been?," NOAA Climate.gov, February 18, 2021, https://www.climate.gov/news-features/climate-qa/whats-coldest-earths-ever-been.
[72] "What's the Hottest Earth's Ever Been?," NOAA Climate.gov, February 26, 2025, https://www.climate.gov/news-features/climate-qa/whats-hottest-earths-ever-been.
[73] "What's the Hottest Earth Has Been 'Lately'?," NOAA Climate.gov, March 5, 2025, https://www.climate.gov/news-features/climate-qa/what%E2%80%99s-hottest-earth-has-been-%E2%80%9Clately%E2%80%9D.
[74] ARUP, "Four plausible futures: 2050 Scenarios", Decemnber 2019, https://www.arup.com/globalassets/downloads/insights/2050-scenarios-four-plausibl-futures.pdf

Figure 10 , ARUP, 2050 Scenarios: Four plausiblefutures, <https://www.arup.com/es-es/perspectives/publications/research/section/2050-scenarios-four-plausible-futures>,photo accessed at <https://www.ingenieros.es/noticias/ver/cuatro-posibles-escenarios-para-nuestro-planeta-en-2050/7769> [accessed Apr 28, 2024]

The FutureTaleLAB, a futurology centre, provides a similar theoretical experiment (Figure 11). It delivers a report of Greater Bangkok as a prediction exercise regarding urbanisation. It is a collaborative work between MQDC with ARUP,[75] from 2021. It features Technotopia, with hierarchal governance and high-tech solutions, which achieve the stability of the climate and economy, urban playground with the focus on tactical urbanism for the promotion of population's well-being, decentralised resilience with sustainable city risen above the floored districts of the poorer classes, accelerated generations with the heavier interconnection between generations leading to the highly educated society and thr transforming lifestyles scenario focused on environmental policy for touristic gain. The thought experiment, quite varied in its scenarios is meant to bring about the reflection of what type of future certain actions, particulary those of the unexpected direction, could lead to.

Figure 11 , Future of Urbanisation scenarios. Greater Bangkok. FutureTales LAB, images source: https://www.futuretaleslab.com/research/future-of-urbanisation-scenarios-greater-bangkok.

[75] FutureTales Lab, "FutureTales LAB - Future of Urbanisation Scenarios," n.d., https://www.futuretaleslab.com/research/future-of-urbanisation-scenarios-greater-bangkok.

2. Technology

2.1 How cotton factories led to woonerfs?

The term "industrial revolution" can be defined as a fundamental change in the way people manufacture their goods.[76] While it uses the term revolution, indicating a rapid change, in reality the change was coming in stages, that based their innovations on their predecessors. However, as the length of time is somewhat relative in history, the term allows to grasp the gravity of the change and its effects, in relation mostly to Europe and the USA. Before the changes of the XVIII century, production was held in small establishments, like workshops, often ending up a family business, using local materials and providing its products locally apart from those made for trade. The village life and community was a centerstage and functioned as a self-sufficient community.[77] The situation began to change mid-XVIII century. The beginning of the Industrial Revolution is attributed to the rise of machinery[78] and is most often linked particularily to James Watt's invention of steam engine in 1765. The invention of the machine enabled all of the further developments, which led to the creation of factories, beginning with textile, and with that, the globalisation of production, increase in its speed and standarisation[79]. The first visual depiction of the Industrial Revolution and the way it changes the landscape is depicted on Philip James de Loutherbourg's "Coalbrookdale by Nigh" (*figure 12*) painting from 1801. The visual has quite a foreboding character to it, with the exhumes from factories as rather foreign beings in an otherwise rural landscape. It is alien and overpowers the scenery[80] which ilustrates well the character of the First Industrial Revolution, which is the change from agrarian to industrial through the use of machinery and steam power.[81]

The primary stages of the industrialisation of society resulted in urbanisation and degradation of the rural environment that were being replaced by the industry. The popularisation of factories over the agricultural or craftmanship introduced the wage labour system. The changes in industry has led to a creation of the new economic system of free market, competition and growth, captured in the framework of Adam Smith.[82] Moreover, the advancement occured also in the chemical processes, as the sulfuric acid, among other chemical substances, started being used to facilitate the production of textiles, glass or paper. More advanced production processes changed the profile of the workforce, that began to require expertise, which had led to investing in technical school and public education in general.[83]

Fig. 12 "Coalbrookdale by Night", painting, Philippe Jacques De Loutherbourg | Science Museum Group Collection," n.d., https://collection.sciencemuseumgroup.org.uk/objects/co65204/coalbrookdale-by-night-by-philippe-jacques-de-loutherbourg.

Fig. 13 "'Over London-by Rail', Engraving, Gustave Dore, London, England, 1872 | Science Museum Group Collection," n.d., https://collection.sciencemuseumgroup.org.uk/objects/co8014229/over-london-by-rail-engraving-london-england-1872.

Fig. 14 The painting depicts the Ford Motor Company's River Rouge Plant in Michigan, "American Landscape", painting, Charles Sheeler, 1930, MOMA, https://www.moma.org/collection/works/79032

[76] Revolution - (Merriam-Westber dictionary) a sudden, radical and complete change; a fundamental change in the way of thinking or visualising something; industry - (Merriam-Webster dictionary) a manufacturing activity as a whole;
"Revolution," in Merriam-Webster Dictionary, April 23, 2025, https://www.merriam-webster.com/dictionary/revolution.
"Industry," in Merriam-Webster Dictionary, April 20, 2025, https://www.merriam-webster.com/dictionary/industry.
[77] Solomon Lartey, 'Exploring the Puzzles and Challenges of the Industrial Revolution: Historical Perspectives and Implications', 25 March 2025.
[78] Mohammad Kashiripoor, 'Fourth Wave Technologies in Construction and Architecture: From Idea to Realization (Part 3: Sample Applications of the Fourth Wave Technology in Construction and Architecture)', Urban Construction and Architecture 14 (24 March 2025): 171–79, https://doi.org/10.17673/Vestnik.2024.04.24.
[79] Minel Kurtuluş, Selin Güner, and Ümit Arpacioğlu, CHANGES IN THE USE OF MATERIALS IN THE FIELD OF ARCHITECTURE AFTER THE INDUSTRIAL REVOLUTION, 2020.
[80] Douglas Youvan, Industrial Visions: How Artists Captured the Transformation of Society during the Industrial Revolution, 2024, https://doi.org/10.13140/RG.2.2.30141.88803., P. 4-5
[81] Mohammad Kashiripoor, 'Fourth Wave Technologies in Construction and Architecture: From Idea to Realization (Part 3: Sample Applications of the Fourth Wave Technology in Construction and Architecture)'
[82] Mengchen Jiang, 'A Review of the Impacts of Industrial Revolutions in World History', Communications in Humanities Research 39 (31 August 2024): 234–39, https://doi.org/10.54254/2753-7064/39/20242245.
[83] Mengchen Jiang, 'A Review of the Impacts of Industrial Revolutions in World History', p 234–39

The emerging industry needed two things, improvement in the existing state of the means of transportation and space for newly found functions. In regards to transportation the revolution boiled down to the creation of railroads. The first industrial and commercial railway was erected between Liverpool and Manchester, both cities with distinct industrial history, in 1830.[84] The need for space not only for the industry, but for the workforce as well, resulted in a creation of new form of habitation- enclosed "company towns", which originated in Great Britain. Those were the towns established for the workers of a nearby factory. The first company town was New Lanark, which stands out among others due to the socialist nature of its later governance, known from the name of its creator as "owenism".[85] Its significance stems from the contrast it provides to the majority of the places, where the focus on industrial growth and economic gain, has resulted in a significant degradation of living conditions. The poorer and the industrial regions inhabited by the workforce, consisted of small, overpopulated houses, without sewage, with narrow, paved streets covered in dirt and waste as descripted in Engel's "Great Town" paragraph on London.[86] Therefore by the time the Second Industrial Revolution was in its primary stages, with the increased speed of production, the effects brought about by the mechanisation have created an environment similar to one depicted by Engels, captured in a series of documental engravings by Gustave Doré's "London: A Pilgrimage" (*figure 13*) which shows a depiction of various sceneries of the neglected "modern city" of his time.

The Second Industrial Revolution is related to the changes of the XIX century, with scientists not being in agreement in regards to its specific timeframe. The progress throughout the new century was about the expansion of the cities and domination of industries in urban landscape.[87] It was driven by the improvement in mass production and transportation, notably through the discovery of electricity and the advancements in the production of iron[88] and later steel, with the Bessemer process for inexpensive mass production receiving its patent in the 1850s. The changes introduced new typologies of the buildings, continuing the tendencies that were born during the previous century, and laid the foundations for the mass produced goods in construstion as well.

The times of the 2IR can be therefore defined as the time perfecting and evolving the innovations achieved by the beginning of the century, amplifying its scope of use. Its landscape consisted of steam-powered machines and growing railways , which allowed for the connections between different cities or port hubs with cargo ships, allowing for yet another area for increased profit and vast industrial zones (*figure 14*). The society that inhabited it, apart from the lucky few born into wealth, consisted of working class living in poor conditions, that together with the poor nutrition, enabled the spread of various diseases such as cholera. The repetitive and hard work involved the use of child labour (figure 15)with the standard workday being 12 hours. The wage gap between sexes was significant, with prejudices against female workers resulting in the wage around 50% of the males'. The categorisation of jobs has lasted for centuries and can still be felt in the XXI century. As the entirety of the first two revolutions was powered mosly by coal, the Industrial Revolution is regarded as a starting point od environmental distress through the emission of CO2 into the atmosphere alongside other greenhouse gases and use of chemicals for production.[89]

Fig 15 Industrial Revolution, in need for the hand for work, utilised the labour of the children as young as 3 years old. The common hours could include 3 a.m. to 5 p.m. Standard workday was 12 hours. Image source: https://www.history.com/articles/second-industrial-revolution-advances

[84] Wikipedia contributors, "Liverpool and Manchester Railway," Wikipedia, April 7, 2025, https://en.wikipedia.org/wiki/Liverpool_and_Manchester_Railway.
[85] Morris Altman, 'Changing the World One Step at a Time by Example: Building on the New Lanark Legacy', Journal of Co-Operative Studies 56 (1 December 2023): 50–62, https://doi.org/10.61869/SWYJ5919.
[86] Friedrich Engels 'The Great Towns. In The Condition of the working class in England' .Transcript by Delaney T., 1998, online Marxist.org, https://www.marxists.org/archive/marx/works/1845/condition-working-class/ch04.htm. (Original work published 1845, Leipzig) p.44-72
[87] Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution
[88] Basma Hamad and Maha Jawad, 'The Fourth Industrial Revolution: A Historical and Conceptual Review', Journal of Economics and Administrative Sciences 30 (1 July 2024): 154–72, https://doi.org/10.33095/gh3a7g38. page 156
[89] Patrick J. Kiger, "7 Negative Effects of the Industrial Revolution | HISTORY," HISTORY, February 20, 2025, https://www.history.com/articles/industrial-revolution-negative-effects.

The issues brought about by the First and Second Industrial Revolution, together with their positive impact on widening the possiblities bore the Modern Movement of the XX century. Modernism as a philosophy can be defined as the way to improve the life of people through the use of science, therefore technological heritage of the XVIII and XIX century. Through the lenses of the history it can be judged to not have succeeded fully. Although modernism, basing on the socialist principles coined before, has brough about distinctive changes in urban structures and introduced basic principles for architectural design, at the same time, it has leaned greatly into the idea of mechanisation. In architecture it could be viewed in perceiving the buildings as machines for living, in art through disintegration, in every-day philosophy of life through the diconstruction of set values, that have accompanied humanity for centuries, such as family or church. The sort of angst and pessimism deepened with the Great Depression of the 30s, Second World War and culminated in the invention and use of the atomic bombs.[90] The individualised and lonely human society of the XX century seems to have grown into self-realisation by the middle of the century and the emergence of postmodernism. Postmodern movement works as a mesh of different approached trying to deal with the uncertainty of the new age.

Fig 16 graphic author horacek, image source: https://medium.com/@mananmonga50/post-modernism-cool-buildings-4b68e093d56

The Third Industrial Revolution, which started around 1970s-90s is oftentimes referred to as "digital age". It begins from the second half of the XX century. Its main innovations include the internet, computers and is associated with access to the information.[91] The Third Revolution is the time, where the scientific dispute gets rather blurry, with some still regarding current times under the 3rd revolution, some talking abouth the 4th while other seeing the emergence of the 5th. That kind of lack of consensus points perhaps to a rather important aspect of the times we are in now. The first two Industrial Revolutions lasted roughly close to 200 years. In the current times, with the evolution of media, and speed of information ,the tendency to speed up is rather visible in all aspects, perfectly readable in fashion trends. Lack of strict borders doesn't stand in the way of defining the implications brought about by the revolution.

Some frameworks can be found. According to Dr Brown each Industrial Revolution introduced three new paths: new energy source, new communication system and new financial system. For the 1IR that meant coal power, steam-powered printing press and stock market, all of those solutions allowing for optaining the desired product in a quicker way than through it predecessors. With the 2IR emerged oil and gas power, electricity that allowed for the telegrammes and telephones and internal combustion engine and liability corporation .[92] For the 3IR the emergence of the new communication system is evident and is its main objective. Internet has revolutionised not only the communication between individuals, but changed the way people get involved with the world,[93] blurring the differences between physical and digital. For financing system the main new contributors seems to relate to democratisation of finance through crowdfunding and peer-to-peer financing. In terms of the new energy, professor suggests the solar power as the main energy of the 3IR,[94] however some attribute the main energy driver of the 3rd Industrial Revolution to nuclear power.[95] The globalising effect of those innovations allowed, for the first time in history, to unite the world, more or less, in this path of progress. Perhaps that may have played a role in the growth of speed of the posibilities.

[90] Peter Tyson, 'Realism, Modernism and Postmodernism: Fontane, Golding and Gillian Flynn.', 2025, 242–54.
[91] Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution
[92] David Brown and Gancalo de Vasconcelos, 'The Third Industrial Revolution -- Internet, Energy And A New Financial System', 2015.
[93] David Brown, 'The Third Industrial Revolution -- Internet, Energy And A New Financial System
[94] David Brown , 'The Third Industrial Revolution -- Internet, Energy And A New Financial System'
[95] T. Ficher. A Third Industrial Revolutio. In Designing Our Way to a better world. University of Minnesota Press. 2016. Page 169-178 as in Mario Ruiz Estrada, The Seventh Industrial Revolution (IR 7.0), 2024, https://doi.org/10.13140/RG.2.2.14881.17763/2.

In the research works of various other scientists[96] the current times are referred to as the Fourth Industrial Revolution (4IR). “Industry 4” as a term relating to current technological developments and practices was coined during the Hannover Fair in 2011 relating to the digitalisation of the production processes with the use of modern technology.[97] Apart from digitalisation it can be related to decentralisation of production through self-control strategies and flexibility through systems sharing information between one another. [98] It was introdused in the wider scope by Klaus Schwab in 2015.[99] It is now a concept, that adresses the dynamic change in technology that has been occuring since the beginning of the second millenia. It seems to enrich itself in technologies, that are a sort of amplification of the technologies introduced during the previous Industrial Revolutions. Where the computers and internet of the 3IR were introduced, 4IR took it a step further and transforms it into a network of devices, that no only communicate with one another, but self-correct and evolve. The Internet of Things (IoT), a network of interrelated devices, reacts to the environment through their inner communication, with the use of sensors, creating a polycentric environment of information management in opposition to a centralised one, characteristic in the Industry 3.0 approach of central servers. The hightened operational efficiency allows for the incorporation of Big Data and complex information management and analysis processes, which are growing in importance in various environments, allowing them to receive a valuable response from isers and consumers, either in the case of app building, marketing strategies or urban planning.[100] Where the previous revolutions introduced and improved the machinery, the 4IR decided to add programmability to it, inventing the robots, making it more and more independent from human interaction apart from the primary programming.

Where the Second Industrial Revolution, backed by by electricity invested into mass production, leading to prefabrication, the 4IR started introducing 3D printing, starting from the smaller scale elements, that now are being able to print a heart in the biotechnological engineering or a bridge in construction. The Augmented reality is a technology that seems to be rather solo-standing, but it also drives from the fantasies of the people of the previous centuries. With all those technologies, the effect of the 4IR seem to be the blurring of the borders between the physical and digial environment.[101] The latest innovation added to every day life is AI and ML. The data processing on such a great scale is the most controversial idea of the current decade so far[102]. The general distrust and environmental impact concerns, as well as the fear of technology outsmarting the humans, a science-fiction notion around hundred years old and concerns surrounding copyright are all valid reasons for assessing the new technology with discretion. However there is never a way to stop the change when it starts, especially in a growth-promoting environment such as the current one. The presented changes and progress since the beginning of the century can back up the idea of humanity being in the midst of the 4th Industrial Revolution. To use Dr. Brown’s metric, the 4IR’s newly introduced or popularised solutions regarding energy source, would include energy from renewable sources, such as solar, wind or geothermal. New ways of communication can relate to either highly portable solutions such as Smart Watches or glasses or the movement of the communication into the virtual world, both in private communication and business. The economic change is particularily difficult to grasp, but could include the spread in popularity of alternative, cloud banking, such as the Revolut.

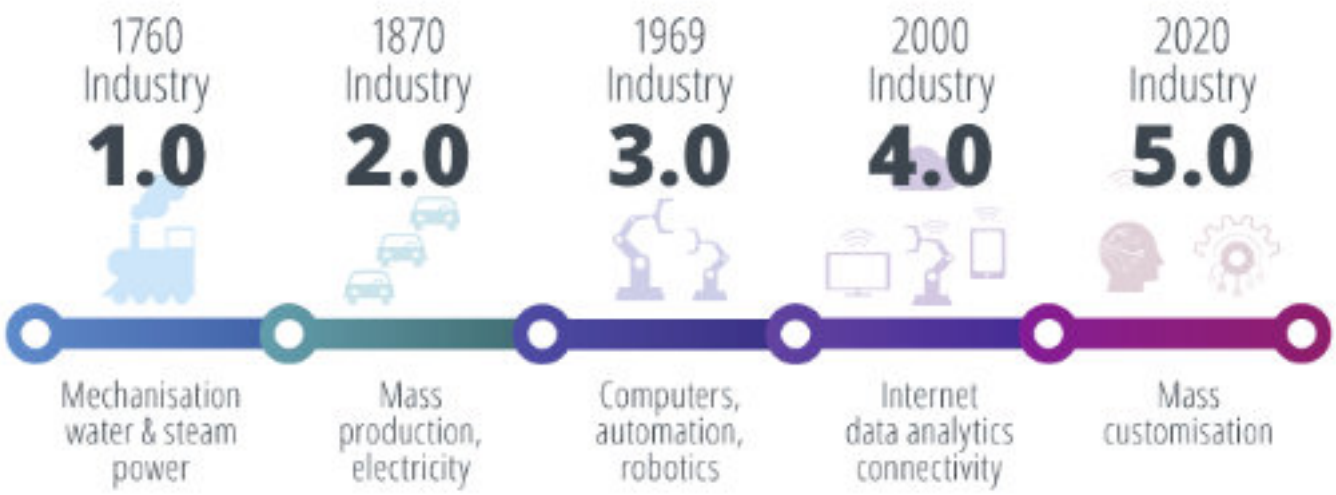


Figure 17 The chronological spread of the Revolutions with the inclusion of the 5th Industrial Revolution, which separation from the 4IR is under discussion. image source: https://nickelinstitute.org/en/blog/2020年/november/customising-the-future-the-next-industrial-revolution/

[96] Umar Turai et al., ‘Contributions of the 5th Industrial Revolution and How the Third and Fourth Industrial Revolutions Differ’ 5 (22 December 2024): 26–31, https://doi.org/10.5281/zenodo.14735606.
[97] Basma Hamad and Maha Jawad, ‘The Fourth Industrial Revolution: A Historical and Conceptual Review’, Journal of Economics and Administrative Sciencespage 155
[98] Christian Leyh, Schäffer, T., Bley, K. and Forstenhäusler, S. SIMMI 4.0: a Maturity Model for Classifying the Enterprise-Wide IT and Software Landscape Focusing On Industry 4.0, Proceedings of the Federated Conference on Computer Science and Information Systems, 2016, pp. 1297-1302. As in Basma Hamad and Maha Jawad, ‘The Fourth Industrial Revolution: A Historical and Conceptual Review’, page 159
[99] Wikipedia contributors, “Fourth Industrial Revolution,” Wikipedia, April 23, 2025, https://en.wikipedia.org/wiki/Fourth_Industrial_Revolution.
[100] Umar Turai et al., ‘Contributions of the 5th Industrial Revolution and How the Third and Fourth Industrial Revolutions Differ’
[101] José Sixto García et al., Journalism, Digital Media and the Fourth Industrial Revolution, 2024, https://doi.org/10.1007/978-3-031-63153-5.
[102] As for September 2024

In the economic sense, the society nowadays has held onto the market framework that was born during the Industrial Revolutions, and continues to value the innovation, growth and freedom of the market. Even the popular notion of current times of talking about the late-stage capitalism, a discussion trending in social media is a redicovery of the concept coined in the beginning of the last century by Warner Sombart. Some argue, that the concept seems to emerge with any economic crisis[103]. However its tendency to reappear showcases the distress that can be associated with the "constant growth" philosophy of the modern economic situation and the fear of collapse with unknown next step. Currently[104] the answer remains unclear, however it is the movements and changes dictated by the environmental crisis that could coin the new system.

The environmental crisis is greatly attributed to the changes in the industry that happened during the Industrial period. Scientists estimate that the year 1830 can be regarded as somewhat the beginning of the anthropogenic climate change.[105] As mentioned in the chapter on history of anthropogenic climate change research and policy, the concern regarding the possible consequences of the human ingeration into the climate have appeared around the same time the new industrial landscape has began to emerge and paint a picture of the possible future. Such foreboding tendency may be viewed as a specific gift of human society, somewhat similar to walking into proverbial lions's den with full awareness of the consequences. However, the technological gains were also the means that allowed humanity to fully grasp the severity of the environmental decline, at the same time providing a better understaning into the functioning of the world. With the progression of the 1980s discussions and colaborations regarding the climate change, one of the significant arguments was delivered through the photographic documentation of the ozone layer above the Antarctic, presented during the Prague conference in 1985 by Pawan Barthia, which proved to be a significant step leading to the recognision of the global warming just few years later.[106]

[103] "Unpacking Late Capitalism," The University of Sydney, December 20, 2022, https://www.sydney.edu.au/news-opinion/news/2022/12/20/unpacking-late-capitalism.html.
[104] As in April 2025
[105] Patrick J. Kiger, "7 Negative Effects of the Industrial Revolution
[106] Sharmila Kuthunur, "How The World Worked to Shrink the Hole in the Ozone Layer," HISTORY, April 25, 2025, https://www.history.com/articles/ozone-layer-hole.

2.2 Influence in architecture and urbanism

Industrialisation brough about change in various scopes of the society, not missing the architecture and urbanism. The First Industrial Revolution in particular, for the sector of construction was no less a shock than to any other. A shock can be defined by an event, that the society might not have been fully prepared for, that brought about change in the way they exist. The shock of Industrial Revolution could be readable in the degradation of spaces, particularily in more industralised areas, where additional waste was not manageble in the way it has been before. Primarily it was caused by the process of human migration to industral hubs for work and the urbanisation that followed. The spaces created rapidly for that use were in vast majority insufficient for human needs. The rapid growth left no space for planning and the preparation of habitable space for the workers was not sufficient. The significant improvement regarding facilities arrived only in 1860, with the popularisation of sewer systems, which was soon expanded to other amenities already available through the Industrial Revolutions, particularily access to water and electricity. That change gave birth to modern infrastructure.[107] On a more social note, that has led to socialist movements in urbanism, like "ownism" which with the arrival of the XX century was picked up by the Modernists. The symbolic representation of the times would include an urbanised landscape, symbolised with the growing skyscrapers, railroads and factories.

The chaos of the industialisation for the cities was the main constributor to the emergence of the variety of urban strategies, coining the current approached to urban tissue management. Urbanisation was, in fact, another effect of the industrialisation. The primary scope of interest in the changing narration surrounding the cities regarded sanitary regulation to prevent the spread of diseases, and with that the emergence of modern urban infrastructures, in a form of sewers, clean water and the management of waste.[108] Hand in hand with that, the urban tissue became wider, as the new vision of the healty city, with improved air circulation, new infrastructure and emerging transportation brought about the reforms of the urban tissue, with most notable examples being the Cerda's plan for Barcelona from 1860, focused on the creation of the grid-like structure of the blocks or the Haussmanisation of Paris, around the same time, with the focus on the wide boulevars. The growing discontent with the quality of life within the cities resulted in the century long search for solutions that have laid the groundwork for the modern cities. With the gradual shift and merging of the urban and rural in the Ebenezer Howard's Garden City concept, the issue of the dynamic between the city and nature had been raised and with that the relation of the nature with the architecture as well. On a more optimistic note, the socially-focused yet highly structured ideas of the urbanism of the CIAM modernism, with the focus on transportation, zoning and standards for basic user comfort in the occupied space laid down the rules, which, partialy opposed or redesigned, set the bar, that now is considered the standard in a civilised environment. As every revolution experiences the stages of birth, rapid growth and then the overexcertion, that too became part of the industrial heritage in the urban development history, with the chaos, that the post-war economic growth brought about in the form of urban sprawl. The later years saw the merging of the both experiences- the tradition and teh novelty, within the New Urbanism and Post-modern thought on growth. All these approaches have shaped the current approach to urban development, where the strategic, often planned from the top approaches utilise the technologies of the 5th Industrial Revolution to answer the same issues as before, as provision of afordable housing or the creation of user-friendly spaces, but through the lens of more sustainable approach, critical towards the solutions, multifaceted and focused on environemental resilience. The current stage for the urban development is a mesh of the past successes and failures and as a complex issue grows more and more in the direction of cocreation and participatory solutions.

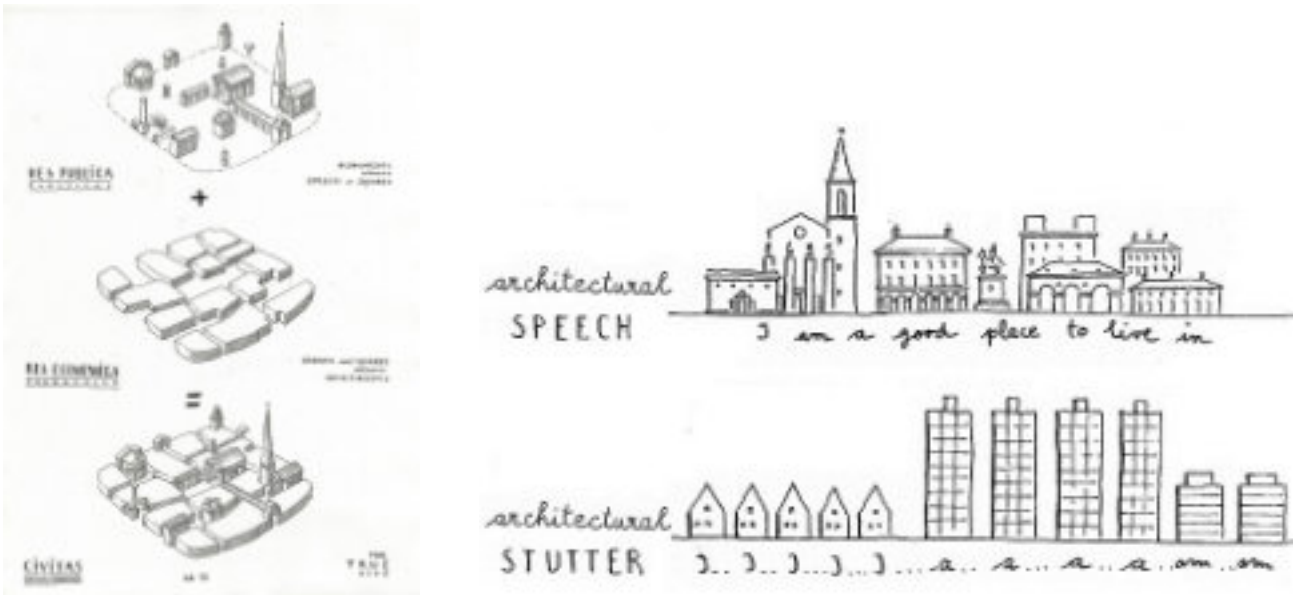


Fig 18 Leon Kier's true city concept as an example of the mixing of the directions of development, image source: Leon Krier, Drawings for Architecture (Cambridge, MA: MIT Press, 2009), page 34 as sourced in https://www.architectural-review.com/essays/leon-krier-on-sustainable-urbanism-and-the-legible-city
Fig x Leon Krier on repetitivity of thought, Leon Krier, Drawings for Architecture (Cambridge, MA: MIT Press, 2009), page 58 as sourced in https://www.architectural-review.com/essays/leon-krier-on-sustainable-urbanism-and-the-legible-city

[107] Francis D.K. Ching, Jarzombek M., Prakash V. A Global History of Architecture. Third Edit. New Jersey: John Wiley&Sons, 2017. As in Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution
[108] "HIST 234 - Lecture 11 - the Sanitary Movement and the 'Filth Theory of Disease' | Open Yale Courses," n.d., https://oyc.yale.edu/history/hist-234/lecture-11.

The growth of the industry and cities determined the need for new typologies of buildings. Firstly for factories, which sizes could only be compared to one type of structure constructed before, churches, which shows a symbolic shift of focus of the society as a whole. On the urban note, the need arose for bigger public buildings. Traditional materials, such as brick, stone or wood have been replaced by new inventions. The introduction of iron as a construction material can be attributed to the construction of Coalbrooksdale bridge in the 1770s. Some say that this point marks the beginning of the Industrial Age in Architecure.[109] Use of iron allowed for the structures with greater span between the construction materials, creating the space for the emergence of yet another invention, sheet, big scale glass. A notable structure, erected in 1851 for the London's "Great Exhibition" was The Crystal Palace, designed by Sir Jospeh Paxton.[110] The glazed elevation, connection between the interior and exterior and showcasing of the structural elements are the characteristics that were later adopted by the XX century architects and designers.

The possibilities of the new material allowed for the city skyline to raise rather significantly. It is not suprising that the most notable attempts of incorporating new construction systems happened during exhibitions. The innovation needs time to find its way into the environment that surrounds the people. The entrance to the 1889 "The Exposition Universelle" in Paris (figure 19), designed by Gustava Eiffel, is an example of one of those experimental exhibitions that were not deconstructed. The Eiffel Tower showcased the possiblity that iron provided for building up, while during the same exhibition, the Galerie de Machines by Ferdinand Dutert exhibited the same possibility on a horisontal scale.
The second part of the XIX century witness the incorporation of steel, more elastic then iron. The primary ages of using steel in construction are interconnected with the American Chicago style, otherwise known as "Commercial Style"[111]. The 1880s and 1890s Chicago buildings were characterised by steel construction with additional cladding, often use of the then emerging elevators, with characteristinc, regular windows. One of the Chicago style design, William Le Baron Jenney's The Home Insurance Building from 1885 is considerend to be the first modern skyscraper.[112]

The field of architecture while being a follower of the changes in industry, resurfaced on the forefront with the introduction of prefabrication. The change of century introduced the reinforced concrete in 1892, founded by Hennebique and Coignet[113]. Due to its structural characteristics, the interplay of concrete with strong resistance to compression and steel with stron resistance to tension, popularised the material rather quickly. The ability it provided, with the possibility of framework structure and more flexible layout, were the basis of the Modernism in Architecture. Apart from the new possibilites of the industrial materials, thinking abouth habitat as a machine, with its noth positive and negative results, would not have been possible without the social changes that happened as a result of the Industrial Revolutions. It can be said that through technology some boundaries of the convenances in design have been outrun and XX century emerged as an era of designing "in contrast", firstly in contrast to historical traditions with Modernism and later in contrast to Modernist overt functionality in the mesh of discourses and attitudes that is Postmodernism.

Fig. 19 Exposition universelle de Paris 1889 postcard, the innovative possbilities fo architectural exhibitions. Image source:https://pl.m.wikipedia.org/wiki/Plik:Exposition_Universelle_de_Paris_1889_-_Universitäts-_und_Landesbibliothek_Darmstadt.jpg

[109] Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution, page 252
[110] Francis D.K. Ching, Jarzombek M., Prakash V. A Global History of Architecture. Third Edit. New Jersey: John Wiley&Sons, 2017. As in Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution
[111] Wikipedia contributors, "Chicago School (Architecture)," Wikipedia, March 21, 2025, https://en.wikipedia.org/wiki/Chicago_school_(architecture).
[112] Minel Kurtuluş, Changes int the use of materials in the field of Architecture after the Industrial Revolution, page 254
[113]

2.3 Future scenarios

With the 4IR being still a current revolution with undefined time framework and consequences, some scientists debate on the next steps that the technological progress will undertake. In the research of Nigerian researchers[114] the 5th Industrial Revolution is thought to be focused on the integration of human creativity with advanced technologies, with the aimes of a more sustainable approach to the one experienced now, which seems to echo the notion presented by the Schwab's believe in the ability to shaping the human-centric world, as citied in Galician researchers work on Journalism in the 4IR.[115] The hypothetical character of the 5IR would be responsive to the issues emerging from the 4th Industrial Revolution. With the growing concern regarding the scope of influence of the AI, new innovations ought to address it with the implementation of systems for ethical uses of this technology, its limits and clarification of copyright regulations. The current trend of incorporating smart technologies would be continued and improved on the urban scale, with self-assessing systems as well as use of sensors and BIM technologies for raising the sustainability of manufacturing through efficiency and waste monitoring. AI and 3D printing could lead the way to personalised and quick healthcare, while the innovations in robotics to the improvement in existing prototypes of sentient robots, care robots and cobots, cooperative robots designed to work alongside humans.[116] In regards to technology, the current state of art being the energy obtained from fusion, the further development might see its more efficient and common use.

The next stage of innovation would focus further on the sustainable solutions, with the utilisation of elective mean of public transport and reduction of plastic use and better adoption of recycling processes.[117] Furthermore the Econographication Laboratory researcher estimates that these innovations would be followed by the 2035 Sicth Industrial Revolution, focusing on the high automation of production processes and robotics alongside the incorporation of big-scale energy storage systems, derived from green sources.[118]

Beginning in the 2050, with the start of the Seventh Industrial Revolution the energetic systems are hypothetised to evolve into more flexibility with the function of removability and the use of laser and auto-energy, with the ability of generating constrant stream of energy. In terms of AI, the researched assumes the possiblity of, what he calles, Natural Organic Artificial Intelligence Systems, a network of complex, intelligent mega and micor devices that communicate with each other. He estimated that the main challenge would be a social one, in regard to redefinition of labour through some jobs been transmited to Humanoids and the issue of social acceptance of the new sentient addition to every-day life.

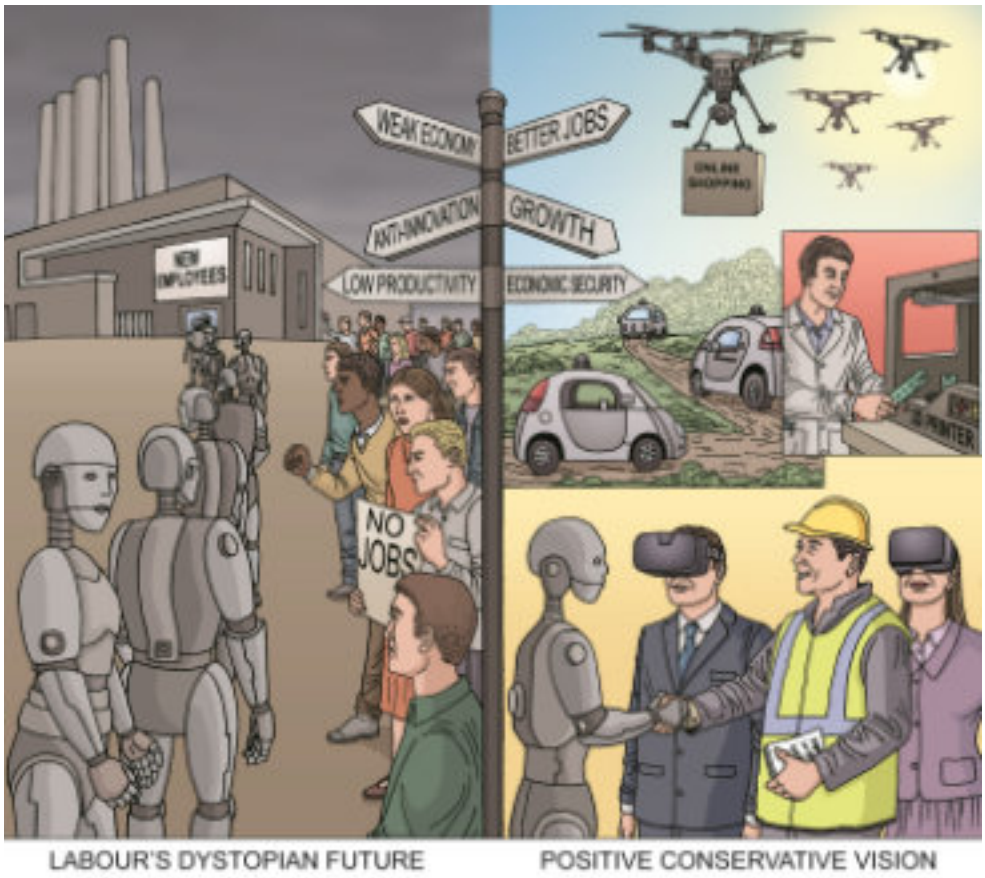


Fig. 20 Vision of the current times/ nearest future. Alan Mak MP. Geyying to the Future First: How Britain can lead the Fourth Industrial Revolution. Edit ConservativeHome. https://www.alanmak.org.uk/sites/www.alanmak.org.uk/files/2017-11/4IR%20ConHome%20brochure%20FINAL.pdf

[114] Umar Turai et al., 'Contributions of the 5th Industrial Revolution and How the Third and Fourth Industrial Revolutions Differ'
[115] José Sixto García et al., Journalism, Digital Media and the Fourth Industrial Revolution, page 5
[116] Umar Turai et al., 'Contributions of the 5th Industrial Revolution and How the Third and Fourth Industrial Revolutions Differ'
[117] Mario Ruiz Estrada, The Seventh Industrial Revolution (IR 7.0)
[118] Mario Ruiz Estrada, The Seventh Industrial Revolution (IR 7.0)

3. The zeitgeist of the XXI century

The "zeitgeist" is a term from the German language, that can be translated literally into "the spirit of time". The term is widely used in reference to the specific "climate" or characteristic of the times.[119]

Defining the nature of the times mid-development is oftentimes a rather taxing exercise, mostly due to the fact, that lack of clear ending, a boundry or significant trend-changing events, the variety of different opinions and point of view in not possible to succumb to a single framework that at least the majority would agree on. However a self-reflection it is a important skill. There has already been a great deal of papers written, videos published and art produced to comment on the current changes or even try to predict the outcomes. The XXI century is widely regarded as an Age of Change, revolutionary to the point of the word loosing its meaning due to the rapidity of changes. Every step seams to bring about planning for the next two. As we only begin to contextualise the emerging changes of the Fourth Industrial Revolution, related to the use of Artificial Intelligence and Big Data systems, it is quickly followed by the emergence of the next step, mentioned for the first time in Japan in 2016,[120] of "Society 5.0".

3.1 Society 5.0 in regard to technological layer

Society 5.0 is a concept decribing the society we are just now beginning to build. While the first use of the concept is almost 10 years old, the idea will most possibly correlate with the timeframes for the 5IR and share its values. The characteristics mentioned in the discussions surrounding the 5.0 Society often refer to the cyberspace, while linking it with the benefits of the evolvement of the virtual reality technology, AI and the lessons of the COVID global pandemic and the climate distress. The digital and physical worlds are intertwined in that concept, meaning that the physical world is translated into the digital data, processed and sprung back into the reality in a form of service.[121] This can be viewed as the extraction of the initiative from the person, a tendency that began with the mechanisation of the Industrial Age, supported by the automation of the robotisation changing into the automation of analysis and decision-making moving into the cloud. As the systems progress and communicate with each other with greater accuracy, the network of codependencies creates an ability to create a holistic space for all interested parties.

The Society 5.0 can be recognised as a human-centric approach. While the previous two decades may have been more focused on the technology-driven approaches, as mentioned in the research based on Japan, the further steps of development would shift into being more human-based. "Super cities" concept, for the Japan's new proposals for the development in this decade reflect that idea, with the main objectives being the wishes of the citizens and a provision of the architect to realise them. That does not mean not utilising the same or enhanced technologies to obtain the desired objectives, rather shifting the focus of the initial actions to be based on bottom-to-top based prerogatives.[122] That can be achieved with the data gathered and analysed through the IoT smart systems within the societies, that could inform about the local needs with more accuracy than the top-viewed objectives. A sort of passive participation of the individual unit. That approach correlates with the current emergence of the active participatory solutions for urban planning and the social character of the variety of the Sustainable Goals. This idea of society aims to drive itself into the space of collaboration and further globalisation as well as the creation of greater flexibility, like in yet another Japanese concept of "digital garden city", which is a concept for the society, that allows for a comfortable living anywhere within the country. That concept is related to the ideas of equity, economic stability, environmental stability, that would allow an individual to freely decide their lifepath, with no limitations based on societal status, gender or climate instability. As for now the ideas seems to be realised mainly through the continuation of the smart city tools, with the widespread monitorisation and data analysis being conducted on the government level.[123]

Fig 21 Evolution of the Society, image source: https://innovaromorir.com/en/society-5-0-concept-challenges-examples/ [accessed 17th of April 2025]

[119] "Zeitgeist," in Merriam-Webster Dictionary, May 20, 2025, https://www.merriam-webster.com/dictionary/zeitgeist.
[120] Manufuture High-Level Group. Manufuture Vision 2030: Competitive, Sustainable and Resilient European Manufacturing. 2018.
Available online: http://www.manufuture.org/wp-content/uploads/Manufuture-Vision-2030_DIGITAL.pdf (accessed on 2 March 2021). As in Mária Kozlovská, Daria Klosova, and Zuzana Struková, 'Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review', Sustainability 13 (2 March 2021): 2683, https://doi.org/10.3390/su13052683.page 1
[121] Chiaki Hirai, 'What Defines the Architecture? An Approach to the Architecture of Society 5.0', in The Architecture of "Society 5.0", 2025, 3–12, https://doi.org/10.1007/978-981-96-2929-9_1. Page 6
[122] Tadashi Kaji et al. "Trends in Smart Cities: Global and Japanese Perspectives: in the *Architecture of "Society 5.0",* ed. Chiaki Hirai (Singapore: Springer Nature, 2024), doi: 10.1007/978-981-96-2929-9_2
[123] Tadashi Kaji et al. "Trends in Smart Cities: Global and Japanese Perspectives: in the *Architecture of "Society 5.0",*

Nowadays, while the individual solutions in line with the Society 5.0 objectives exist, the idea as a whole is at its starting, ideological moments. The common solution for now, regarding the point of view of researchers, is the creation of further, more detailed methodologies,[124] which echoes also the tendencies within all globally discussed issues, such as sustainability in environment preservation for example, that often works through the globally set objectives. The current and approaching age could possibly be refered to as the Age of Standarisation. However there's truth to the fact, that such system can be utilied quite well when it comes to global cooperation and a better option has not yet been invented. Perhaps with the development of the AI, the learning machine would sooner or later be the ones to set the standards that dictate their own functioning. Such a thought have been echoed in the works of fiction for quite some time. The tendencies from the world of fiction tend to be implemented into the reality in one way or another as they herald the visions of the people from the past.

The Japanese concept of Society 5.0 underscores the main 6 key aspects that need to be taken into consideration on the path of implementation. Primarily, the implementatation of smart solutions must be based on "Social Acceptance" transparent decisions to building trust in the citizens or end-users, both to the representatives and to the systems.[125] Such trust would become more and more important with the integration of future innovations and therefore is heavily based on the cybersecurity structures implemented by the governments. Such doubts are not unfounded. The recent times seem to maintain the big scale cyber failures as a common occurance. Some of the more notable examples include the October 2021 Meta global outage, that was an outcome of a server communication failure and ended up in a total withdrawal of the Meta products from the internet[126], resulting in the inability of the companies that used Meta for their work to function and hence decreasing their further support for the tool. Moreover the increasing number of cyber attacks, experienced worldwide within both the government representatives and civilians, have not helped the situation. As recently as in March 2025 in Belgium an anonymous Russian group brought down the Belgian government website, effectively cutting its citizens from access to their tax fill platform, or accessing public health website.[127] While not being as aggressive as data stealing-focused attacks, that tend to happen as well, such situations pose great threat to the feeling of security and to the effectivity of the incorporation of new technologies within the social structures, which is, in the end, one of the main reasons for progressing the technological path with the social services organisations.

The ensurance of the beneficial character of the technological investment is yet another objective of the Japanese Society 5.0 concept, under the name of the Quality-of-Life based assessment. As the shift will require a great amount of financial focus to achive the goal, it requires advanced and innovative security systems. The society generally is cautious, when it comes to relinquishing its privacy. While such a statement may seem counterintuitive in the face of the oversharing tendencies of the current social media users, the difference lies in the consent of what information is released out into the society and in what way and scope. Data Governance key factor, mentioned in Japanese vision refers to that issue of data ownership, together with Citizen Participation objective. The data insecurity within society is most visible in the discussion surrounding the use of the AI. With the lack of sufficient and clear systems of AI data protection, the issue that emerges repeatedly withing the social media discussions is the issue of the unauthorised use of works of individuals, available online, for training of AI. As the discussion is multifaceted, it would be hard to summarise it. One thought, however seems to be most prevailing. The rise of technological solutions and tools rise the inicial protests and if not equipped with the clear and precise way to bypass them, such as a ability to include an embeded statement within the work, that make the work unreadable for the AI, or analog solutions for parking or banking, that do not require more apps or more subscriptions, that forceful approach to bringing about change would result in the contrary reactions among the masses, driven by the distrust and rising hostility. The Society 5.0 concept related to that occurance, in some way, in Human Resource Development keypoint, through pointing out the importance of technological education and enabling the gradual familiarity within all social groups.[128]

Figure 22 Vision for the Society 5.0 with automated driving, AI-based analysis, sustainable and environemtally friendly solutios and full automation of production. Image source: https://cloud-ace.jp/column/detail253/

[124] Atsushi Degushi, Derivation of the Key Factors as Methods and Implementation Procedures for Society 5.0 Architecture, in the *Architecture of "Society 5.0"*, ed. Chiaki Hirari (Singapore: Springer Nature, 2024), 10.1007/978-981-96-2929-9_3
[125] Tomoyo Sasao and Shin Osaki, Six Key Factorsfor Making a Smart City People-Centric and Sustainable in the Architecture of "Society 5.0", ed. Chiaki Hirari (Singapore: Springer Nature, 2024), 10.1007/978-981-96-2929-9_4
[126] Josh Taylor, "Facebook Outage: What Went Wrong and Why Did It Take so Long to Fix After Social Platform Went Down?," The Guardian, October 6, 2021, https://www.theguardian.com/technology/2021/oct/05/facebook-outage-what-went-wrong-and-why-did-it-take-so-long-to-fix.
[127] "Pro-Russian Hackers Attack Belgian Government Websites," belganewsagency.eu, March 24, 2025, https://www.belganewsagency.eu/pro-russian-hackers-attack-belgian-government-websites.
[128] Tomoyo Sasao and Shin Osaki, Six Key Factorsfor Making a Smart City People-Centric and Sustainable in the Architecture of "Society 5.0"

The vague idea of the technological future is not, however, hard to imagine. While the majority of the most state-of-art technologies have developed roughly since 1980s, moving into their matury and becoming widespread with the emergence of the new century, the previous century and the centuries before that have laid the groundwork for the direction of the development and continues to do so. The forseeable possiblities for the technologies, derived from the needs of the society and their vision for the future, have inspired a great deal of creatives. The ideas for the current technological innovations can be tracked by to the various pieces of fiction, art, movies or literature. The dreams of those of the past have shaped the reality of today.

The most discussed technologies nowadays are ones related to smart infrastructre, aiming to optimise and automate everyday systems, from motion-based lighting to smart homes networks, the growing usage of AI, which emerged in that form only in the past few years, household robotics and self-driving cars, as well as discussions regarding commercial space travels and Mars habitats.

While there are multiple examples of science-fiction literature, that has inspired actual scientific inventions, it is the cinema, that has had a particular relationship with science, both driving inspiration from the technological innovations and bridging a path of making their science-fiction visions come to reality. This may come from the fact that cinema, due to its specific ability to depict a plausible reality and sell it well to the viewer, is a great media for any sort of idea propagation.

In terms of AI, in the research on the correlation between technology and cinema by Federico Monaro, he mentiones three pieces of cinematography that are crucial to understanding the ideas behind the current AI discussions. The films he refers to are *The Bicentennial Man, Ex Machina and Her*. *The Bicentennial Man,* a film from the 1999 focuses on the idea of humanity through the "eyes" of the robot that developes consiousness and the desire to be treated as human. The boundaries between human and robot and the underlying fear and wonder on the possibility, that humanity will become a creator of the new intelligent species is echoed in a more novel productions, such as *Ex-machina* film from 2014[129] or a video game *Detroit: Become Human* from 2018, that focuses on the androids path to gaining rights, which outcome is determined by the players decisions. The humification of robots is a recurring theme with the rise of AI in everday life.

The new technologies develop in the direction of the grand Metaverse, which, in general, is a virtual space, characterised by immersion, interactivity and user agency, in the future, ideally, working as a interconected system of co-dependent areas. The areas of life, from gaming to house buying would therefore be moved into cyberspace, where the avatar substitutes of real-human interested parties would manage the issues at table. That is the most probable development for the near future as of now.[130]

Figure 23 A view from the game Detroit:Become Human, showing the androids march fro freedom and autonomy. Image source: https://isaacmeyer.net/2022/08/detroit-become-human-the-game/

[129] Federico Monaro, 'AI, ROBOT, AND CONSCIOUSNESS: A BRIEF HISTORY IN CINEMA', Orbid Idearum 12, no. 2 (n.d.): 59–71.
[130] Claus Rosenstand, Jacob Brix, and Christian Nielsen, 'Metaverse and Society 5.0: Pivotal for Future Business Model Innovation', Journal of Business Models 11 (22 November 2023), https://doi.org/10.54337/jbm.v11i3.8124., Page 64

3.2 Philosophical layer

Through the lenses of a more philosophical approach, the inability to clearly define current times stems from the fact that the "previous" methods, under the umbrella term of Post-modernism, haven't really been defined either. A researcher Jésus B. Quintero, raises this issue[131], citing Ihab Hassan's article from the beginning of the century, "what was postmodernism in the first place? I am not at all certain, for I know less about it today than I did some thirty years ago."[132] Although the criticism regarding the ouvert belief in the progress, and a sort of naive implication of the novel ideas of the first decades of the XX century are rather valid, it can't be denied that Modernism has laid a groundwork of human rights, especially in spatial terms. Postmodernism, in Jean-François Lyotard's view started with Aushwitz,[133] however the atomic bombing of Hiroshima and Nagasaki migh be just as good starting point. The horrors of the two world wars have undoubtedly created an environment of nihilistic form of irony and disbelief, which in the first two decades after the wars in particular, regarded under the term of Late Modernism or Postmodernism, have led to a distrust. When Modernisim can be viewed as a possitive belief in the possibilities of new approaches, validating the disregard to the historical heritage of humanity, Postmodernism has already seen the worst of the outcomes such unwavering trust in new can bring. It can be debated that the inability to define Postmodernism, mostly due to its fragmentation of views and very policentric nature, can be attributed to that very distrust in humanity as a whole and therefore in any kind of holistic metanarratives that coudl drive it. Timotheus Vermeulen and Robin van den Akker's echo the view of Postmodernism as a term as simply the "buzzword" for the choas of different perspectives that was the middle of the XX century.[134]

Understanding the source of the postmodern distrust can allow a better understanding of the XX and XXI century shifts. The last two decades of the XX century have been the final stages of the postmodern thought, along the wonderings of the next step. While its beginnings can be traced back to the nuclear bomb and Auschwitz, current times, in Quintero view, and therefore the final end to postmodernism, can be pinpoint to the 9/11 terrorist attack. He defines this as a interstitial period of passage to the current times, with its end in the 2012 finishing stages of the Arab Spring and the Occupy Wall Street movement.[135]

An interesting view on the current times directions can be provided through the perspective of continuity of the modern narrative since the Enlightment. Jurgen Haberman has stated such in the 80s, indicating the XX century as a continuation of the search of objective science and human-centered appraoch.[136] While this narrative is not in tune with the general characteristics of the postmodern times, that can be accepted as a counter movement to the general narrative, which has been a rather intuitive human reaction- to oppose and to question. Each Reformation has brought about a Counter-reformation, and it can be argued that the opposition of the Modernism towards the historic traditions and then the Postmodernism towards the Modernist functionalism and machine-like unified approach to human issues, do not negate the continuity of thought provided by that few centuries long discourse. While the source-effect and the influence of the past on the present can never really be negated, the narration of this thought can be regarded as more related that through the lenses of simple causal reaction.

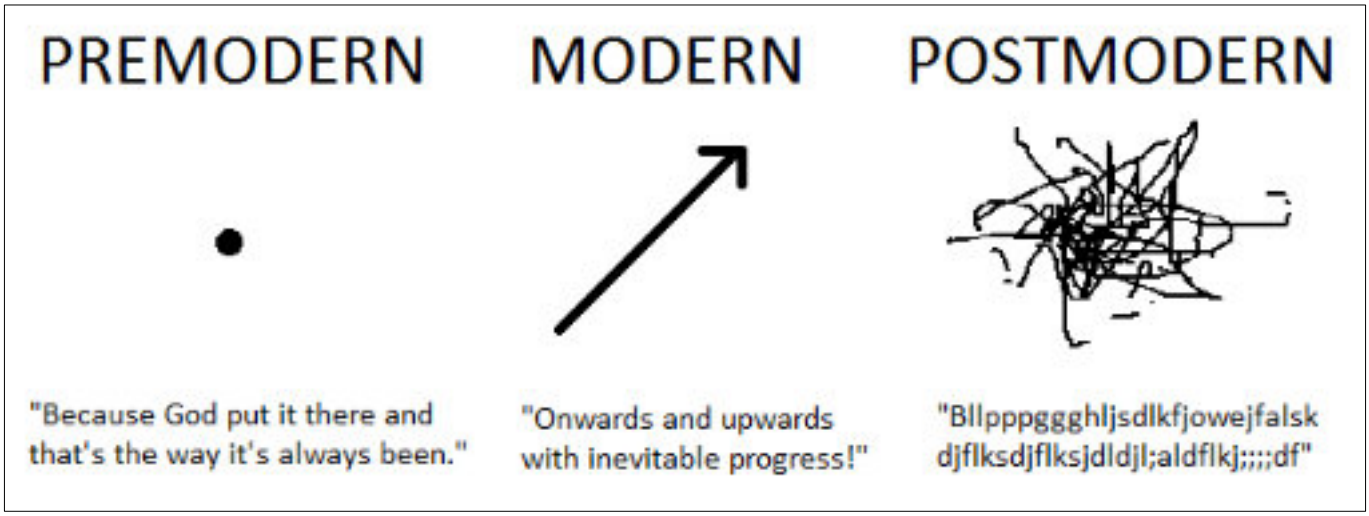


Figure 24 A symbolic view on Premodern, Modern and Postmodern, image source: https://owlcation.com/humanities/Postmodernism-Explained [accessed 12 April 2025]

[131] Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium', Oceánide, no. 15 (2022): 17–25.
[132] Ihab Hassan. "Beyond Postmodernism: Toward an Aesthetic of Trust." In Beyond Postmodernism: Reassessments in Literature, Theory, and Culture, ed. Klaus Stierstorfer, 199–212. New York: Walter de Gruyter., 2003, page 200 as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium'
[133] LYOTARD, Jean-François. 1991 (1988). The Inhuman: Reflections on Time. Translated by Geoffrey Bennington and Rachel Bowlby. Cambridge: Polity. As in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium', page 18
[134] Vermeulen Timotheus and Robin van den Akker. "Notes on Metamodernism." Journal of Aesthetics & Culture 2.2010 as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium',
[135] esús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium',
[136] Habermas Jürgen. 1981. "Modernity versus Postmodernity."New German Critique 22: 3–14. As cited in esús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium' page 18

A similar sort of idea can be found in Critical Realism of Lopez and Potter, which goes back to the last century to redefine Post-Modernism as a reformist stage of Modernism, therefore critical of its predecessor values.[137] The next stage would therefore be yet another critical response to the gifts of the past. Kirby agrees with that approach to an extent in his *digimodernism* philosophy. In Quintero's words Kirby "defends the modernity is an unfinished project (...)"[138] and thus regards both the Modernism or Postmodernism as stages of Modernity. At the same time he puts great importance on the point of distinction of what's to come from what's known, but should be analysed through its own tools, achieved through both the Modernists ideal and the "stance of disbelief towards metanarratives" achieved through the mid decades of the XX century. Similarily the *hypermodern times* of Lipovetsky looks towards the future as a continuation, but regarding that *project of modernity* as a mix, that can't simply go back to the Modern or Premodern solutions due to the irreversible changes that *atomised* the society through the freedom of choice, independencies and dispelling of myths an therefore created an environment which lacks singular narrations and the safety they can provide.[139]

While the decisivness to move forward in the narrative of the current times in predominant, some kind of nostalgy can be found in variety of thinkers philosophies. Eshelman's performatism views the transition from the Postmodern to the new century as a return of the refereciality of the past epochs through *ostentation, double framing, dense subjectivity and an authorial mode of organisning temporal and spatial relations.*[140] His view creates a picture of the monistic subject, possibly as a distinction to the fractualisation of narratives of the Postmodern narrative, that operates through sincerity and belief. Authenticism is echoed in the Edward Docx's 2011 work, where he defines the emerging times as the Age of Authenticism as he refers to the common "(...) desire to be redeemed from the grossness of the consumption, the sham of the attitudising, the teeming insecurities(...)".[141] Nicholas Burriaud on other hand notes the *hark back* to the previous period in his version of current times, *altermodern*, a reaction against standarisation, therefore stating not a return of previous narratives, which he deems impossible, but a sort of remixing of traditions for the global network.[142]

One of the most successful alternatives to postmodernism, according to Quintero, is Vermeulen and van den Akker *Metamodernism*, as it creates a in-between space for discussion, in their words "(...) between a modern enthusiasm and a postmodern irony, between hope and melancholy, between naivete and knowingness, empathy and apathy, unity and plurality, totality and fragmentation, purity and ambiguity"[143]. Therefore metamodernism works as a self-regulating pendulum that swings back and forth between those extreemes, as a result, achieving a sort of balance.[144] Interesting in its versitility, Metamodernism can be viewed as an outcome of Postmodernism, not its alternative and alonside the Post-postmodern narratives of Jeffrey T. Nealon could lead the discussion of a mutation past a "tipping point" in Nealon words[145], without going back into previous solutions or forced relation to them, however understanding current ideologies as their result, continuation or even escalation in some aspects. All in all that view would suggest, that current times are not the New Age in terms of thought, but rather previous thought morphing into something new or the embodiment of previously theorised views changing into current day truisms and therefore that philosophy is applicable to the majority of cases of the Now, with neoliberalism taking on new roles and capitalism transforming into the present moment rather that being at its final stage.[146] The amplification seems to continue under new forms and its end cannot yet be determined.

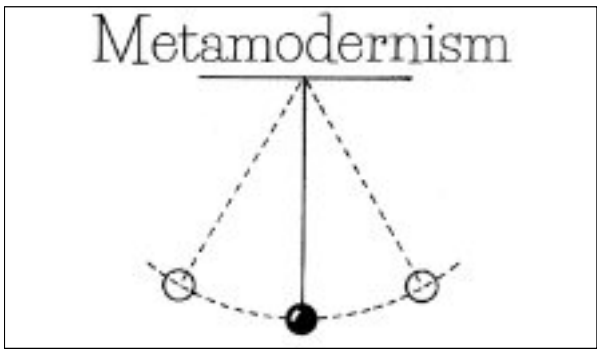


Figure 25 Metamodernism's oscillation between serious modernism and ironic postmodernism, image source: Peter Clarke, "The Bleeding Edge of Metamodern Culture," The Decadence Project (blog), January 23, 2023, https://peterclarke.substack.com/p/the-bleeding-edge-of-metamodern-culture.

[137] LOPEZ, Jose and Garry Potter, eds. 2001. After Postmodernism: An Introduction to Critical Realism. London: Athlone. as in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium
[138] Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium', page 22
[139] CHARLES, Sébastien. 2005. "Paradoxical Individualism: An Introduction to the thought of Gilles Lipovetsky, by Sébastien Charles." In Hypermodern Times, by Gilles Lipovetsky, translated by Andrew Brown, 1–28. Cambridge: Polity. As cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium',
[140] Esherman Raul. Performatism, or the End of Postmodernism. Aurora, CO: The Davies Grou, 2008, pages XII-XIII, as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium'
[141] Docx Edward. "Postmodernism is Dead." Prospect Magazine, August. 2011 as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium', page 19
[142] Bourriaud Nicolas. Altermodern: Tate Triennial. London: Tate. 2009.as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium', page 22
[143] VERMEULEN, Timotheus and Robin van den Akker.2010. "Notes on Metamodernism." Journal of Aesthetics &Culture 2. https://www.tandfonline.com/doi/pdf/10.3402/jac.v2i0.5677?needAccess=true (Last access: December 11, 2019). As cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium' page 22
[144] Luke Turner and Luke Turner, "Metamodernism: A Brief Introduction - Notes on Metamodernism," Notes on Metamodernism - (blog), February 8, 2019, https://www.metamodernism.com/2015/01/12/metamodernism-a-brief-introduction/.
[145] Nealon Jeffrey T. Post-Postmodernism: Or, the Cultural Logic of Just-in-Time Capitalism. Stanford: Stanford UP. 2012 page 9 as cited in Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium' page 23
[146] Jesús Bolaño Quintero, 'Post-Postmodernism: Mapping Out the Zeitgeist of the New Millennium' page 23

The Quintero interstitial period of the first decade of the XXI century can be summarised as a longing for the rediscovery of the initial modern values through the relative balance achieved with the opposing tools and approaches provided by the Modern and Postmodern reactions, a desire that is not so much about going back into the modern values in their true form, but a continuation of thought. He argues that the outcome for the current times, through the co-existing of the contrasting narratives in the last few decades have fed an emergence of "pseudo-objective perception of reality" and a society filled in micro-metanarratives and lacking in relativism towards one's own believes and empathy towards the process of creation of the metanarrative of others. The results of that are visible within any topic of public dispute, which often bases its statements on *post-truths,* and results in a society radicalised, almost polarised, on few reemerging issues, namely regarding social issued, such as women bodily autonomy, LGBTQ rights and climate change. The modern values provided by the previous century filtered through the individualisation and relativism of the Postmodernism seem to result in distortion of the same values to fit the mold of the subjective worldview, resulting in a cognitive dissonance on the subjective-objective spectrum. The search of authenticity and indentity will most probably be more and more prevailing with the continuation of the evolvement of the meta reality. The next decades will possibly see the concluding thought to the fall of authenticity stated by Boudrillard in his hyperreality theory, and the unknown border between real and not real, stated in the 1980s.

3.3 Business layer

Alongside the blurring of the lines of the radical approaches of the XXI century, a similar tendency can be observed in other aspects of the human society. Dehnavi and Dehnoi argue in their research that the current narrative of business has integrated itself into human lifestyle.[147] They pinpoint the said characteristics of the change within business, where the main focus being shifted into flexibility, personalisation and sustainability.

The personalisation withing the business sectors is an effect of the individualised nature curated through the XX century influences. Within the scope of capitalism the main narrative places the customer as the main driver of the economy, the kind that dictates the nature of the business. Free market is drived by the competition, therefore the adjustability to the needs of the customer has been growing in importance possibly since the Adam Smith's *laissez-faire* economy theories of the XVIII century. The tendency to choose the business most in line with one's needs and worldview is therefore not a new occurance and similarily, neither is the business adaptability to that state of things. However, the novelty of the XXI century brought about in regards to the individualisation of the business sectors lies mostly in the technological advancements.[148]

Flexibility is based on the the new ways we work and live. One of the significant innovation of the XX century has been a widespread of short-term rentals, redefining the sector of hospitality, for better of for worse, as well as the real estate. New renting patterns have affected traveling choices and delegations and remote work choices. The emergence of the co-living options provide a specific, affordable option of living, while co-working spaces, particularily those designed for rent, have redefined the nature of work. Those opportunities cater to the society that values adaptability and freedom.[149] Within the scope of finance, that has materialised throught the solutions of decentralised financing, with the growth in popularity of the online banking systems like Revolut or the alternative currencies, such as cryptocurrencies. The freedom of expression of thought, mixed with the availability of information and options have, together with a general distrust to traditional institutions have popularised those alternatives to traditional banking.

Sustainable solution come from the growing environmental awareness of the younger generations in particular, alongside with the governmental and international organisations legislations and standards. The customer demad shifts more into the optimisation of the functioning of the building they live or work in, to provide smart solutions for water and electricity usage, as well as HVAC.[150]

Additionally, the work and education have seen a growth in the area of digitalisation and virtual reality. The online conference platforms, online trainings and university-curated, often interactive, online courses have brought those two area closer to the place of living and risen the affordability and adaptability to various human needs. The solutions emerged and evolved thorough the XXI century, laying the ground work for their own amplification, after the pandemic. For every human need, there is a platform to provide that marker, from real estate, through grocery shopping with delivery, up until remote doctor consultations.

Figure 26 Author Santiago Bara, image source https://www.demilked.com/illustrations-social-issues-santiago-bara/

Figure 27 a photo from the polish shop, the collection of coupons available to buy at the cash register, among which a coupon for phone consultation with a doctor

[147] Mohammad Dehnavi and Morteza Khani Dehnoi, Modern Life: Lifestyle Innovation, 2024.
[148] Mohammad Dehnavi, Modern Life: Lifestyle Innovation, page 4
[149] Mohammad Dehnavi, Modern Life: Lifestyle Innovation, page 5-6
[150] Mohammad Dehnavi, Modern Life: Lifestyle Innovation, page 6-7

The variety of sectors have embraced the shift from ownership to access solutions. Where the first decade of the XXI century offered selling products, either movies, property, cars, the current companies provide subscriptions. The streaming services, ebook access subscription, architectural programmes, even subscriptions to real estate webpages or, most curiosly, dating apps, have dominated every availabe area of human need. Subscription-based access, while providing an orbitrary feeling, as the user is never the owner of the platforms or services they rely on in their daily life, has its benefits in the fast-paced worls, providing accessibility to the state-of-art technologies and new productions, accessible from the comforts of home almost as soon as they're launched into the market.[151]

The subscription to society, as this occurance can be summarised as, main characteristics include the economy of sharing, sharing home through Airbnb, sharing carrides through Uber, co-working through workspace rental, warehouse rental, and further all of the rentals of the access to online databases and webpages.

The background for the Society 5.0 interactions is the city. According to the data provided by NATO, as cited by the Dehnavi, the population living in the city will reach 68% by the middle of the century.[152] That puts an emphasis on the importance of providing smart, environmentally concious solutions within the urban tissue, as well as ones that optimise the service provision to cater to a growing number of users. The public transportation, housing, renewable energy solutions become fundamental issues. Within the emerging society, the arising problems would be managed through the rising technologies. Primarily, the quick reaction network, based on systems, would provide the information of some need or issue, through the use of AI, Big Data processing and the Internet of Things sensors. Secondly, same systems would propose an adequate solution and implement it. All that process would ideally happen automatically, without human intervention, only notifying the person of its actions, like with the inefficient HVAC systems utilisation or security measures in the real estate systems or courier-driven shopping.

The move from the current Society 4.0, the society of the technology, into Society 5.0, a society of the meta, requires the businesses to focus on flexible products and solutions, that can be attached to the network of interconnected area, due to the fact, that in the Age of Metaverse, the lone-standing solutions would most probably be left behind. The easiest example would be the connection between shopping platforms and banking ones. Lack of instant connection would result in the loss of interest of the potential buyer, focused of their comfort. However, the development, for the development in itself is not he way to go, as it lies in the innovations, particularily technological innovations, steming from the societal needs of the moment. The need-based revolutions lead to more withstanding emergences and leave less time for the initial fear of the new.

Business model elements	Society 1.0 Hunter-gatherer	Society 2.0 Agrarian	Society 3.0 Industrial	Society 4.0 Information	Society 5.0 Super Smart
CUSTOMER SEGMENTS	C2C	B2C	B2B	Hybrid	AI-2-Hybrid
VALUE PROPOSITION	Survival	Status	Convenience	Transformative	Meaning
CHANNELS	Personal	Markets	Shops	Online	Virtual space
CUSTOMER RELATIONSHIPS	Ad hoc	Merchants	Standard	Customized	Tailor-made
REVENUE STREAMS	Barter	Trade	Delivery	Subscription	Minds
KEY RESOURCES	Nature	Cultivated	Factory	Data	Algorithms
KEY ACTIVITIES	Hunt & collect	Extracting	Producing	Analysing	Sensing
KEY PARTNERSHIPS	Tribes	Guilds	Value chains	Ecosystems	Ecospheres
COST STRUCTURE	Health	Workers	Material	Computing	Mental

Figure 28 Summary of the business models of society 5.0, image source: Claus Rosenstand 'Metaverse and Society 5.0: Pivotal for Future Business Model Innovation', page 69

[151] Mohammad Dehnavi, Modern Life: Lifestyle Innovation, page 8
[152] Mohammad Dehnavi, Modern Life: Lifestyle Innovation, page 9

3.4 Cultural layer

The culture within this context refers to the functioning of the informal sphere, with the tendencies visible within the society in regards to the cosumption of works of creation, as well as the general though processes that tend to be domineering. The current times, to repeat the Metamodernism summary (*3.2 philosphical layer*) are a space of in-between, encapturing the radicalities within discussion, however, interestingly enough, without the tendency to entertain the centic and middle solutions. The culture, in the meaning of the main tendencies of the period are oftentimes depicted as an ever-emerging movement of idea and counter-idea, building on the Hegelian early 19th century dialetic, that the thought throughout history is a subject of the structure of concept-negation-reconciliation (or thesis-antithesis-synthesis as it is often depicted now) (figure 29).[153] The idea has been echoed and adopted by various thinker since that time, with an interesting addition of the Strauss-Howe theory of *saeculum.* This generational theory theorises on the recurring nature of the tendencies in the Western history. The four repeating phases that they name are high, with strong centalisation of power of institution, awakening, of the individual, unraveling, with the social fragmentation and crisis, leading to redefinition. Their theory was used to understand the differences between the tendencies of approach of the currently still living generations.[154] While all of the generalisating theories are overtly simplified and undergo rightful scrutiny, the general direction of thought seems to coincide with the main narratives that reach the mainstream and therefore prove useful for the wonderings the sources and directions of the tendencies within the society. With the majority of theories, that examine the circular nature of archetypes, the current times are in the moment of late crisis or antithesis and leading into its conclusion through the redefinition and synthesis in the nearest future. The decades leading into the XXI century were characterised by the general positivity, due to the widespread political and economical liberations. With the shift of the century, the neoliberalism and individualisation began to shift into the radicalised approaches with the emergences of the antithesis in ideologies. The recent decade and a half has seen the rise in nationalism as well as racist and xenophobic tendencies, as well as emergences of protects to counter those movements, with the Black Lives Matter in the USA or polish Black Protest of 2020. Each sphere of public dispute has faced an emergence of a sort of dual thought- the environmental protest and current European Green Deal- the anti-Green Deal movements, the fights for abortion right- the fight for anti-abortion rights. Such a polarisation of thought could be one of the main reasons for the sensitivity of the curren societies to populistic visions and a furtile ground for the metanarratives, that structure the society and make the reality more understandable in the face of uncertainties.

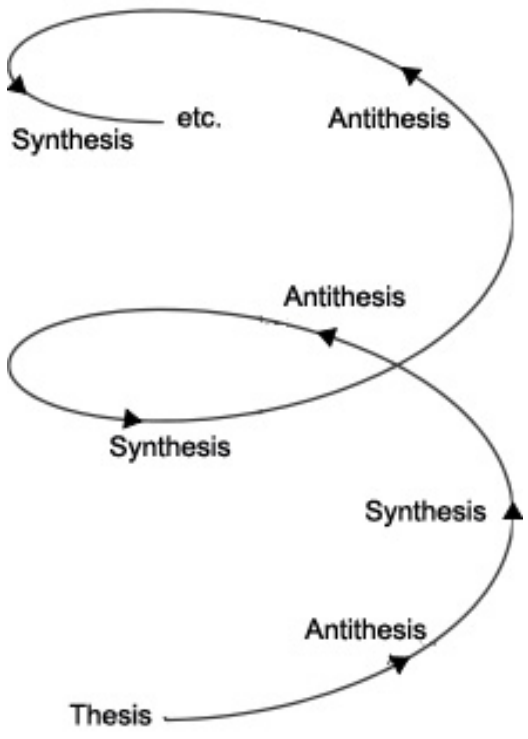


Fig 29 A visualisation of the dialectival progress based on the theories of the Hegelian dielectic logic structure of ideas image source: https:// brightshinyobjects.net/2012/09/30/dialectical-progress {accessed online 19 of April 2025}

An example of the population of radical approaches and along that, a search of community and kinship in the face of adversity is the phenomena of Cancel Culture, developed around the 2017. The Cancel Culture is a social media occurance of mass boycoting, greywalling, unsubscribing etc. the public personas or products, that were deemed by the big enough public as problematic. In it's positive aspects it is a social tool of inserting justice, where the institutions have not been succesful, or have not ever tried to extend it. A form of social pressure to limit the harm done to the society is generally a positive occurance to have, as opposition is one of the main right of the democratic and free society. However, the radicalisation of the process and its perderverance in the society, on all sides of the political spectrum, matched with the tendency to undertake quick action, rather than conduct a thorough analysis indicates the growing distance between individuals, where the ideology comes before the human compassion.

The current society has experience years of peace and prosperity and the emerging possibilities of losing that, due to conflicts and crisis, has created an environment of fear, which is a main driver of interhuman conflict. The coexisting of all possible extremes at ones has shift the irony of the Postmodernism into the Metamodern pendulum, where they exist simultainously, while contradicting one another. The culture, that emerges from that mix is polarised as well, self-reflective and depricative, with the pessimistic undertones on the one side while the hedonistic and deprived of the deeper meaning on the other. This contradictory nature of what can be called "Internet culture" is captured in the Bo Burnham's "Welcome to the Internet" song (figure 30), which captures the absurdity of the coexisitng of the serious and unserious narratives within the same "social media scroll" and with irony being more of an aesthetic of expression, leading to uncertainty of the sincerity of the cultural message of the piece, rather than a form of providing the specific message in an ironic way to emphasise it or provide humour.

[153] *Michael Filimowicz PhD, "Hegelian Dialectic for Dummies - Higher Neurons - Medium," Medium, November 15, 2024, https://medium.com/higher-neurons/hegelian-dialectic-for-dummies-84ab5ba2fd67.*
[154] Wikipedia contributors, "Strauss–Howe Generational Theory," Wikipedia, May 24, 2025, https://en.wikipedia.org/wiki/Strauss%E2%80%93Howe_generational_theory.

Figure 30 Bo Burnham's "Welcome to the Internet" screeshot of the video clip, image source: Bo Burnham's youtibe channel at boburnham, https://www.youtube.com/watch?v=k1BneeJTDcU

3.5 Conclusions

The current times bring about the feelings of uncertainty. There are different types of socil uncertainty- one could be driven by the unknow way to utilise the new possibilites, achieved by the change fought for, and that one is, overal, a positive uncertainity, leading more into hope. However uncertainty related to the unknown danger and a fear of losing the freedom and human rights, achieved by the previous generations is a driver of fear. The rapidity of technological progress transgressed into other aspects of life as well, as the consumer society is one in need of the constant novelty. The tendency to replace with the great rapidity has been recognisable in the trends and media, particularily of the 2010s before the social and economical crisis of the 2020s, and while its still prevailing nowadays, it is countered more often by the critics, who point to the detrimental working conditions of big corporations and the negative impact such production has on the environment.

The main narrative remain unanswered, leaning into the conclusion of the current stage being an in-between period, before new mechanisms for the ever-existing problems show the new direction of dealing with them. The industries seem to reach their final stages of the character they have had for decades, the economy shifts into service, and sustainable systems. The multiverse of options creates ever-existing tensions.

Such a society characterises in the preference of escapism and devulging in the stimulis to the point of numbness. They need spaces for interactions, which is lacking in the day to day life, and would benefit from the creation of public spaces that allow that, preferably without much paying involved. The society that has spent a significant time on the path to isolation, would need time to open up again, therefore the inicial creation of opportunity for connection, may bring a mixed result, however the emergence of various initiatives of this sort, in a form of women's circles, fantasy fairs or even online gathering events for those who prefer it, show the need for interactions.

The future perspective depends heavily on the next few years. With the current tendencies it can be assumed that the discussion surrounding climate change would continue, however, with the current counter-green laws movements, the intensification and cementation of certain future solutions will probably be a result of not only the continous small changes, but a reaction to some significant future disaster. The future times may see the fall of privacy and the resolutions that rise as a reaction to that issue and in turn provide a solution to the exisitng issue of the use of AI. The intensification of anti-technological movements could occure in the nearest future, however history shows, that no big scale progress can be stopped, only redefined. Paradoxically to the possible continous rise of new technologies, the future may see a rise in religion and belief, which has started to emerge few years ago with the neospiritualism and in the future could lead to situations, where the use of an AI Jesus, such as a Swiss example, used in the Lucerne church confessional[170] is no longer an unthinkable occurance, but evolves technology-related belief on its own.

It is never possible to predict the future, however the currently emerging issues would likely need addressing. The main areas of interest would therefore be related to the identity of humanity and their place in the world, and on a more day to day note, the character and ideology behind human labour, which could rely more on creative persuits, as it was initially theorised with the rise of automation and now AI, therefore leading to the discussion of the human-technology scale, the fight for equity in the emergence of oligarchy, the newfound ways to cultivate community, and a emergence of the new approach to preserve human societies in the face of the climate change.

[170] https://www.dw.com/en/switzerlands-ai-jesus-answers-questions-of-faith/video-70737962

4. Ecotechnology

The current approach to human-nature relationship is one of the 17UN Sustainability goals, and a backgroud factor for a few other. In terms of the construction sector and urban planning that translated to the incorporation of various solutions that allow for the decrease in the impact the intervention has on the environment.

The relation with humans and nature has always been of a parasitic character. The increase in production and speed of the societies since the First Industrial Revolution has however, constributed both to the enormous increase of the human impact on the planet as well as a evolution of the science of ecology. Paradoxically, climate decline has been a significant factor in the journey to get to know the rules of the planet we inhabit better.

On a less scientific scale nature has been an inspiration or element of the architectural design very much since its beginnings, which can be explored through vernacular architecture, using local materials, rococco organic ornamentation, Howard's City Garden or modernists' attention to providing light and ventilation and merging the outside and the inside through the design based on pillotis and glazed openings. However none of that compares to the extend of environment incorporation observable in the design nowadays. During the beginning of 1990s the environmental awareness in design has just been emerging, while the mainstream of thought was still centred within the objectives of postmodernism and deconstruction.[155] The second part of the XX century was an experimental period on the verge of the final stages of the Industrial Era and the beginnings of the Information-Ecology one. The unpacking of the last two centuries industrial heritage culminated in the high-tech architecture refering to the fascination with industrial aesthetic, technology or visible structural element and the emergence of "green buildings" of the 80s and 90s which main prerogaitive was the apparent environmental friendliness of their design, however with the uncertain validity of this marketed characteristic.[156]

The critical nature that characterises in part current society, one may say, selectively critical, and the current tendencies to verify the information and the intention of providing social justice, has its advantages in terms of reevaluating the tendencies of so-called green-washing, not only in design, but also in the widespread marketing. Green-washing is an occurance of using the supposed product's environmental friendliness for the marketing purposes, while the actual process that leads to the final product doesn't meet the proclamed standards. The marketing purpose may be achieved through the use of vague language, that just sounds good and a purposeful repackaging to a more "natural" looking one, for the correct first impression,

Within architecture, the green-washing can occure through the implication of well-recognised solutions, like green roof or solar panels to claim the title of being environmentally friendly, without the mention of the buildings energy demand and use, considerations on its life-cycle or the sourcing and the embodied energy of the materials used. It is a tendency directly linked with the growing awareness of the importance of climate-concious design, which nowadays we have the tools to verify and call out. However it has been and still is a symbol, that there is a expectation towards the designers in regards to the implementation of the environmentally friendly solutions that they are be expected to comply with.

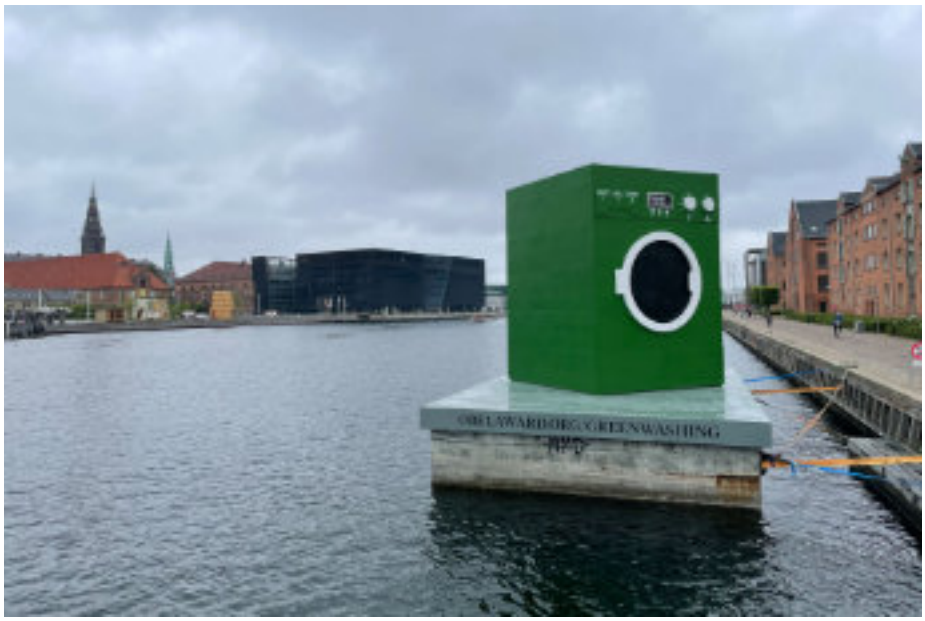


Figure 31 Obel Award: Unpavilion, Architecture: MAST, © Jakob Schoof, Greenwashing Pavilion for the UIA World Congress of Architects in Copenhagen, with the objective to visualise the 17UN Sustainability Goals, 2023, image source: https://www.detail.de/de_en/sdg-pavilions-in-kopenhagen

[155] Amerigo Marras. Hybrids, Fusions and Architecture of the In-Between. ECO-TEC: Architecture of the in-Between, 1. ed, StoreFront Books 3 (New York: Princeton Architectural Press, 1999). Page 3
[156] K. Zielonko-Jung, Kształtowanie przestrzenne architektury ekologicznej w strukturze miasta, Prace Naukowe Politechniki Warszawskiej, Seria Architektura nr 9 (Warszawa: Oficyna Wydawnicza Politechniki Warszawskiej, 2013). Page 6

The radical approaches, both the rigid tendency to put the alleged green solutions above all other aspect of the building's design together with the rejection of the technological innovation for the sole use of the traditional methods in construction as well as the overreaching cultivation of the technology and blind faith in its indispensability, have been mostly abandoned.[157] [158] In the more low-tech tendencies the criticism that arised regarded the fact, that the traditional systems are not sufficient for the current needs of the society and that the traditional materials, such as newly produced CLT wood products, without taking into account its actual embodied energy and the disruptive use of resources, might not be as "green" as they claim to be. Such discussion can be held regarding the 2023 BIG HQ in Nordhavn, Copenhagen (fig 32), that on the first glance wouldn't be the example of climate-concious thinking in architecture, being a big block of concrete and glass, however, its attempt to reduct its footprint stems from the use of the new type of concrete with less emission of CO2 into the environment, untreated, for additional CO2 absorption and uses the geothermal energy as the most stable energy source for such type of building with the least negative impact on the global environment.[159] That is not to be said that the use of wood always means the attempt to "greenify" the design or the use of concrete, even modernised or from recycled sources is the way to go, rather that the environmental friendliness of the structure cannot be taken at face value and requires some thought, cooperation between the sectors and the knowledge of the environmental context of the site. That is what the "green" approach in architectural and urban design is trying to capture.

A similar rational approach can be placed in regards to the technologies used in the building. The building's infrastructure and more and more popular smart sensoring, that is supposed to lead to self-reliency and more adeqate analysis of the achieved functionality of the space can ba a valuable addition to amplify the way the structure works. However, overreliance on the technology to provide the neutralisation of the constructions embodied negative impact on the environment, without the preliminary analysis of the possibilities to use the existing site's advantages through passive solutions is not the way to aproach the issue. An example of that rational approach to technology could be the biomonitoring of polish tap water through the use of clams for primary real-time water contamination analysis. It is in the nature of the clams to close in the event of detection of pollutants and chemicals in the water, therefore alerting the water plant workers that the water filtered through the tank cannot be forwarded to the citizens. The only technology used for primary detectionare the sensors, detecting the closing of the clams. While the water plants are also equipped with additional security measures through modern technology water contamination sensors, the incorporation of a passive detector can be viewed as a smart solution to cut down on the excessive use of the technology.[160] The resulting approach is far from being radicalising, focusing on the search of the space in-between.[161]

Figure 32 BIG HQ in Nordhavn, Copenhagen, image source: Bjarke Ingels Group

Ecotechnology (ECT) alongside similar, adjancent design strategies of the past few decades, like bioclimatic architecture, environmentally friendly architecture, eco-architecture, organic architecture is a sort of umbrella term for designing with climate-concious mentality. The tendency to add the "green" label to variety of products, buildings included, has been an issue since the beginning of discussion regarding the climate safety on global scale. The marketing companies especially created an environment of distrust and uncertainty about the actual meaning of incorporating any kind of more alternative solutions to the design. While the rationality of the implementation of the design solutions should be the superior motive for achieving the balanced outcome, the paths that leads to it can be vastly different. The green architectural tendencies can focus on following the pre-determined objectives (LEED Certification, Passivhaus), determine that the need for smart reaction to environemtn stimuli is the right solution (smart buildings) or efficient use of space (tiny house movement, pop-up architecture) among many other.

Therefore the question arises what can and what shouldn't be included under the term of ecotechnology. To try to answer that question the further section researches different definitions and possbilities to define this philosophy.

[157] Amerigo Marras. Hybrids, Fusions and Architecture of the In-Between. ECO-TEC: Architecture of the in-Between,page 4
[158] K. Zielonko-Jung, Kształtowanie przestrzenne architektury ekologicznej w strukturze miasta. Page 7
[159] "BIG HQ: Bastion in Raw Concrete - Danish Architecture Center - DAC," Danish Architecture Center - DAC, April 27, 2025, https://dac.dk/en/knowledgebase/architecture/big-hq-who-decides/.
[160] Robin Mitchell, "The Power Of Nature: How IoT Clams Help Keep Polish Water Safe," Electropages (blog), November 7, 2022, accessed April 5, 2025, https://www.electropages.com/blog/2022/11/power-nature-how-iot-clams-help-keep-polish-water-safe.
[161] Amerigo Marras. Hybrids, Fusions and Architecture of the In-Between. ECO-TEC: Architecture of the in-Between. page 6

4.1 Defining ecotechnology

Ecotechology is a term that has been in use since the 1970s.[162] It is a combination of two terms, ecology and technology. Technology in itself does not only refer to what we tend to associate it with- highly advanced electronics and machinery, that serve us in the everyday life. Technology comes from Ancient Greek word tekhne, which translates to "craft" or "knowledge how to make things" and logos, which can be translated as word or expression, which would suggest that technology relates to the discourse regarding the way something is created.[163] In modern times, it began to be regarded more as "a practical application of knowledge".[164] Ecology, is a concept, that has its origins in Ancient Greek oikos logia translated to "the study of home" and is a branch of biology ("study of life"), that focuses on relations between living organisms and their physical environment.[165]

Ecotechnology, therefore, is an applied science on the verge of technology and ecology, which main objective is to determine or discuss the creation of something within the existing "home", ecosystem consisting of its biotic and abiotic elements and their creations, to include not only nature, but also humans and the built environment of cities they have created. With that view in mind, ecotechnology can be regarded as a philosophy of respect and mindfullness, which for the purpose of designing withing the architectural and urban fields can be achieved through rational incorporation of solutions based on context and purpose.

Eco-tech transends the studies on architecture and at its core is a philosophy applicable to different fields, its definition can be therefore found within the variety of studies. Some define it as a "the strategic application of technology in ecosystem management, aiming to minimize intervention costs and reduce the negative impact on the global environment".[166] The research on its terminology and appearence in academic papers from 2018[167] verified three themes where ECT was implied- in regards to mean, benefits or the process. They have identified the primary continuums of the usage of the ecotechnology term, which can be summarised as an approach, working through hard or/and soft technology for the good of nature and/or society through making society work for nature, the reverse, or both.[168] The definition they have agreed on reads as "'Eco-technologies are human interventions in social-ecological systems in the form of practices and/or biological, physical, and chemical processes designed to minimise harm to the environment and provide services of value to society".[169] Those two definitions, while remaining vague, indicate the socioeconomic benefits or aims as one of the goals of implementation of ecotechnological solutions. The minimisation of the environmental impact should be regarded as a reduction in comparison to the negative impact implemented on the environment with the construction of the building in general to reach the lowest negative nevironmental impact possible.

Using ecotechnology in design in the fields of architecture and urbanism should therefore be a holistic apprach, which utilises the technology with the awareness of their possible effects and reduces the excessive use that can be otherwise achieved through different solutions, such as passive ones. The definitions implicate, that the interventions should be efficient and provide value to the society. It should be adequate to local requirements and needs, and hold the objectives of material efficiency, control of impact, and the planning for the usage of the building and the buildings' future.

[162] Neal Haddaway, Jennifer Mcconville, and Mikołaj Piniewski, 'How Is the Term "Ecotechnology" Used in the Research Literature? A Systematic Review with Thematic Synthesis', Ecohydrology & Hydrobiology 18 (1 July 2018), https://doi.org/10.1016/j.ecohyd.2018.06.008.
[163] "Technology," n.d., https://web.engr.oregonstate.edu/~funkk/Technology/technology.html.
[164] "Technology," in Merriam-Webster Dictionary, April 22, 2025, https://www.merriam-webster.com/dictionary/technology.
[165] Wikipedia contributors, "Ecology," Wikipedia, April 14, 2025, https://en.wikipedia.org/wiki/Ecology.
[166] M. Straskraba, Ecotechnology as a new means for environmental management, Ecol. Eng. 2,1993,, https://doi.org/10.1016/0925-8574(93)90001-v. As in Ricardo Ruiz-Sánchez et al., 'Exploring Research on Ecotechnology through Artificial Intelligence and Bibliometric Maps', Environmental Science and Ecotechnology 21 (1 September 2024): 100386, https://doi.org/10.1016/j.ese.2023.100386.
[167] Neal Haddaway, 'How Is the Term "Ecotechnology" Used in the Research Literature? A Systematic Review with Thematic Synthesis'
[168] Neal Haddaway, 'How Is the Term "Ecotechnology" Used in the Research Literature? A Systematic Review with Thematic Synthesis' page 1-15
[169] Neal Haddaway, 'How Is the Term "Ecotechnology" Used in the Research Literature? A Systematic Review with Thematic Synthesis' page 15

4.2 Main directions and concepts of architectural development of the XXI century

Within the fields related to architecture, urbanism of civil engieenering the shift towards nowelty is slower than within the realms of Computational Science. Due to the complex nature of those industries, a variety of stakeholders and enormous intrinsic cost of any possible experimentation, society needs time, roughly 10 years of so, to reach for the new solutions. That does not stand in the way of researchers, whose job, one could argue, is to lead with the possibilities. For the purpose of this project three main fields have been proposed as a mean to categorise the tendencies of implementation the solutions of a specific character. The machine-human cooperation based solutions rely mostly on the heritage of the Industrial Revolutions and using the innovations reached under the development of the 4th Industrial Revolution are sometimes referred to as "Construction 4.0".[171] Solutions reflecting the the relationship between the design process and time will be gathered under the name of Chronomorphia and the solutions focused primarily on resource management and circularity. It can be noted that none of those are directly linked to sustainability and eco-friendly design, which is under the assumption, that all currently implicated or theorised solutions maintain sustainable design as a superior objective.

4.2.1 Construction 4.0

The term of construction together with Industry 4.0 appeared for the first time in a article from 2014.[172] Similarily to the general characteristic of the Industry 4.0, Construction 4.0 should be associated primarily with the use of digital technologies and secondly with the drive towards automation and information management.[173] As such it gains additional characteristics associated with modern technologies, interdisciplinary cooperation between stakeholders and specialists from various field of the industry or technological cooperation of the interconnecting of the smart systems. The section below explores the different technologies adopted into the construction process.

Figure 33 Constrution 4.0, image source: https://www.mela.work/blog/construction-4-0-managing-the-construction-site-in-2021

[171] Mária Kozlovská 'Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review'
[172] Heiner Lasi et al., 'Industry 4.0', Business & Information Systems Engineering 6 (1 August 2014): 239–42, https://doi.org/10.1007/s12599-014-0334-4. As in Mária Kozlovská 'Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review' page 4
[173] Mária Kozlovská 'Impact of Industry 4.0 Platform on the Formation of Construction 4.0 Concept: A Literature Review' page 1

4.2.1.a Robotisation

The word robot can be defined as "'a machine that resembles a living creature in being capable of moving independently (as by walking or rolling on wheels) and performing complex actions (such as grasping and moving objects)" or "a device that automatically performs complicated, often repetitive tasks (as in an industrial assembly line)"[174]. The difference between a robot and a machine is therefore the autonomy of the operation. The first stages of the industrial revolution are characterised by the mechanisation of processes, including manufacturing and creation of the heavy machinery from construction that followed. The incorporation of the machinery within the construction sector is related witht eh progression of the Modernism.[175] Robotisation is generally associated with the 4IR, as it relies both on the knowledge of the machines and the wireless connections and the internet. The current development is the outcome of previous innovations and visions for the future of technological advancement. The robots withi construction sector follow the example of the 1950s industry robotisation, with the first introduction of the robots being attributed to the Japanese company Shimizu Corporation in the 1970s and 1980s[176] to address labor shortages and poor construction quality. The transformative use of automised machines aimed to improve efficiency, quality and safety of the construction processes.[177] The field od RIC (Robots in Construction) became more defined with the introduction of the Robot Oriented Design (ROD) in 1988, a strategy of approach, that originated from the Tokyo conference[178]. Since that time the use of robots has evolved and the current use of robots in construction is varied, but could be tracked down to three main areas- manufacturing, asembly and smart building solutions.

The research conducted by the international team on the roles of robotics from 2024[179] reviewed the main areas of focus for the development of robotics that can be nowadays observed as well as gaps in research. The main dimentions of interest pinpointed through the study group the tools and approaches into three areas, technology, including smart infrastructure, such as IoT, automation, with prefabrication and uses of robotic arms in construction, and environment, refering to solutions that allow cycle-assessments. The current need for further development lies within the scopes of future-proofing and assessing, standarisations and user-friendliness in the aspects of the interfaces or the security measures of the robots.[180] According to a automantion in construction focused researcher Borja García de Soto, as mentioned in the DBR Innovation article regarding the RIC, the current focus of innovations, with the smart systems or AI, lead in the direction of a construction site similar to a factory,[181] bringing the Industrial Revolution curated image of the society of progress into a new level.

The progression into the automation of the construction sector seems to be an inevitable process. The efficiency has been the main driver of progress of human societies for the past few centuries, therefore it would be rather impossible to leave that tendency now. Various researchers agree that the progression into the automation of both the structures we spend time in and the process of constructing them will continue to evolve and curate the new age in architecture and construction, that is heavily focused on prcision, analyses, providing the ability to create novel strategies that utilise both the innovative and vernacular appraches in the manufacturing of the new way in accordance to modern standars and need.

[174] "Robot," in Merriam-Webster Dictionary, May 19, 2025, https://www.merriam-webster.com/dictionary/robot.
[175] Victor Delaqua, "A Brief History of Automation in Architecture," ArchDaily, July 12, 2021, https://www.archdaily.com/964683/a-brief-history-of-automation-in-architecture.
[176] "A Brief History of Construction Automation," n.d., https://www.markdavisdesign.com/blog/insights-from-the-construction-industry.
[177] Abdullah Masri et al., 'Roles of Robotics in Architectural and Engineering Construction Industries: Review and Future Trends', Jounarl of Building Design and Environment 3 (6 May 2024), https://doi.org/10.37155/2811-0730-0302-9.
[178] Thomas Bock, 'Robot-Oriented Design' (The 5th Internation Symposium on Robotics in construction, Tokyo, 1988), https://doi.org/10.22260/ISARC1988/0019.
[179] Abdullah Masri et al., 'Roles of Robotics in Architectural and Engineering Construction Industries: Review and Future Trends',
[180] Abdullah Masri et al., 'Roles of Robotics in Architectural and Engineering Construction Industries: Review and Future Trends',
[181] "Architecture's Robot Revolution: Pioneering Robotic Construction - Design & Build Review | Issue 50 | June 2019," May 20, 2024, https://designbuild.nridigital.com/design_build_review_jun19/architecture_s_robot_revolution_pioneering_robotic_construction.

An example of using robots extensively for the construction can be observed in the design process of the Seoul Robot&AI Museum (RAIM), designed by the Turkish architecture office MAA (figure 34-35). The project, finalised in 2024, utilised various forms of the robot integration into the design. The use of BIM provided integration and analysis of the incorporated systems. The Off-Site Construction (OSC) provided the prefabrication of the complex forms of the building's components, which were manufactured with the use of robots. The construction process utilied robots for the building assembly, that, programmes into the network of co-functioning components using the Computer Numerical Control (CNC) technology of pre-programming the functionality and collaboration of the automated robots. All in all the programmes used the help of AI for their writing and equiped the building with sensors managing its functioning.[182]

Figure 34 Robot Science Museum in Seoul by Melike Altinisik Architects (MAA), an example of the structure constructed entirely by robots, a cisualisation. Image source:
Figure 35 Robot Science Museum, photo, image source:

[182] Hana Abdel, "Seoul Robot & AI Museum / Melike Altınışık Architects," ArchDaily, January 21, 2025, https://www.archdaily.com/1022554/seoul-robot-and-ai-museum-melike-altinisik-architects.

4.2.1.b Additive manufacturing

Additive manufacturing (AM) is defined by the ASTM society as “a process of joining materials to make objects from 3D model data, usually layer upon layer,as opposed to subtractive manufacturing methodologies”.[183] The object is firstly created in the Computer-Aided Design software (CAD) or through a photogrammetry solutions. There are various different types of 3D printing. In regards to materials, the printers include, most commonly the possibility to print in polymers, metals, ceramics or clay. The 3D printing processes are generally grouped inth the 7 categories in the International Standards, as summarised on the Wikipedia page. The differences between the processes lie in the way that the layers of the material are added to the object. The techniques include ones that focus on operating on the powder such as Selective Laser Sintering (SLS), which uses laser to compact powder into shape, a material extrusion in a form of Fused Deposition Modeling (FDM), that works through the continuous addition of the material onto the object under print or the solidification of the resin, such as in sterealoithography (SLA).[184] The mentioned techniques are among the more popular ones, however they barely scratch the surface of the possible solutions to 3D printing. The choosing of the right method is dependent primarily on the material in which to print and then on the scale and the complexity of the design.

Within the Architecture, Engineering and Construction sector (AEC), the innovative nature of the 3D printing is to increase effectivity of the design process or allow for more complex or organic structures. Within the primary stages of the building design, 3D printers can be utilised for a rapid prototyping. The designing of the 3D models to visualise the design can be achieved much quicker than through the traditional model creation. During the assembly of the building the 3D printing can by utilised as a way to obtain customised, often complex elements, with specific geometry of pattern, that would be hard to obtain otherwise. And more so, 3D printing is becoming more and more common for the construction of entire buildings. While still in the small scale, special types of 3D printing can be used on site to print the house or other structure. Some claim 3d printing to be a more sustainable way to design as the additive nature of the process reduces the material normally wasted during the manufacturing actions- cutting, shaping, etc. The ability to construct entire buildings is nowadays the most interesting feature of the 3D printing in AEC sectors, as it opens up a great number of possiblities for future application. For the warmer climates it could allow for a rapid fabrication of single component walls housing, such as showcased throigh the Tecla clay 3d printed housing from Mario Cucinella Architects and Wasp, printed in Italy, which utilises the local riverbend material (figure 36). More future-focused researchers examine the possibilites of using the 3D printing technology for the construction of shelters on Mars.[185] The current scope of development within the 3D printing for construction seems to focus on increasing the scale, complexity, and most importantly mobility of the proces, with an objective to extend the possible materials to use for the on-site structure printing. Within the works on extending the scope of printing, the state-of-art technologies focus of developing 4D printing elements, which add another dimention to the printed objects, related to kinetic properties of the achieved solution. The printed object has the ability to shape itself and modify, as a reaction to stimuli, such as humidity, temperature or voltage. The future possibilities notices by some researchers include the development of self-healing materials that with the creation of a comprehensive network of self-assesing softwares and robots could lead, according to some to the emergence of 5D printing, as a system of live manufacturing of structures with automated cost efficiency and material adaptability.[186]

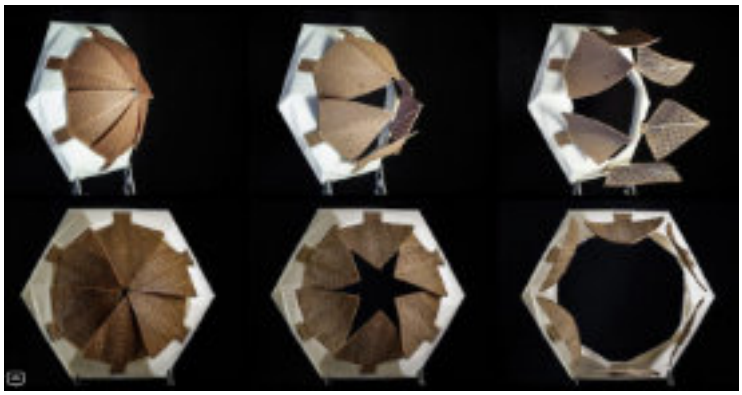


Figure 36 Tecla 3d printed clay house by Mario Cucinella Architects studio and WASP engineers, image source: https://www.dezeen.com/2021/04/23/mario-cucinella-architects-wasp-3d-printed-housing/
Figure 37 Kinetic printed architecture as an exampple of 4D printing technique, image source: *https://www.archdaily.com/966556/have-you-heard-of-4d-printing-bridging-additive-manufacturing-with-smart-materials*

[183] ‘Additive manufacturing’ in Science Direct, May 20 2025, link:https://www.sciencedirect.com/topics/engineering/additive-manufacturing
[184] Wikipedia contributors, “3D Printing Processes,” Wikipedia, May 17, 2025, https://en.wikipedia.org/wiki/3D_printing_processes.
[185] ‘(PDF) In-Situ vs. Prefab 3D Printing Considerations for CO2-Free Pop-up Architecture’, ResearchGate, accessed 20 May 2025, https://www.researchgate.net/publication/382438250_In-Situ_vs_Prefab_3D_Printing_Considerations_for_CO2-free_Pop-up_Architecture.
[186] Rane Nitin, ‘3D, 4D, and 5D Printing in Architecture, Engineering, and Construction (AEC) Industry: Applications, Challenges, and Future Scope’, SSRN Electronic Journal, January 2023, https://doi.org/10.2139/ssrn.4609912.

4.2.1.c Internet of things, BIG data and GPS

Internet of things is a technology structure of a network of individual devices connected and communicating with one another.[187] Within the field of construction are used mostly for real-time optimisation of the processes. Smart grid networks are growing in popularity for home use, with sensors reacting to the changing environment for the comfort of its occupants and increasing of energy efficiency. It is popular to use sensors for smart lighting, heat control, security. The can gather, store and forward information regarding water use, electricity generetion, etc., that, especially for the bigger interventions can lead to efficient use of technology or adequate timing in management. Sensors can help with the optimisation of the construction porcesses, such as machine control or optimisation of transit, with the use of GPS. The information are transfered through clouds, which allows for the creation of a quick-access database for various devices and therefore various specialists.[188]

An example of implementation of this strategy could be the use the traffic control of the urban intersection. First, the sensors of the perception layer of the system would gather data of the amount of pedestrians crossing the streets in certain hours of the day. The sensors could be equipped with motion and image detection. The data is transported through the transportation layer such as wifi to the processing layer, which is responsible for gathering, processing, analysing, as well as securing the received data. In the case of many instances to record and analyse, this process could be done through cloud processing, which would need connection to a server. Databases are analysed and stored in the application layer through softwares, where they undergo task completion, before being projected on the business layer, which includes data visualisation, dashboards, and in case of this example, could be the layer presented to the city administrations to back up decision of improving the ity's transportation networks.

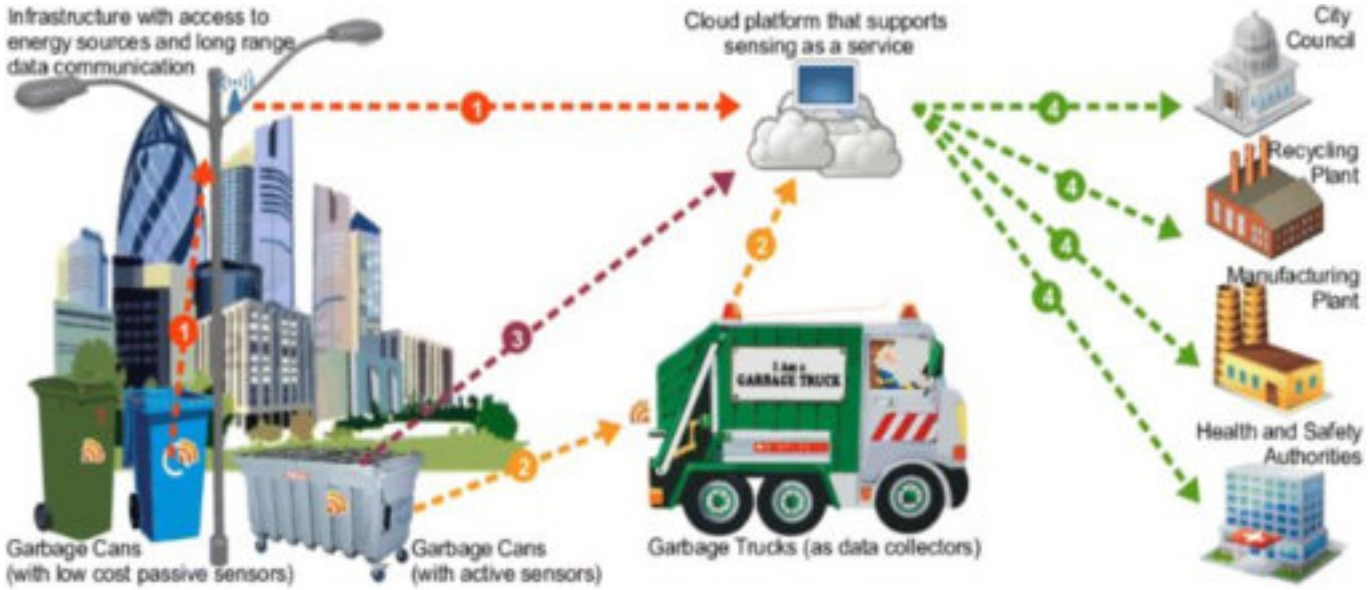


Figure 38 Use of IoD for the optimisation of the waste management in the city, image source: Fayez Alqahtani et al., 'Internet of Things-Based Urban Waste Management System for Smart Cities Using a Cuckoo Search Algorithm', Cluster Computing 23 (1 September 2020), https://doi.org/10.1007/s10586-020-03126-x. Page 2

[187] Edidiong Akpabio, Idaraesit Akpabio, and Ifiokobong Akpabio, 'The Internet of Things and Its Transformative Applications and Emerging Challenges Across Sectors: A Review', JOURNAL OF INTELLIGENT SYSTEMS AND COMPUTING 6 (19 April 2025): 23–32, https://doi.org/10.51682/jiscom.v6i1.65.
[188] MongoDB, "What Is IoT Architecture? | MongoDB," n.d., https://www.mongodb.com/resources/basics/cloud-explained/iot-architecture.

While IoT could be named the process or a way of obtaining and managing data, it is related to other innovations of XXI century, mainly Big Data and GPS.

GPS reqers to the technology of using signals from the satellites orbitting the Earth for precise data on location, movemnt and time. It is one of the universal way to optain data related to space.

Big Data is is a set of data that is too complex for traditional data processing tools. Their characteristics include big volume, variety, velocity of generation and veracity, as it affects the inside on the issue the data is gathered on. The main issues regarding the management of BD is providing an adequate infrastructure, that could adjust to a growing size and complexity, energy-efficiency and cost efficiency, the unifiaction of the data from various sources, some strategy of data sifting and assessment and data security.[189]

Using the example from above, a visualisation of the use of Big Data could be the amplification of the urban transportation project. If such data were to be obtained from the whole city, the use of sensors on every intersection would be neither manageble nor sustainable. Therefore, a possible way of furthering the research could include the use of public information data from devices with GPS, such as smartphones and car navigations and layering it on the map of the city. An aaditional sensors could be useful in bigger intersections and transportation nodes. The data gathered through the inclusion of IoD, GPS and other would be considered Big Data and require special attention to developing a infrastructure for its managing and interpreting.

Through the scaling of the similar solution and putting it to use in various fields, the modern technologies of data gathering and management allow for conduction of analysis of the social patterns like never before. Current use, all for one of the favourite word of the Industrial World, optimisation, can lead to more adeqate design solutions.

[189] Mohammad Dehnavi and Morteza Khani Dehnoi, Artificial Intelligence and Big Data, 2025.

4.2.1.d AI

Various sources determine different contribution of the construction sector in the total contribution of the total global carbon emission and energy consumption, however that number is often rounded up to around 30+ %. The grand contribution of the construction sector to the environmental instability is rather intuitive. Buildings and other structures require great amound of various materials and infrastructure, that all have to be produced, with raw materials sourced an manufactured into the final product, later transported and assemblied into the design, producing some waste in the meantime. The embodied energy of any built structure is already significant, without taking into account its functioning and end-of life. The AI is there to combat that.

The Artificial Inteligence is a computational system tasked with the problems usually managed by humans up to that point. The main idea for the AI to the creation of a tool that can learn and adapt based on new infroamtion, analyse big amount of information and be able to make judgements based on the information provided.[190]

Within the architectural an urbans design, AI is another step after the introduction of BIM. While AI is used heavily for the analysation of Big Data, the use of AI in design goes beyond that. In its core AI as a tool is meant to aid the designer and optimise their work. From the outside the use of AI is most notably visible in the creation of visualisations. Generative AI is able to take into account various pre-determined parameters and provide a selection of design options based on that, either for the site, the functional layout, elevation or more. This allows the architect, or more importantly a client, to view different options of design, before settling on one specific. In general AI is not made to provide a ready to go outcome, but work as a design aid- the options for the design can be later reimagined or adpoted by the architect according to their vision and other needs, however the first stage, regarding the analysis and inicial design constrains is optimised. The use of AI within any moment of creative creation is however heavily disputed due to the issues of authoriship and doubts regarding the property right. Simply saying, the AI as a learning machine needs to be provided with the data on actual designs and therefore the generation of ideas can already be considered as a violation of the rights of others. The counterarguments used in that dispute refer usually to the copying nature of humans as well. All creative persuits get inspired, more or less depending on the project, on the designs of others and no designer is resilient to the tendency to get inspired by the exisitng solutions. The art and most notably architecture is a creative reinterpretation of the same schemes. While that explanations stands in its truth it is widely insufficient to satify the growing distrust to that medium. The issue of AI attributions is yet to be resolved.

AI, apart from being a controversial design tool is also an analysis tool, in whivh respect it rises less controvercies. Due to its analitical nature and ability to process great amount of data, it is a valuable source of help in the process of environmental analysis, veryfing the possible faulty solutions, and especially integrated into BIM is the powerful tool of running all kinds of analysis on the buildings structural integrity and compliance with the pre-determined objectives. The idea behind the creation of such a powerful tools lies in the faulty-prone nature of human mind, which wil make a mistake or forget about an important aspect that should have been insorporated into the design, simply due to the fact, that construction sector deals with an enormous amount of interconnected parameters, that all have to be addressed in the design.

Apart from being used during the analysis and design stage, AI is also used for buildings'management. The incorpration of AI into the IoD network allows for a thorough analysis of the factors and gathered data. Such constant vigilance of the building's state is a change to prevent significant damages caused by faults in the infrastructure or optimise the functioning ones for energy or water efficiency.

An Architectural Studio, that utilises the AI within its processes has to shape its work accordingly to achive the desired optimisation. The research on that topic, concluded in the 2025 paper underlines the main objectives that should be implemented, if the incorporation of the AI into the design process occurs. The AI-Assisted Architectural Design Studio (AI-a-ADS) requires a preparation of all required data that would have to be incorporated into the AI. That could include information about the site, design constrains based on the subject or client's needs, legal constrains, and initial sketches, showing the design options. The output should undergo verification, especially one related to the correct structural and legal measures. In general, some researches state, that it is easier for the human mind to find mistakes in the ready or semi-ready product, that to initialise the process of creation.[191] That psychological aspect is sometimes used as a productivity trick to deal with the difficult tasks. For the later stages of the project, the generated imaes can be run through the AI systems again with the architects commentary to generate more desired effect and in the last stages of the design phase, it can generate the analysis on its possible functioning. The process of interchangable analysis and decision-making made by the architect and then the AI would function as a collaboration with a human, with whom the ides are exchanges, in this scenario at least.

Even though the current use of AI is a controvercial topic, the tools, that base their functioning on artificial intelligence are widespread and sometimes are utilised in places, where the designer not accustomed to them might not this of the tool in use as AI. The Intellignet cropping is one of the examples. Content-Aware Crop or Object Erasing is an ingraned tools of the Photoshop and similar softwares, that are utilised by the variety of photographers or designer to erase the unnecessary objects captured in the frame. Those functionalities are powered by a learning AI, as it requires an intelligent tool, that would, in case of the erasure of the objects, assume the logical background. Therefore, the avoidance of the use of AI is not as clear as it may be stated by some. As it usually is with any novelty, its emergence creates fear and uncertainty and the only way to battle those is through the familarisation of the technology to find the adequate way of its usage and provide a valuable arguments for the important discussions on the scopes of its restrictions.

[190] Wikipedia contributors, "Artificial Intelligence," Wikipedia, May 26, 2025, https://en.wikipedia.org/wiki/Artificial_intelligence.
[191] Guliz Ozorhon et al., 'AI-Assisted Architectural Design Studio (AI-a-ADS): How Artificial Intelligence Join the Architectural Design Studio?', International Journal of Technology and Design Education, 17 March 2025, 1–25, https://doi.org/10.1007/s10798-025-09975-0.

4.2.1.e Simulacra - virtual reality and simulation

Virtual reality, in general, is a broad term relating to now mainstreaming technology of virtual immertion. Defining its scope was well captures in a 2019 research by a group of researchers[192], focusing on different environments where the term is used, from academic literature to marketing campaigns and producers' information. Based on therir overview an adequate description of VR would be along the lines of 'a complete real-time computer-generated semi- or fully simulated environment, that allows immersion into alternate reality through use of 3D technology and interactive solutions'. While VR is usually associated with a headset, it may be better to regard it as s concept that mean to trick our senses to believe the projected reality.[193] The way to do so is secondary as it is as dynamic as the technological progress of devices it relies on to create that illusion.

Virtual Reality as a theory and aim has existed in peoples' minds since the first half of the XX century. The development of the concept relies on two main technological innovations: perspective and panoramic paintings and a XIX-century stereoscope.[194] First inventions and science-fiction literature ideas related to simulating environments include "Link trainer" (figure 39) a commercial flight simulator from 1929, which was used for entertainment and training future pilots or glasses from Stanley G. Weinbaum's "Pygmalion's Spectacles", that allowed its wearers to experience alternative world and questioning the borders between reality and dream, reality and simulation.

Figure 39 First simulator, image source: https://interestingengineering.com/transportation/the-worlds-first-commercially-built-flight-simulator-the-link-trainer-blue-box

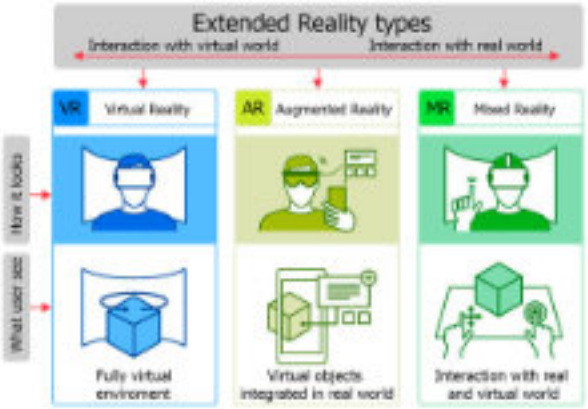


Figure 40 Overview of the Extended Realities types, image source: Shatokhin, Oleksii, Andrius Dzedzickis, Milda Pečiulienė, and Vytautas Bučinskas. 2025. "Extended Reality: Types and Applications" Applied Sciences 15, no. 6: 3282. https://doi.org/10.3390/app15063282

Currently Virtual Reality refers to the technology, that allows for the immersion into the non-physical, curated environment. It is a subtype of the Extended Reality (XR) (figure 40), which refers to the general technology that merges the virtual information with the real world. ER has three main subtyped. Augmented Reality (AR) refers to the technology of overlaying the digital information onto the real worls through the use of camera. It doesn't provide full immersion, just additional information and is often used as GPS, architectural visualisation or tourism, creating interactivity for the sightseeing or visualisation of the historical layer. For the head-mounted AR, that come in the form of glasses, they provide a layer of information additional to the exisitng surrounding, semi-transparet to not obstruct the surrounding. Virtual Reality (VR) is a full immersion technology, which utilises headsets. Mixed Reality (MR) provides the interactive immersion that displays both the real world and the virtual additions.[195]

XR's main function lies in the display of information. The purpose may be varied and depends on the programme designed for the use of the technology. Common XR purposes include gaming, training of the professional of the various fields or visualising of objects, useful for the designers, architects or historians.

[192] Morelia Maravilla et al., Defining Virtual Reality: Insights from Research and Practice, 2019, https://doi.org/10.21900/iconf.2019.103338.
[193] (Video) Immersed Robot, "Is This the First Mention of VR in a Work of Fiction?," August 22, 2021, https://www.youtube.com/watch?v=ynp53alO2QM., Timestop 6:43.
[194] "History of Virtual Reality - Virtual Reality Society," Virtual Reality Society, January 2, 2020, https://www.vrs.org.uk/virtual-reality/history.html..
[195] *Shatokhin, Oleksii, Andrius Dzedzickis, Milda Pečiulienė, and Vytautas Bučinskas. 2025. "Extended Reality: Types and Applications" Applied Sciences 15, no. 6: 3282. https://doi.org/10.3390/app15063282*

The technologies used for the VR or MR include the headset the motion controllers. (figure 41) The additions, such as wireless adapter provides the ability to detach the headpiece from the PC managing the functioning of the device, and therefore rises the comfrot of use. The lighthouses for VR are devices, that track the location of the elements and therefore the user, for more accurate representation of the location and movement in the virtual reality. For more detailed uses, such as for the purpose of movement and reaction research or ditailed trainings, the VR may use additional on-user trackers or cameras capturing the view, also using the existing technologies known in the cinema for motion tracking.

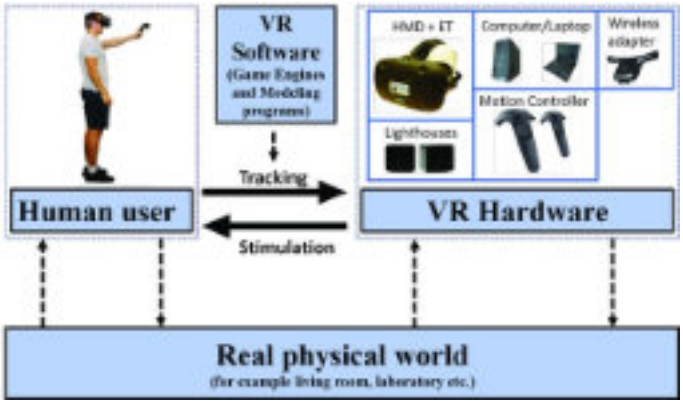


Figure 41 Components of the VR set, image source: Stefan Pastel, 'Visual Perception in Virtual Reality and the Application in Sports' (2022), https://doi.org/10.25673/58200. Page 7

Within the sector of construction, architectur and urbanism, XR technologies are a way towards the Industry 5.0. The main usage that comes to mind is the real-time visualisation of the project, construted with the use of BIM software, onto the reality with the use of tablet, glasses or headset. The visualisation of the intervention in real time proves useful when working with the client and makes the evaluation of the design properties more detailed.[196] The interactive aspect of such visualisation allows for a real-time analysis, such as an analysis of the sunpath and shading in the designed interiors, change of the finish materials or design options. The ability to transport the user, a client of the architect for example, into the design allows for the detailed discussion regarding the clients preferences, as they're able to see, which options correspond better with their perception. Such a solution may come in hand particularily during the design of the public spaces. If the project is meant to be used by the general public, the provision of its BIM digital twin before the beginnings of the construction may provide a participatory character for the design, allowing for the opinions of the public to shape the space they're meant to use in the future. Such transparency may proof to be beneficial for building trust between the investor, developer, architect and user.

The rise in the use of VR for detailed architectural visualisations when working with clients is a solution, that, when becoming a standard practice, would probably redifine the relationship between the client and architect. The current way of visualising the project, through rendering software, has already set the standard of providing high quality views on the design, before the construction. In a way, such tendency is a shift of initiative and decisionmaking onto the client, and possibly lowering the trust, that before the rise of computer-aided design, had to be placed in the architect's vision, shown only though drawings and models, if even. The conclusion if that aspect of the progression of the visualising technologies in beneficiar or detrimental for the sector could be an issue for the wider discussion.

The emerging and theorised possible other uses of XR within the sector of construction relate to the management of the site. The AR headset could provide an informatio layer on the construction, with the technical draing of the specialists, in a form of layer displayed on the view, rather than information on paper

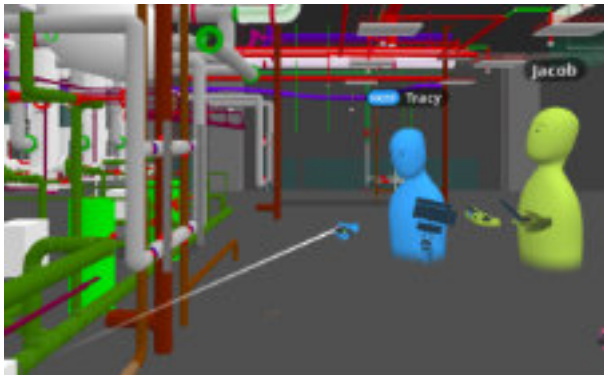


Figure 42 Use of VR for the pre-construction, image source: https://www.constructionbusinessowner.com/latest-blog-posts/decoding-use-collaborative-vr-construction

Figure 43 Use of AR on construction site, image source: https://www.desapex.com/blog-posts/how-ar-vr-are-transforming-construction-industry

[196] *Shatokhin, Oleksii "Extended Reality: Types and Applications" page 5*

Just as Virtual Reality as a technology can be used in architecture, architecture can be used in the VR. The emergence of the new technology has provided an extention of the architect's job possibilities, from the creation of architecture in games, to the creation of digital twin of the cities, that could be managed through the merging of the 3D modeling and photogrametry or the historical visions, that could be layered onto the exisiting cities for educational purposes of showing the changes the city underwent in time.

The current development of VR, apart from the provision of solid, affordable system to populise the solution withing different sectors, is related to the research on human comfort in the virtal world. Multipule research state, as mentioned by researcher Stefan Pastel[197], that the ideal VR immersion would provide a multisensory experience. Most importantly, the issue refers to the provision of the equipment, that mirrors the virtual reality, such a handpiece in a form of a sword, if the virtual gaming experience makes the player use a sword, or a creation of the simplified reflection of the virtual world inreal life, so the user could experience the touch they see in the virtual world through 3d printing the elements. The real world creating the vision of the virtual seems like a full circle of the technology development. The main way to transfer the feeling of the heptic experience in the visual world, is through the vibrations of the motion controler, which could reflect the encounterance of an obstacle in the VR, or the obtaining of punches, if the VR game is related to fighting.

The further issues related to sensory experience through the use of VR relate to the comfort of the user, particularily one not used to the use of Virtual Reality device. Both the development of better quality and experience of the VR technology and the propagation of its use through open workshops could prove useful for solving this issue. The issue of the visual limitations is particularily visible for even inexperienced users, as the rate of refreshing the screen can result in a dizziness, furtherly enhanced by any mismatch in the fluidity of vision, movement of the controllers or absence of the body parts in virtual reality.[198] As the current direction of Virtual Reality leads to the increase in use, addressing those issues is critical to the populisation of the technology's usefulness in all sectors, including construction.

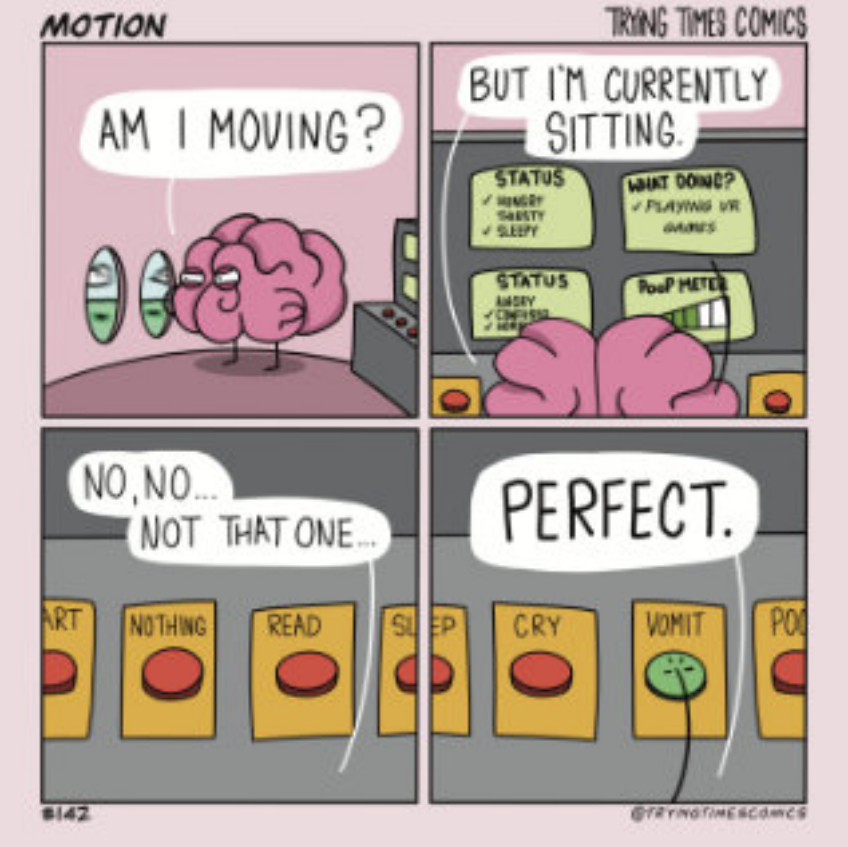


Figure 44 Comic on VR motion sickness by tryingtimecomics, image source: https://www.reddit.com/r/OculusQuest/comments/rvfx0j/fs_in_the_chat_for_those_prone_to_motion_sickness/ [accessed April 2nd 2025}

[197] Stefan Pastel, 'Visual Perception in Virtual Reality and the Application in Sports' (2022), https://doi.org/10.25673/58200.page 12
[198] Stefan Pastel, 'Visual Perception in Virtual Reality and the Application in Sports' page 22, 59

4.2.2 Chronomorphia

The drive to view the building through the lenses of its temporality is compliant with the 4R, *Reduce, Reuse, Recycle, Recover* philosophy. The current climate anxiety and evolving sustainable solutions have pointed the attention to the changes that happen with time, throught the awareness in resource depletion or need for brownfield regeneration. The partial abandonment of the idea of the building's static and unchanged nature is also in accordance to the current rapid state of thought, with ever-changing trends and needs, leading a more dynamic narrative even withing the construction field. The tendency to view the building through the lenses of time can manifest itself in varous ways, such as pop-up architecture, adaptive architecture, design for demolishion philosohpy or even the life-cycle analysis of thebuilding, that showcases the sensitivity not only to changes that occure in continuity in society but also the touch of time on technology and materiality of all that is constructed. This section of the paper explores those examples of tendencies related to time in architecture.

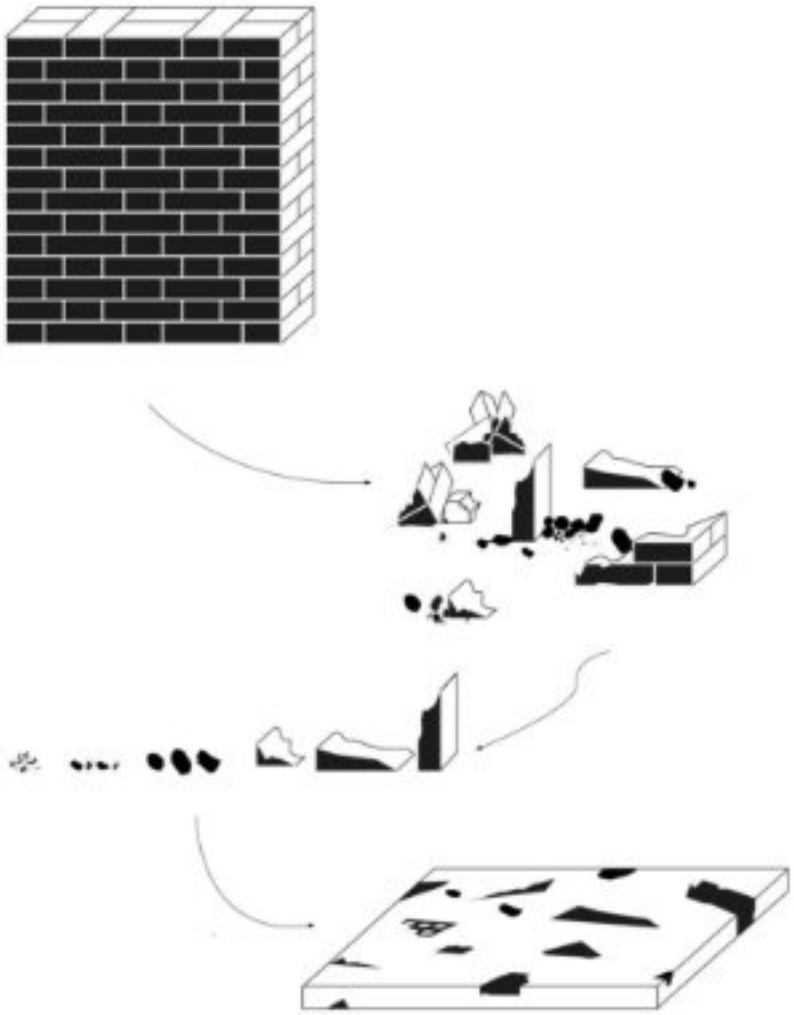


Figure 45 In Situ Recycling at Le Parissy, Paris, image source: https://www.archdaily.com/922608/the-paris-researcher-pioneering-a-new-way-to-recycle-building-materials/5d4b0c3e284dd155ac0000a2-the-paris-researcher-pioneering-a-new-way-to-recycle-building-materials-photo?next_project=no

4.2.2.a Architecture in a box

Figure 46 Kisho Kurosawa, Nakagin Capsule Tower, image source: https://archeyes.com/nakagin-capsule-tower-kisho-kurokawa/

The idea of compartelisation of the functions due to the necessity has been present in various forms thorough history, from monastery rooms to ship cabins. However, the modern interpretation of "contained" architecture can be tracked down to the Kisho Kurosawa's Capsule Tower (figure 46) and later, the first Capsule Hostel in Osaka of the 1970s, inspired, by the general notion of treating the structures as machines, visible in the Modern movement and the fututristic visions of later Metabolists, which Kurosawa was a part of.

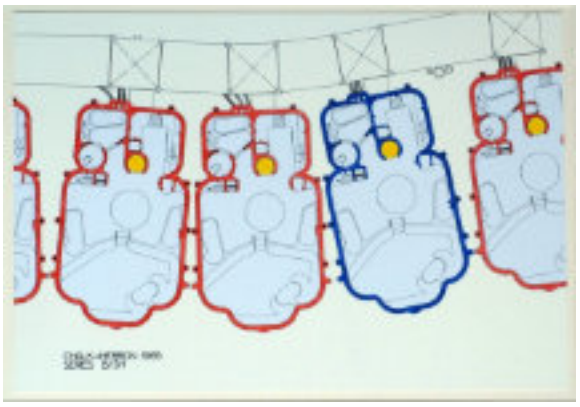


Figure 47 Archigram Capsule Homes, Warren Chalk, 1964, image source: https://studioarewethereyet.wordpress.com/2016/03/24/precedent-archigram-capsule-homeswarren-chalk-1964/

The researcher Peter Senk explores the idea of borders imposed on architectural objects through the research on capsualisation. In his research he refers to the Lieven de Cauter's vision of the "capsular civilisation", one that focuses on digitalisation, individualism and which products, from mobile phones to living quarters, reflect that drive for separation and compartelisation.[199] The popularisation of the capsule design may have been driven by the downfall of communal tendencies, as well as economic stability, an overpopulation. In the XXI century, it had gained gained the characteristic of envionmental friendliness, which in some cases may be true, and of isolation necesities, after the trying period of the COVID pandemic. Senk addresses the capsualisation tendency to exist within different scales and different transparency, which relates to access to the space and colntrol imposed on the user. The general idea for a capsule within that understanding relates to the imposition of seclusion of some sort, control of access, control of behaviour, or a creation of a distinct nature.[200] While some of those impositions may seem as drastic, in many cases, they are a beneficial tool for social security, if they don't exceed the tendency to define non-permeable borders to the point of exclusion of the other societal groups of seclusion of the capsualised one.

Collective capsualisation, as he calls it, refers to that tendency to provide closed off spaces for specific purpose and group. Within that space, the character it may grapple with relates to the Debords idea of hyperreality, curating an image of a social situalion, with the imposition of more control.[201]

Individual capsualisation is more related to the concept of capsule as initiated by Kurosawa. Capsules are compact architectural objects, either fully mobile or easly movable and provide some sort of temporality.[202] The capsules as living spaces rely on two concepts primarily- the minimum dwelling Existenxminimum evelved by the Modernists and the forms inspired by the Metabolists and Archigram designers (figure 47) from the 1960s. The modern adaptations of the concept focus more on mobility, sustainability and freedom from the capitalistic drive for owning more and more. In the recent decades, it related to the tiny-house movement under the Minimalism or the popularisation of "van life", where indiiduals or whole families decide to life of van to allow for the freedom of movement and exploration, related to the rise in travelling of the XXI century.

The sustainable character of the capsules relate to their size and mobility.Capturing a certain function within a box or a pod, makes it possible to relocate it to a different space, should the need arise, and with that attribut to the multifunctionality of the space, which is one of the main drivers for the urban spaces as of now. The current rise in typology of the functional pods, such as coworking pods or sleeping pods, can be perceived as a symbolic reflection of the flexibility, that is highly valued in the current society. The society of Subscribtion, as mentioned before is one to appreciate the availability of solutions that solve their immediate desires and needs, without the need to limit themselves with long-term consequences of traditional space renting. The use of capsule architecture within the public space as it is envisioned now is a driver of the fast-paced citizen of the society as it exisits now.

[199] De Cauter, Lieven. The Capsular Civilization: On the City in the Age of Fear. Rotterdam: NAi Publishers. 2024 As in Peter Šenk, 'On Capsularities: Physical and Diffuse Envelopes between Accessibility and Representation', Spatium 50 (30 December 2023): 1–10, https://doi.org/10.2298/SPAT230917012S.
[200] Peter Šenk, 'On Capsularities: Physical and Diffuse Envelopes between Accessibility and Representation',
[201] Debord Guy., "Society of the Spectacle. New York" Zone Books. (2004) as in Peter Šenk, 'On Capsularities: Physical and Diffuse Envelopes between Accessibility and Representation',page 2
[202] Peter Šenk, 'Aesthetics of Sustainability: Capsule Architecture in the City and in Nature', SAJ - Serbian Architectural Journal 11 (1 January 2019): 463–72, https://doi.org/10.5937/SAJ1903463Q.

4.2.2.b Adaptable and kinetic architecture

Adaptable architecture in general refers to the object's ability to undergo modifications. The idea is rooted in the dynamic character of the current times as well as the built environment heritage, as it captures not only the solutions to provide flexiblity to the design for future use, but also directions for approaching the exisiting structures and how they can be adopted for the modern times. The idea of adaptable architecture starts with the process of adaptation, which is a term used to describe the modifying of the structure to fit a new purpose. As a design tool it is reactive in its nature with the design work is tailored for the specifica function in mind. The two main scopes that can be identified within the architectural adaptations are adaptive reuse, which involves changing the building's function from one to another and is often the part of revitalising post-industrial regions on a urban scale or repurposing existing architectural heritage for the new functions, or incorporation of elements of the universal design, which boils down to the modifications made into the buildings to accommodate people with different diabilities and needs and can be often found in public-use buildings. Adaptations have been a part of the architectural design as long as any tipe of structure has existed as the change of needs have been a constant in human history and resources have always been scarce. Therefore history knows many example of changing the buildings with the emergence of new religions, like in the case of Hagia Sofia in Istambul, Turkye or Mesquita-Catedral in Cordoba, Spain, repurposing former city fortifications into parks or streets or, in more temporary solutions, alll adaptations made for the times of wars, such as underground metro shelters or temporary living spaces in churches, similar in XX century's and XXI century wars. Recent years have seen some more interesting and bold examples, that like to defy a certain norm, such as Kruisherenhotel, a hotel and bar in the gothic church or a Dominican Bookstore in a 13th century Dominican church, located both in Maasticht, Netherland. Adaptation of this sort are a genre of their own, as they deal with specific solutions, that allow for the comfortable use of those spaces in accordence to current laws, inclusive design strategies and functional needs of modern user.

The modern solution of adaptable architetcure is, however, a wider concept, that related more to the adaptability as a skill that is engineered into the building in its design stage. While adaptation is releated to planning for the new function, adaptability is a more uncertain process as it related to the potential possibility to adapt to new function, including temporarty adaptations, but without the clear vision of what those changes might include.[205] Adaptability is more of a philosophy of leaving a open end to the buildings history, assuming its function, structure might change with time. There are three types to mention in terms of the building's adaptability: multifunctional use, that allows for a varied use of space for years, designing elements of the building or its structure in a way that allows easy modifications and the real-time adaptability, that is stimulated by the users movement or enviromental changes and are often captured under the term of kinetic architecture, architecture that moves and changes based on some stimuli.

Multifunctionality of the building is a intrinsic design solutions of current times due to the tendency to densify the build space, lower the amount of unused built spaces, limt the urban sprawl and ucontrolled expansion of the city and regenerate the nightlife of the space through the inclusion of functions, allowing the space to live 24/7, as a security measure to reduce the fully amandoned spaces at certain hours of the day. All of those tendencied have been brought up in the last century as a opposition to the Modernist rigid and functionalist approach to zoning and seperation of functions. In a modern city, the incorporation of different functions in one structure has become a standard practice. In terms of adaptability of the building it provides a need to take into accound various design measure withing one intervention to allow it to host different functions, especially with the high degree of mixing conditioned and unconditioned spaces, different hours of functioning or particular functions grouped in one spape. The knowlegde designers now have from desiging structures as commerical centres or airport alone provide a variety of solutions and appraoches that can be adapted to different scales, ones that have not been a standard practice few decades ago.

Designing the building or its parts to allow modifications relate to flexibility both on the every-day use scale as well as "future-proofing" solutions. Both are a response to changes in current living and working patterns, such as home office, coworking and hybrid work[206] and conciousness to design in aligment with the definition of sustainable approach. To understand the possibilities of changing within the building it is imperative to understand the building in itself first. Some researchers have coined systems of determining the layers within the building, which Frank Duffy called "layers of longevity"[207], along with their durability. Primarily the concept was broadened by Steward Brand,[208] however it has been since adapted and adjusted by others.[209] Brand's layers (figure 48), under the name 7S, include site (assumed as non-changing), structure (30-300 years), skin (20 years), services (7-15 years), space plan (5-10 years), stuff (3 years) and souls (users changing every day).[210] Some add the layers of access, which refers mainly to vertical communication with ranges from more durable as lift shafts to less durable like secondary stairs.[211]

[205] Wysocki Marek and Joanna Kabrońska, 'Adaptabilność obiektów architektonicznych we współczesnym projektowaniu / The adaptability of architectural objects in contemporary design', MOST Wiedzy - portal z wiedzą dla Ciebie (Politechnika Gdańska, 2018), https://mostwiedzy.pl/pl/publication/adaptabilnosc-obiektow-architektonicznych-we-wspolczesnym-projektowaniu-the-adaptability-of-architec,150409-1.
[206] Arge K., Adaptable office buildings: theory and practice, "Facilities" Vol. 23 Issue 3/4., 2005 as in Marek Wysocki, 'Adaptabilność obiektów architektonicznych we współczesnym projektowaniu / The adaptability of architectural objects in contemporary design',
[207] Jeremy Keith, Resilient Web Design—Chapter 5, accessed 3 May 2025, https://resilientwebdesign.com/chapter5#A%20building%20properly%20conceived%20is%20several%20layers%20of%C2%A0longevity.
[208] Stewart Brand, How Buildings Learn: What Happens after They're Built (New York: Penguin Books, 1995) as mentioned in Jeremy Keith, Resilient Web Design—Chapter 5
[209] Ed van Hinte, ed., Smart Architecture (Rotterdam: 010 Publishers, 2003), page 26
[210] Marek Wysocki, 'Adaptabilność obiektów architektonicznych we współczesnym projektowaniu / The adaptability of architectural objects in contemporary design',
[211] Ed van Hinte, ed., Smart Architecture

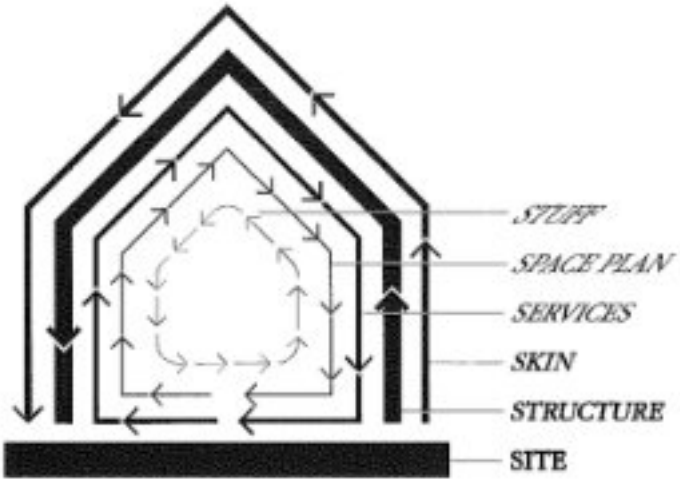


Figure *48 Brand's shearing layers of change of the building, image source Brand Steward.' How Buildings Learn: What Happens After They're Built', page 13 as accessed in Bhakti Shah, "How Buildings Learn: Shearing Layers - Bhakti Shah - Medium," Medium, December 11, 2021, https://medium.com/@bhakti1711/how-buildings-learn-wip-619bd89e845e.*

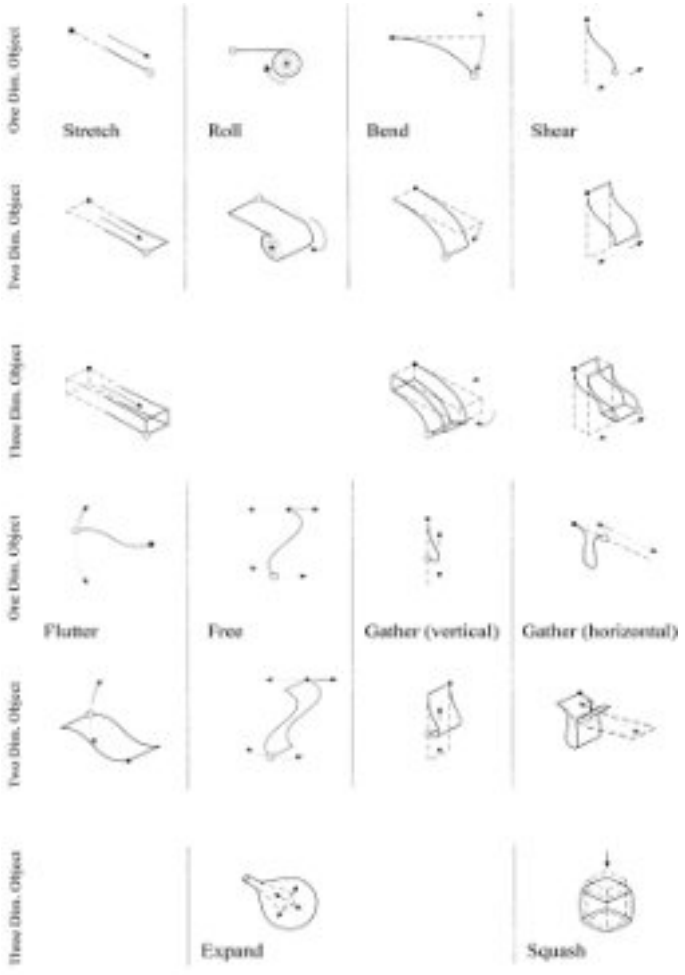


Figure *49, Types of movement in Smart Materials, source Schumacher, M., Schaeffer, O., & Vogt, M. M. (2012). Move: architecture in motion-dynamic components and elements. Walter de Gruyter. P. 47, as sourced in Youssef Elkhayat, 'Kinetic Applications of Smart Materials in Architecture: A Descriptive Analysis', Journal of Engineering Research 7 (31 December 2023).page 2*

Real-time adaptability of the building can be regarded under the term of kinetic architecture. In general kinetic architecture refers to addition of the dynamic value into architecture, an addtional layer of movement and change in time, creating a shift from viewing architecture in traditionally static light. There can be five types of elements succeptable to movement to classify: rigid, deformable, soft and flexible, elastic and pneumatic.[203] The functionality can be trigerred by a mechanism or physically, and the scale of the design ranges from the changes in the building to micro changes in the materials used. Modern materials, that posess the specific characteristic of being able to deform under some sort of impulse are reffered to as Smart Materials.

Smart Materials are a kinetic solution that relay on the materials' properties to add the adaptability to the design. The triggers for the changes include mostly temperature, light, pressure, chemical, magnetic or electrical simuli.[204]

The adaptability in such a traditionally stagnant area as architecture, is a reflection of the change of perception, triggered by the fast-paced changes of the current age. While it brings about benefits to both the movement of environmentally-concious architecture and attributes to the rational use of the spaces, the social implication of the high popularity of adaptable solutions, paint the vision of the society, where the constant change is not only an occurance, that has to be accepted, but a need and a parameter of perception. The fast-paced society, one that is used to stimuli and impatient in the finding the resolution for their needs is one to create that solutions that allow for almost immediate response to their desires.

[203] Youssef Elkhayat, 'Kinetic Applications of Smart Materials in Architecture: A Descriptive Analysis', Journal of Engineering Research 7 (31 December 2023).page 1
[204] Youssef Elkhayat, 'Kinetic Applications of Smart Materials in Architecture: A Descriptive Analysis',

4.2.2.c Resilient design

Resilient architecture or resilient city is one, that can adopt to changing environment and recover from the shocks. Primarily, the resiliency is related to environmental risks of the climate change. Therefore the main actions of implementing resilien city solutions relate to the reduction of carbon footprint, providing energy efficient solutions, smart water management or green areas within the city to lower the occurance of the heat island. The localised approach is essential as the analysis of the local needs provides the right solution for the region and the utilisation of local materials and manufacturers lowers their embodied energy through the reduction in transportation distance. The resilience relies on context and adopting the solutions to the specific character and needs of the place.[212] The inspiration is often drawn from the biophilic solutions, as the provide the options and inspirations of incorporation nature into the design or, more importantly, he ways of reinterpreting the ecosystems functioning and nature's solutions to battle the issues faced by the built environment.[213]

The resilience, according to researchers, may fail to be fully functional if it fails to take into accound the well-being and comfort of the occupants.[214] This approach goes hand in hand with the current direction of thought regarding sustainable design and stems from the human-centric thought process. Cities and habitats in general exist to cater to the needs of the society. In the cases when too much focus is placed on the structural solutions, and not enough on the social ones, this dichotomy results in the weakening of the social structures that makes it succeptaible to stresses. With the overt focus on the functionality, without taking into account the emotional aspects related to the implemented solutions, the movement faces the risk of being short-lived and suceptible to protest and resistance, no matter the adequacy of the functional solutions.[215]

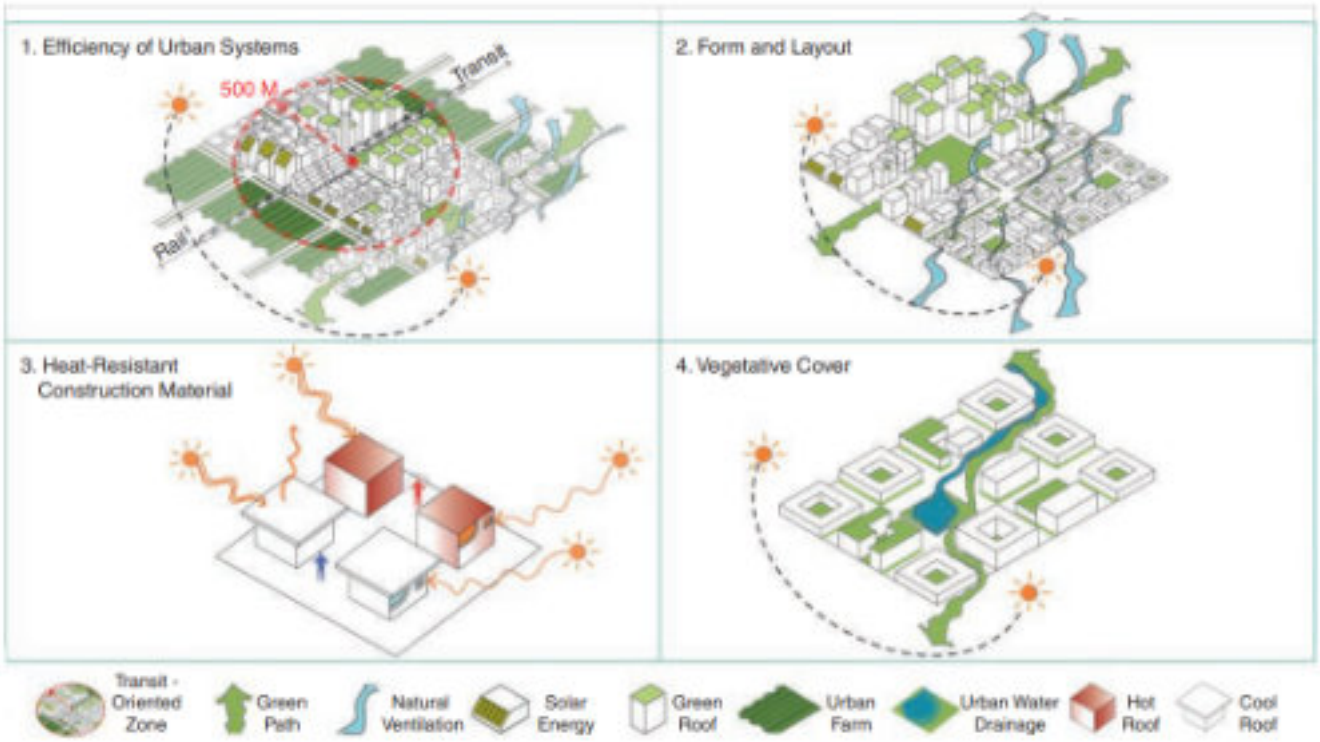


Figure *50, Example of the resilient city, image source: https://www.uccrn.education/what-is-the-meaning-of-resilient-city/ [Accessed 11th of April 2025]]*

[212] Mocerino Consiglia, Abderrahim Lahmar, and Mohamed Azrour, 'Towards Resilient Architecture in Technological Innovation and AI', in Vernacular Architecture: Support for Territorial Development, 2025. Page 326
[213] Terri Peters, 'The Social Contexts of Resilient Architecture', in Multisystemic Resilience, n.d. page 627
[214] Terri Peters, 'The Social Contexts of Resilient Architecture'
[215] Terri Peters, 'The Social Contexts of Resilient Architecture page 626

Within the smart cities, utilising the Big Data, IoD and AI for the creation of self-analysisng networks, that provide the ability to optimise the functioning of the city and pinpoint the areas its lacking, resiliency may not refer just to the resiliency fo the structures and infrastructures of the city, but to the resiliency of the technological systems as well. The AR-Edge Computing, Autonomous Resilient Edge, focuses on the creation of secure framework. The main objectives llie in the decouplin and decentralisation of the system components.[216] The system security is cloud security, both in regards to the data processing and storing capabilities and cybersecurity. For the current environmental focus, the resiliency of the design of technological networks, that in itself can provide data on both possible dangers, with tracking the city's ecosystems and with the use of AI processing, provide solutions for improvements, lies in the solutions that lower the carbon footprint and embodied energy of the technological solutions. Edge computing functions on reduced latency between processing and performation of the dataand data source, which can be achieved through the fragmentalisation of the systems, basing more on the policentic approaches, then monocentric. According to research it allows for the increase of the energy efficiency of the system.[217]

The resiliency of the cities with all of its components- architecture, infrastructure, technological networks and citizents is a layer of thought an analysis that added to the design process provides a framework for discussing more adequate and future-proofing solutions for the well-being of the society. Its emergence is the effect of climate discomfort and the uncertainty of the future. Therefor the direction is to focus on the implication of the solutions to reduce to possible future negative impact on the environment, while equpping the designs with ways to withstand the possible drastic weathers, with the solutions that promote human health and comfort.[218]

The coexistence of resilient city functional and social solutions can be observed in the flooring-resistant urban renovations strategies that are being implemented under the Climate Adoptation Plan and Cloudburst Management Plan in Copehangen (figure 51). The solutions include actions like changing roads into pedestrian paths or bikelines and general optimisation of road infrastructure to promote outdoor activities, incorporation of greenery into the design and canals to redirect water from possible heavy rainfalls from the buildings.[219]

Figure *51, Sankt Kjelds Square and Bryggervangen renderings of the climate adoption regions, image source: Terri Peters, 'The Social Contexts of Resilient Architecture', page 640*

[216] Ronghua Xu, Deeraj Nagothu, and Chen, 'AR-Edge: Autonomous and Resilient Edge Computing Architecture for Smart Cities', in Edge Computing - Architecture and Applications for Smart Cities, 2024. Page 1
[217] Ronghua Xu, Deeraj Nagothu, and Chen, 'AR-Edge: Autonomous and Resilient Edge Computing Architecture for Smart Cities', in Edge Computing - Architecture and Applications for Smart Cities, 2024.page 4-5
[218] Terri Peters, 'The Social Contexts of Resilient Architecture', page 627
[219] Terri Peters, 'The Social Contexts of Resilient Architecture', page 639-640

4.2.2.d The buildings life-cycle

Builings life-cycle is a method of regarding the building long all stages of its creation, existance and end. Within most researches it consists of 5 stages: design, production, construction, use and end of life (figure 52).[220] The design stage is sometimes not considered as a separate stage, but an action that binds it all together. Building life-cycle is analysed through the lenses of its stages impacts on the environment and in science are refered to as Life-Cycle Analysis or LCA in short.

table 1. The stages of building's life-cycle

Stage	Actions	Environmental impact
Production	1. Extraction of raw material 2. Transportation 3. Manufacturing	- Extraction and use of non-renewable materials - Emission of green gases - Consumption of energy and water
Construction	1. Transportation 2. Installation of the material on site	- Emission of green gases - Consumption of energy and water - Construction waste
Usage	1. User impact 2. Maintenance, repairs or refurbishments	- Consumption of water and energy; user's waste - Consumption of water and energy; material waste
End-of-life or after-life	1. Demolishion 2. Deconstruction 3. Redesign through change of function	- Material waste - Consumption of water and energy, material waste - Consumption of water and energy, material waste

The initial considerations regarding the cyclical nature of the building and its componens date back to the 1970s and 1980s, when the studies regarded the load the infrustracture of the building had on the environment during its functioning.[221] The push for the implementation of the environmntally-friendly solutions in the designs has expanded into all elements and stages of the design, which should be taken into consideration to back up the solutions chosen for the building. The holistic approach of LCA is useful both for the inicial analysis stages of the future constructions and as an analysis tool for the comparison of the negative environmental impact of the traditional buildings and ones that incorporate the ecological solutions, which is a fundamental argument in the propagation of the solutions, that, at the inicial stages, require more considerationa and often financial strains. The comperative research on that issue finds, that the buildings, that take into consideration the embodied energy of all elements, through all differen stages of life of the building prove to leave a lesser mark on the environment than the ones that don't.[222] While that conclusion seems to be intuituve, it is important, within the sctor of construction, that grapples with the needs of multiple stakeholders, to have a reliable source of information on the actual impact of alternative solutions.

Figure 52*, Building's life-cycle stages, image source: https://ocw.tudelft.nl/course-readings/3-1-2-life-cycle-of-a-building/ [Accessed 11th of April 2025]]*

[220] Gaetano Bertino et al., 'Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials', Applied Sciences 11 (20 January 2021): 939, https://doi.org/10.3390/app11030939.
[221] Wikipedia contributors, "Building Life Cycle," Wikipedia, May 24, 2025, https://en.wikipedia.org/wiki/Building_life_cycle.
[222] Kimberly Jane, 'Life Cycle Assessment of Energy Consumption in Green vs. Conventional Buildings', 12 January 2025.

The LCA follows four stages, defining goal, the analysis of the inventory, the assessment of the impact and the interpretation. The data is site and project specific and takes into accound various aspects of the design, including transportation.[223]

The availability of the assessment tool of LCA proves as a valuable addition to the theoritical life-cycle considerations due to the possiblity of verifying multiple choices for the intervention in its initial design stages. With that, the adequacy of using innovative materials or the merging of the modern and traditional solutions can be verified. While highly valuable, the LCA is a tools, and as any other may provide sometimes curious results in regard to certain technologies. The future use of the LCA required the continuation of evolvment of this analitical technology as well as the tendency to verify the technological tools the architects are provided with.

In current sustainable movements, end-of life is a stage that undergoes biggest transformation in regards to approach. The goal is to change end-of life of the building into after-life through deconstruction or redesign. Deconstruction refers to the purposeful de-assembly of the building with the aim to repurpose the materials. Redesign refers to actions that are undertaken when the function of the building changes and therefor its structure requires refurbishments to fit new situation. Both of those actions can be planned to a certain extent beforehand, during the inicial design stage. This paper goes into further datail in regards to the "designing for after-life of the building" in the next subchapter.

[223] Lea Hasselsteen and Kai Kanafani, 'Mapping the Climate Impact of Construction Processes: A Case Study from Denmark', IOP Conference Series Earth and Environmental Science 1402, no. 1 (October 2024).

4.2.2.e Design for Deconstruction

Design for Deconstruction (DfD) is a method of designing buildings for deconstruction during the end-of-life stage. Deconstruction as a term refers to a well-planned disarrangement of the components of the building, providing a prolonged use in different construction.[224] The idea stems from the rise of solution related to circular-economy. Deconstruction, in comparisson to demolishion, allows for materials to be recycled or repurposed, which assures that less material ends up in landfills and allows for the reduction of extraction of raw non-renewable materials.

While the idea in itself is rather new, as buildings have been viewed in history as permamaent structures. However, at the same time the repurposing of materials has been more common in the past due to less amount of new raw materials, which extraction was not possible to the extent that it is now. The repurposing usully originated from need or want. The components needed to be repurposed to provide material for rebuilding structures destroyed, for example during the wars or other military conflicts. An example could be the dis-assembly of various buildings around Poland to provide materials for the rebuilding of Warsaw after its destroying in the II World War. The buildings which materials were repurposed usually suffered some level of destruction as well, but oftentimes could have been repaired if not for the greater purpose imagined for them, like an example of lower-secondary school in Pomeranian city of Prabuty, deconstructed fully to obtain red brick for Warsaw, even though its own destruction related to the roof.[225] Secondly varied shelters and homes of the lower social classes have always been built with what's at hand. Components of the building have also been repurposed by the want factor, as a purpose or effect of various conquests and colonisations. Examples can be found everywhere, but an interesting one is the Cathedral Basilica of San Marco in Venice, Italy[226]. Its history includes theft since even before the construction of basilica had began, with Venicians stealing the body of Saint Marco the Evangelist from Egipt. The current design of the Basilica, especially the outside is the outcome of the Fourth Crusate, which resulted in the fall of Constantinopole and for Venice the receiving of various treasures and architectural elements, particularily the columns, that ornate the outside face of the basilica with their varied shapes and colours.

It is therefor quite clear that the permament view on buidlings relates mostly to the structure of only the most famous ones or ones owned by the higher classes. But with the socioeconomic changes of the XX century, particularily the increased speed of technological development and society's way of life and the introduction of prefabrication in construction, that view began to change to let it evolve into the sort of philospohy of construction it exists as now. What is lacking now is the clear methods, design guides, and shared information databases that could allow for a better management of the DfD process.

Figure 53 *Wall mock-up in deconstructed form, credit Kaia Nielsen_Roine, image source: https://blogs.ubc.ca/design4deconstruction/designfordeconstruction/*

[224] Gaetano Bertino et al., 'Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials', Applied Sciences 11 (20 January 2021): 939, https://doi.org/10.3390/app11030939.
[225] Wiktoria Dudek's relative, personal comunication, January 2025.
[226] 'St. Mark's Basilica: Kidnapping, Treasures, & Other Secrets', 11 April 2023, https://www.walksofitaly.com/blog/art-culture/6-fascinating-facts-about-st-marks-basilica.

Every project requires an individual solutions to handle future dismantle and to source materials for its construction. There is a preference when handling the sourced materials. Not all materials achived through various recycle-related means have the same embeded energy. The preparation of the material before repurposing it in different building requires different actions, from reusing the material, through recycling or downcycling, down to disposal. The graph below shows the preference of the approach and action related to its process.

In the DfD approach to design, each building is viewed as a storage of construction materials, with their own deconstruction plans deve,loped during the design stage and a "Material Passport" which is a list of building elements and materials with proposed post-life purposes. While deciding on the right approach for DfD important decision include deciding on the load-bearing and non-load bearing components. Deconstruction of the structural elements (load-bearing) requires a specialised method and use of machines. Depending on the technique od construction it is not always doable, especially in cases on on-site construction with wet nodes. Structural deconstruction is an area least researched at the moment. Non-structural elements deconstruction related to all components like wall infills, windows, doors etc. and methods used to deconstruct as well as solutions to deal with the deconstructed material vary depending on the element and its state.

Table 1 showing recommendations for the parameters to take under consideration during the design stage to improve the buildings' longevity as well as the probability to gain sustainable after-life purposes for its components, table by Wiktoria Dudek, based on Bertino et al., "Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials."

Building layer	Components	Design for demolition solution
Load-bearing elements	Beams, columns, walls, slabs, foundations	Using dry connections for easy dismantle*, such as dry stack bricks, bolting instead of welding for steel constructions or use of prestressed concrete instead of prepared on-site, use of wood or steel in construction (higher reuse value)
Enclosure	Buildings' envelope, exterior walls, roof	Easily dismanteled and reused after deconstruction
Partitions	Walls, slabs	Using dry connections for easy dismantle*
Doors and windows		Easily dismanteled and reused after deconstruction
Technical installations	Wiring, plumbing, HVAC, fire extinguishing system	1. High-quality installations components to prolong the longevity of the building (outdated systems may lead to non-functional buildings and bring about its end-of-life quicker) 2. Flexibility in design, so that the system is modifiable in case of the need for renovations, repairs or redesigns; examples of implication: suspended ceilings allowing for easy access to installations
Finishes	Suspended ceilings, flooring, wall finish	Easily dismanteled and reused after deconstruction

** Alternatively, in case of using wet connections, the materiials during later deconstruction can be shredded and used as a secondary material, such as filling for concrete instead of gravel for non-load bearing concrete walls or pavements or roadbeds from recycled, shredded bricks.*

The deconstruction effectiveness can be hightened through strategies, that can be implemented as soon as during the design process.[227] Firstly the reduction of the complexity of the building through the use of modular, larger materials, preferably prefabricated and lightweight as well as their connections simplifies the construction process and therefore the de-construction process. Secondly the choice of materials with higher reusability value, like steel, wood and brick, with the preference of solid materials to composites for easier dismantle.

Many of the choices regarding the prioritisation of easier to dismantle materials can be made during the design stage of the building. Additionally DfD goes hand in hand with its own "child"- using the recycles materials in the design.

Design for Deconstruction as a philosophy of construction reflects both the fear and conciousness of the climate decline threat as it is a solution of the utilisation of what is available and preparing the future, that, under the ideas of a sustainable society, provides the genertions to come with no less opportunities as they were presented with. The conciousness to think about all of the stages of the existance of the building and their impact on the environment may be a fundamental perception shift in battling the anthropogenic climate decline.

[227] Bertino et al., "Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials."

4.2.3 Circularity

Circularity in construction refers to the implementation of the circular economy principles in the constrcution process, creating a shift from viewing the elements in a linear fashion of production-use-disposal to circular one, focused on the creation of the closed loop of the element's. It is related to previously mentioned philophy of viewing buidlings, and other structures and products through the entirety of their life-cycle and making a plan for their disassembly. The circular aspect of that approach is focused on the utilisation and management of materials, as well as implementation of repurposing into the design throught ecotechnical solutions for the construction and functioning of the building, such as greywater management or heat recovery heat pumps.

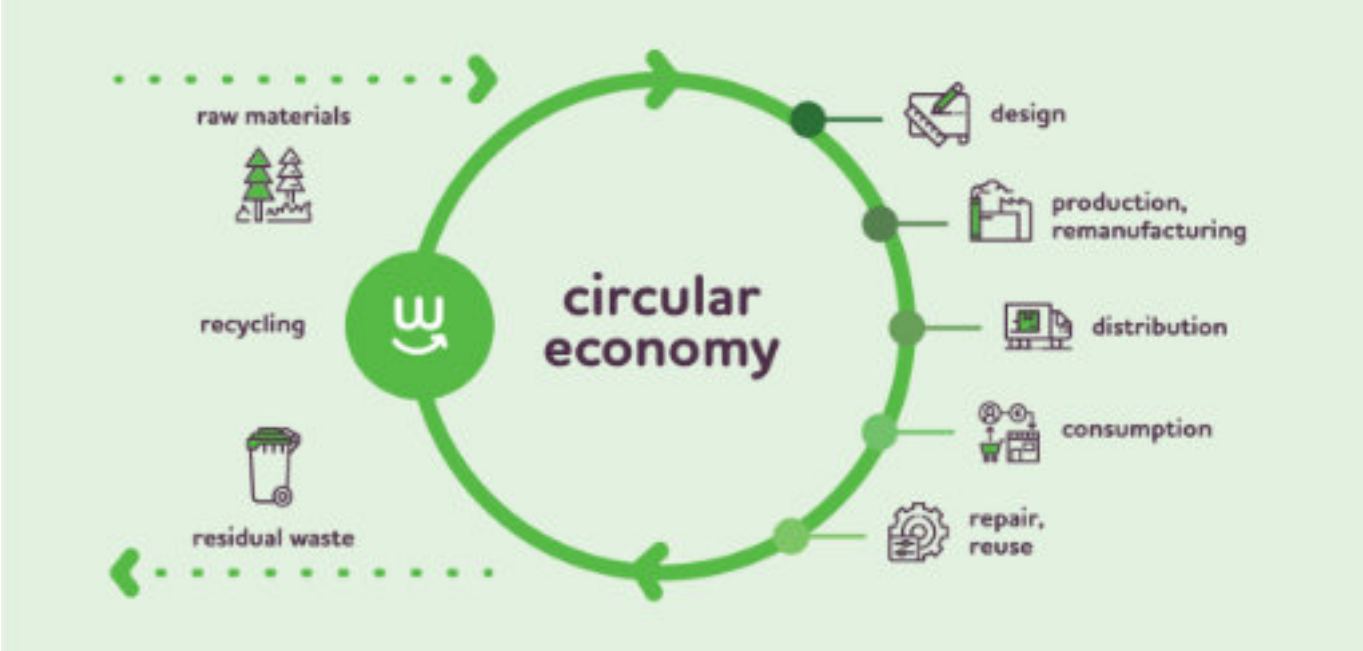


Figure 54 *Circular economy, image source : https://www.linkedin.com/pulse/circular-economy-construction-industry-advantages-challenges-kuşcu, {accessed 13th of April 2025}*

4.2.3.a The 4R

Circular economy (CE) in architecture manifests itself most notably through the attitute towards architectural materials, according to the research based on the occurance of the keywords[228]. The shift into cautiousness is related to the groowth in conciousness regarding the impact the process of construction has on the environment in all of its stages.

The 4R principle is a systematic approach to managing waste. The 4R are Refuse, Reduce, Reuse, Recycle.[229] They refer to the approach, that, if applied in that specific order, naturally leads to the reduction in the wasted material. Sometimes the refered to 4R can be Reduce, Reuse, Recycle and Recover, and that version as well serves the same purpose.

Within the scope of the sector of construction, circular mentality is adjacent to the life-cycle considerations and DfD. The adequate approach would include the analysis of the materials planned for the construction of the building during the design stage. The issues taken into consideration during that analysis include the envisioned path of the material. Firslty, the raw material for later manufacturing has to be extracted and transported into the production plant. Secondly the product is produced and later transported into the site, where it can be adjusted and assembled into the building. It withstands possible changes and deterioration during the functioning, the "life" of the building and by its end is faces with the possilities of further management. The 4R, with the additional possible stages, adequate for the construction is aplicable for that stage. The possible futures of the material post-demolishion include the reuse of the material, which is a preffered choice, as it produces least amount of waste. Secondly recycling, with its three types: upcycling, relating to enhancing the materials properties, proper recycling, which uses energy and generates more or less resources depending on the material or downcycling, most common in construction. The last choice is disposal of the material to the landfield.

The awareness of the possibilites and knowledge about different solutions and options allows for the architect to determine the future material at the primary stages of the design, through analysis of the local market in search for two main information, available productions, to lower the transportation of the material onto the side, and availability of companies that manufacture materials with the use of recycled waste. A proper calculation of the embodied energy, that the material chosen for the component of the building gives a proper estimation of the actual negative impact of the building on the nevironment and allows for the possibility to lower it.

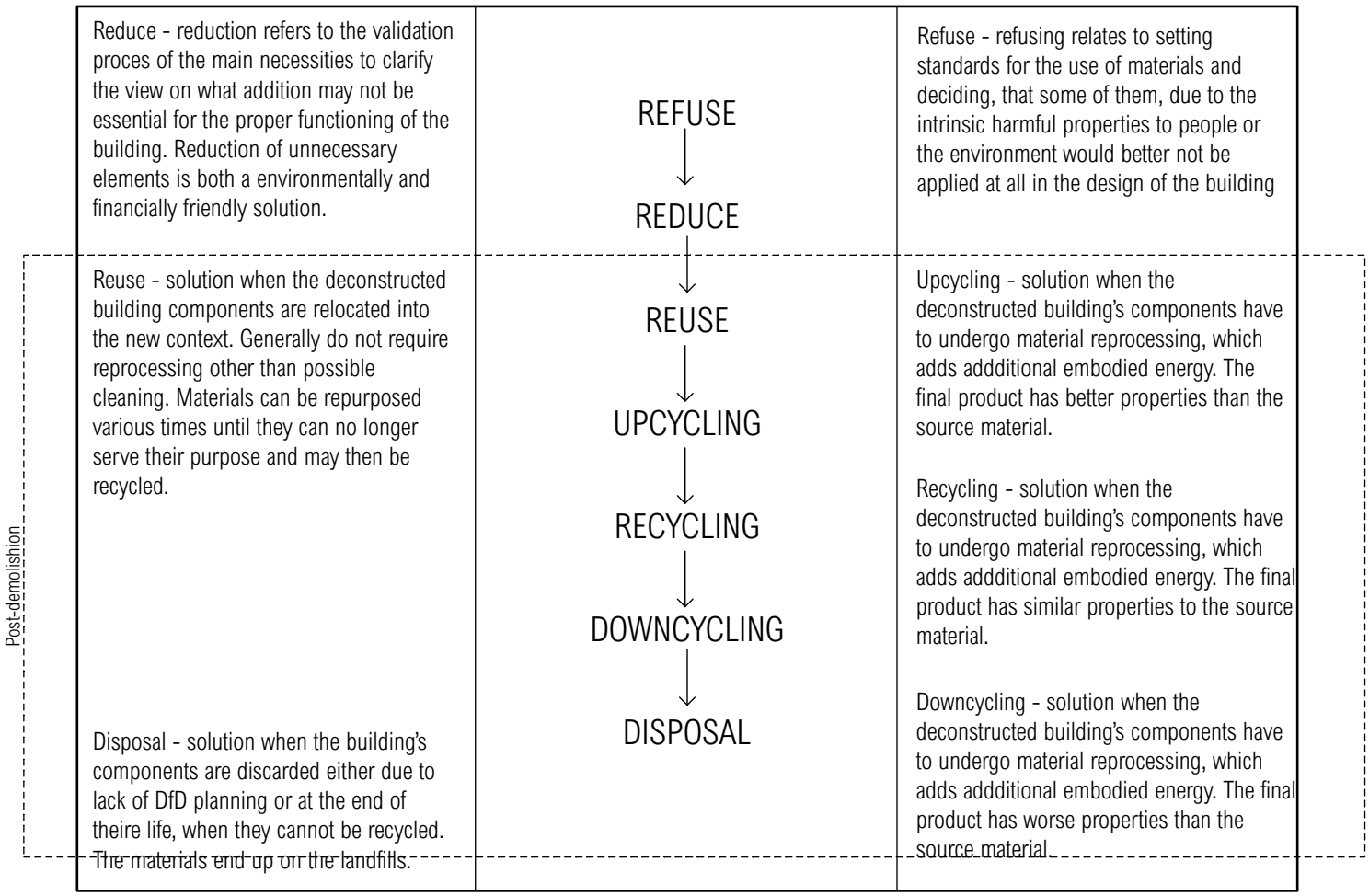


Figure 55 Graph showing the hierarchal relationship between different methods of handling construction mterial "waste". The hierarchy refers to the the solution's impact on the environment due to the works required and the effect of it. Own work, based on Bertino et al., "Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials."

[228] Burcu Kısmet, Rethinking Sustainability in Architecture through Circular Economy, 2024.
[229] The Ministry of Infrastructure Cook Islands (ICI), "4R'S - REFUSE, REUSE, REDUCE & RECYCLE - the Ministry of Infrastructure Cook Islands," The Ministry of Infrastructure Cook Islands, April 4, 2022, https://ici.gov.ck/wastemanagement/4rs-refuse-reuse-reduce-recycle/.

4.3 Conclusions

In comparison to the XX century, the XXI century presents itself as a constrant pendulum of the inbetween. Between irony and sincerity, meaning and void, reality and simulation or isolation and community. The coexistance of the radicalities suggests, that, in the light of Hegel's dialetic, the clearer view on the character for the years to come will emerge in the next few years to come. That gives us, as its creator, time to sit back a bit and think, which directions would be the ones that would bring us closer to the future we envision.

The architecture of the time reflects society is a reflection of the society. Both a catalyst and byproduct, analysis of the directions of the architectural design can help understand the society that inhabits it and vice versa. So the question is, what characterises both, and what possible direction could it take?

The main two defining characteristics of the current society and heavily discussed topics are technology and the environment. The technological advancement, started through the First Industrial Revolution, has now led to the creation of society, that is started to be named a post-industrial society, one that has transended the norms, that dictated the lives of its ancestors for the last few centuries. The industrial revolutions have granted humanity more than just mobile phones and internet connection. They have redefined the way society looks and works. The current day-to-day life of middle class person, while still with its own hardships, is able to have an initiative, that was hard to even think about for the fctory workers of the 12 hours shifts. The inicial need for more workers to produce more goods, open market and rise of public transportation has granted the society of the XXI century great freedom in terms of choosing the lifepath they long for. It has redefined the societal structure, the role of the womem or the rights of all children to education. If there ever was a need to judge the state of the society, the society of the XXI century up to that point can be marked as relatively good, in comparison to its history. Which is the very reason for the stress and uncertainity, that it hardly manages to grapple with, as it is always more scary to face the uncertainty of loosing the comfort of the lives. That is why, for those, who view the current climate crisis in line with the scientists mark it as one of the main issues, that have to be addresses in the current century. The view on the progress presented here is very Eurocentric and focused on the progress of the West, with various places in the world grappling with serious social matters. However, the awareness of that, still puts us at a better position than the society was at more than a century ago.

The current society is a global one, with all its advantages and disadvantages. The access to information and people all around the world has made it both more informed and more numb, due to the overstimulation of information, especially the bad ones. The numbness is a contributor to the tendency of escapism, which in part has fuelled the evolvement of the technology, that allows us to escape. The society created as a result is one that is pressed to be interested and informes and, at the same time, longs for the sweet comfort of ignorance, that seems often unrecheable.

The surroundigns of such complex society reflects that. The architecture and urbanism of the now are granted two main identities by the general narrative- they're a product and a medicine. The accesibility of technology for the architectural design studios, such as BIM, rendering or emerging Virtual Reality, paired with the client inspired by the information provided by the www has aided the shift of the architecture from the artistic persuit towards the craftsmanship. The difference lies in the utility and the identity of the outcome- a product with artictic character, not an art piece. As every aspect of daily life, architecture has leaned into being a machine- however not in a way the Modernists have envisioned that. The current architectural design no longer reflects grand ideas as "Form follows Function" or otherwise, but could be contained within the worlds of "I rised from the constrains". The role of the architect is therefore a multifaceted juggle of finding that little free space for their own mark.

The constrains mentioned stem from the society's needs and directions. Firstly, the urban development theories have reached the point of valuing the clear and concise directions to prevent the overflowing of the growing cities, that has been already experienced and rejected. Secondly, the intervention cannot go against the environmental constrains, laid out by the governments and by the peer pressure and therefore forces the hand of the architect to analyse their every choice to win that contest of "who did it better" in terms of environmental friendliness. The tools are all there- certifications, LCA's, decarbonisation solutions, material sourcing analysis and more. Thirdly, a society used to rapid progress and instant gratification is a bored and impatient one. It doesn't want to wait for the next bus in the rain, so the architect answers that need by optimising the transportation and building bus stops. With solar panels. Then the bored memeber of the society can't stay in one place, so the designer designs the spatial layout, the furniture and the entire elevation of the building with flexible, kinetic solution to provide the option of movement for the office worker and introduce change and optimisation to their surroundings. Fourthly as a mean to answer the desires of ownership, of quick access, of availability, it scales the comforts, available to the selected few before, to fit the tight flat, or a tiny house, or a box to grant that wish.

The impatient member of the society is not really in the wrong in wanting all of the comforts, that the current progress grants them. Not at all. They might even realise they really appreciate it if the pay attention. But that silent comfort is scary as it can be lost. To not allow that to happen the bored member will eventually undertake action. They will put money in the regenerative architectural design, that uses brick from biowaste above one, that doesn't consider the environmental solutions, asking for the critical opinion on the internet before making final decision. To rest they invest in a space that thinks for them, was built for them with the use of AI-supported robots and integrates virtual reality layer on the real one to seemingly simplify their immediate environment. To not settle on one option they will choose the flexible option over static one, that uses modules, AI and mechanised surrounding to match the circadian cycle or emotional state of its inhabitant. By the end of the day they will take the elevator to the highest floor of the structure to pick up the new game, they ordered though their AI assistant. And as such the new picture of the reality is a product on the human needs in the human-centric world.

Figure 56 *Shot from the movie "The Pod Generation". In the scene the married pair goes to the AI therapist to discuss their fears regarding their approaching parenthood. Between them is the baby, growing in the innovative pod, as reproduction managed to be comfortably managed outside of the female body. Image source: https://www.latimes.com/entertainment-arts/movies/story/2023-08-11/pod-generation-review-emilia-clarke-chiwetel-ejiofor-sci-fi [accessed online 20th of May 2025]*

Figure 57 *The future cafe. Episode 9: 100 years later by @winnie_thepooj and @Benton McClintock, screenshots from the tiktok skit, link: https://www.tiktok.com/@winnie_thepooj/video/7434964733658254623 [accessed online 20th of May 2025]*

PROJECT

6. Pre-construction analysis

6.1 Location

6.1.1 The historical character of the region

The project is located in the Spanish Autonomus Community of the Basque Country, a region on the north of Spain, bordering with France. In the language of the local people, Euskera, it is called Euskadi or commonly referred to as Euskal Herria, the Basque people, a currently transnational term that refers to all Basque people, their identity, traditions, language, shared heritage. It captures a greater region, with Autonomus Community of the Basque Country and Navarre (Navarre's inclusion is debatable) as well as French Northern Basque Country.[230]

The cultural influence of the region is varied. A simplifies overview of the influences is visible on the graphic (fig 58). The existance of people in this region can be tracked down as far back as before 35 thousand years ago, due to the existance of various caves [1] in the area and close to it, such as Ekain near Azpeitia. Neolithic period bore the first settlements, alongside pottery and sheepherding, followed by megalith culture and gradual change into the Bronze Age and Iron Age.[231] The first instances of indo-european influences begin around 1500 BC with the Celtiberians [2] which influenced the land up to the beginning of the New Era. Around 200 BC the Celtiberians influence varied in different regions, with the regions around the Pyrenees being occupied by Aquitanian people [3], such as Vascones or Aquitani, among others. The cultural influence in the region surrounding now Basque Country was a mix of the Aquitanian and Celtic influence. While the Celts' language and ethnicity are considered to be Indoeuropean, Aquitanians are a distincs ethinc group with isolated language.[232] That dynamic mix, between European heritage and a distinct isolated heritage is prelevant in current-day Euskadi with Euskera, particularily its origins, being an enigma of history. Around the change of eras the entirety of the Iberian Peninsula was under the influence of the Roman Empire [4]. After the fall of the Roman Empire, the region undergoes constant changes of influences. Various maps showing the region through different points of time mark however the existance of the territory of the Basque, in a form of Wasconia with influences from both Frankish Kingdon and The Germanic Visgoths in the 5th-8th century, with periods of both dependence and independence [4]. Within that tumulous and unclear period researchers agree of the preservence of Basque culture and failures to subdue the region to either. Muslim conquests of Spain of 8th and 9th century, while not reaching Wasconia make references to its people and various rulers, as well as polytheist beliefs, which indicate some form of independence and holding onto distinct identity. Around the period between 10th and 15th century and fragmentation of now independent Basque people regions, with the three significant forces of the Kingdom of Navarre, Kingdom of Castille and Kingdom of France [5].[233] By the and of 16th century, after long periods of conflicts, both inner conflics and changes of power within the countries, the enstablished borders schived the shape they have up to this day [7], through the entirety of modern history, full of Basque persecutions of witches hunt of 1600s, revolutions, wars and, importantly for the Spanish Basque Country, the hurtful period of Franco's dictatorship and controversial opposition. Through ups and downs the Euskal Herria has remained to be a distinct entity on Europe's map.

As history shows the region of Basque Country has a long history of human societies, change and preservation and the mixing of cultures, which are characteristics on the first glance contrary to one another. One of the lessons that can be drawn from its story is that the past reflected in tradition and the future viewed through the change brought about but unforseeable circumstances or human development can coexist and supplement each other. That characteristics makes the region a solid candidate for being the driver of innovation.

[230] Wikipedia contributors, "Basque Country (Greater Region)," Wikipedia, April 6, 2025, https://en.wikipedia.org/wiki/Basque_Country_(greater_region).

[231] Wikipedia contributors, "History of the Basques," Wikipedia, February 7, 2025, https://en.wikipedia.org/wiki/History_of_the_Basques#Basque_Country_in_prehistoric_times.

[232] Wikipedia contributors, "Celtiberians," Wikipedia, March 10, 2025, https://en.wikipedia.org/wiki/Celtiberians.

[233] Wikipedia contributors, "History of the Basques," Wikipedia, February 7, 2025, https://en.wikipedia.org/wiki/History_of_the_Basques#Early_Middle_Ages.

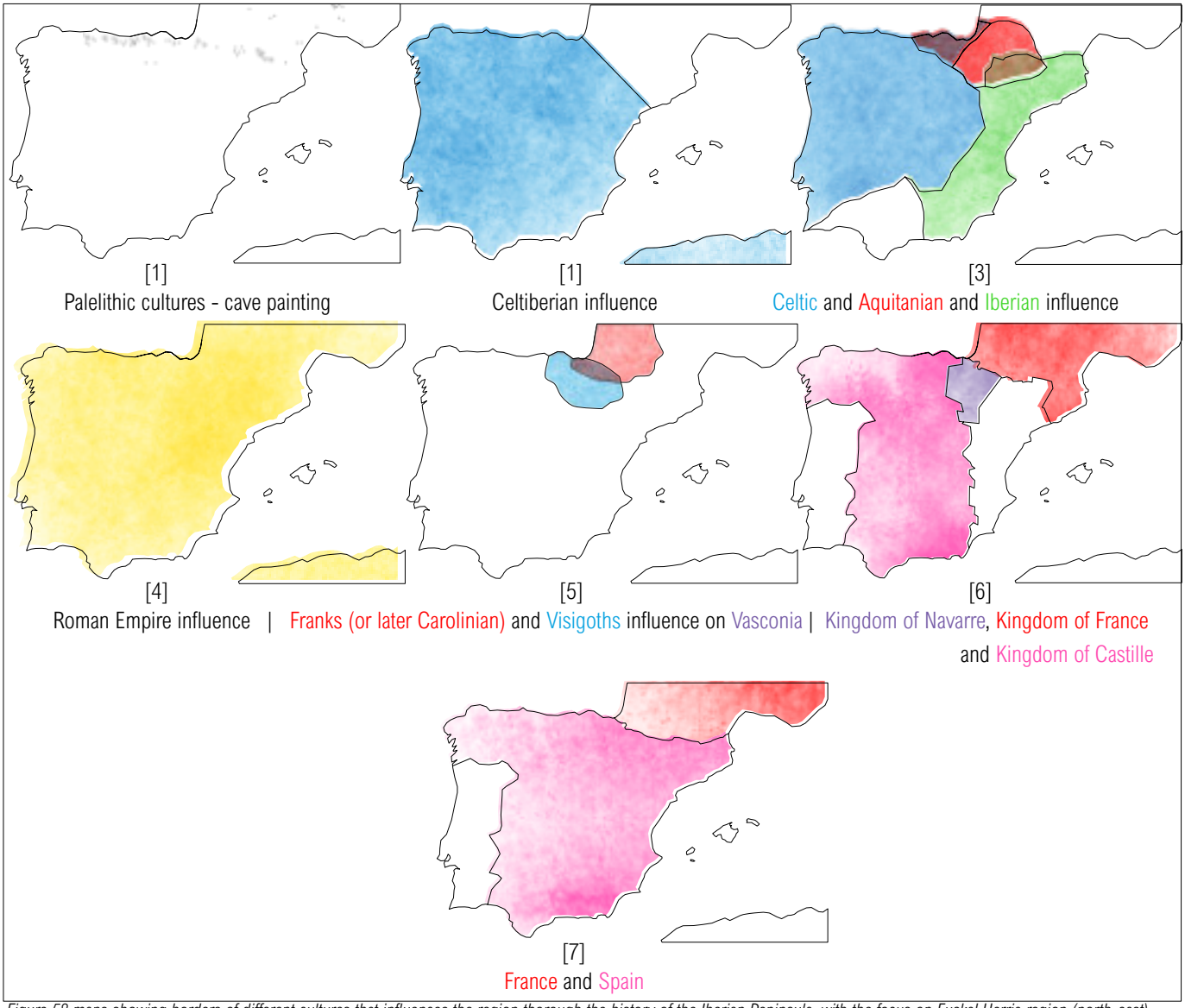


Figure 58 maps showing borders of different cultures that influences the region thorough the history of the Iberian Peninsula, with the focus on Euskal Herria region (north-east), own work, summaries based on the data available on the webpage https://historicborders.app
**The summary shows a simplified version and allows for slight inaccuracies. Its primary goal is to explore the origins of varied nature of Basque culture.*

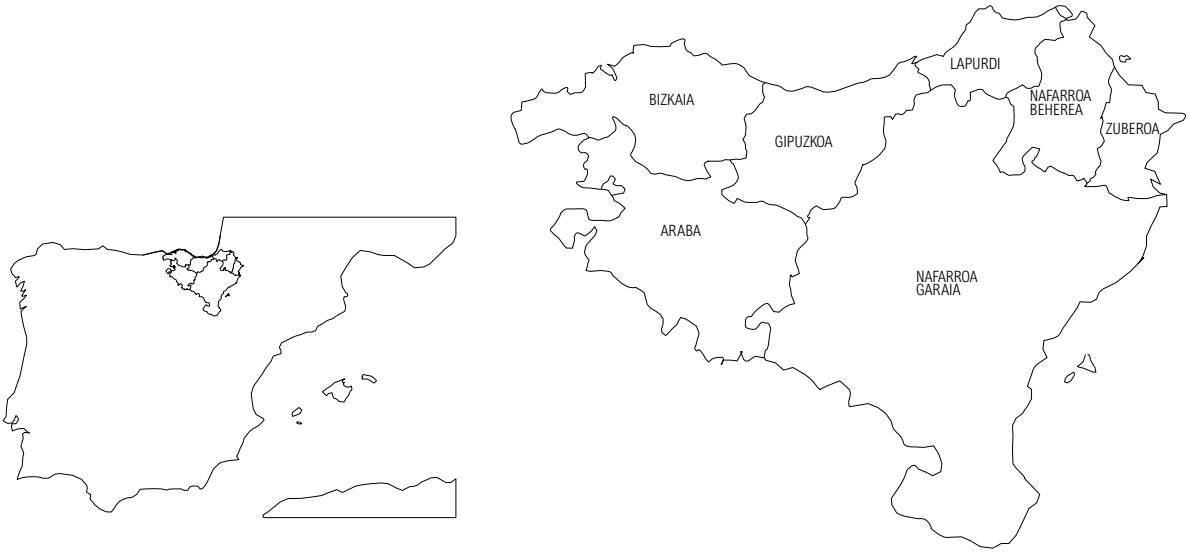
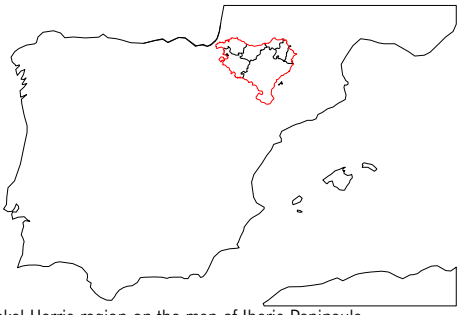


Figure 59 Map of the Euskal Herria region's location on the Iberian Peninsula
Figure 60 map showing the regions of Euskal Herria, both French and Spanish, based on the map available on Wikipedia contributors, "File:Euskal Herriko Kolore mapa.png - Wikipedia," October 18, 2008, https://en.wikipedia.org/wiki/File:Euskal_Herriko_kolore_mapa.png.

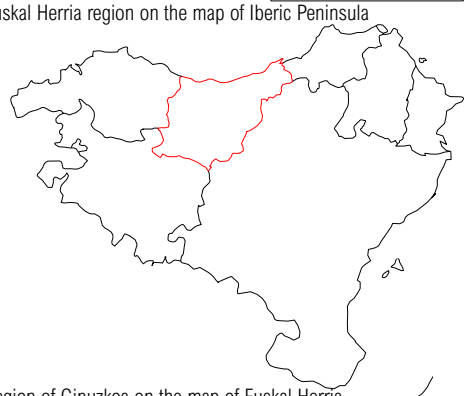
6.1.2 Main urban development strategies and tendencies

The past few years the Spanish Autonomous Community of the Basque Country has been active in terms of urban planning and strategies regarding sustainable design. Current direction of development of the built environment, planned for theyear 2040 is established under the Report of the Planning Guidelines for the Basque Country (Directrices de Ordenación Territorial) which is a strategic document indicating areas of interest and desirable actions.

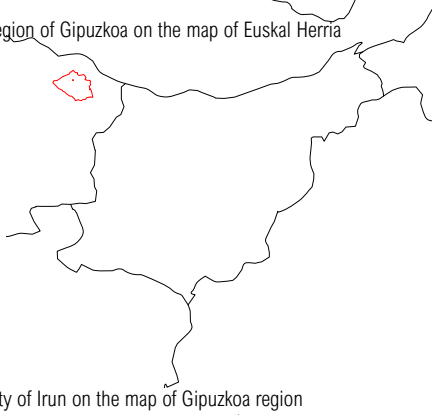
The fields of particular interest in the Basque Country include the natural habitats, that they're well known from, industrial areas, scattered around the entirety of the community, rural environments, communication-related zones, shift towards sustainable solutions, improving detailed and clear planning guidelines on various scales and creation of smart regions, ones that use the existing structures to boost economy with innovative solutions. The focus on the current directions of development continue the ones set in 1997 for the current times, which main objectives related to integration between different regions of the Spanish and French Basque Country through shared networks, polycentric urban models, growth of housing supply, improve economic competitivness through reimagining of traditional industrial models and designing processes for renewal of degrading spaces. The current Basque Spatial Strategies focuse on green infrastructure, rural and urban interventions, recognising their distinct nature, landscape preservation and touristic solutions, sustainable management of the resources, logistics of mobility and interdisciplinary issues.[234]



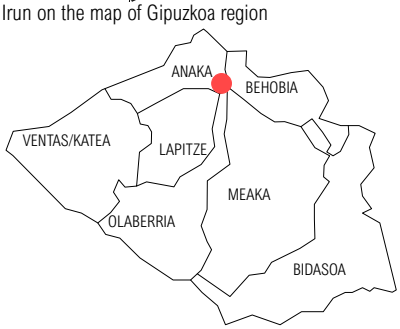
Euskal Herria region on the map of Iberic Peninsula



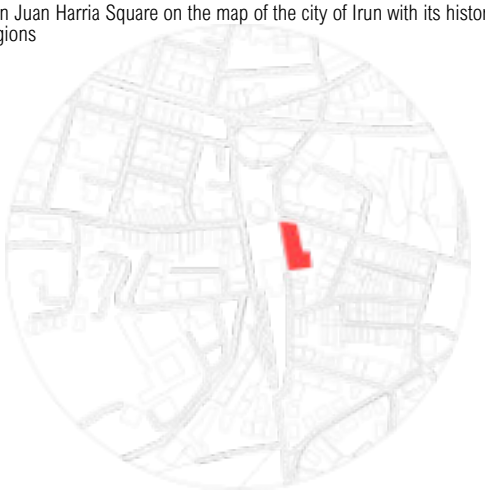
Region of Gipuzkoa on the map of Euskal Herria



City of Irun on the map of Gipuzkoa region



San Juan Harria Square on the map of the city of Irun with its historic regions



The site on the map of the surroundings of the San Juan Harria Square
Figure 61 Maps showing the location of the project, own maps, based on on Google Street maps, own work

[234] Gobierno Vaso, REGIONAL PLANNING GUIDELINES OF THE BASQUE COUNTRY

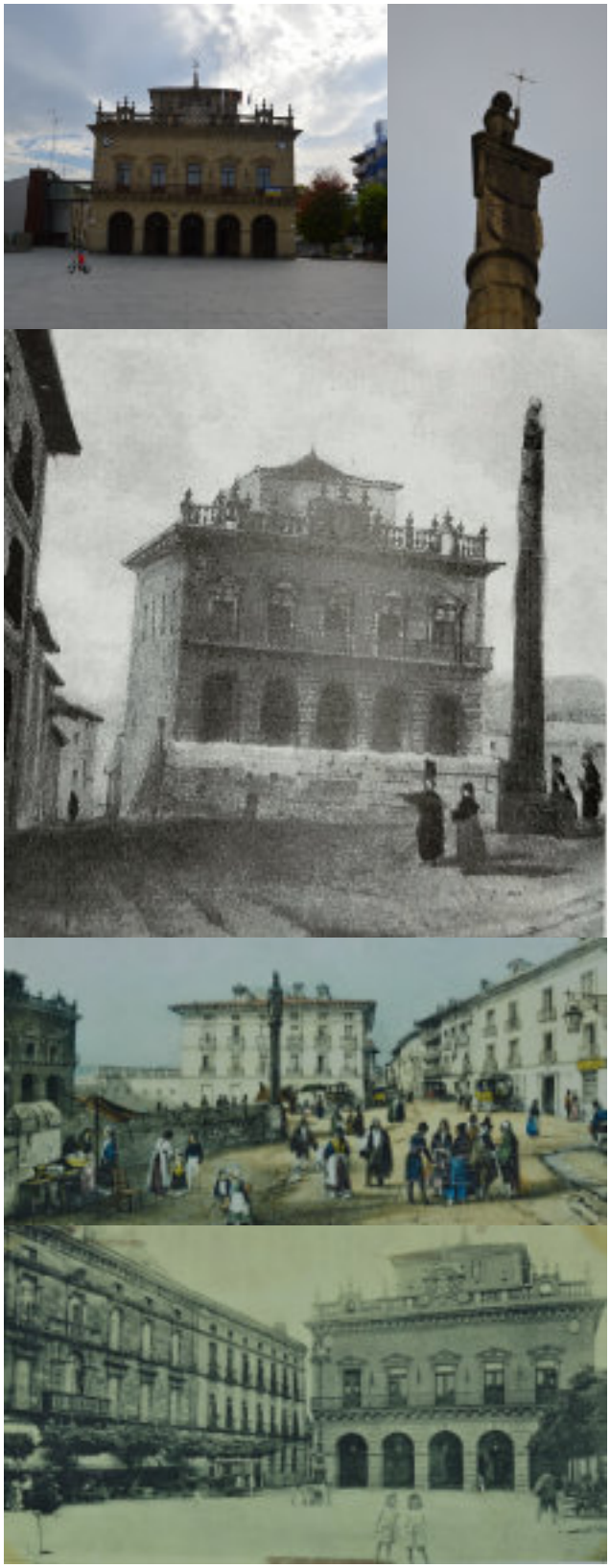


Figure 62 Town Hall of Irun, photo by Wiktoria Dudek
Figure 63 San Juan Harria column, photo by Wiktoria Dudek
Figure 64 San Juan Harria Square, the entry to the city, possible date before 1800, image source José María Castillo, Libro Irún 1936, imágenes de una guerra. De Castillo, José María (Luis de Uranzu Kultur Taldea, 1999) p.88
Figure 65 San Juan Harria Square, 1800s, picture source photo exhibition on San Juan Harria Square, author unknown, photo of the image by Wiktoria Dudek, February 2024
Figure 66 San Juan Harria Square, 1900s, photo source photo exhibition on San Juan Harria Square, author unknown, photo of the image by Wiktoria Dudek, February 2024

6.1.3 Greater City characteristic

Site is located at 43°20' N and 1°47' W, on the main square of the old town of the city Irun, located in Spanish Basque Autonomous Community.

The city of Irun is a border city, and part of Functional Urban Area, that consists of cities Irun and Hondarribia on the Spanish side and Hendaye on the French side. Its closeness to Donostia-San Sebastian, the capital of the region Gipuzkoa, the Donsotia-San Sebastian airport, located between Irun and Hondarribia and the stations of Euskotren, connecting Spanish and Basque Countries, makes it an important transportation hub and a bridge between two countries.

The region is limited by the Atlantic Ocean on the north and Basque Mountains on the south. The Basque Mountains are mainly a limestone range, full of ocean climate vegetation, of top heights around 1500 meters and are one of the reasons the region is known for a distinctive climate from the majority of Spain.

6.1.4 City characteristic

The region of the current city of Irún has been inhabited as far back as the known prehistory goes. During the Roman conquest of the region the area surrounding the hill, now the antique part of Irun was known under the name Oiasso. The sites that have prevailed since that times include the Necropolis of Santa Elena, working primarily as a necropolis and space for death-related rituals, later as a hermitage, a religious retreat,[235] the mines form the 20th century iron extraction on the site where mining dats back to the Roman times[236] and Roman Thermae.[237]

After the fall of the Roman Empire the region continued to be inhabited by one of the the Basque tribe, related to the region of Navarra, later a kingdom. The first written depiction of Irún appears in the beginning of the XIII century, around the time of the Kingdom of Castille's conquest of the Iberian peninsula. Irún's location as a border region thorough its history has led to various conflicts being experience by its citizens, among which, the most notable, the battle of San Marcial of the XVI century is still being commemorated during the Sanmarciales festival. Irún was established as a city in 1776 (figure 64-66) and evolved as an important seaside region. Irún had faced great destruction during the XX century Civil War, the project's site included, which can be noted in the architecture surrounding the San Juan Harria square, all dating back to times after the war (figure 67-70).[238]

Figure 67 San Juan Harria Square, doña Vicenza de Olázabal palace, later Casino, before the fire, 1939, photo source José María Castillo, Libro Irún 1936, imágenes de una guerra. p 128
Figure 68 San Juan Harria Square, doña Vicenza de Olázabal palace, later Casino, after the fire, 1939, photo source José María Castillo, Libro Irún 1936, imágenes de una guerra. p 129
Figure 69 San Juan Harria Square, doña Vicenza de Olázabal palace, later Casino, after the demolishion, 1939, photo source José María Castillo, Libro Irún 1936, imágenes de una guerra. p 129
Figure 70 San Juan Harria Square, during the civil War, 1939, photo source José María Castillo, Libro Irún 1936, imágenes de una guerra. p 196

[235] "Necrópolis Santa Elena," Oiasso Museoa, n.d., https://www.oiasso.com/es/ciudad-romana/necropolis-santa-elena.
[236] "Cierre Minas De Irugurutzeta," Oiasso Museoa, n.d., https://www.oiasso.com/es/ciudad-romana/minas-de-irugurutzeta.
[237] "Termas," Oiasso Museoa, n.d., https://www.oiasso.com/es/ciudad-romana/termas.
[238] colaboradores de Wikipedia, "Irún," Wikipedia, La Enciclopedia Libre, April 27, 2025, https://es.wikipedia.org/wiki/Ir%C3%BAn#Historia.

6.1.5 The neighbourhood characteristics

The site is located in the historical centre of the city. However, the great majority of the surrounding buildings have been distroyed during the Civil War (*Figure* 68) and the current character of the neighbourhood is modernised, with the exception of the Town Hall. The neighbourhood is characterised by the quarter built, with semi-private courtyards, with the height of the buildings ranging from 12 to 22 m above the ground floor at the entrance (figue 72).

The square is a significant urban public space, a characteristic landmark in the city. The functions of the square's neighbourhood include mostly residential buildings with small commercial on the ground floor, gastronomy, and most notably city administration and the cultural centre (figure 71). On the ground level it includes the entrances to the local Town Hall and urban park, while the underground of the square is the location of the town's CBA Cultural Centre with the existing library and, currently in the last stages of construction, the theatre space [239] [240].

The oldest element of the San Juan Harria Square is the San Juan Harria column (figure 63), erected in 1564. It is believed that it was build in memory of the bravery of the Irunian people in their fight agains the French invasion and time it began to symbolise the character and drive for independence of the citizens of Irun. There are six shields on the column, among which teh recognaisable three include the shield of Asturias, Gipuzkoa and Irun. The Town Hall (figure 62), which now, together with the column is considered to be one architectural complex was constructed between 1756-1763. The architect responsible for the design of the building was Felipe Crame.[241]

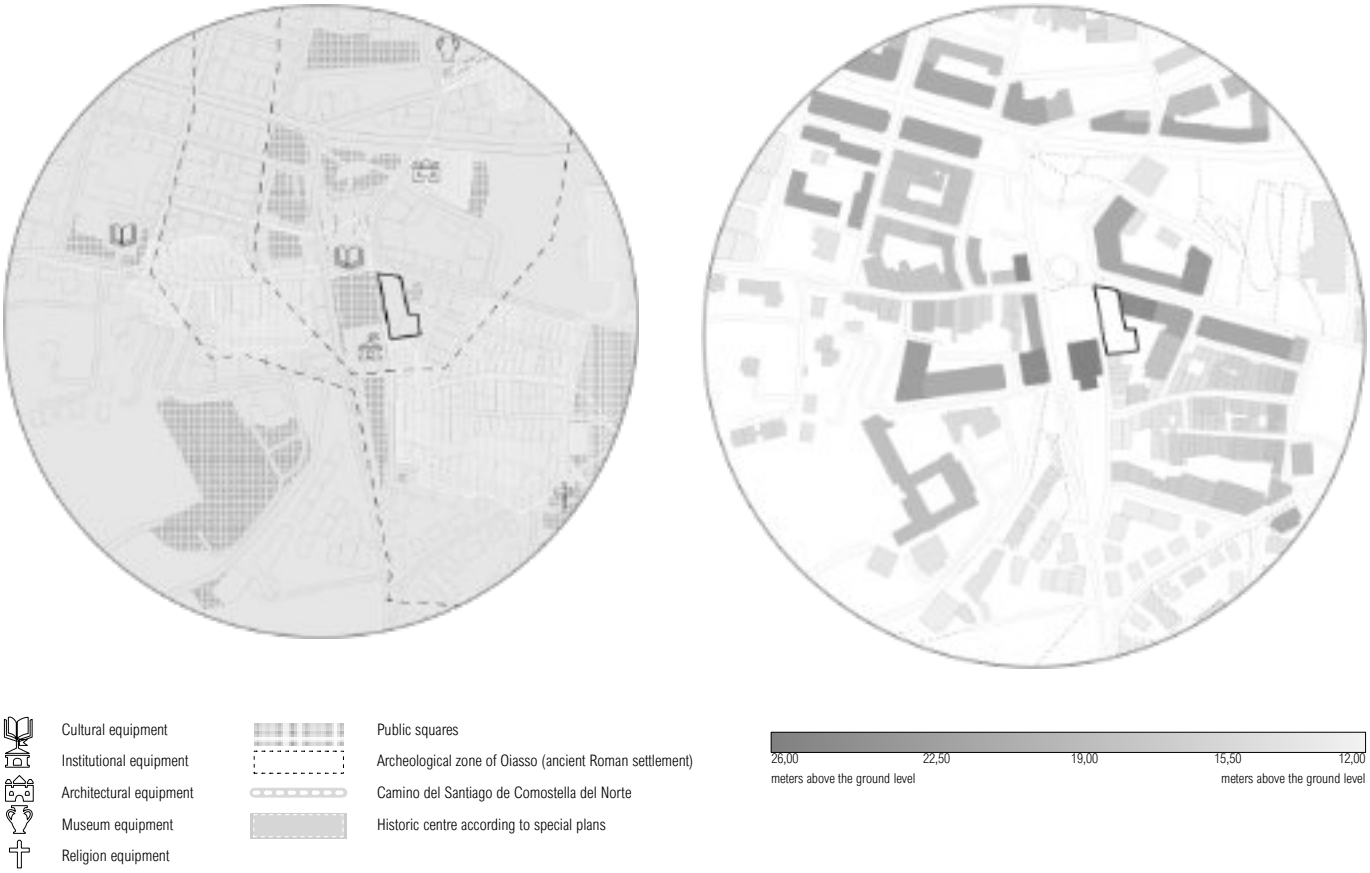


Figure 71 Equipment analysis
Figure 72 Architectural analysis
(Own work)

[239] Ayuntamiento de Irun, "Habilitación Del Espacio Para La Segunda Fase Del Equipamiento Cultural CBA," n.d., https://www.irun.org/es/via-publica-obras/obras-y-proyectos/proyectos-en-marcha/habilitacion-espacio-segunda-fase-equipamiento-cultural-cba.
[240] Carmen Murillo, "Proviser | Empresa Constructora De Obra Civil Y Edificación - Proyecto En Curso | Equipamiento Cultural Carlos Blanco Aguinaga (CBA) En Irún.," July 17, 2024, https://proviser.es/actualidad/proyecto-en-curso-equipamiento-cultural-carlos-blanco-aguinaga-cba-en-irun-2.
[241] Information boards at San Juan Herria Square, February 2024

The neighbourhood is well-located in term of the public transportation, with the bus lane on the main street and railway station within a 10 minute walk. The site has sufficient parking spaces for the residential and public use needs, due to the exisitng two-story parking under the urban square (figure 73).

The nature nearby consists of urban planned greenery and unplanned green spots, that are rather in minority (figure 74). The whole region is however, surrounded by green mountains. The top of the mountains are located west of the site, however the urban square is still elevated in comparison to surrounding built.

Main road
Secondary road
Pedestrian path
Sidewalks and courtyards
Bus stops
Railway ststion
P Parking
Undergroud parking
Access to underground parking

Green spaces (urban green parks and surrounding nature)
Trees

Pedestrian paths, sidewalks, public squares lit and visible during the night

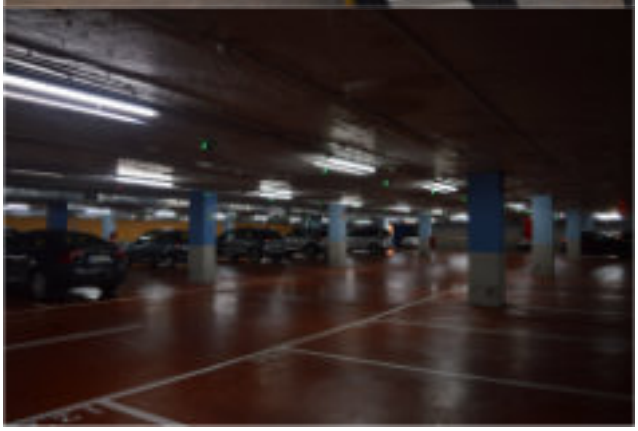
55,00 meters above the sea level
3,00 meters above the sea level

Figure 73 Communication analysis
Figure 74 Nature analysis
Figure 75 Public spaces analysis
Figure 76 Topography analysis
(Own work)

Currently the neighbourhood of the site main function reflects the main historical functions- entertainment. The San Juan Harria Square is either the starting point of finish line of various events, such as a cyclist marathon or Sanmarciales, the most important event of Irun which celebrates the victory of Irunians over the French in 1522. The party includes various activities in the span of few days, mostly the street marches,and is celebrated on the 30th of June.[242]

Fig. 77 The San Juan Harria Square during the Sanmarcos, photo source "Todo Lo Que Necesitas Saber Sobre El Alarde De San Marcial De Irun" Basque Administration Web Portal

[242] "Todo Lo Que Necesitas Saber Sobre El Alarde De San Marcial De Irun" Basque Administration Web Portal, n.d., https://turismo.euskadi.eus/es/blog/todo-lo-que-necesitas-saber-sobre-el-alarde-de-san-marcial-de-irun/webtur00-contfichapost/es/#:~:text=El%20alarde%20de%20San%20Marcial%20tiene%20su%20origen%20hace%20m%C3%A1s, San%20Marcial%20son%20mucho%20m%C3%A1s.



6.1.6 The site characteristics

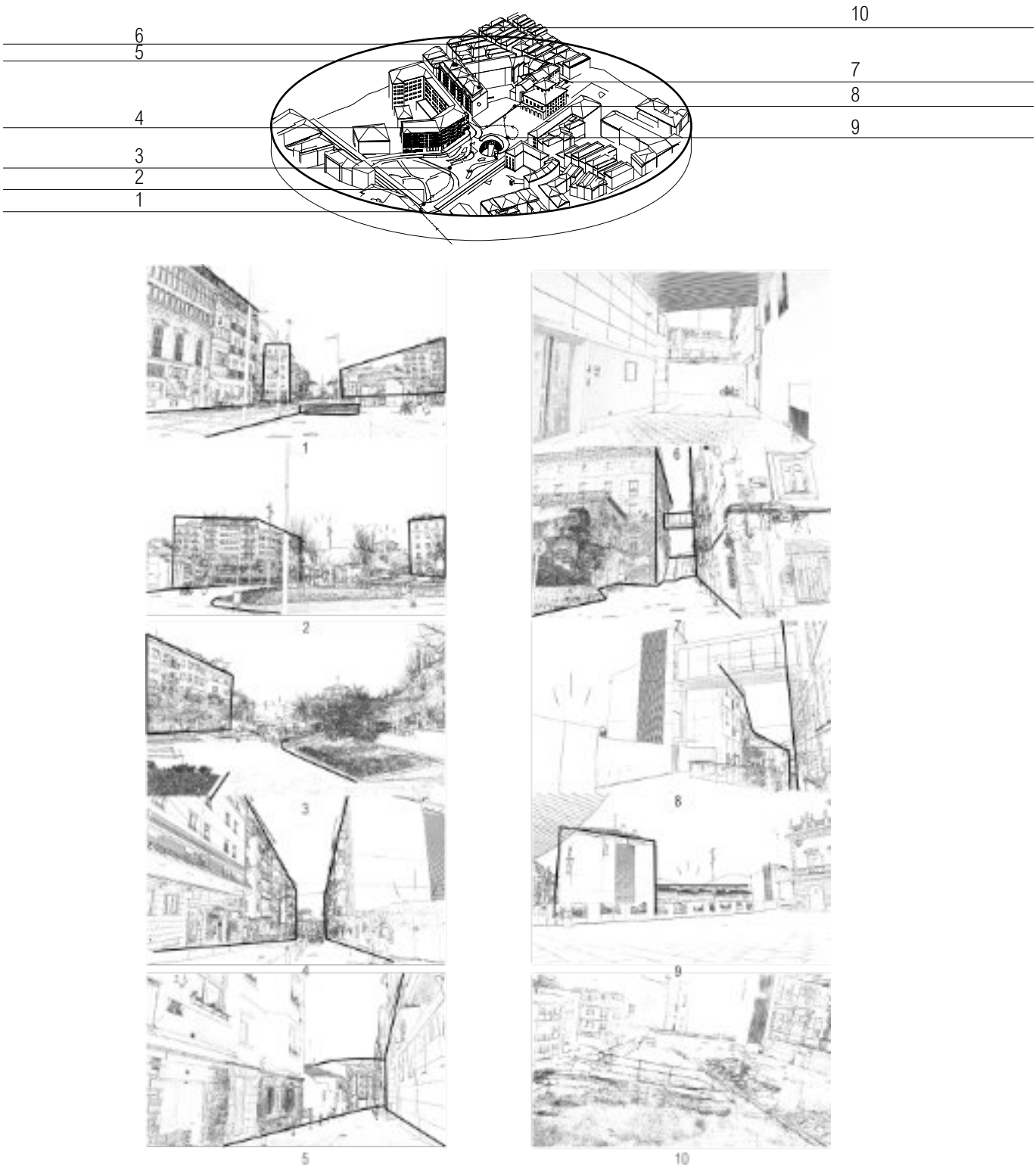
The chosen site for the project is located right next to the historic Town Hall. Although the San Juan Harria square has been an important public space for centuries, it is not included, similarily to the site in the Rehabilitation Plan for the Old Town of 2006.[243] The General Urban Development Plan's Terrain cards[244] of the San Juan-Etxeandia region including the chosen site proposes, for the improvement of the urban integrity the incorporation of the function of the institutional, sociocultural, tertiary hospility facilities, underground parking and actions of limiting the residential uses, limiting the amount of open spaces and redefinition of traffic. It also limits the maximum elevation of the interventions to 49 m above the sea level. The site is included in the Archeological region of protection, however the site itself is not a subject to any restrictions. The nearby sites under protection include the Town Hall, the Jesus Fountain, The San Juan Harria column and the Roman Era deposits north of the San Juan Harria Square.[245]

Historically the site was a location for the doña Vicenza de Olázabal palace, functioning as well as a Casino in its last years, before being destroyed in the fire (figure 67-70). The space has not been filled on the ground level.

The site is a L-shaped concrete slab with three exising underground levels. The project is a filling in a dense urban environment.

Fig 78 View on the site from the San Juan Harria Square
Fig 79 Stop view on the site from the nearby building
Fig 80 The view on the Cultural Centre in the sites proximity
Fig 81 Underground parking under the San Juan Harria square, adjacent to the site

[243] "Plan Especial De Rehabilitación," IRUNVI, n.d., https://www.irunvi.com/es/rehabilitacion/ari/rca-proceso/11-rehabilitacion/178-rca-plan-especial-rehabilitacion.
[244] Ayuntamienot Irun, Documento B. Fichas de ambitos de planeamento. Volumen 2. Plan General de Ordenación Urbana de Irun, January 2015, page 79-83
[245] Ayuntamienot Irun, Documento C. Catalogo de patrimonio arqeologico. Plan General de Ordenación Urbana de Irun, January 2015



1- Paseo Colon, main street in Irun, the greenery obstacje makes a pedestrian pay attention to what's on the right
2- The Jenaro Etxeadia Square, which organic shaped urban greenery and surrounding build lead deeper into the square
3- The square openes up into the nothingness, a perspective view on the distant mountains
4- Following the buildings on the right, the turn leads into the San Marcial Street
5- The turn on the right from San Marcial leads into smaller build on the Sargia Street
6- The view on the site from the Sargia Street, significant level difference
7- The view on the site, a hole in the urban tissue
8- Coming up the stairs and looking back the focus is drawn to the urban elevator, which typology stands out
9- Two rights lead into the Jesus Street, the lower street adjacent to the the Town Hall
10- The top view on the site's top slab from the nearby buildings

Fig. 82 Urban path towards and around the site, own work

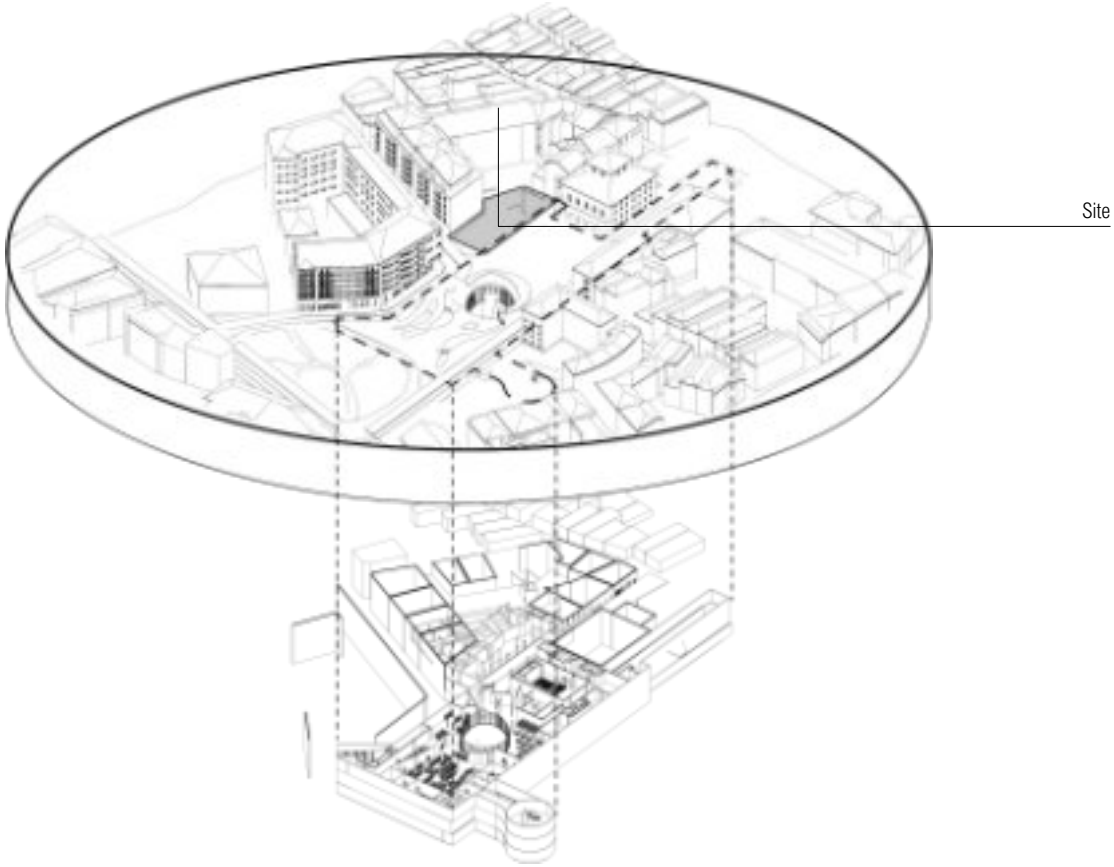


Fig. 83 The view on the sites existing underground structures, both under the site and adjacent to the site, under the square, own work

6.1.7 Conclusions on urban analysis

The chosen site, due to the mix of the historical significance of the neighbourhood, it later history of redefinition due to damage sustained during the war and the current mix of styles is a good symbol of inevitable change and progress. In accordance to the current Urban Strategies and local design tendencies, the insorporation of new technology oriented structure withing that space would be a marker of current focus for the direction of development.

The nearby functions and accessability emphasise the importance of the neighbourhood as a space creating the identity of the city and providing a place for urban integration.

The intervention should merge all the needs of the neighbourhood, with the mix of functions, and work as an extention of the square and prolongation of the existig functions through the creation of open-to-all third places.

6.2 Climate analysis

In the current times, due to the growth of climate sensitivity and awareness the research on both global and local climate has increased in all sectors. Within the scope of architecture it allows for the addition of adequate solutions, that help solve the issues brought about by the specific cllimate of the region or leverage the possiblities it provides.

6.2.1 Macroclimate

The Spanish Basque Country is located on the north of Spain. Its geography includes access to the Atlantic ocean and mountains, which surround the area. Those two factors contribute significantly to the region's climate, creating a sort of microclimate, locked by the mountian's range. According to a Köppen-Geiger Climate Classification[246] (figure 84), majority of the northern part of Spain, Basque Country included, is located in the Cfb climate zone (figure N), which translates to warm temperate, fully humid, with warm summer.

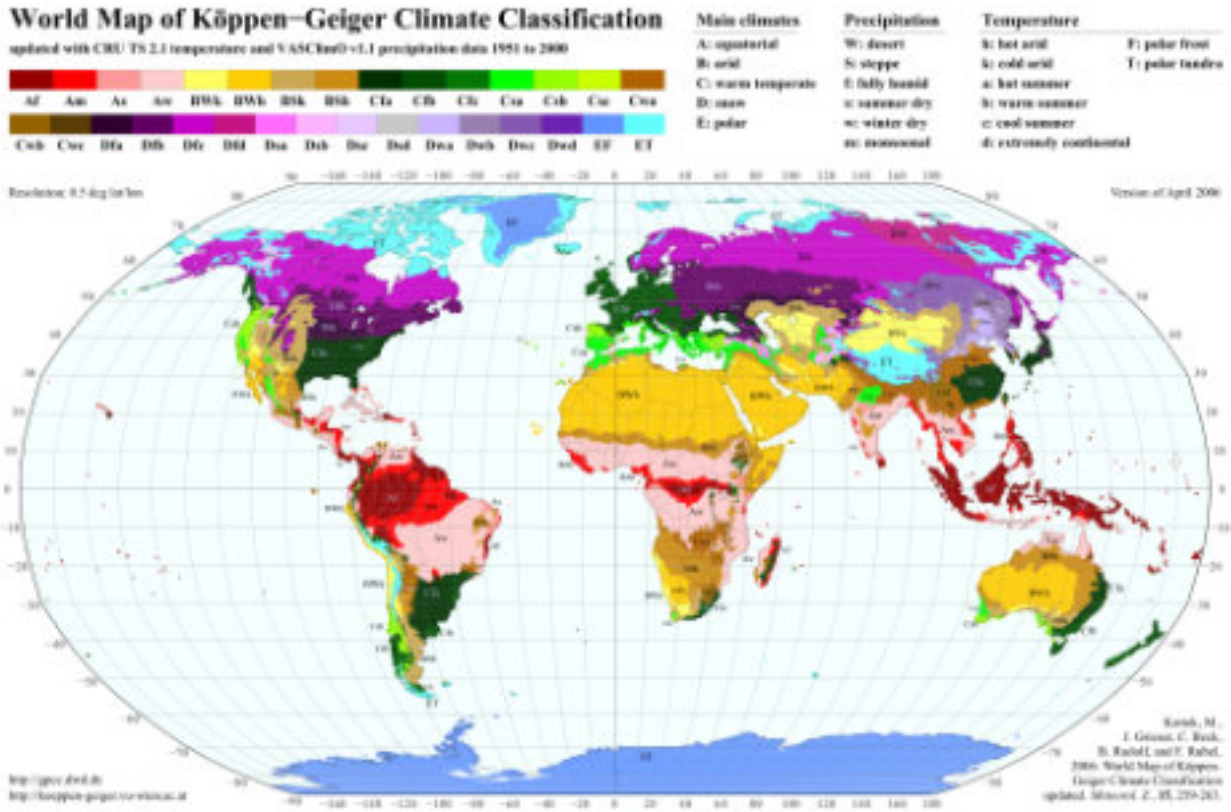


Fig 84 The Koppen-Geiger Climate Classification map, image source: Koppen-Geier Climate map updated, via koeppen-geiger.vu-wien.ac.at/present.htm

In current years, with the on-going climate changes, the climate shift maps from Koppen-Geiger[247] have been prepared, based on the Tyndall Centre[248] data. It consists of 4 different possible scenarios, ranging from more economy to more ecology based societies in a 25 year spread. In all scenarios there is a visible shift of the region of interest from the Cfb climate described above into Cfa, around the ages 2026-2075, depending on the scenario. A Cfa is a warm temperate climate, fully humid, with hot summer. The tendency of periods of warmer winter and higher temperatures in summer is one, that can be clearly noted by the locals even now, a visible change, when compared to the weather from the beginning of the millennium.[249]

As visible in weather diagrams on image 5, the region's main characteristics regarding weather are high precipitation, high humidity, high cloud cover and relatively medium, warm temperature. Although with the impending climate change, the temperature is rising.

[246] 3 Marcus Kottek, Jurgen Grieser, Christoph Beck, Bruno Rudolf, Franz Rubel, ´World Map of the Köppen-Geiger climate classification updated´ in Meteorologische Zeitschrift;,Vol. 15, No. 3, p. 259-263, (Berlin, Stuttgard: Gebruder Borntraeger, June 2006), < https://koeppen-geiger.vu-wien.ac.at/present.htm >, [accessed Apr 25, 2024].
[247] 4 Franz Rubel, Markus Kottek, Observed and project climate shifts 1901-2100 depicted by world maps of the Koppen-Geiger climate classification, in Meteorologische; Zeitschrift, Vol. 19, No. 2, p. 135-141, (Berlin, Stuttgard: Gebruder Borntraeger, April 2010), <https://koeppen-geiger.vu-wien.ac.at/shifts.htm >, [accessed Apr 25, 2024].
[248] Tydall Centre for Climate Change Research, < https://tyndall.ac.uk >
[249] Donostia-San Sebastian locals, private conversations, January 2024

Buildings designed in cities in a climate similar to this work well in some shading, which allows for the building to be relatively close to one another. The closeness of the ocean draws a big focus on managing airflow, to preserve good ventilation, lowering the level of humidity at least to some extent. Therefore the distance between the buildings should allow that. For warm summers, turning into hot summers soon for this region it is important to incorporate multiple green spaces, in a form of bigger parks, but also, even more importantly, smaller green squares, and green incorporated into the buildings, like in a form of a green roof. The most logical approach for creating pleasant conditions in a region like that is to focus on good ventilation, allowing passive dehumidification, good insulation of the walls and openings, to keep the heat inside the building, and searching for a passive preservation of heat gain from direct sun radiation, as well as incorporation of active systems.

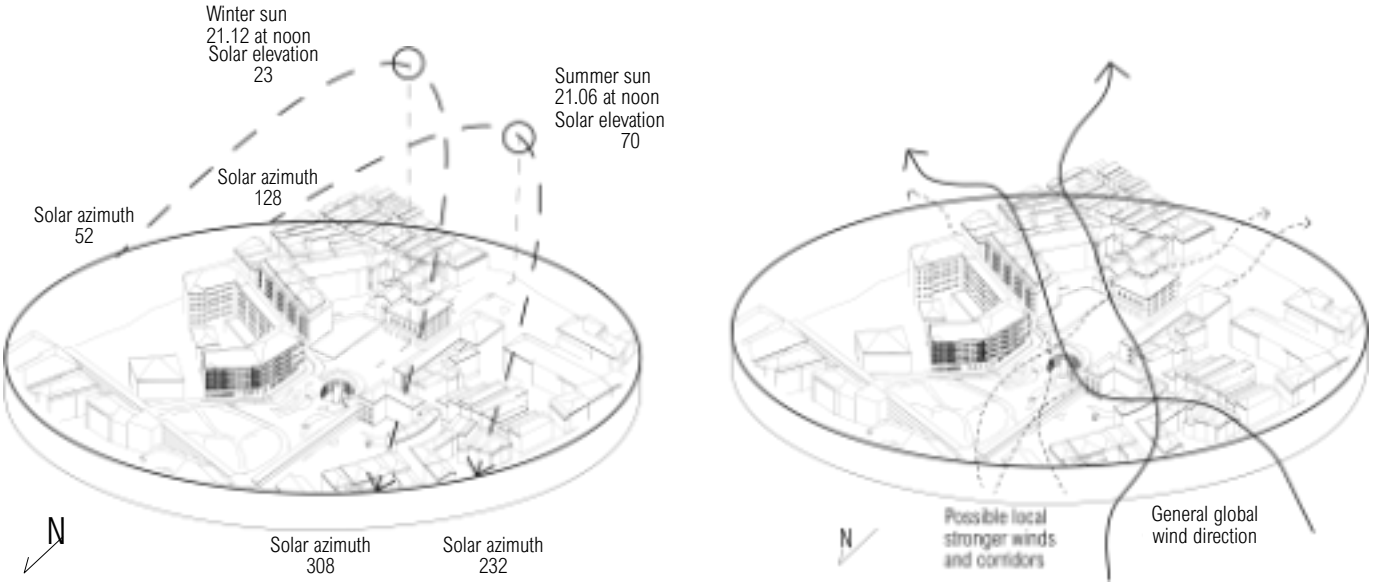


Fig. 85 The visualisation of sun path and wind direction, own work

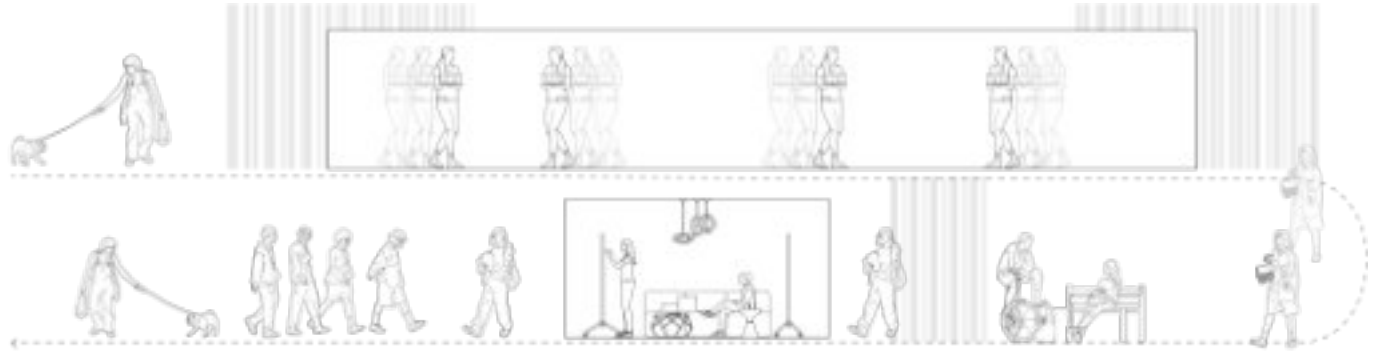


Fig. 86 The visualisation of the typical weather during late winter day in regards to precipitation, own work

Fig. 87 The visualisation of a typical weather during an early autumn day in regards to precipitation, on work

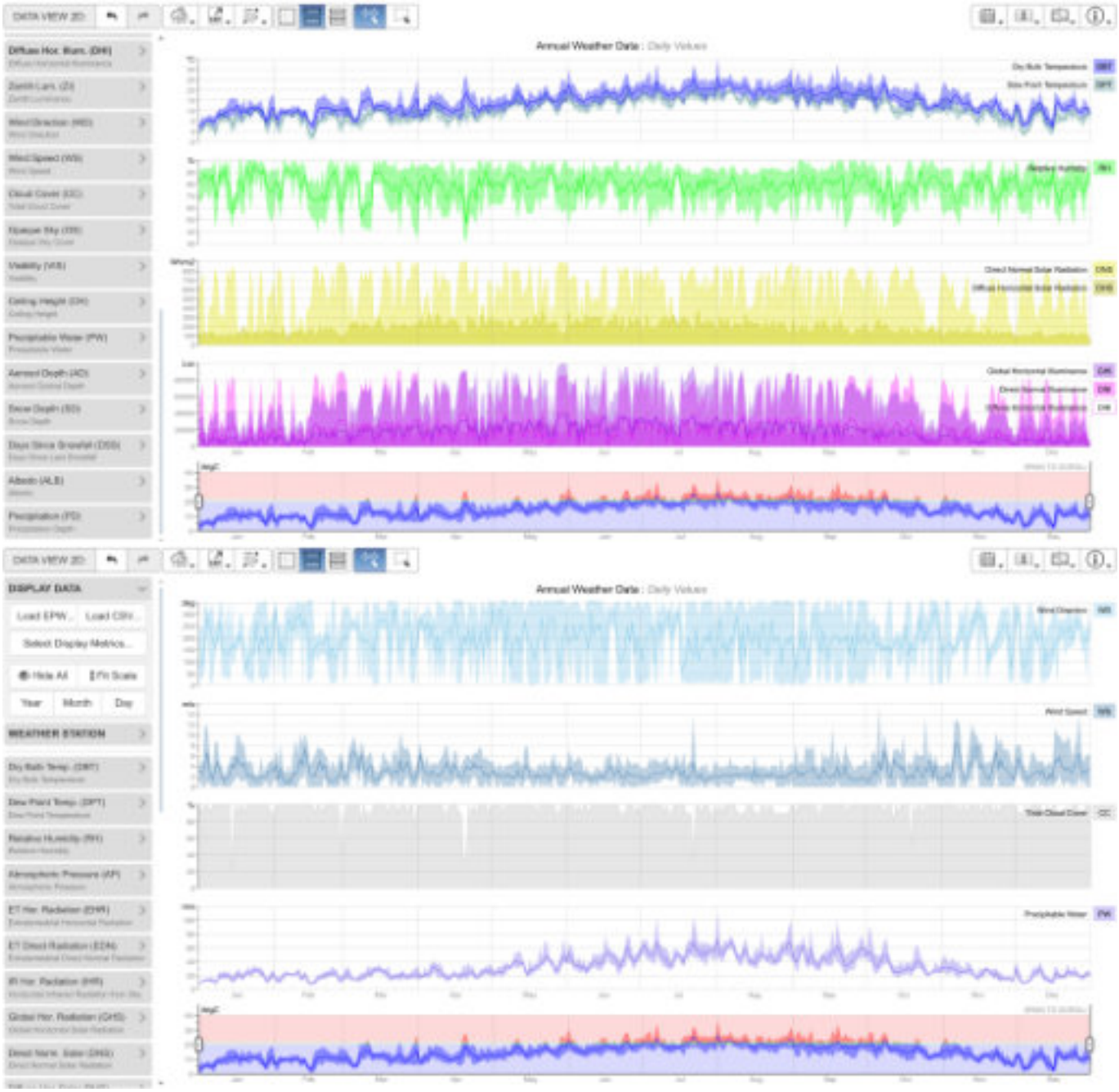
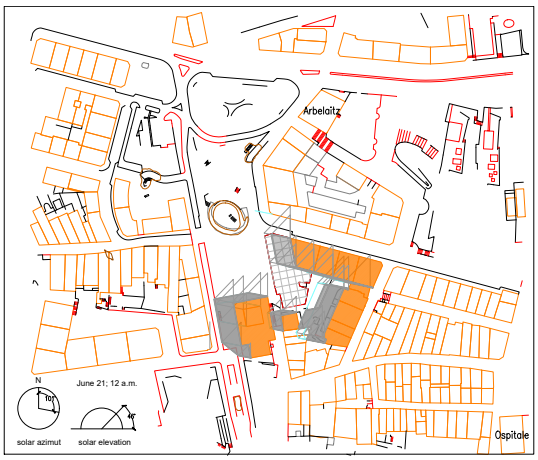


Fig. 88 Annual Weather Data tables, Andrew Marsh, <https://andrewmarsh.com/software/data-view2d-web/ >, [accessed Apr 27, 2024]

The analysis of the meteorological data supports the Koppen-Geiger classification. The temperature can be defined as moderate, with the majority of the year with diurna mean temperature around 14°C year average. That translates too quite stable temperature thorough the day. The highest temperature happens around summer month of June to September, with the standard of around 24°C and peaks up to 30°C and lows of 15°C. The temperature in the winter is particularily suceptible to humidity. As it is common to experience the temperature around 5-10°C during the day in winter months, the wet bulb temperature can lower the temperature felt down to -5°C. The cold humidity is particularily uncomfortable to withstand. The relative humidity is very high thorough the year, with the average around 75%, rarely reaching lower than 60%. The sky is usually at least partily overcast and rain is a common daily occurance, with some moments in the year being characterised by a constant raining periods of around one week.

6.2.2 Mesoclimate

The project site is located in the historical centre of the city, therefore the local conditions, especially ones regarding shading and air flow are different than the general weather conditions in the area. Primarily, as the city is located in the mountains, the moment of the sun setting behind the mountains or the urban tissue buildings lead to a shorter access to direct solar radiation. However, the historic centre is located on the hill and therefore can gain more solar exposure than the surrounding neighbourhoods. The shading caused by the movemnt of the sun is visualised through the analysis below (figure 89-90). The urban typology in the proximity to the chosen site consists mostly of building quarters. The streets are of midium width, with the secondary communication streets being of 10 m. The width of the streets allows for some solar penetration of the upper storeys. It can create wind tunnels with some narrower moments, however such occurance is not so common near the site to cause significant discomfort.[250]



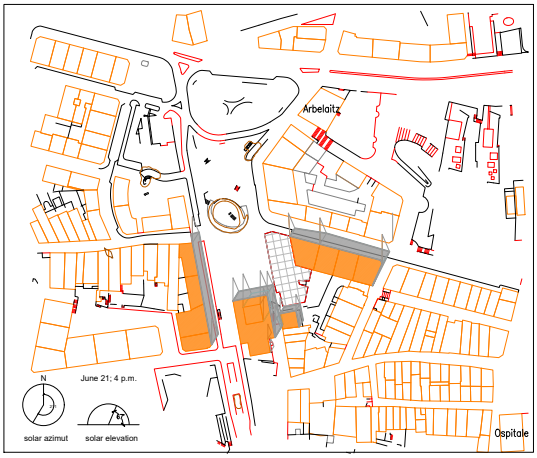
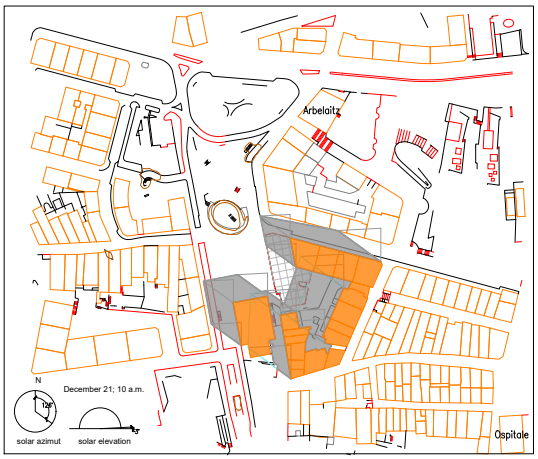
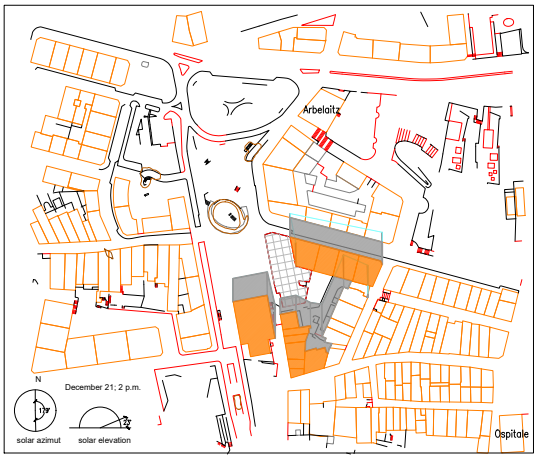


Figure 89 Shading analysis around the site in June 21 in specified hours, own manual analysis through descriptive geometr, data sourced from Andrew Marsh, 3D Sun-path, <https://andrewmarsh.com/software/sunpath3d-web/> , [accessed Apr 27, 2024]





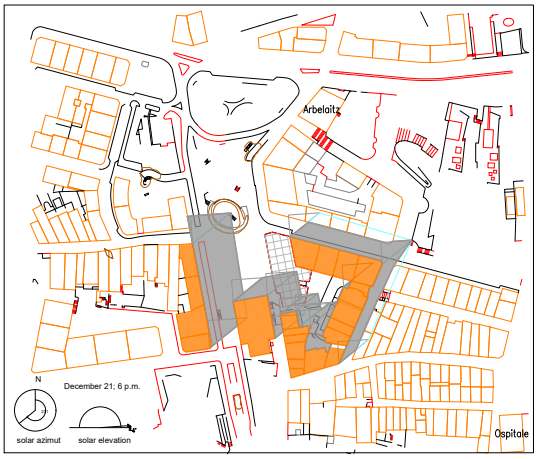


Figure 90 Shading analysis around the site in December 21 in specified hours, own manual analysis through descriptive geometry, data sourced from Andrew Marsh, 3D Sun-path, <https://andrewmarsh.com/software/sunpath3d-web/> , [accessed Apr 27, 2024]

[250] Own experiences, based on the site visits during different seasons of the year.

6.2.3 Microclimate

As shown in the mesoclimate analysis regarding shading, the site expriences least shading during the few hours after the midday. The main elevation exposed to the sun, which could allow for solar gains, is the west elevation. The site is surrounded by concrete, throught the pavement, existing underground storeys, adjacent buildings and courtyard. Any provision of greenery could be beneficial to prevent creation of heat islands.

6.2.4 Design constrains based on climate analysis[251]

Heat
- While the south facade is occupied by the adjacent exisiting buit, the roof can be used for solar panels.
- The main pasive sun collector would be the west facade, which provides quite a becent exposure. There is little chance of overheating, most of the year, however during th summer, autumn months it would be good to implement shading options for he comfort of use. Therefore an integral part of the design has to be the semi-translucent sun shutters, such as perforated shutters on the outside of the window, not to gather additional heat from solar gain when its not desirable. Moreover, the dimishing of the excessive solar exposure could be achieved with drawin the window's frame towards the inside of the building, creating self-shading for the opening. Additionally operable widow shutters can heal reduce winter heat loss during winter nights.
- To diminish overheating of the top floors, the addtion to greenery on the roof could reflect the sun, lowering the absorbtion of the solar power by the building materials, which in part would prevent the overheating from above, which is significantly disadvantageous for the human comfort.
- The heat produced by the electricity can be leveraged.
- Heat gain can be achieved with the use of a skylight.
- An active heating and cooling system should be incorporated, with preferably high sustainable characteristic.
- The conditioned rooms ahould be grouped together.

Insulation
- To achieve thermal passivity, the outside walls have to be well insulated to prevent either heat escape or unnwelcome heat gain.
- Windows of the building shoul be double paneled with high performance glazin Low-E.

Ventilation
- Central top-stacked ventilation through the use of a trompe wall could lower the humidity in the buidling without creating drafts.

Top
- While flat roof would be useful for functionality purposes, it has to be equipped with adequate raon drainage system

[251] *Annual Weather Data tables, Andrew Marsh, <https://andrewmarsh.com/software/data-view2d-web*

7. Construction stage - concept

The solutions incorporated in th building were chosen with the whole life-cycle of the building in mind. While the most sustainable solution would be to not build at all, or even more so to regreenify the site fully, the society has other needs related to living and thriving. Those can be achived with the respect for the environment as well.

Within the first stage, production, limiting th negative impact of the building on the environment is achieved through use of locally manufactured materials to transportation. Additionally the companies chosen for the construction of the building manufacture their products using recycled, downcycled materials, by-products or any other material that has already been produced. That choice leads to reduction of the energy needed to manufacture material, as long as the re-manufacturing of the chosen solution is also energy efficient. In regards to usage, during the design stage the project incorporates passive and active solutions (HVAC, water management, waste management, lighting) that aim to reduce the environmental impact of the building. For the end of life stage the design of the building incorporates solutions for more efficient disassembly, be it necessary, or for efficient redesign of the buildings due to possible changes in function.

7.1 Main design constrains and concepts

The architectural intervention is a filler to the exisitng urban structure. Therefore it is designed to continue the frontage of the adjacent streets, to enhance the visual and therefore intuitive “leading”of the pedestrian towards the square. Additionally, the west elevation of the project is the main contributor to the feeling of the urban room of the square. Due to the common use of the square for the public festivities, it provides openings and roof terrace to allow public viewing of the events.

The designed building’s height stays below the maximum height for the site, provided by the regional legislations of 29 meters above the sea level. The architectural expression provides common points, with the surroundings, such as rounding of the corner of the building, an addition of arches, that correspond with the Town Hall or the use of stone as a finish material. However the general form of the building and its expression expresses the current times, through the use of modern elevation solutions.
The design utilises the west exposure to the sun with elevation-mounted sun collectors, while providing shading through the norrowing of the openineg and shuttle systems, due to the changing tendencies towards hotter weather and increased sun exposure.

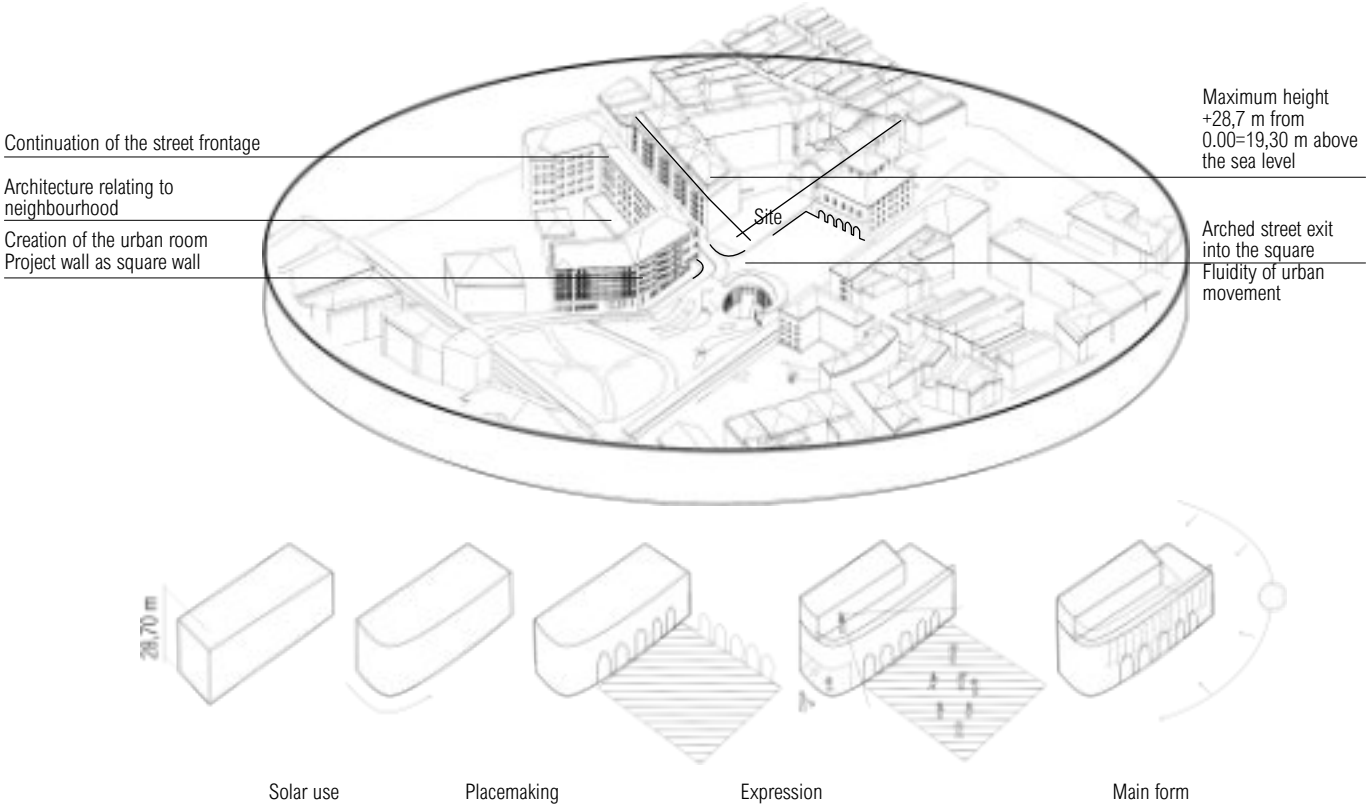


Figure 91 Design constrains and spatial concept, own work

7.2 Function

The building, while being defined by the Virtual Reality related functions, is designed to be a multifunctional structure, that incorporates various purposes. The idea stems primarily from the actual needs of the area, stated above (*see 7.4*) as well as the analysis of the current directions of the architectural development, which focus on the mix of funcitions, continuing the postmodern opposition to monofunctional zoning.

The functions are visualised symbolically below (figure 92). The closeness of the Town Hall office determines the inclusion of office spaces, that link the existing, currently more or less separated structures (figure 92.1). The exisitng underground structures should be filled to provide an adequate use of space, with functions, that don't require direct access to daylight for user's comfort. Therefore additional storage and technical spaces should be located within the underground storeys, together with the addition of printing spaces, with traditional laser printers as a supporting feature for the offices as well as 3d printers, which reflect the technology-driven character of the design (figure 92.10). The central part of the building bears the function of the VR spaces, with different uses, that would be reflected in different specific types of virtual reality devices and softwares used (figure 92.4-6). A supporting function for the Virtual Reality is the office of the VR devs, which gathers the VR operators, programmers, gamemakers and researchers, that focus on both the devices, testing their possibilities and the human inside the virtual reality, assessing the comfort and reactions of the users (figure 92.2). The rest of the building is designed to include less defined spaces, that drive the user and accommodate to their needs. An important driver behind the type of functions provided relates to the idea of the third place. This current discussion on the availability of additional spaces for the people, apart from their homes and places of work, as a current train of thought, relates to the search of connection and community in the XXI century. The project realises this need through the addition of co-existing spaces, such as coworking and rest (figure 92.9), digital detox analog gaming (figure 92.8), small gastronomy (figure 92.3-4) and treating the vertical communication (corridors) as a meeting and event space through the addition of flexible furniture. The ground floor can open up to the square, marking the building more as an extention of the public, outdoor urban space and culture-related equipment nearby.

The aim of the multifunctionality of the building is to answer to the Town Halls needs, while introducing the design that provides options of the third places for a wide range of potential users, listed below.

Figure 92 Visualisation of the functions within the building, own work

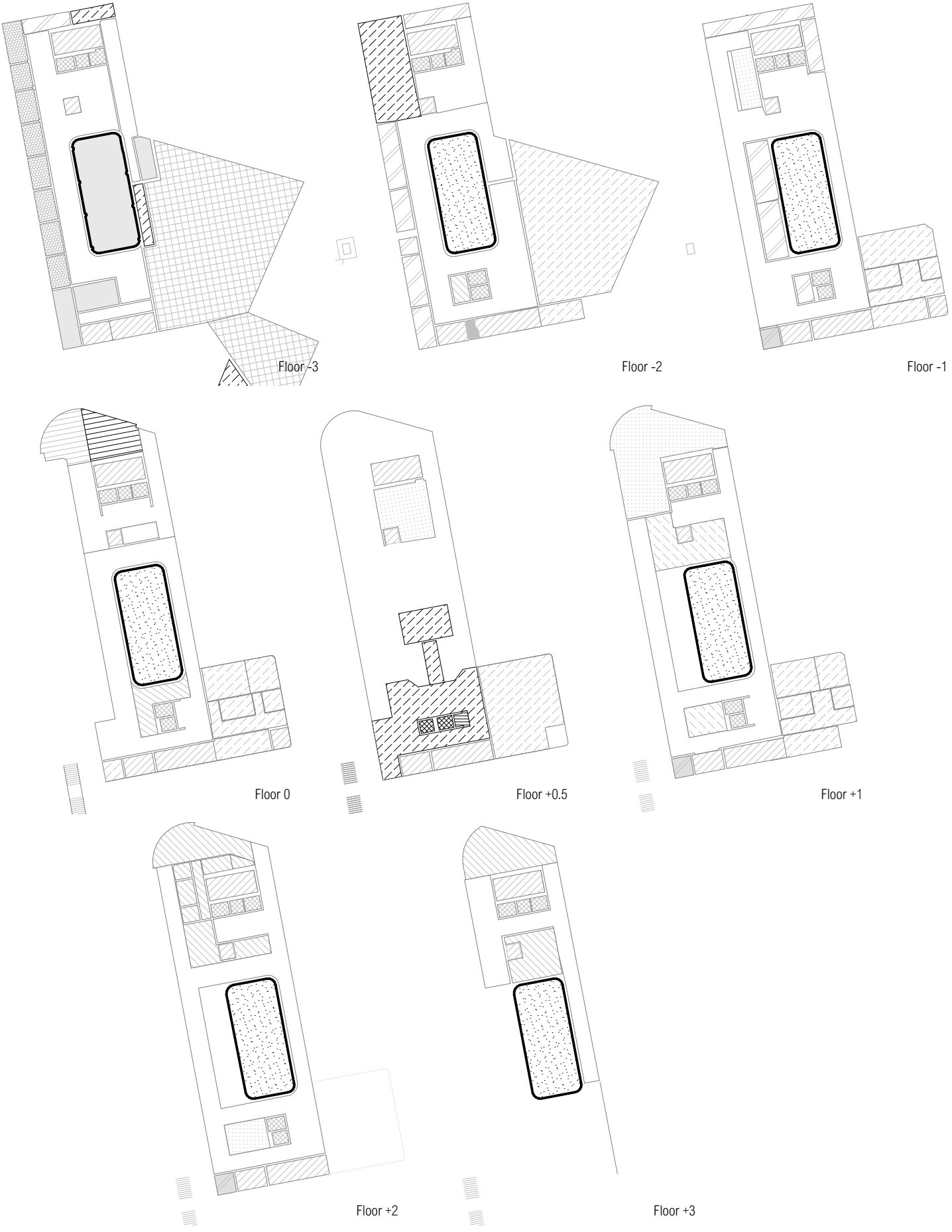


Figure 93 Layout of the functions within the building, own work

7.2.1 Virtual Reality

The current state-of-art technological function provided in the building is related to virtual reality. The virtual reality, as a subtype of the extended reality was explained in the section regarding the XXI architectural development directions (*4.2.1.e Simulacra*).

To enhance the Virtual Reality as the main driver of the identity of the building, the VR spaces are located in the centre of the intervention. The building's programme assumes the mulifaceted use of the virtual reality, for the research, exposure and entertainment purposes. Designing the space for the VR in determined mainly by the type of human movement, while using the device.
The VR function is designe to provide multidimentional use, both commercial and related to conducting research. The main purposes are listed below.

1. Eductional

Educational Virtual Reality simulations revolve usually around specific scenarios, that allow the VR users to experience the steps they have to undertake to solve the situation. From the perspective of the trainees these simulations let them experience the situations impossible to replicate in real life either due to lack of cases or equipement. From the point of view of professors, they may track the trainees reactions to stressors, quick-thinking abilities, practical aplication of knowledge and collaboration abilities due to multiplayer functionalities. In those fields as in many others practice and intuitive action is often what saves lifes, therefore any addition to a standard curriculum could lead to a more educated staff. Most of currently available programmes are directed either to pilots or medical field workers, like UbiSim by Laster[252] with always growing choice of peer-reviewed scenarios for nurses.

2. Therapy, especially PTSD, addiction and phobias related therapies[253]

As virtual reality provides the immersive experience of "stepping into" the alternatice reality, such technology can be used for the purposes of therapies related to the management of triggers. For example, researches show, that a variety of addicts experience the particularly intense pull to engage with their addiction when encountering a specific trigger, such a bus stop, for heavy smokers, or a foodball match for an alcoholic. The use of Vritual Reality with the guidence of a therapist specialising in the treatment of the addiction, phobia or triggers and a specialist for the VR can provide special sessios, when the patient had to face their trigger in the virtual reality as a mean to work on overcomming it.

3. Individual gaming

The individual gaming is the most popular resreational use of VR and refers to the space occupied not the type of game, that is being launched. That means, that the person using the VR set may be immersed in the collaborative game with other poeple currently online in the virtual reality, however physically, the space the person occupies is for one player. The project could provide the ability to rent the VR set for the specified time for individuals interested in this form of recreation.

4. Social gaming

Social gaming is similar to individual gaming, with the exception, that the players participating in the virtual reality simulation would be also present at the same place in reality. For that purpose the VR gamerooms would be scale to fit a specific number of players. This solution would be available for a group activities, such as during the immersion programmes, introducin g the technology to various groups of people from childeren to seniors or group rental targeted for companies' integrations or events such as birthdays.

5. Special VR equipment

While the majority of VR functions could use the same space- the space designed for the use of Virtual Reality could be rented by hour first by the individual gamer, then for the therapy session, the special gameroom would provide specific VR equipment for the immersion of the certain scenarios, that require additional gear. Those could include the VR with suspention, lines holding the person up to simulate parachute jumping, small planes for flight simulation, other vehicles for the immersive simulation of car or motorcycle racing or even learning to drive programmes.

6. Turism

The VR headsets, located at the reception and local guide meeting point could be used as a aid during the touristic tours exploring the city. The headset or tablets could provide the tourists with the opportunity to experience the historic Irun or participate in more interactive explorations.

7. Research

The allocation of the VR devs office within the building could provide an on-site specialists that would both manage the technology as well as conduct special sessions with the VR headset to track peoples movement tendencies, behaviour and feelings to gather data useful for the further technology development.

[252] "UbiSim | Virtual Reality Training and Simulation for Nursing," n.d., https://www.ubisimvr.com/.
[253] Cristiano Chiamulera et al., 'Virtual Reality for Neuroarchitecture: Cue Reactivity in Built Spaces', Frontiers in Psychology 8 (13 February 2017): 185, https://doi.org/10.3389/fpsyg.2017.00185.

Due to the wide range of options for the use of the VR spaces, the intervention could attract various potential users.

1 Developers

(developers working with professional end-users or non-professional, augmented, full-, semi- or non-immersive VR programmes, specialist in a thematic field (medical, geology, history etc.) either working in the devs office full-time or visiting for workshops and exhibitions)

1 –medical programmes developer
2 – software writer and developer, collaborates with hardware artists and architects, consultant
3 – game developer
4 –experience designer and writer, animation developer
5 – architect VR designer, creating spaces outdoor and interior for offices and town hall
6 – product creative VR designer
7 – NASA prototype developer
8 – historical reconstruction and photogrammetry specialist

2 Professional end-users

(Users searching for a product or service related to the VR, who could use the equipment and staff locally or remotely)

1 – architect with clients
2 – script-writer
3 – physician, medical students' professor
4 –NASA worker
5 –product designer
6 – historian, archivist
7 – journalist
8 –businessperson using conference space

3 Non-professional end-users

(using mostly ready products locally, sometimes remotely)

1 – class of 5th grade on geography lesson
2 – medical, architectural etc. students
3 –gaming hobbyists
4 –family going into a cinema
5 – tourists using tablets to see XV century Irun
6 – person watching a documentary made in the Centre on their home computer
7 – person looking for a creative workout

Other users

1 – Basque Museum Interactive curator
2 – Administration and maintenance
3 –Educator and researcher in VR for architects, etc.
4 – Certifies non-immersive educators (BIM, Unreal Engine, Unity Education partner, ARK etc.)

Fig. 94 Example of a wireless VR set, with headset, controllers and on-body trackers on ankles and waist, producer VIVE; 'Ksp2-1366.Jpg (1388×1388)', accessed 7 April 2025, https://www.vive.com/media/filer_public/fed-assets/vive-ultimate-tracker/images/jpg/ksp2-1366.jpg.

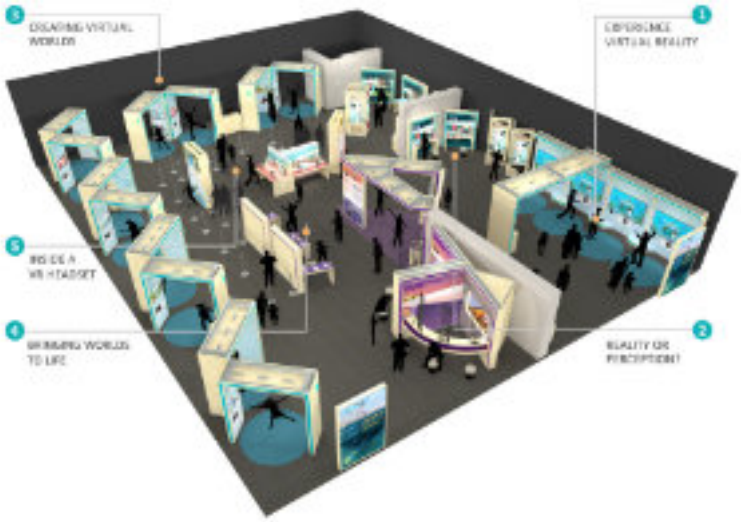


Fig. 95 Virtual Science Centre, <https://www.virtualsciencecenter.org/experiences>, [accessed Apr 28, 2024]

Fig 96 VR Theme Park, <https://www.9dvrcinema.com/blog/2020/10/07/how-to-plan-and-start-your-vr-theme-park-vr-center-vr-zone-business/>, [accessed Apr 28, 2024]

Fig 97 VR Gaming Area in Winterhur, <https://vr-room.ch/2023/09/19/vr-gaming-arena-in-winterthur/#>, [accessed Apr 28, 2024]

Virtual Science Centre (fig 95) is a space that allows for the inicial introduction of the Virtual Reality through the interactive stands and games, similar to those available in the other Technology Centres or more interactive museums.

The VR Theme Park (fig. 96) is more focused on the gaming aspect of the VR, with the use of special VR equipment to imitate simaulations, such as racing, flight, golf etc. The layout and character of this Virtual Reality space is inspired by the traditional arcade gamerooms.

The VR Gaming Area in Winterhur is an example (fig 97) of a freeroaming VR space, where the players use the untethered VR headsets for playing VR games that require movement in all directions. The characteristic aspect of this type of VR rooms is the design of the walls and floor, which are finished of with the geometric tracking friendly patterns that enhance the VR ability to locate itself in the space.

The Casa Battlo in Barcelona Immaersive visits (fig. 98) use AR to visualise the organic nature's inspirations, that Gaudi had for his designs.

Fig 98 Immersive visits, Casa Battlo, Barcelona, <https://www.casabatllo.es/en/news/new-immersive-visit/>, [accessed Apr 28, 2024]

The VR set up consists mainly of the headset, motion controllers and a PC. Additionally lighthouses may be used for motion sensing, alongside sensors attached to humans or ceiling cameras. The design focuses on the full immersion spaces, which, ofr the commercial and research purposes require the full set up. The types of availabe VR include untethered VR, which is a wireless VR that connects with computer through build-in adaptor by radio frequency or tethered VR - headset is connected to a computer by the cable, either a PC stand or with a more mobile version to a backpack with laptop[254]. For the research purposes the project would utilise different types of VR sets, however for the majority the sets available for the clients would be the untethered ones.

Virtual reality, being one of the newer technologies around, brings many opportunities, but in the same time, its innovative and new, unstable nature poses threats for industries, that decide on investing into it in some aspects. Some lessons and recommendations, mostly from the IMAX VR Centre fiasco[255], include:
- Attention to the coherence of the set- access to different games require a full set from the same producer.
- At is an expensive industry, both for business and for the end user
- Closed pod in VR don't work well, as users need attendants (usually one person for 2-3 users)
- Standalone VR headsets not-connected to the computer are less problematic, and therefore the future (connecting devices is opening doors to problems)
- It is better to put importance on experiences where users can interact with one another, as they tend to like it more
- The VR experience is better if one uses real objects match virtual ones (doorhandles, etc.)
- Multiple-ending stories are usually more interesting for the end-user

Based on availeble research, the general constrains regarding the VR space design include[256] [257]:
- Minimum allocated space for user comfort (fig. 99)
- Visual markers non-repetitive patters for better space tracking with objects in varies scale with high contrast, both on the alls and floors
- Add sidewalls for seperation and better space tracking
- Materials of finish (walls) vinyl stickers, vinyl banner, polyester facric banner
- Materials of finish (flooring) reverse print vinyl flooring, top print vinyl flooring, carpet, vinyl tape mark-up
- Storage and charging space for devices

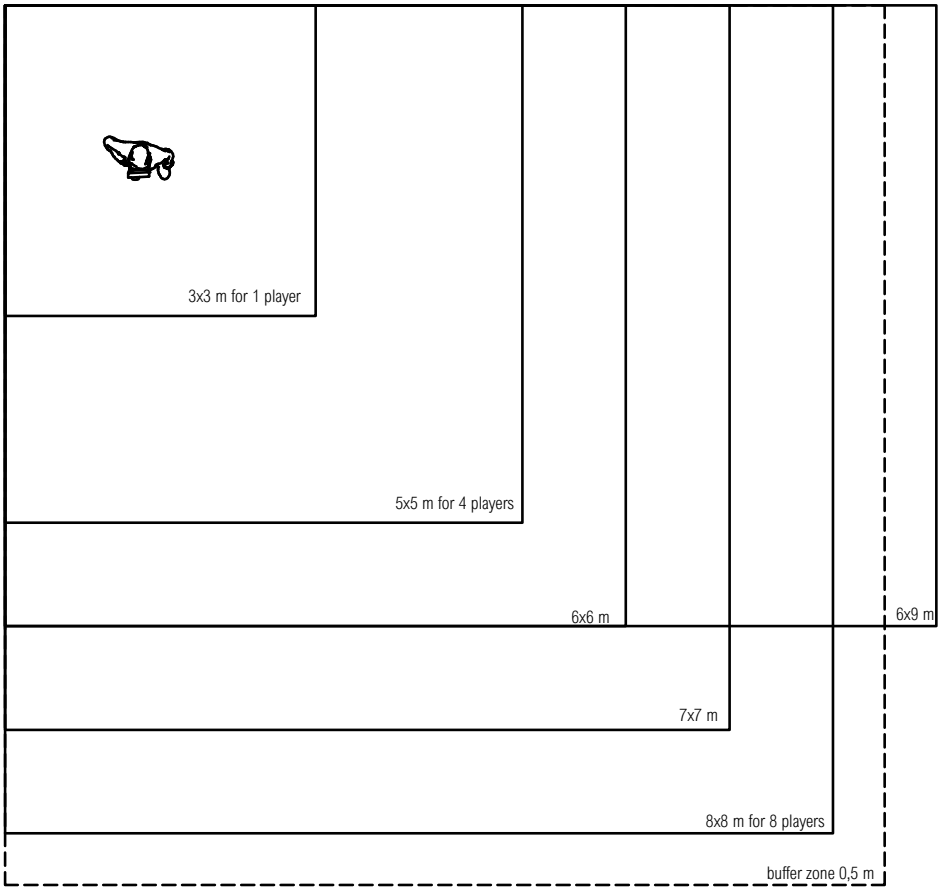


Fig. 99 Minimum space for the freeroaming VR gameplay

[254] Admin. "Differences Between Tethered and Untethered VR." VR Kingdom Sydney, July 4, 2022. https://vrkingdom.com.au/differences-between-tethered-and-untethered-vr/.
[255] Janko Roettgers, Future of IMAX VR uncertain after company closes two centres, Variety.com, <https://variety.com/2018/digital/news/imax-vr-closures-1202906222/>, [accessed Apr 28, 2024]

[256] (Video) FREE-ROAM VR ARENA SETUP - Space Allocation, Tracking Design Fundamentals & Graphic Materials, 2024, https://www.youtube.com/watch?v=Rrc7x7wy1_8.
[257] THIS IS One of the LEADING VR Arenas. HIGH QUALITY VR Experience, 2024, https://www.youtube.com/watch?v=N1lQqIlrmw0.

The final design of the VR spaces provides a wide range of options and ways of immersion to choose from. The incorporation of the design pattern for VR spatial tracking incorporates the traditional Basque symbol of laubutu, which is a symbol for prosperity and good fortune. (figure 100)

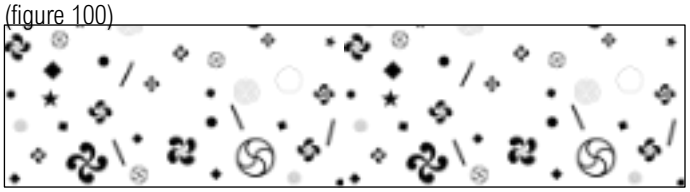


Fig. 100 Geometric pattern for the VR reality spaces design

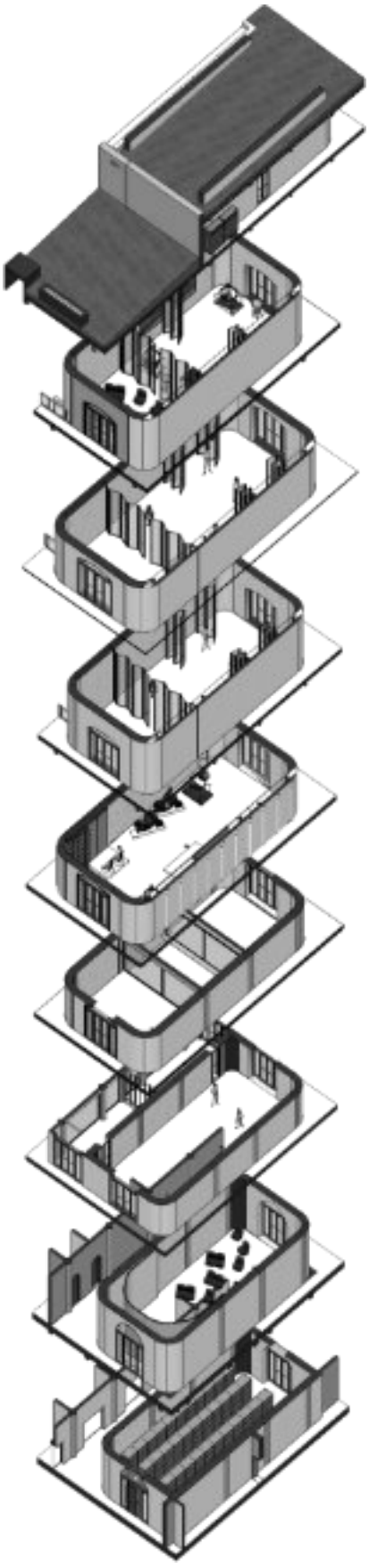


Fig. 101 Exploded axonometry of the virtual reality function

7.2.2 Town Hall offices

Town Hall office is a extension to the existing office structures, located on San Marcial Street and inside the Town Hall. The project is located between the two spaces and therefore this setting for the extention allows for a comfortable communication between different units of the Town Hall without the need to go outside.

The design of the space is focused on the possiblity to provide flexibe use. The design doesn't go fully into the coworking solutions, as the administration is more location based and the lexibility of everyday use, such as lack of allocated desk may be uncomfortable and inefficient. Therefore the flexibility can be incorporated in the future-proofing of the design, through tha use of modular and easily modifable partitions. The walls are designed as plywood finished with textile for good accoustics, places strategically to create rooms in the office spaces. Additionally the adequate space has been allocated for the bigger conference or workshop space, as such a space has doesn't exists as far as the available floorplans of the Town Hall spaces allow to determine. Withing the workshop space, the flexibility of design is realised through modular furniture, that allow for varied uses. The priority of material selection for the furniture and partitions should be given to local companies and ones that incorporate secundary materials in their production.

As the office space is located within the courtyard, the glasing is designed as bigger vertical opening to gather more daylight while limiting the visual interaction between the interior and its surroundings. The location of the windows allows for cross ventilation.

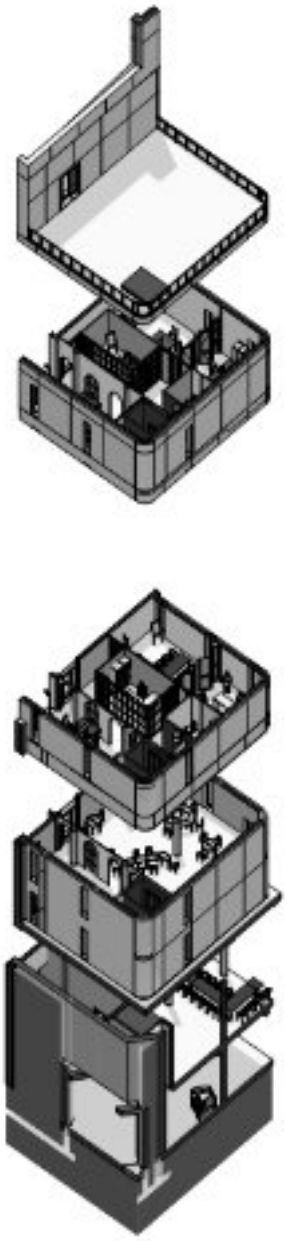


Fig. 102 Exploded axonometry of the Town Hall office function

7.2.3 VR developers' office

The VR developers' office is the space of work of the workers managing the Virtual Reality spaces. They employ both the people that manage the spaces as they're used by the clients of the Centre, work on their research relating to VR product testing and research relating to human reactions and feelings inside the Virtual Reality. The space is located close to the VR Gaming and consists of the main office space, with open layout, conference room, located above the VR space and a workshop space, for multipurpuse use of conferences or workshops with visiting specialists. The VR devs would work both on their projects by the computers and on-site inside the VR rooms, analysing the gameplays of the test subjects.

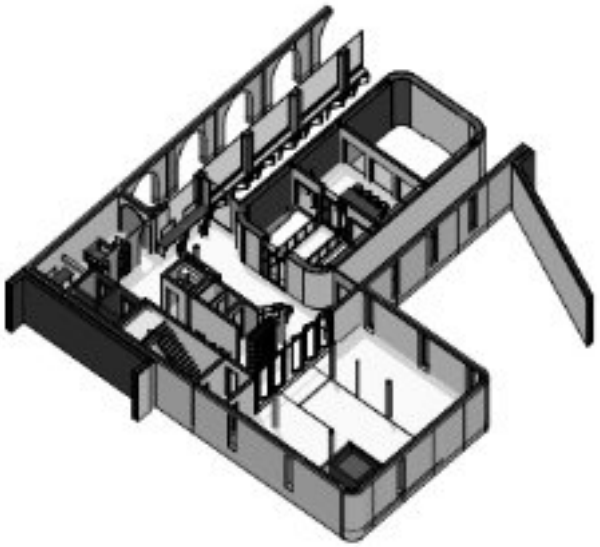


Fig. 103 Exploded axonometry of the VR developer's office function

7.2.2.d Gastronomy

Due to the public character of the building and the focus to provide third places, the incorporation of small gastronomy expands the possiblity of use and allows for the visitor to spend the whole day without leaving. The designed spaces are planned to allow for the changes fo function. The main gastronomy consists of up to three food court boxes and the additional rooftop bar.

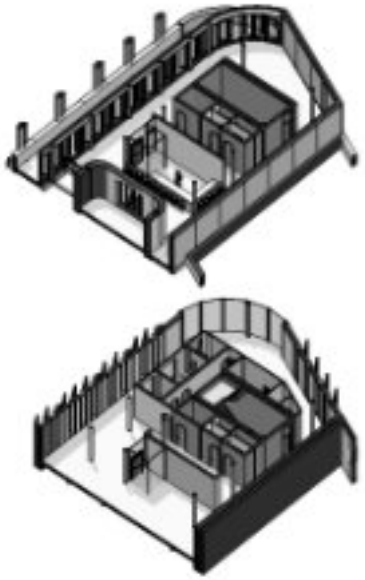


Fig. 104 Exploded axonometry of the gastronomy functions

7.2.2.e Third places

As a public building and an extension of the urban square, the buildin aims to provide various third places for the citizens and guests of the city to allow for urban collaborations and placemaking.

The provicion of the third places is expanded into work, with the provision of co-wroking booth, pods and stations on the corridors of t project. Additionally, due to the fact, that the building is located next to the path of Santiago de Compostella del Norte and close to the local airport, the rest or sleeping pods are located within the design to provide a space for rest for the travellers.

To balance the high technological focuse of the design's functions and provide a comfrotable third-place space, the design assumes the assition of the digital detox room, with board games, reading space an platform installations inspired by Ken Isaac's spaces for "exisitng".

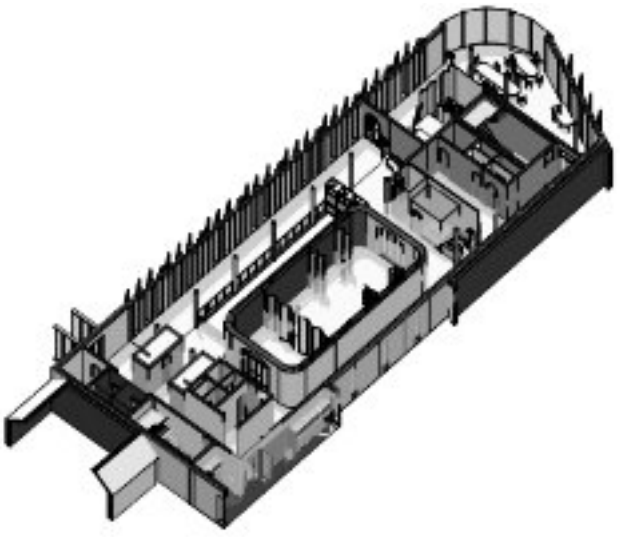


Fig. 105 Exploded axonometry of the implication of some of the third place functions

7.2.4 Other

Other parts of the project supplement the designed functions through communication, utilities, management rooms, technicl rooms etc.

The underground however spaces, exisiting before the addition of this project are unused or underused, therefore part of that would provide the additional functions of storage spaces and printing and 3d printing laboratories.

Fig. X Exploded axonometry of the underground structures functions
Existing underground structures with the addition of new inner layout

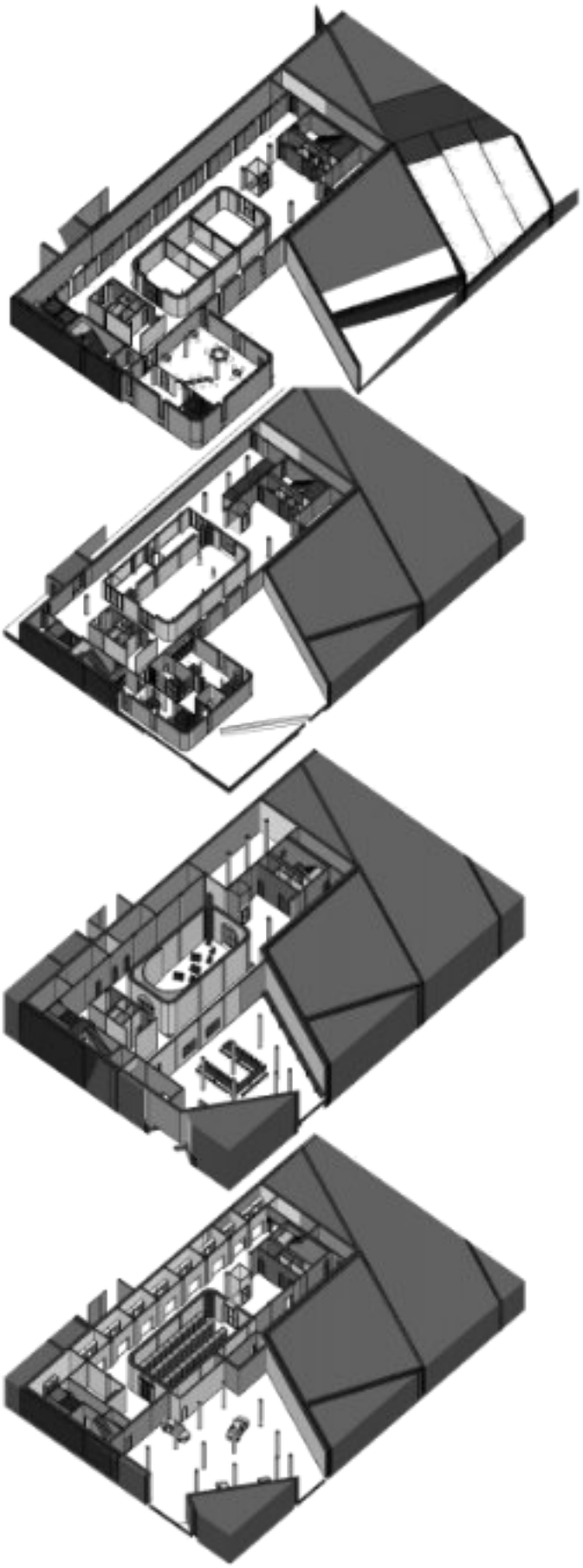


Fig. 106 Exploded axonometry of the underground floors

8. XXI Eco-Technology

The current direction of architectural development is based on the providing for the need of the Society 5.0. as defined in the previous part of the paper. The currently emerging society can be defined through its strive for the technological advancement, hyper-inidvidualisation and environmental-focus. While those characteristics interact with eachother and realise themselves in various ways, a selected set of few has been a driver for the wonderings and direction of the development for the project part of the thesis of the Virtual Reality Research Centre.

If the design process could be compared to the life-cycle assessment stages, chapter 6 related to the main analysis that have to be done during the initial pre-design stage, regarding the location and the constrains, that it puts on the design in term of the legislations, climate or specific historical or social aspects of the region. Secondly chapter 7 refered to the initial decisions relating to the imagined “construction” of the building. The concept stage is the first one to make decisions, based on the knowledge of the region’s need, and includes the main vision for the shape of the intervention, as well as defining its users and functions. The further chapters refer to the later stages of “construction”- decisions regarding materials, structure, infrastructure and functioning of the building through the decision on the way the designed functions are realised. The final stage is the stage of the end-of-life of the building, or, in some cases, the after-life, which is depicted through the three scenarios for the building’s future. The structure of “life-cycle”-ish separations act as a visualisation of the simplified version of the thought process that is fundamental in the way, the architect initialises the process of designing in the XXI century.

8.1 Sustainable construction solutions

8.1.1 Production stage

The production stage in the building's life-cycle consists of extraction, transportation and manufacturing of the materials used for construction. The main principles when choosing the adequate ones for the project are flexibility, recyclability and sustainability in regards to transportation. The material solutions suggested for the project try to be as localy sources as possible. The current construction laws of the Autonomic Community of the Basque Country require an indication to impliment at least 40% (since 1.01.2023) of secondary materials, such as by-products, secondary raw materials, recycled materials, or materials from preparation for reuse processes[258] in specifications for execution tenders. This law is meant to highten the sustainability of the buildings and promote the movement towards circular economy of the construction sector . According to the interpretations of the law[259] secondary materials are to be calculater in regards to weight. The percentage is derived from the total of all building's components ad can include all of the materials apart from air conditioning equipment, pumps, motors and renewable materials of entirely biological origin or its composites of over 95% to promote their use as materials good for the environment. Basque organisations, like IHOBE[260] have prepared guides dedicated to architects, designers, engineers, investors etc. that propose solutions of implementation and provide examples of local companies that produce building components with secondary-sourced materials.[261]

The main material chosen for the design is concrete. Concrete would be used for the structural system, that continues the stractural layout ot the exisitng underground floors. The addition of new structure would require joining the new load-bearing columns to the exisitng ones through firstly removing parts of the top of the existing concrete to reach inner reinforcement and then adding on the reinforcement of the new column. The joinery could require the additional use of epoxy or other raisin to minimise the friction.

While the concrete is not the first material to come to mind, the current research and implication of eco-concrete solutions aim to reduce the concretes footprint by managing its production. It was chosen for the project to address the future-looking works on making the material more sustainable. Eco-concrete utilises supplementary cementous materials (SCMs), such as fly ash or silica fume, and materials comming from waste, like demolishions of concrete structures, other construction demolishion waste of even general industrial waste, with plastics for example.[262] The replacement of cement could lead to a significant reduction of the material's footprint, which with taditional cement ranges around 0.5 tons per a ton of material. Estimations range between 40-80% reduction, based on the SCMs used. The emerging technology includes the Carbon capure, utilisation and storage (CCUS), which relies on the capturing and storing the produced during construction material precessing CO2, to later utilise it in various sectors, from e-fuels, through construction, to food and beverage industry.[263]

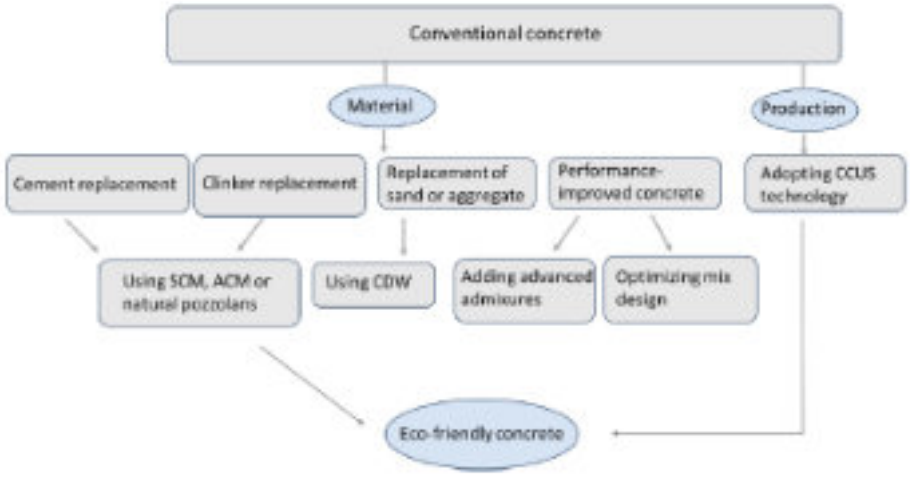


Fig. 107 Concentional concrete alternatives, image source: Shaheda Akter and Allan Hawas, 'Current Insight on Eco-Friendly Concrete: A Review', Buildings 15 (21 February 2025): 682, https://doi.org/10.3390/buildings15050682. Page 3

[258] Comunidad Autónoma del País Vasco, 'Ley 10/2021, de 9 de Diciembre, de Administración Ambiental de Euskadi', Pub. L. No. Ley 10/2021, § 1, BOE-A-2022-951 6323 (2022), https://www.boe.es/eli/es-pv/l/2021/12/09/10. Paragraph 84.3.
[259] https://www.ihobe.eus. 'Inclusión de materiales secundarios en contratación de obras'. Accessed 14 April 2025. https://www.ihobe.eus/publicaciones/inclusion-materiales-secundarios-en-contratacion-obras.
[260] 'Ihobe - About Ihobe', accessed 11 April 2025, https://www.ihobe.eus/about-ihobe.
[261] 'Guía para el uso de materiales reciclados en construcción', https://www.ihobe.eus, accessed 11 April 2025, https://www.ihobe.eus/publicaciones/guia-para-uso-materiales-reciclados-en-construccion-3.
[262] Shaheda Akter and Allan Hawas, 'Current Insight on Eco-Friendly Concrete: A Review', Buildings 15 (21 February 2025): 682, https://doi.org/10.3390/buildings15050682. Page 1-3
[263] Shaheda Akter'Current Insight on Eco-Friendly Concrete: A Review',

The SCMs are usually a byproduct of the production of a different material. Ground Granlated Blast Furnace Slag (GGBS) is a byproduct of iron and steel production and may enhance the structural durability. Fly ash, a byproduct of coal compustion. With the decline and change in the production of materials in the future, the byproducts may become unavailable, therefore the research on the possible SCMs include not only waste but other available materials as well as calcined clay.[264] The further research could discover new ways to "greenify"the construction concrete, discovering alongside the possible enhancements to its functining, like the current emergence of the permeable or self-healing concrete.

Within the project eco-concrete would be chosen as a main material for the non-flexible walls. The use of eco-concrete instead of concrete for the structural system is possible as well, but would have to be thoroughly examined.

The material chosen for the elevation is a stone panel on steel construction. The stone elevation references the architectural traditions of the region, and the solution of the easily assembleable and disassebleable stone panels means, that the panels prove high reuse properties, which is of higher environmental value to the recycling, according to the 4R. A national example could be the stone panels from Neolith, a producer with manufacturing company located in Almassora, Spain. The material is indicated in the IHOBE guide for using recycled materials in construction[265] with the featable threshold of recycled materials at 52%.

Other types of materials could be sources as sustainably as possible, with the use of the recycled brick of wood for flooring or sourcing the desired type of material as locally as possible, veryfing there it is manufactured, where the raw materials are source to estimate the embodied energy and choose conciously as much as possible.

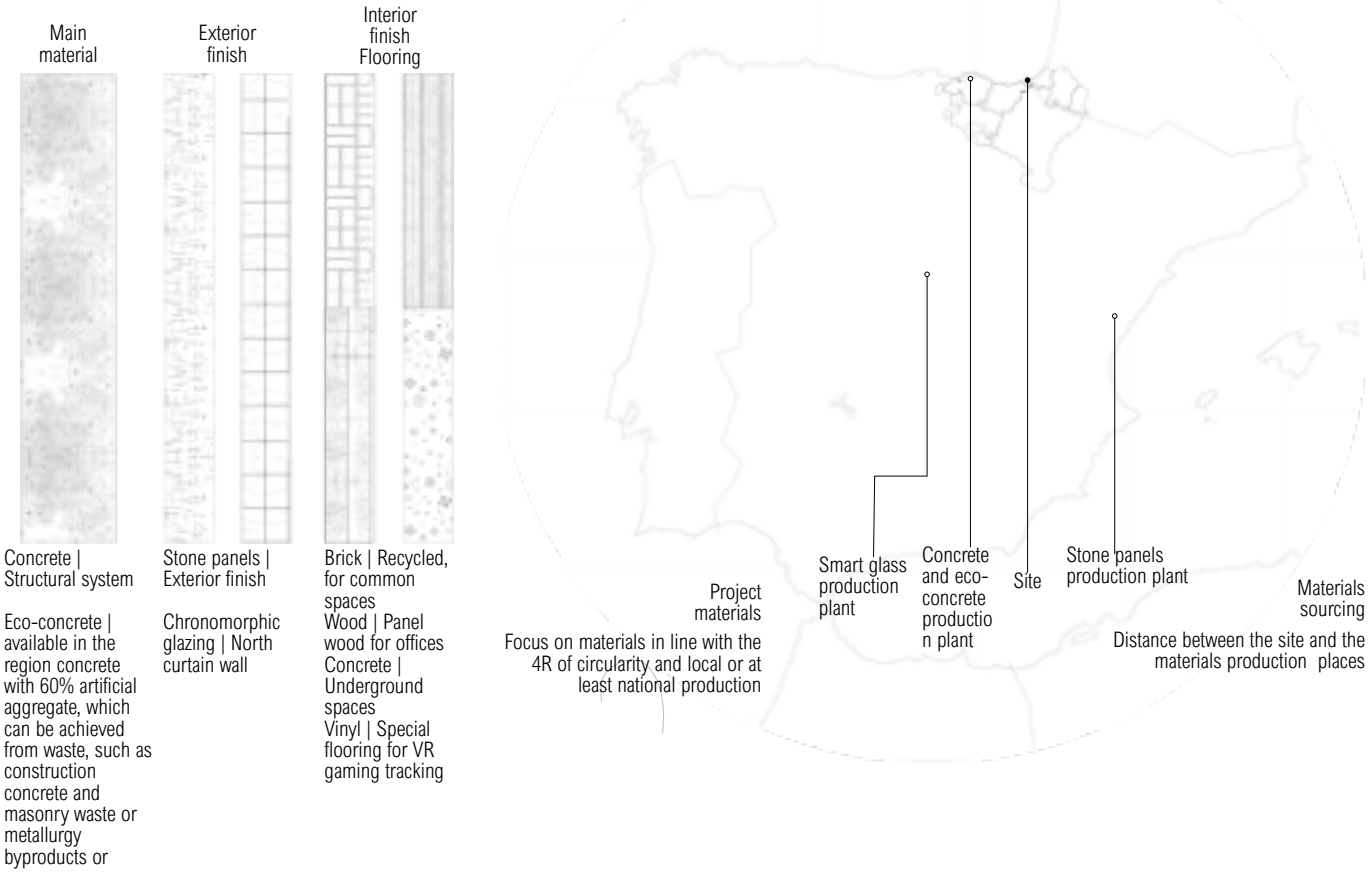


Fig. 108 Materiality of the project, main materials used and localisation of their production plant, own work

[264] Shaheda Akter'Current Insight on Eco-Friendly Concrete: A Review', page 19-22
[265] IHOBE, "Inclusión De Materiales Secundarios En Contratación De Obras.", p. 20

8.1.2 Construction stage

As mentioned in the *7.3.4* Basque Country is characterised by mild, oceanic weather, with mild temperatures thorough the year, consistent rainfalls and high humidity.
The objectives when choosing the right solutions for the building include:
- Efficient ventilaton as a solution for high levels of humidity and adequate building air exchange, particularily in office and virtual reality gameroom spaces, due to workers comfort and need to lower the CO2 levels in the room due to human exhales and working technology
- Adequate heating systems, for indirect heat gain during colder months
- Heat gain systems through passive and active strategies, compiled with the ability to store energy gained from heat or sun
- Shading systems to provide cooling during warmer month
- Efficient active systems with least negative impact on the environment, preferably powered by renewable sources
- Reliance primarly on passive systems to possible extent
- Flexible but durable structure
- Incorporation of recycled materials above 40% (see *8.1.1*)

8.1.2.a Structural system

The construction stage of the building's life-cycle consists of transportation of materials and construction works on-site.

The designed building functions as a filler for the urban structure, therefore the space that it occupies is important composition-wise to maintain the feeling of a closed and logical public urban square. The building that will stand there should therefore be assumed with longevity of structure in mind, built to last. The chosen function is however one that tends to change dynamically with time. Virtual Reality as a function taking up grand portion of the building and a driver behind its expression is a technology that is doomed to evolve rapidly even to the point of being replaced by yet another technological novelty. For that reason the designed space has to allow for alterations, so that the building doesn't loose its value with the loss of its main functional driver and is able to adapt to newfound situations.

The construction system chosen for the building is a rigid frame from pre-stressed reinforced concrete columns and beams, that corresponds with the material used for the load-bearing element of the underground existing structures. Rigid frame allows for higher level of flexibility of material used for infill walls, especially exterior walls. If the walls don't have to bear all of the loads other than their own, the material used for them can have a higher percentage of recyceld components either by using materials with high percentage of recycled material used for its production or incorporating reused material from other deconstruction, cleaned and prepared for repurposing.

The most tricky elements of constraction relate to the joining methods between the existing structure and new construction. The existing underground structure consists likely of load-bearing exterior walls and reinforce concrete beams and columns prepared on site (conclusion based on available floorplan drawings). The ceiling is a two-way slab with beams. Columns seem to be of 500x500 mm section, but for ensuring the adequate load-bearing properties as well as improving their slenderness ratio, the project assumes widening the columns to a 600x600 section with additional reinforcements. The spans of beam range between 4 to 6 m.

New build structural system consists of a rigid frame with 300x300 mm section columns. The new structural elements are designed to be made from pre-stressed concrete columns and beams with dry nodes as connectors. The use of dry nodes instead of wet ones reduces the need for binders, such as cement. The horizontal actions are carried by infill wall material.

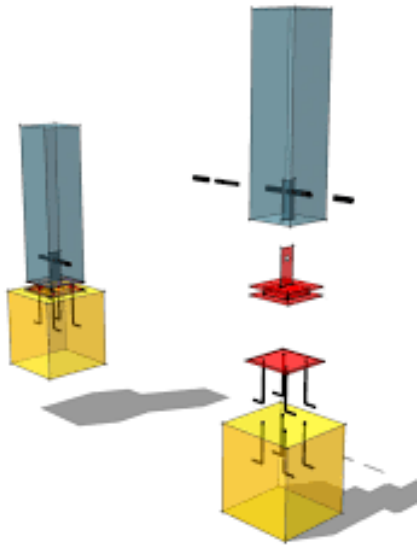


Fig. 109 Example of the way for the continuation of the existing concrete structure in case of lack of lap reinforcement, image source: https://www.quora.com/How-do-you-extend-a-new-reinforced-concrete-column-unto-an-existing-concrete-floor [accessed 10th of May]

The eco-technological value of thu use of the rigid system with infill walls is related to the conciousness for the benefits of leaving the open space for future redesigns. Additionally the minimalisation of the mass of the componets, that carry the main loads allows for more flexibility in therms of choosing the materials for the walls, which, as it doesn't have to have such as hight load-bearing properties in comparison, it can be more freely planned to be made with eco-materials in mind.

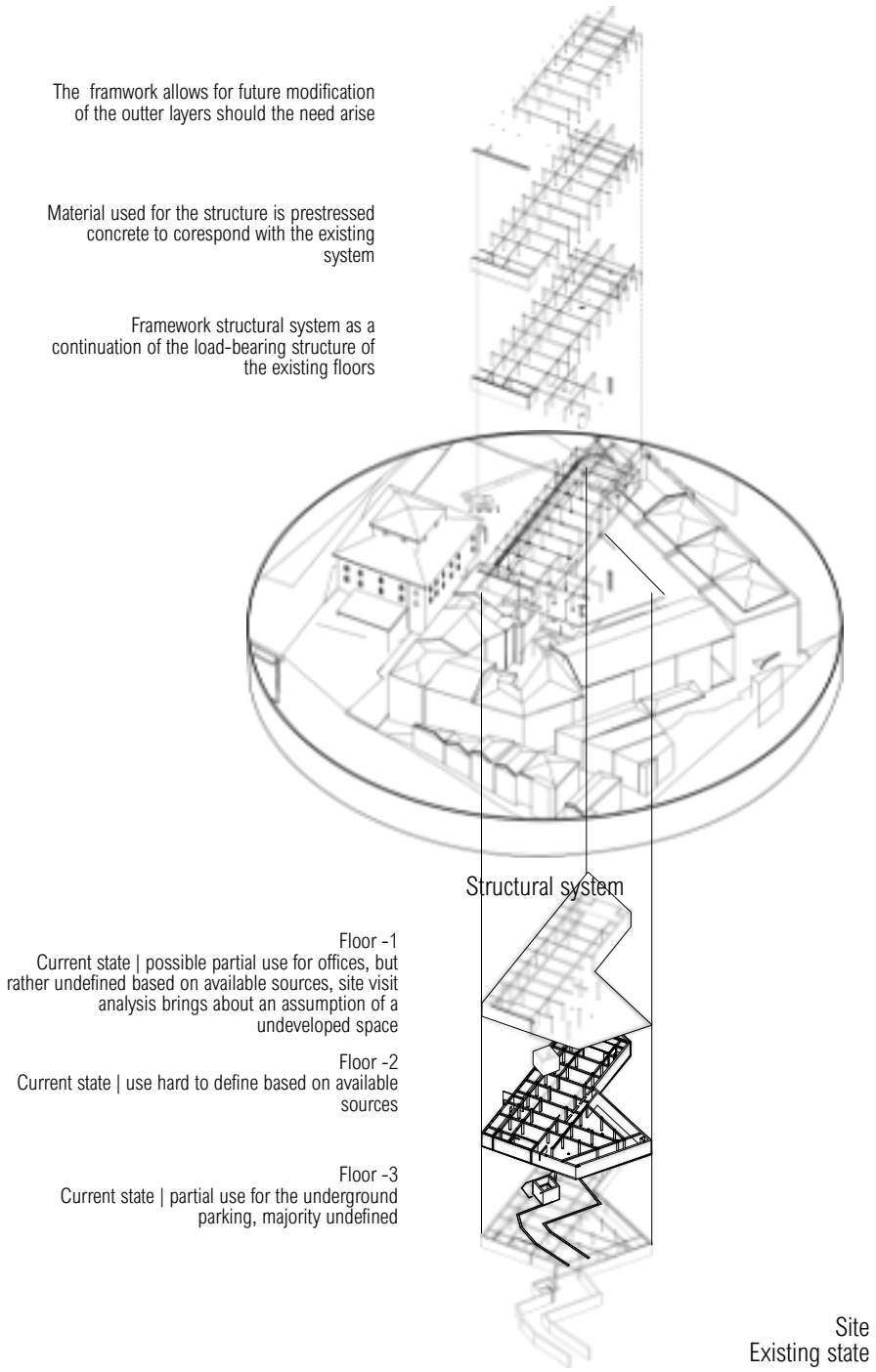


Fig. 110 The rigid frame structural system of the site, continuin the structural system of the existing underground storeys, own work

8.1.2.b Skin

The outter layer of the building, its skin, provides protection from the outter environment. Due to the use of a framework structural system, the elevation can be more felxible in terms of the material used. Main objectives to the design of the elevation refer to the provision of a comfortable indoor environment. The objectives include:

• Insulation of the good quality can indirectly help to lower the humidity of the interior as it minimises the condensation of water through keeping the interior layers at stable temperature. The stable indoor temperture improved the efficency of HVAC systems

• The provision of vapor barriers in the layers of the walls and roof is intrinsic to protect the indoor from the humidity inside

• The most important feature to refuce humidity is good ventilation, therefor the outter layers have to be equipped with an air gap

• As the load of the structure rely on columns and beams, the infill of the outter walls can be of lesser structural properties, providing the possiblity of using a higher percentage of the materials obtained through recycling

• The quality of the indoor environment requires an adequate provision of daylight and sun exposure. Due to the mild climate, that requires both the increase of sun exposure during more rainy seasons and protection from the sun during more dry seasons, particularily in the coworking or recreational areas, the elevation has to adjust to the changing environment and needs through kinetic solutions.

• The elevation of the building is a main contributor to its relationship with the surrounding. The projects aims to relate to the neighbouring structures and the character of the urban tissue through the materials used. Regarding the rhytm of the elevation the building is not planned to replicate the scale of the neighbourhoos, rather reamin in truth to the inner spread of functions, however the cohesivness of the square has to be maintained. The building's skincould transform from being more monolithic to more scattered through the use of shatters.

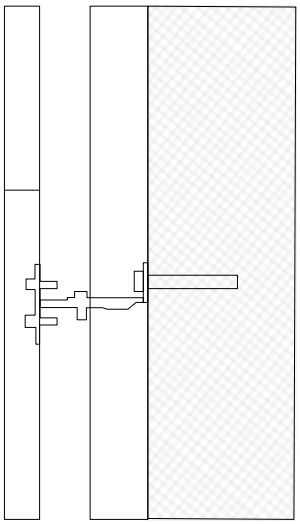


Figure 111 Symbolic section of the exterior wall layers; (1) stone panel d=6mm (2) steel frame (3) air gap d=3mm (4) vapour barrier (5) insulation d=16 mm (6) concrete wall Own drawing, based on the system detailes provided by the producer, reference source: https://a.storyblok.com/f/150360/x/87616f8183/neolith_catalog_skyline_en-es.pdf

The outter layer of the exterior walls would be finished with the use of stone panels, as mentioned in the chapters with materials. The local IHOBE guide for using recycled materials in construction[266] recommends, among other, the company Neolith[267] for the stone panels solutions for both interior and exterior, with products being manufactured in Spain. The percentage of the secondary materials usage is there astimeted to be around 52%. The company provides lightweigh stone panels, produced with raw, recycled, materials that are arranged on steel frame. The design would provide a full opportunity to reuse it, in case of the building's deconstruction.

The solution chosen for the project would provide a textured slate finish, most similar to the natural state of the stone. The dimentions of a panel are 3200x1500x6 mm.

While the embodied energy of steel elements have to be taken into consideration, the possiblity of using already exisiting frames and materials, the use of recycled materials into the production of the stone panels and the possibility of reusing the system in different sturucture at the end of the project life-cycle is deemed more sustainable material solution, as it reduces the necessity of managing the material post-production after dimantleing apart from the deconsturction process in itself and transportation.

[266] IHOBE, "Inclusión De Materiales Secundarios En Contratación De Obras.", p. 21
[267] "NEOLITH - Kitchens | Bathrooms | Claddings | Furniture," n.d., https://www.neolith.com/en/.

As exterior walls do not have to bear the loads of the entire structure, the materials used may possess less structural integrity, which allows for a more flexible use of materials

The material used for the outter walls in recycled concrete

The elevation is finished with stone panels from the local manufacturer, the panels are made with recycled materials and allow for full disassembly during the end of life of the buldigns

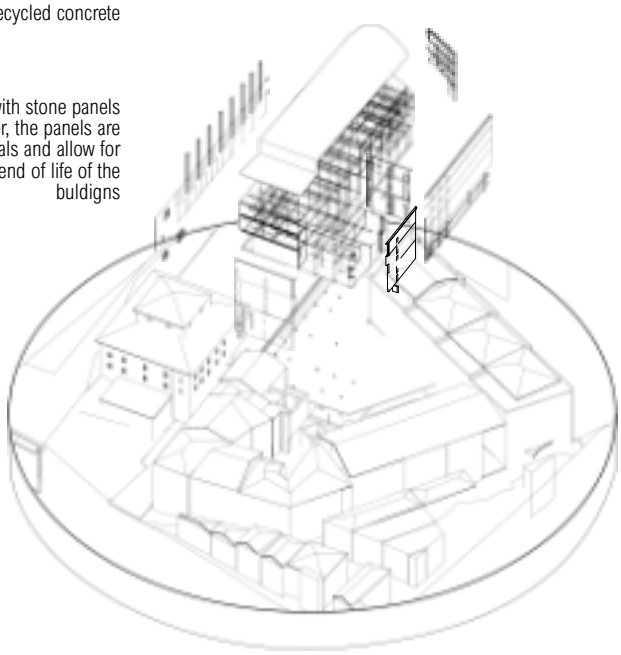


Fig. 112 Building's envelope layers, own work

The roof of the building is designed to be a flat, green roof and partially a terrace. While green roofs may not always be a fully environmentall-firendly solutions as the additional width of the structure required use of more materials, in this scenario, as the intervention is fully surrounded by the buildings or paved surface, the incorporation of at least a thin green layer would help with the occurance of the heat island phenomena, which could become especially noticeable with the increase in temperature in the next few decades to come, leading to hotter summers and more solar exposure.

The buildings openings are vertical to allow just the right amount of sunlight in, and covered by the kinetic solar cells shutters with the main movement of rotating around its own centre, a central rode for suspention. They would provide both the appropriate shading during different moments of the day and utilisation of the solar power.

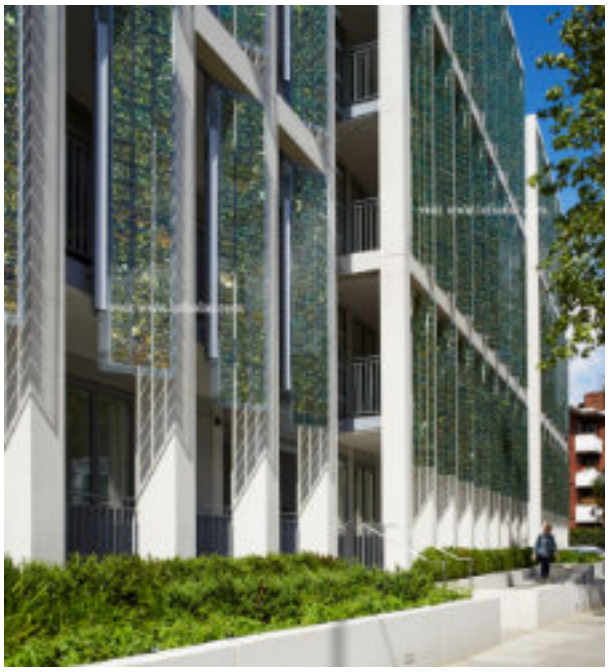


Fig 113 London Kingsgate House with solar-cell green elevation panels by BIPV, 2014. Similar solution is implemented in the Virtual Reality Design, in the lower scale.

8.1.2.c Passive and active systems

If the building's structural system is its sceleton, envelope its skin, then installations are the weins, respiratory system etc. Their well functioning is the basis of a functional building. Outdated systems, installed in an unflexible way can lead to quickenig of the building's end-of-life.
Therefore, the right choice during the design stage can allow the prolongation of the buildings functionality.

The concept of this project doesn't go into technical details to design the systems properly, but makes assumptions to determine the basic necessities and spatial requirements both outside and inside the building. The main aspects of consideration include ventilation and heating.

H. Heating and cooling

The project assumes primary heat and cooling generator to be goethermal energy. Groundthermal energy is considered to be one of the most sustainable energy source. The system uses geothermal heat pump (GHE/GHX) and can be used both for heating and cooling. Heating energy can be stored for colder days.[268] Important information about the system for the concept include the amount and the depth of boreholes, their location, location of the technical room inside the building.

The 2013 Gipuzkoa's hydrological research may let us make an assessment for the underground temperature of the region. The research verifies the underpround water points of the mountain Jaizkibel, a mountain range west of Irun, spanning from the three border cities- Hondarribia, Irun and Hendaye till Donostia-San Sebastian. Their conclusion regarding geothermal temperature gradient indicate the regional tendencies. The underground temperature remains constant for the first 20 m to rise a bit at between 40-60 m below ground level from 13,7°C to 14,5 °C to stabilise at 80 m below the ground level at 13,5°C to 14,5 °C, depending on the exact spot. The geothermal gradient is calculated to be 3°C/100m.[269] That estimation allows for a assumption that the ground/underground water level temperature surrounding the borehole would be around 14°C. The source of heat could be sufficiently used for the purpose of cooling in summer and warming in winter with the aid of the heating pump.

As the surroundings of the intervention's neighbourhood consis of the dense urban tissue, the better choice would be to utilise the vertical GHE. Horisontal ones can sometimes be arranged in the lowest parts of the building, like basements, however in the case of already existing structures and not designign from the begining, this option has been decided to be too invasive. The VGHE stilll requires some space and cannot be placed directly within the projects limits, as it is surounded by the urban sidewalks and courtyards, with underground installations.

The first choice of the location of the boreholes for the heat pump would be the green slope behind the Town Hall, which could fit close to 40 boreholes. The estimated depth ranges between 120-200 and would require further research. For the total area of 7170,02 m² the intervention, counted together with the exisitng structures, the 5977,91 m² should be conditioned to some extent and with variations in timing thorough the day.

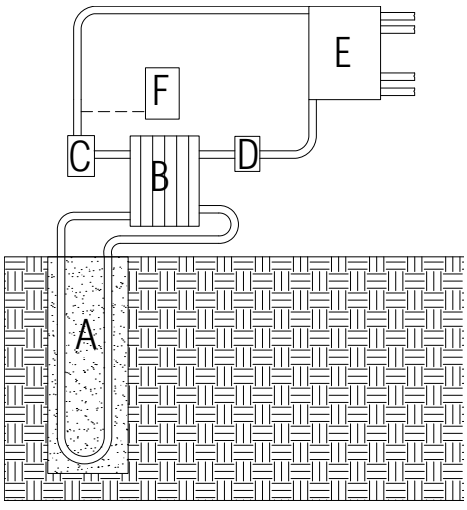


Fig. 114, Simplified scheme of GHS, own design
A- underground U-loop in the borehole, B- Heat exchanger, C- Compressor, D- Expansion valve, E- Condenser, Own work

[268] J. Cullin et al., 'Validation of Vertical Ground Heat Exchanger Design Methodologies', Science and Technology for the Built Environment 21 (13 February 2015): 137–49, https://doi.org/10.1080/10789669.2014.974478.

[269] Ane Zabaleta et al., 'Mejora En El Conocimiento Hidrogeológico de La Masa de Agua Subterránea Jaizkibel', Munibe Monographs. Nature Series 2 (1 January 2014): 47–57, https://doi.org/10.21630/mmns.2014.2.03.

V. Ventilation

The main system for passive and active ventilation is the central technical space, surrounded by the trombe wall. The solution provides a vertical ventilation and air circulation that integrates waste heat from the server room and virtual reality playrooms (which include heat producted by technology and people). The guidelines for designign such a solution in this specific context include:

• The server room is located on the third floor underground,in the existing structure with -3 floor level at -18.50 m from the projects 0.00 level. The -3 level is adjecent to a existing underground parking under the San Juan Harria square and a smaller parking under the courtyard of the city block. The air intake therefore must be located at the space that provides fresh air, must probably from the courtyards ground level of -7,50 m from the project's 0.00 level.
• The whole system has to be equiped with filters for the CO2 emissions and filters cleaning the heated air from servers.
• The vertical cavity has to be equipped with the adequate fire protection, such as fire dampers.
• The trompe walls should limit the number of openings to not obstruct the airflow.
• The vertical air cavity should control the airflow through separation of intake and escape air.
• The use of the high thermal mass material for the trompe wall could proide additional heat storage, which let out towards the night, would moderate the diurnal temperature of the building, preventing significant drops in temperature in comparison to the outside and with that the chance of capilar moisture transmittence through the walls.

The solution would utilise the stack air circulation, with the chance to adapt to seasons based on the ventilation opening ability to open and close in accordance to the pressure or temperature (fig. X). While the system has the ability to work passively, the important factor of its functioning lies in the air exchange for the high-tech spaces, as the technology has the tendency to gather dust particles. The central system would redistribute air to the nearby functions, such as office or third place spaces.

To aid the ventilation, the building was designed to utilise the cross-ventilation and stack ventilation in a passive way though the location of the openings on all available facades and on the roof through the skylight. The openings, mostly windows, equipped qith self-regulating vents.

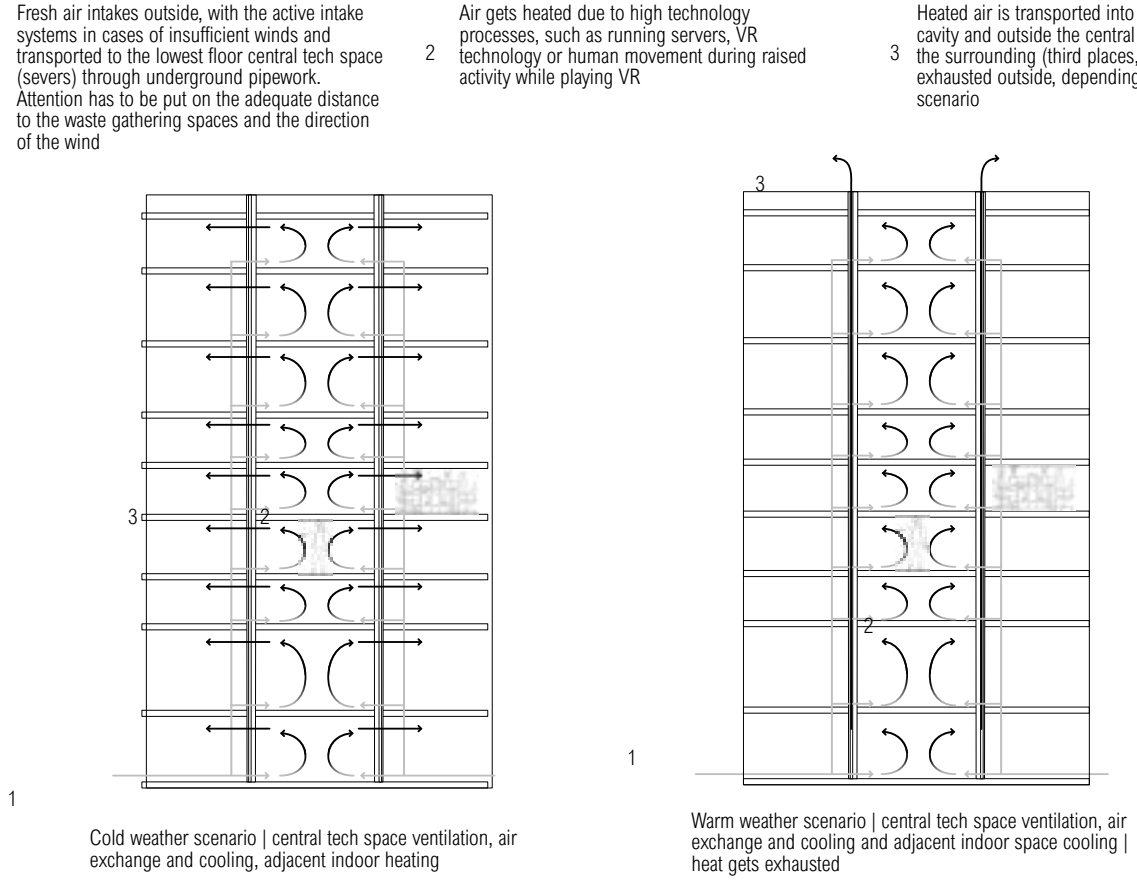


Fig. 115, Air circulation, own work

8.1.2.d Smart solutions

The incorporation of sensoring and tracking within the building would have to be implemented within the areas of the Virtual Reality, as it aids the functioning of the technology and allows for the conduction of research. That idea can be expanded onto the entirety of the design, particularily with motion sensing lighting and trackers, that would gather information of space using to optimise the temperature and gather data on the building's functioning.

8.1.2.e Water management

Due to the frequent rainfalls in the region, the rain can be captured through the catchement area on the roof or courtyard and distributed throu te pipes for the use for cleaning and flashing. After proper filtration the water may be used for washing as well or drinking. The gathering areas could be equipped with the tanks to store additional water, particularily in case of the courtyward.

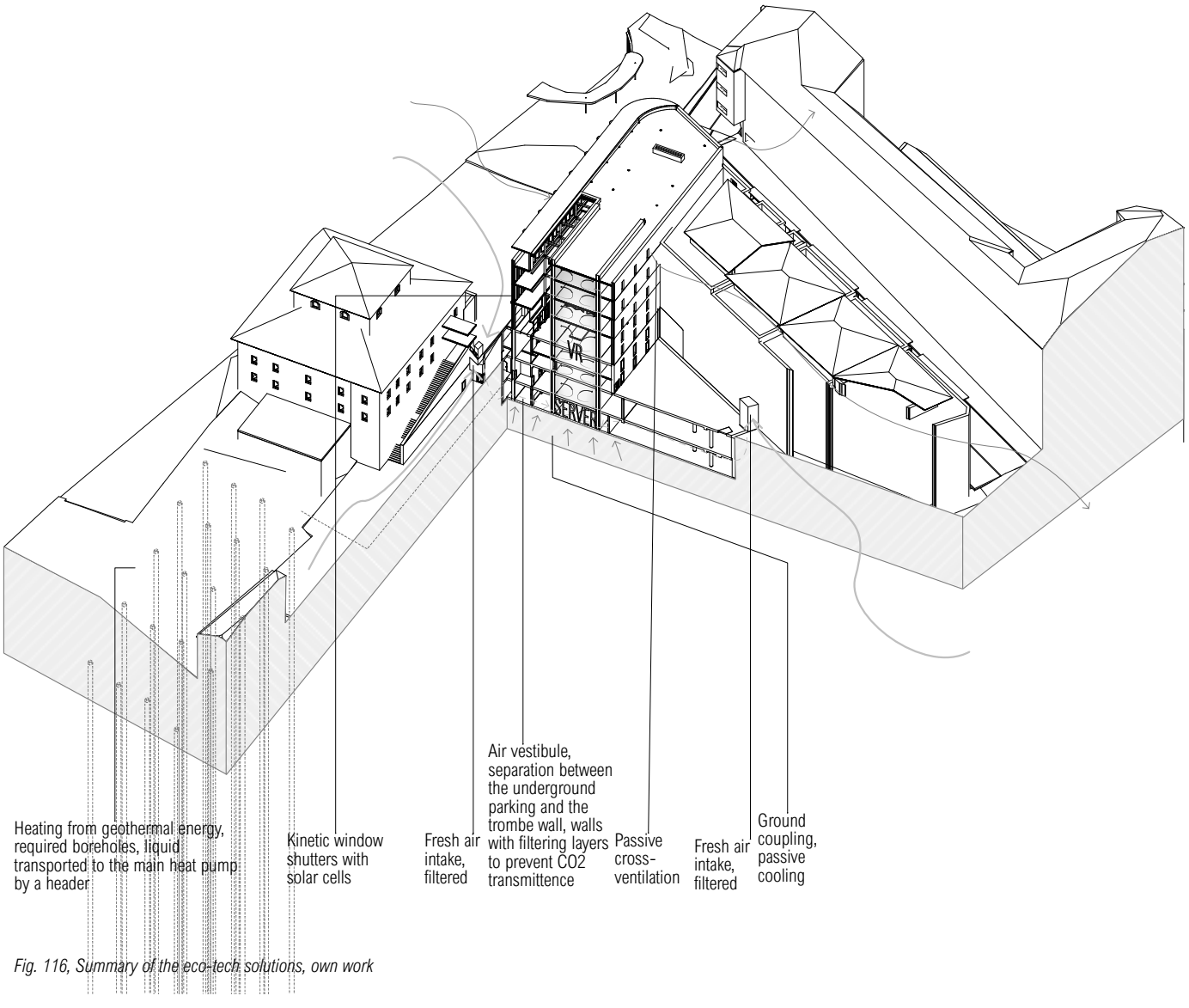


Fig. 116, Summary of the eco-tech solutions, own work

8.1.2.f Fire safety

Poland's fire safety regulations have distinct provisions regarding the distances between different types of buildings. That is not the case for the Spanish fire safety regulations. The required distances can usually be found in the General Plans of Urban Order (PGOU). As a rule of thumb it is beneficial to provide the height-to-distance proportion, however that is not strictly obliged in the dense urban tissue.[270] To provide adequate ventilation the part of the thesis project located inside the courtyard is setoff from the inicial layout of the existing top slab, to provide sunlight exposure to the part of the residential building. The part exposed to the courtyard is mostly the inner vertical communication part.

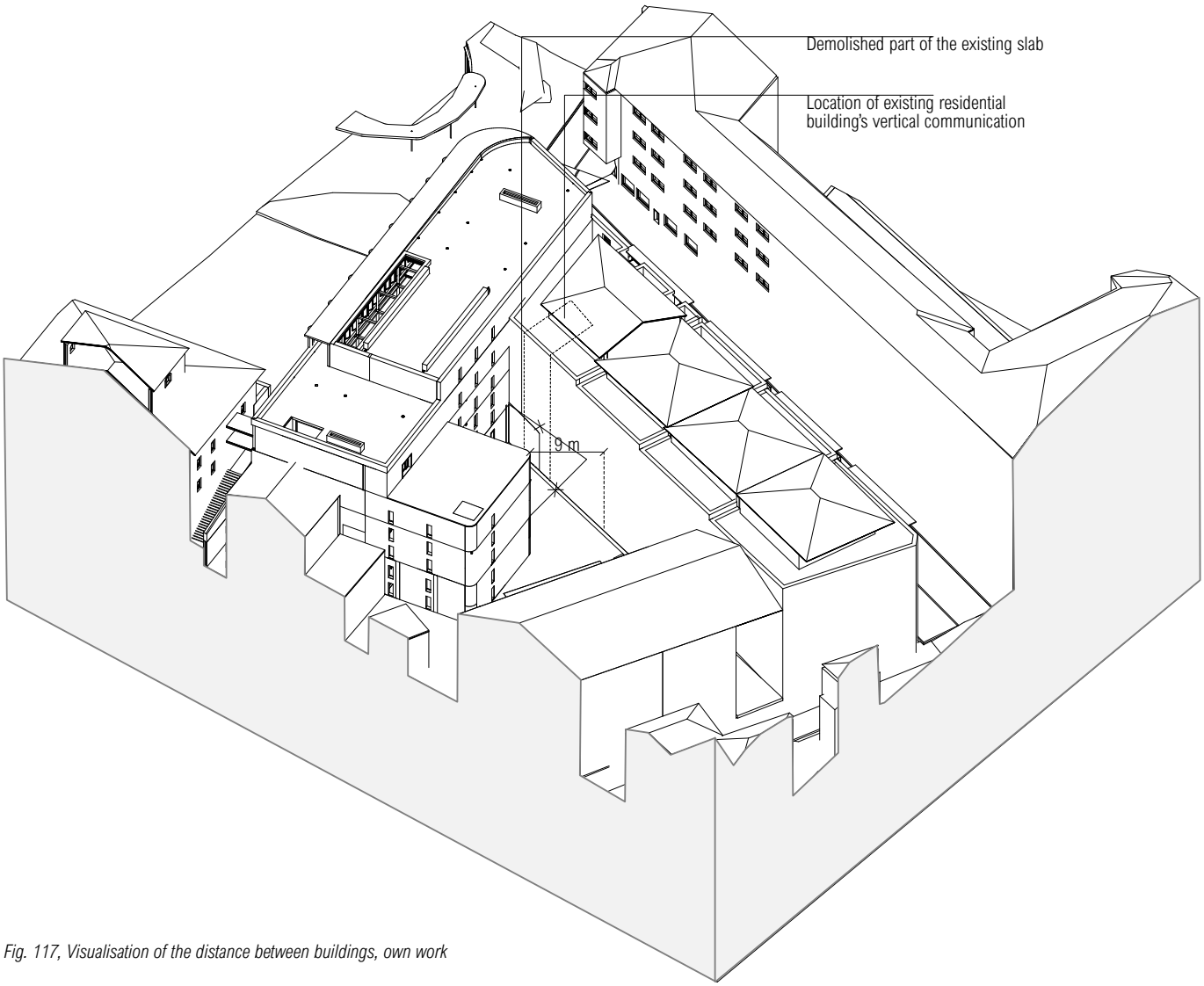


Fig. 117, Visualisation of the distance between buildings, own work

8.1.2.g Accesibility measures

Building's easier access is ensured through the incorporations of doorways of the width surpassing 90-100 cm, without thresholds, wide corridors and accessible elevators with audio announcements. The special bathroom stalls, equiped with bars and a space for wheelchair turning are located on every floor. The lighting introduced into the building should be adjusted to provide glare-free vision. While the main function of the building of Virtual Reality relies on the visuals, the incorporation of other types of immersion programmes is possible.

[270] The provided information rely on the knowledge of the author and may prove to be not entirely accurate.

8.1.2 Functioning stage

8.1.2.a Space for change

The maintenance and using of the building are aspects that can be taken into account during the design stage. The functional layout in particular and the adaptable and flexible solutions have been the interest of the architects. The current popularity of modular, kinetic, flexible and adaptable solutions stems from the fact of high level of individualisation of the society, which leads to the emergence of personlised solutions in a variety of products, not ommiting architecture. The adaptability is incorporated into the functioning of the intervention through framework structure (*8.1.2.a*), which allows for the design to be open to future changes. The use of elevation shutters and chromomorphic glazing, that adjust to the solar radiation to provide comfortable environment of the interior (*8.1.2.b*).

In terms of the functioning of the building and its daily use, the main design guidelines relate to flexibility of use through modular furniture and adaptability of space. The approach is best visible in the design of the office layout. The opennes of the space to change in visible in two main appraches. The first is the adaptability as a long-term solutions. That is achieved through the use of partitions, that are easily transferrable, however with the objective of possible future redesign of the space not day-to-day modifications. Such solution is most useful in the administration office of the Town Hall, which relies on the pretty structued work, therefore the interior should reflect that, while leaving enough space for easy change of usage. The second type is flexibility, expressed through smart use of modular furniture, for the areas that require short-term changes, like the workshops area of the Town Hall of devs' offcie space.

Adaptability of space in the design of the Town Hall office is expressed through the example of the possible redesign of the space if the need arises, shown through the addition of the second option. The flexibility of design is shown through the possible rearrangement of space, based on day-to-day needs.

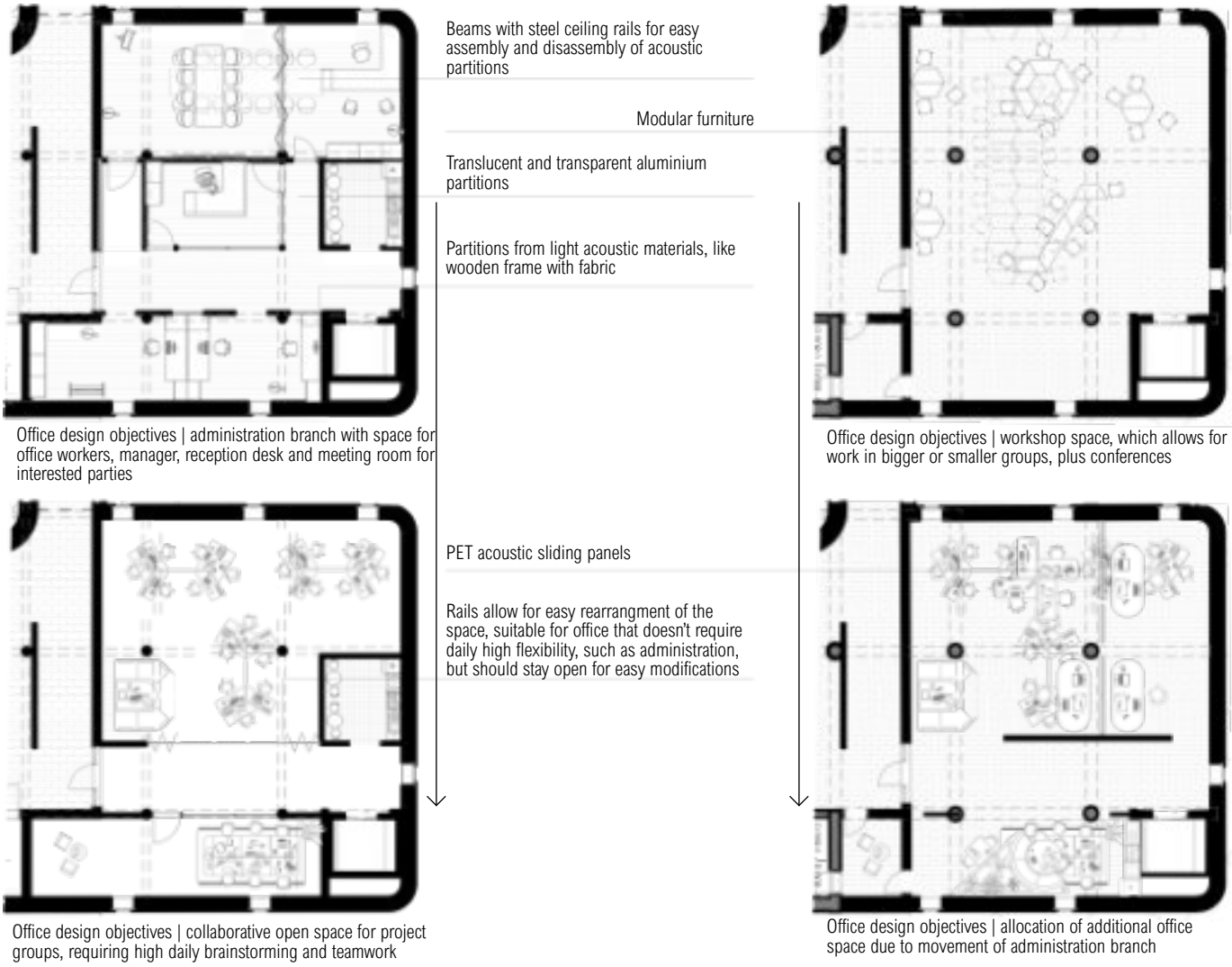
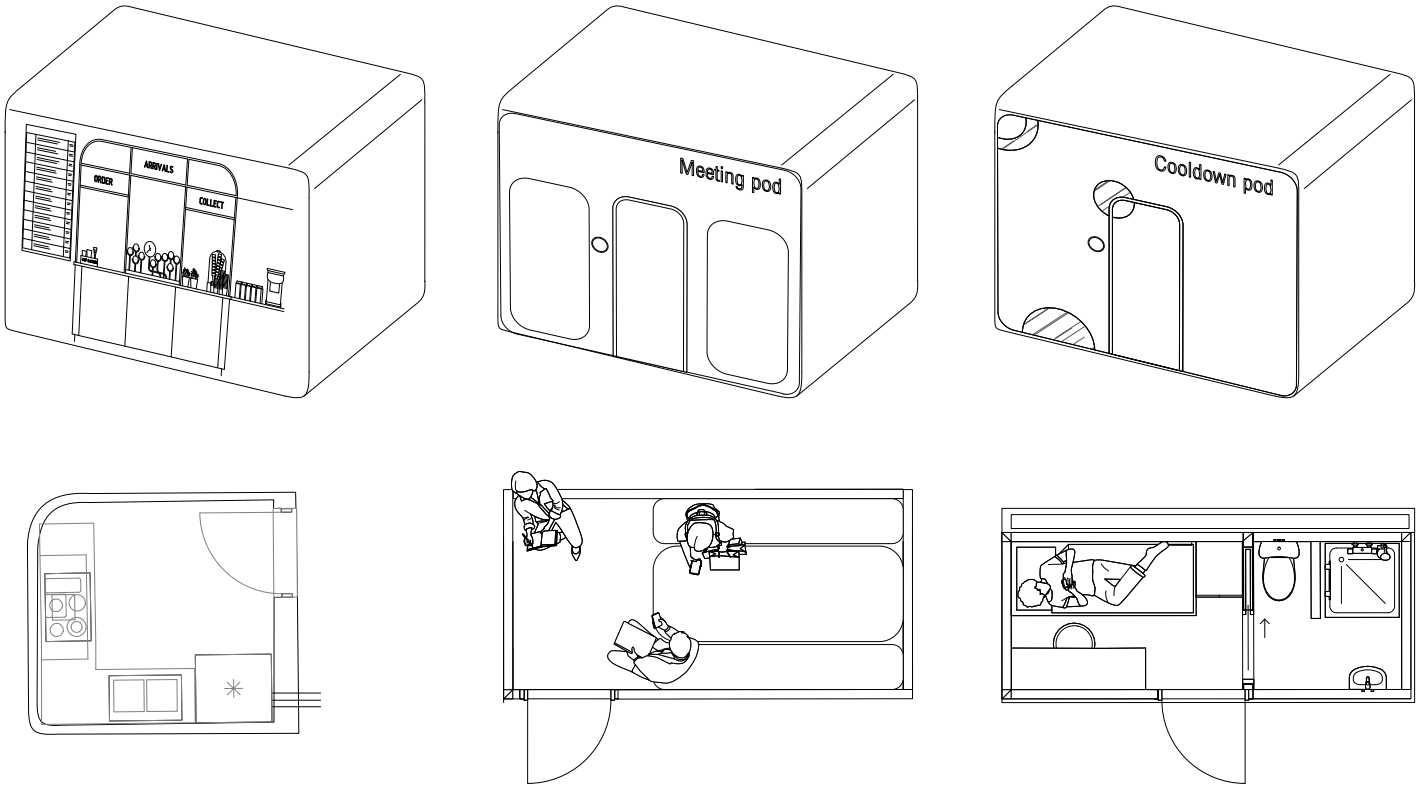


Fig. 118 Flexible design solutions, example of the Town Hall offices, own work

8.1.2.b Compartmentalisation

As noticed by de Cauter, the current society likes to compartmentise ideas, things, people, or any any thing for easier digestion. Within the scope of the design sphere that is expressed through the use of capsule-like solutions, or boxing the desired functions within some limits. Within the thesis project, this tendency is visualised in rather literary, through the use of pods.

The project incorporated three types of pods. The first relates to the functioning of the gastronomy. The food court provides three empty boxes, with equipped kitchen, that can be filled with a ceratin type of gastronomy. Th idea takes into account the possible rotation of the available function. The decond type of pod is the meeting pod, a closed, soundproofed space for co-working, which would be located thorough the project to aid the co-working and provide the third space for students or individual researchers. While the project is located next to the library, the space within the existing cultural centre is not equipped with the space for collaborative work, that requires communication, rather a quiet space. The project would add a variety of choice to choose from in regards to wroking environment. The meeting pod, like studying stations could be rented by hour. Lastly, another pod-like design allocated within the project is the cooldown pod, which works as a sleeping and resting pod. It is inspird by the Sleepbox[271] idea of providing a closed space for rest. Similar designs can be found in places like airports or railway station. The relate to the idea of capsule hostels, but with the provision of mobility, as the sleeping pods can be moved. The pod designed for this particular project is equipped with the utilities. Therefore it would require additional installations to provide water and manage sewage. For comfortable managing, the Cooldown pod would incorporate both plug-in water hookups and power imputs and mobile options, giving it the opportunity to be able to function more locally, while being connected to the grid, or providing mobility through the off-grid electrical solutions of battery banks and mobile water tanks systems. The sleeping pod would function as a short term rental for rest or sleep and would require a cleaning personel to manage in-between guests. The availability will be managed by the system. For the comfort of the users the area, where the pods would be located would be equipped with the corridor cameras to provide security.



Food pod

A food court cubicle with basic necessary kitchen appliances,
-allows for different food provisions
-stable connection to the grid
-stable connection to the water supply network

Co-working pod

A space for temporary rent for teamwork
- possibility to connect to the building's electrical grid
- equipped with battery for more mobile use

Rest pod

A space for temporary rent for sleep, nap, siesta
- possibility to connect to the building's electrical grid
- equipped with battery for more mobile use
- possibility to connect to the building's water supply network
- equipped with water tank for more mobile use
- requires human assistance to clean after guests (maybe in the future that would be done by a robot)

Fig. 119 Variations of pods designs withing the project, own work

[271] Sleepbox, "Sleepbox," Sleepbox, n.d., https://sleepbox.com/.

9. End-of-life or after-life stage

The end-of-life stage in the LCA refers to the demolishion of the building. Current sustainable design measures aim to provide the controled deconstruction insted of a chaotic demolishion to preserve valuable materials for further use. Moreover, various designs, including this thesis project undertake measure to ensure structure's adaptability to changing needs, to reduce the need building new buildings, while the exisitng structures can be re-utilised.

To envision the possible future functioning of the building, three scenarios have been curated. The first assumes th total deconstruction of the building, which, according to the DfD design can lead to reuse or recycling of the materials in different places. The second scenario predicts the need for a response to crisis, in this specific example overpopulation and migration crisins, which stems from the climate change. The third scenario implies the possible change of function due to the change in the technology, as Virtual Reality becomes a standars. As this scenario resloves heavily on the technological progress, the inicial idea has been created with the use of AI, to signify the possible future of architectural design, that utilises this tool on a daily basis.

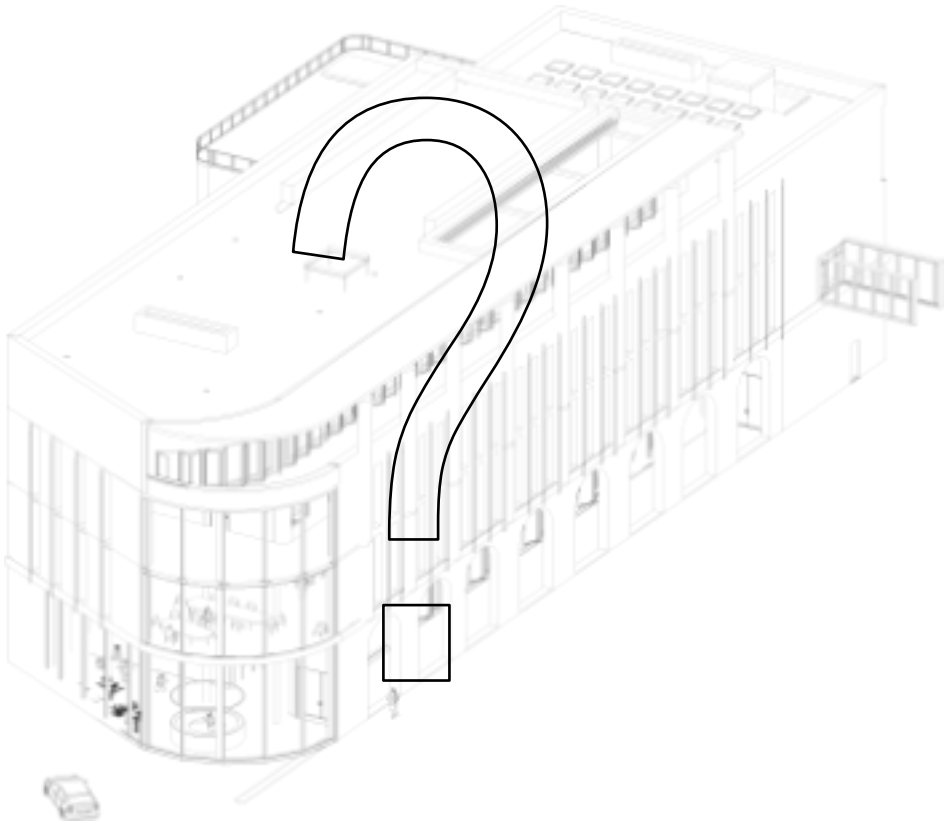


Fig. 120 Designed project future, own work.

Scenario 1

Year 2055. The environmental movements have achived the desired maximum increase in global temperature according to the Paris Agreement. However, years of climate instability have shifted the climate for good. Themelting of glasiers caused significant rise in water levels and in the Basque microclimate, due to region being clossed of by the mountains, even higher humifidy and frequent heavy rainfalls. To prevent flooding the city has built multiple urban water tanks to manipulate the water accumulation. The Virtual Reality Centre was one of the first to be deconstructed, as the DfD philosophy simplifed that process.

+
+ 1,0 °C

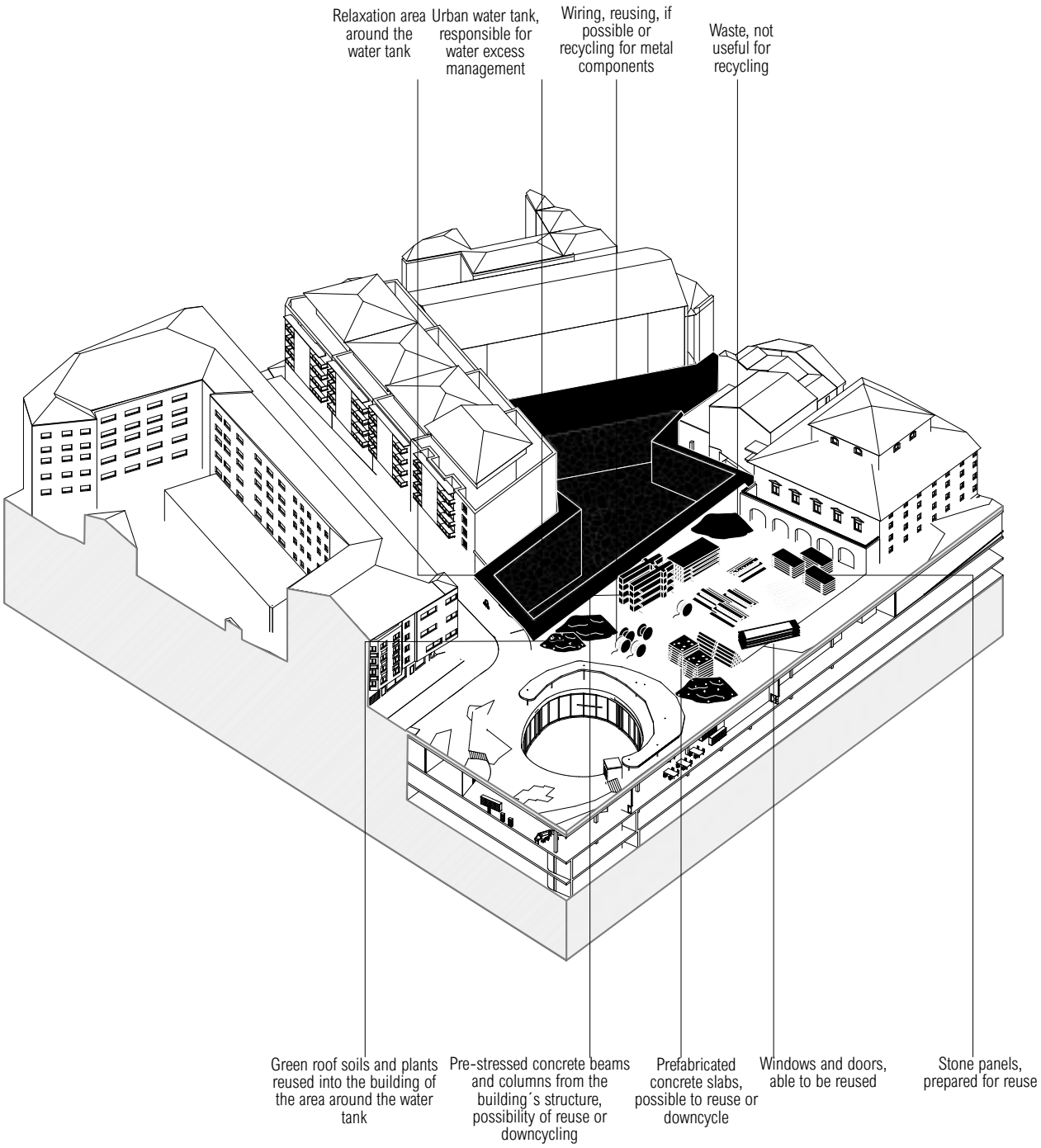


Fig 120 Scenario 1 of the possible future changes in the building. Deconstruction. Own work.

Scenario 2

Year 2055. With the progression of climate change, and the rise of the temperature, the nearby Spanish regions of Aragon, Castile and Leon, Madrid and Castilla-La Mancha became very hot, leading to the thousands of people to migrate into cooler regions, such as the Basque Country. The rapid growth in population has led to the need for housing. Therefore the Virtual Reality Centre was quickly transformed into a block of flats.

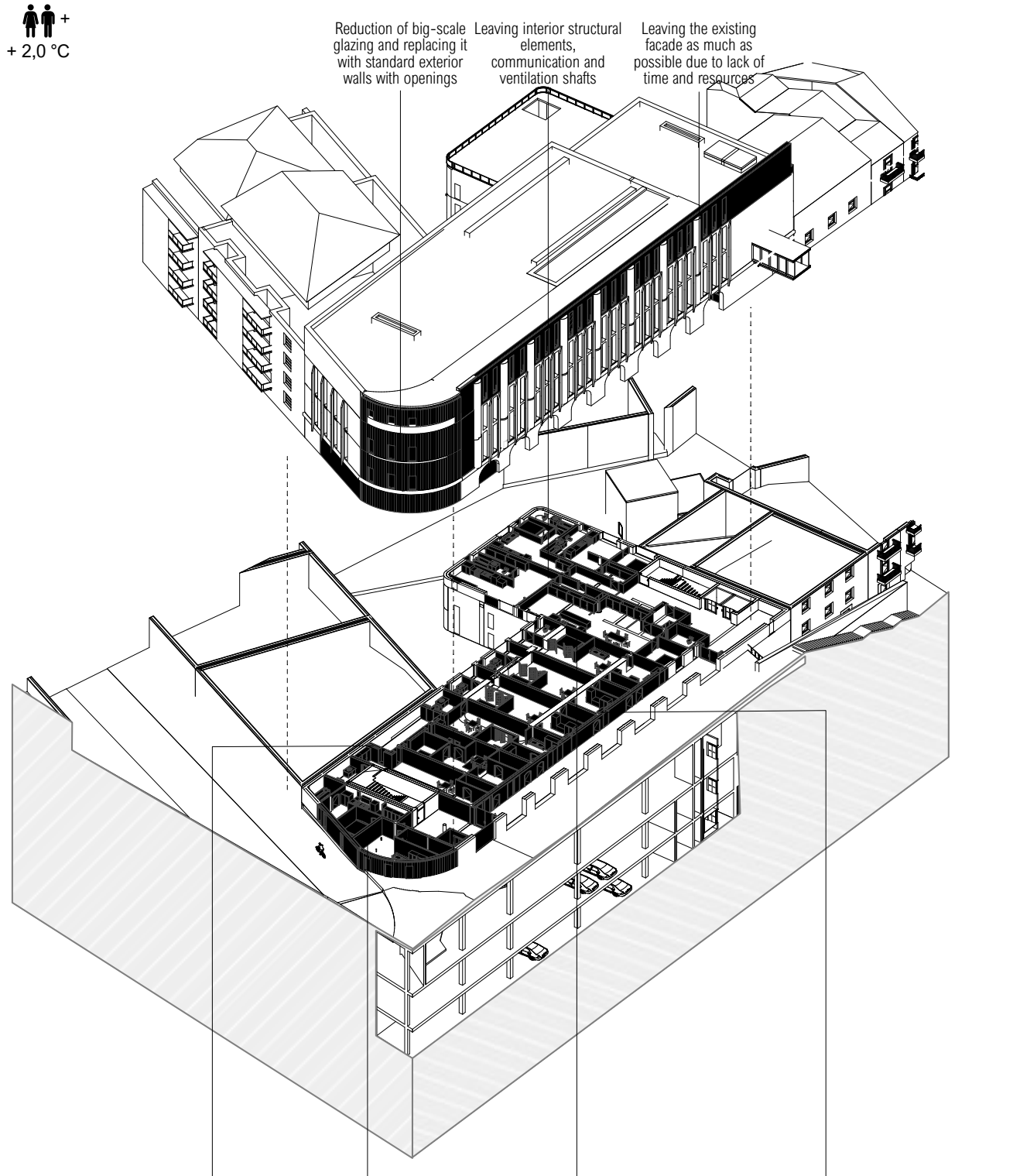


Fig 122 Scenario 2 of the possible future changes in the building. Change to residential scenario. Own work..

Scenario 3

Year 2055. The Virtual Reality technology has progressed into Brain-Computer Interface technology.[272] The Virtual Reality Research Centre was a perfect place to transform into the function of BCI Research Facility. The character of the space changed from being a space for public integration, to a closed-off centre of elite research. The development of the technology and research on human mind possibilities of manipulating the technology has become the fundamental technology to progress the colonies on Mars. The Basque Country has taken this opportunity to attribute to that cause. The redesign was conducted by the architects aided by the AI.[273]

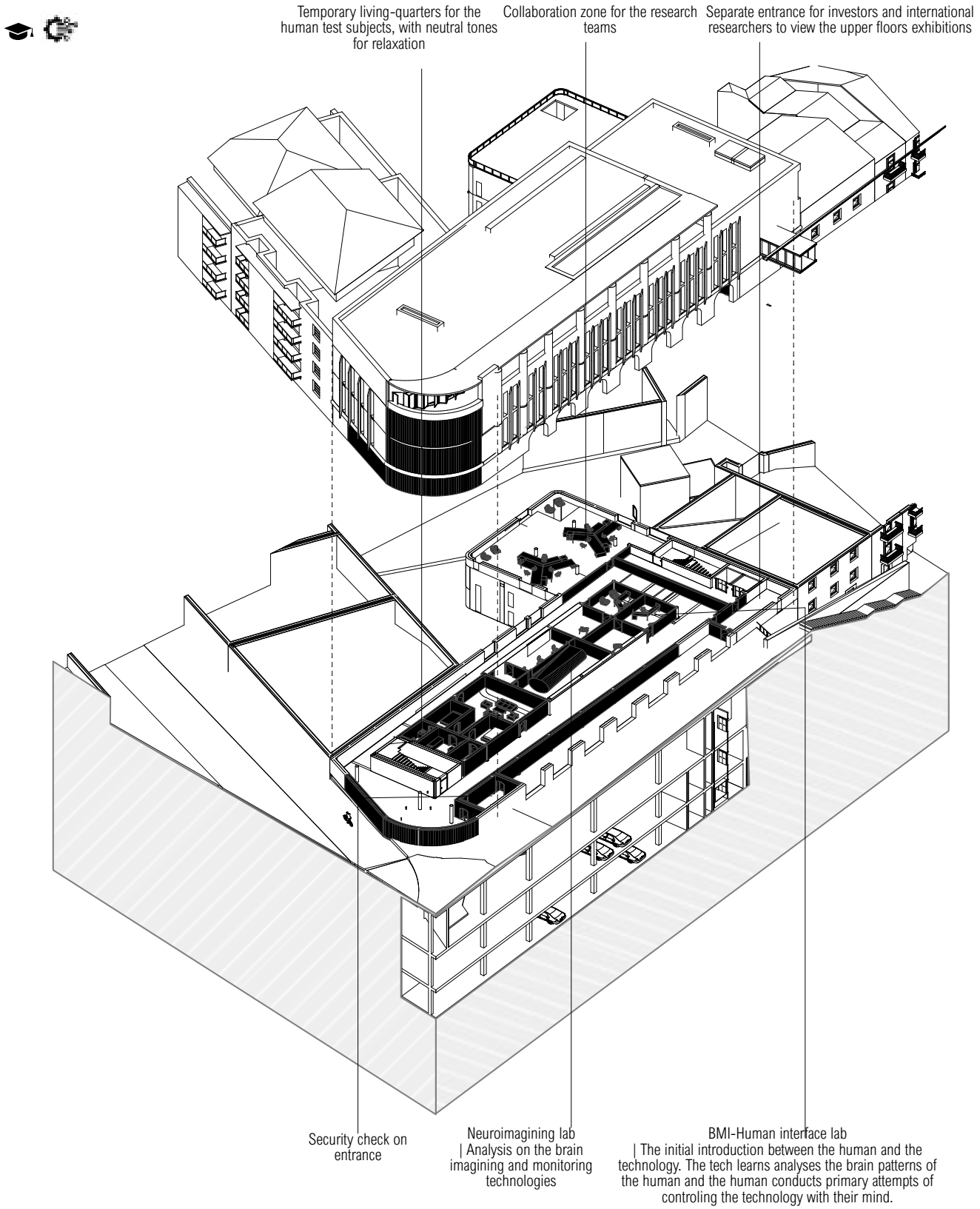


Fig 123 Scenario 3 of the possible future changes in the building. Change in technology scenario. Own work with the aid for design idea by AI

[272] ChatGPT, response to the author's question, prompt "My project is a design of the building for the Virtual Reality Research. Due to the dynamic nature of the technology, the building is deemed to change function. What will be the next big technology after the Virtual Reality in your opinion?", *Open AI,* May 29, 2025
[273] ChatGPT, response to the author's question, prompt "Number 2 sound promising. Provide the overview of the functions that can be located on the ground floor to visualise the function. What construction and functional elements as well as spatial area would those options require??", *Open AI,* May 29, 2025

10. Conclusions on the project

How to design environmentally-friendly building? is a oxymoronic question. In fact, most sustainable building is the one that was never build. Similar idea can be attributed to almost all creation. Humankind is inherently a parasitic being within the ecosystem. However, inaction and simple existance has never been a defining factor of the human society in general. Across vast cultural differences the direction and strive towards, further, has always preservered.

While it is impossible to predict the future, it is an valuable exercise to wonder and to think about the results of our actions. The current society, especially of the West, is fast-paced, even impatied. The past decades have made it used to instant gratification, from the quick access to information through the internet to availability of options for entertainment, gastronomy, workplaces and so on.

The architecture that reflects current society is one with the focus on production, always answering to the customers' needs. The current main needs could be boiled down to the following priorities. Comfort comes first, through the addition of solutions that provide all the desired function with great rapidity, through personalisation second, readable throught the more and more common inclusions of various ways to modify the space, both real and virtual, both through movement and data, to safety third (yes, in that order) through the introduction of the solutions that would not worsen the crisis situation the climate is in.

As we go on further into the century, the main question that arises is: which one will prevail? Which of these priorities will become the centerpiece? The answer will define the future reality, that most of those shaping it will still live to see.

As for now we're left with wonder. The wonder concluded in this thesis aimed to ask question more to really answer them and along the way has served as a mark in time of the individual point of development.

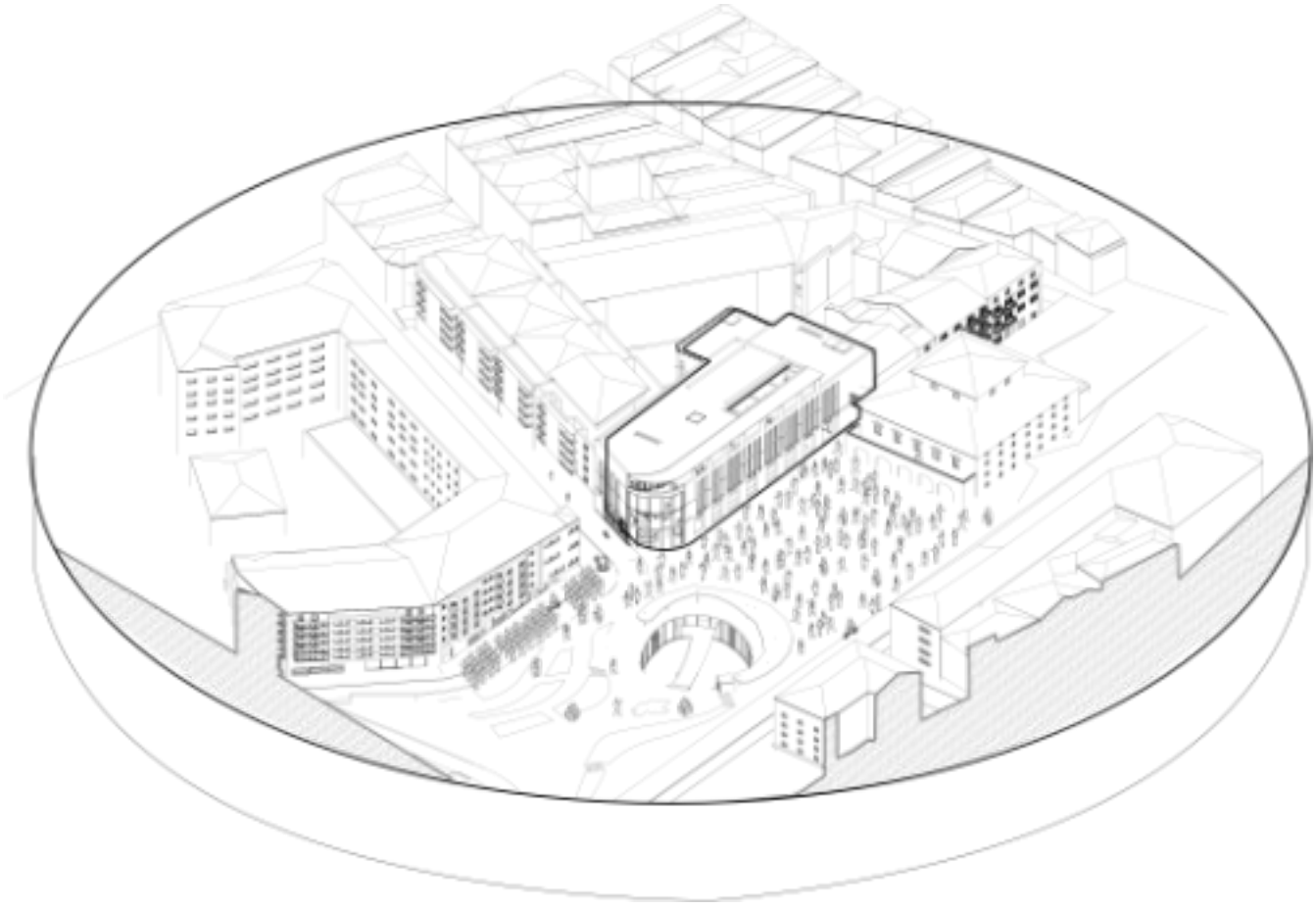


Fig 123 Final project axonometry. Vision on the neighbourhood durin the annual festival of San Marcial.

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