Planning for the regeneration of listed buildings for vulnerable social groups using Zero-Energy and Circular Principles

The case of the refugee settlements of Alexandra's Avenue in Athens, Greece

Nikoletta Dimitriou, 2022

Cover Image: Koulira, A. (2014). What is happening in the Refugee Settlements of Alexandra's Avenue? [Photograph]. https://popaganda.gr/stories/ti-simveni-sta-prosfigika/2/

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Abstract

The present thesis discusses social, cultural, economic and environmental aspects of problems related to heritage building depreciation, homelessness and lack of affordable housing, with a focus on the more vulnerable social groups. It additionally argues the mitigation of the impact of the cities and the building sector on climate crisis. The aim of the thesis is to find a sustainable, in terms of longevity and feasibility, connection between the unexploited building stock and the shelter-less people, for the benefit of the users, the society and the environment alike, through zero-energy design and circular adaptation.

The study analyzes the possible approach of renovation and adaptive reuse of the existing, untapped, residential buildings in order to meet the current climate regulations and future occupants' needs. A literature review examines three main domains separately: zero-energy design, circularity and collective housing. A case study analysis of alternative collective housing models in particular monitors the porosity of this plan and its ability to be combined with zero-energy and circular principles. This research offers the opportunity to recognize possible methodologies that can then be applied on a specific case study.

Research is consolidated in the case of the refugee settlement complex of Alexandra's Avenue (1933-36), in the city of Athens, and seeks to propose a number of recommendations for its renovation, energy upgrade, redevelopment and reuse. The fact that the research refers to listed buildings, constitutes the biggest limitation, in terms of design decisions. The case study it-self, clearly depicts the afore-mentioned issues in the Athenian context, and alongside includes building, social, historic and other characteristics that compose an ideal example for an energy efficient, user-oriented, adaptive reuse.

A step-by-step approach is adopted in order to develop (re) design methodologies for the energy transition and circular adaptation of the case study. In addition, a possible network of interactions between the involved stakeholders is proposed so as to create a holistic and functional business model. Ultimately, the thesis proposes an inclusive and integrated framework for the renovation of the existing, old, heritage, building stock, driven by zero-energy and circular principles, for the less-favored, towards a new typology of social and collective housing. The development of this framework is based on facts and data that can make it potentially applicable to similar cases elsewhere.

Further research on the topic would help facilitate the transition to integrated frameworks of renovation processes.

Keywords

Adaptive reuse – social housing – residential buildings – listed – heritage – collective housing – zero energy design – circularity – circular renovation – operations scheme

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1.

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Introduction

The streets of the Greek capital, especially of its city center, are dominated by abandoned buildings or buildings in poor condition, that most often than not become risk for the public safety and health. Part of these edifices are listed (Tsoni, 2021), that the state and owners are obliged to preserve. However, usually due to lack of financial sources and/or of an efficient institutional framework, they remain in disuse, bearing evidence of negligence or even indifference.

At the same time, and despite the numerous empty buildings, the corners and thresholds of these streets accommodate thousands of homeless people (Mavridis, 2018). This is mostly due to the economic crisis, high unemployment rates and the difficulty of the state to absorb the large amounts of refugees. In addition, there is limited to zero access to affordable, decent housing and a complete absence of social housing policies.

Furthermore, Greece is no exception to the global climate crisis. Almost 13% of the country's CO2 emissions are produced by the building sector (Worldometer, 2016). Even though in other European countries it exceeds 40% (C40 Cities, 2021), this number can still not be considered as negligible.

As part of the European Union, Greece is subject to EU's rules and regulations. The European Union recognizes the multiple faces of the problem and has already begun to develop numerous policies and intensive practices in order to motivate interventions to the new and old building stock with zero energy techniques. A systematic effort is also made for the adoption and inclusion of circular principles.

Since the building sector is one major factor in every country's emissions, is therefore; a pillar in its Long-Term Strategies (LTS) for 2050. The Greek state, among other EU countries, as it heads towards a zero-carbon future, focuses its regulations on the new buildings. However, it will not be easy to achieve the building sector's zero carbon emission goal in 2050; without also improving the energy performance and reducing the carbon emissions of the already existing building stock. For this reason, in October 2020, the European Commission announced a major initiative, the "Wave of Renovations for Europe", to address a dual challenge, of energy efficiency and of affordability (European Commission, 2020).

Therefore, the regeneration of the unexploited building stock, using the afore-mentioned sustainable principles, and their utilization for accommodating the most vulnerable social groups, offer a big potential in bridging the gap between empty buildings and homeless people, in environmentally friendly terms.

The present thesis aims to conceptualize the key challenges and opportunities associated with the unexploited, existing, (heritage) building stock in Europe and more specifically in the Greek capital. The study analyzes the possible approach of renovation and adaptive reuse of the existing, untapped, residential, buildings in order to meet the current climate regulations and future occupants' needs. In addition, taking into account other values too; like social, economic, political, historic, etc. the thesis aims to form a feasible framework, in order to create symbiotic/synergetic relations for affordable, carbon neutral, collective housing, using circular and positive-energy principles. This plan could potentially operate as a pilot project for future efforts to achieve the 17 SDGs within and through the built environment.

Research is consolidated in the specific case study of a refugee settlement complex in the city of Athens (1933-36) and seeks to propose a number of recommendations for its renovation, energy upgrade, redevelopment and reuse. The case study itself, clearly depicts the afore-mentioned issues in the Athenian context, and alongside includes building, social, historic and other characteristics that compose an ideal example for an energy efficient, user-oriented, adaptive reuse.

The current chapter (Chapter 1) continues with describing the set of problems that initiated the present thesis, including climate crisis, heritage building depreciation, homelessness and the social housing crisis in Greece. Moreover, the research and design questions and sub-questions are stated, and the methodology followed is analyzed.

Chapter 2 is focused on the 3 main domains of the thesis, which are: zero-energy design, circularity and collective housing models. This chapter presents the biggest part of the literature review and case study analysis.

Chapter 3 is dedicated to the analysis and re-design of the specific case. The proposed redevelopment follows 3 main steps: the energy transition, the circular adaptation and the operational plan, the combination of which create an integrated framework for renovating the existing, old building stock.

At the end of the thesis (Chapter 4), the conclusions and reflection are being discussed.

Problem Statement

Climate Crisis

Climate crisis is an undoubtable, global, major issue of our times. The way the humankind has affected, and is still continuously affecting, the environment is irreversible. Global warming and climate change are caused by the extensive use of fossil fuels, deforestation and increasingly intensive agriculture. This results to an unhealthy, unpredictable and dangerous environment to live in.

One way to calculate the human activities' impact on Earth is by measuring the greenhouse gases concentration in the atmosphere. One of the major gases responsible for the greenhouse effect is carbon dioxide – CO2. By calculating the carbon emissions of different activities, services, sectors, products, etc., it is possible to classify the urgency of taking further action.

This thesis is focused on the building sector related climate crisis, which is responsible for more than 40% of the global carbon emissions (C40 Cities, 2021). This number includes emissions related to building operations as well as building materials and construction. Considering the tendency to urbanization and the fact that the global building floor area is expected to double by 2060 (Architecture 2030, 2021), the need to eliminate all carbon emissions from the built environment seems more urgent than ever.

Image 1.1. Asakawa, G. (2020). Downtown Denver in February 2020 [Photograph]. Denver Post file photo

Heritage Building Depreciation

Despite the increasing need for new buildings, most of the existing building stock will still be available in the next decades. In the EU, half of these buildings are already more than 50 years old (European Commission, 2014) and of that 70-80% is residential (Synnefa et al., 2017). These are constructions built before the first thermal regulations, that are struggling to accomplish their occupants' needs, in terms of comfort and affordability, and to keep up with the continuously advancing new systems and technologies of the sector.

While the conversation on whether the existing, old, building stock should or should not be preserved and reconstructed, is still in progress, there is a group of buildings that, by law, cannot be demolished. Listed buildings are considered part of our cultural heritage, and therefore, governments are obliged to reserve and reconstruct them.

In this research, the focus is more on the heritage buildings found within the urban tissue of European cities. Sometimes, listed buildings in urban areas can be a great example of how an old structure, that is part of the city for perhaps some hundreds years, can accommodate new users and facilities, serve contemporary needs and still guard and narrate stories of the past.

In addition to the old, dilapidated and poorly functioning building stock, Greece has an estimated 20,000 individual listed buildings (Tsoni, 2021). However, in Greece, the protection of the listed buildings is a very complex issue, and a subject to a complicated legislative framework, frequently

Image 1.2. Stergiopoulos, G. (2016). Abandoned Buildings in Athens Greece Vol. 1-003 [Photograph]. Flickr

overlapping competences between different Public Services, unclear ownership status and significant financial costs related to their restoration and reinforcement (Alexoudi & Karavelas, 2018). The lack of maintenance leads to a depreciation of these buildings. The problem of vacant and abandoned properties and the degradation, specially, of the center of Athens is economic, social and environmental.

The preservation and reconstruction of listed buildings is, not only an obligation of the state, but also one of the most significant challenges of cultural heritage of our times. The renovation potential of these buildings could lead to the complete overhaul of the city center of Athens, and; therefore, it should be a major objective of town planning.

Homelessness & Social Housing Crisis

The right to housing has been constitutionally guaranteed in Greece since 1975 as is, characteristically, stated in the article 21 paragraph 4: "the acquisition of housing is subject to special care by the State for those who lack of housing or those who are inadequately housed" (Emmanuel, 2006). Although this provision could be the basis for extensive state interventions in the housing sector, comparable to those of other European countries, where there are similar definitions of the state-residence relationship, the Greek case remains unique (Goudis, 2020).

While there is a huge building stock that remains untapped (Triantafyllopoulos, 2018), and located in areas where needs are more demanding, approximately 9000 people live in the

Image 1.3. Wardkhian, C. (2016). An impossible hope [Photograph]. Getty Images

streets of Athens (Mavridis, 2018). The long sovereign debt crisis and the recent, layered immigration waves from Syria, Afghanistan and Pakistan, have increased the unemployment and poverty rates (Statista, 2022). In combination with the lack of a social housing sector and the dependence of the Greek housing model on homeownership, it is increasingly more difficult for the lower status social groups to find adequate and affordable accommodation.

For decades the lower status social groups, in Greece, in order to access homeownership was depending on other ways, like self-promotion and self-construction. These solutions, however, are no longer an option. Additionally, the intense presence of Airbnb-like policies, specifically in the center of Athens, have cause a great rise in rent and sales prices, resulting in an increasingly unequal, in terms of class, access to housing.

New policy tools that would allow the improvement of the deteriorating housing stock and the expansion of housing opportunities for those facing risks of housing deprivation seem to be matters of urgent priority, today and in the immediate future (Kandylis et al., 2018).

Research Question

How can we create integrated approaches for renovating heritage buildings or old building stock using zero-energy, circular principles and collective housing models?

Sub-questions:

• What is zero energy? What are the methodologies, approaches and steps being used to achieve a building's energy transition to zero? And why is it necessary to make the transition?

• What is circularity (in the built environment)? What are the related principles? And why is it important to adopt them?

• What is collective housing? Are there existing, successful collective housing models? Why is it important to create new housing policies?

•Are there any other integrated approaches combining two or more of these issues?

This thesis is based on a research that focuses on the utilization of the existing, untapped, heritage building stock. It explores methodologies connected to the sustainable transition of cities into carbon neutral, circular and climate adaptive. The research aims in the empowerment of the most vulnerable groups, including refugees, unemployed and homeless people. It looks into methodologies, steps and principles already developed in the fields of zero-energy design and circular adaptation. It additionally presents case studies of alternative collective housing models, in order to support the concept of an inclusive, user-oriented approach. Cases that combine two or more of the afore-mentioned issues have also been taken into serious consideration.

Design Assignment

Circular transformation of a 30's refugee building complex into a zero-energy neighborhood of collective social housing units.

Sub-questions:

- How to apply zero-energy principles on heritage buildings?
- How to apply circular principles on heritage buildings?
- How to design a business model for synergistic relations between the multiple stakeholders?
- What are the design implications of integrating multiple principles?
- What are the limitations and opportunities?
- Based on the design analysis of the refugee settlement of Alexandra's Av. in Athens, is it possible to create integrated plans of interventions?
- Is it possible to scale-up the developed methodology in other cases too?

The selected case study is a representation of all the problems that initiated the present thesis. Its redesign is an attempt to combine a set of methodologies on different aspects, explored in the research part, in order to develop an integrated framework for the old building stock regeneration. For this reason it is important to identify these approaches, select the most suitable and apply them. Limitations, along with opportunities, come in the way. For instance, the fact that the thesis is referring in the case of a listed building clearly orients the design decisions. The ultimate goal is to find, through the case of the refugee settlements in Alexandra's, integrated plans of intervention that can potentially be applied in other similar cases.

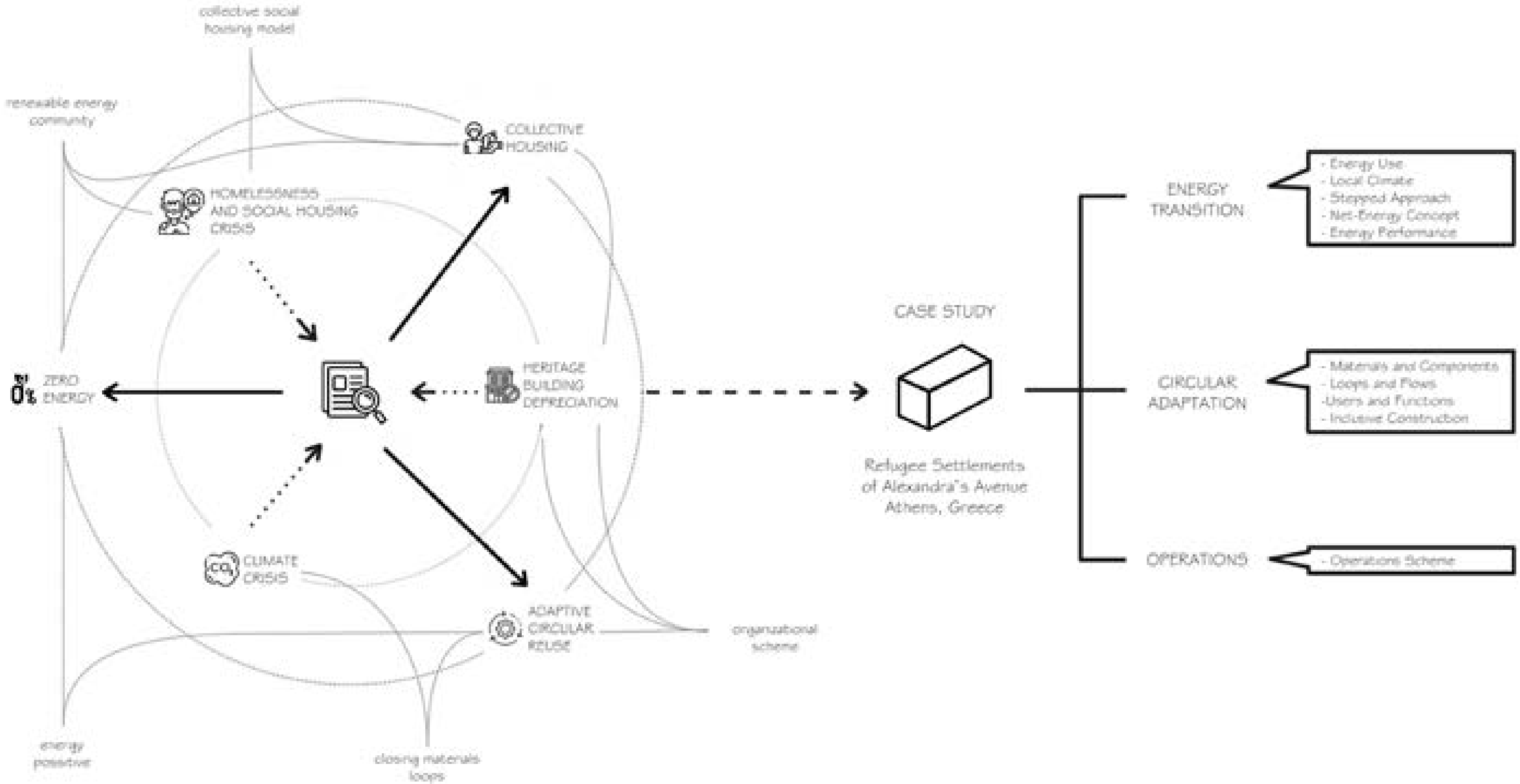


Image 1.4. Author (2022). A systematic approach [Scheme].

Methodology

This thesis develops in two parts: the first part consists of a literature review to showcase the possibilities that arise from a determined set of problems. The second part, focuses on the analysis of a specific case study and its re-design through investigation of multiple solutions in an integrated manner. The two parts are closely related and interdependent. The order in which they have been recorded is not related to the chronological order they were conducted, since the process of the research required continuous alternation between literature review and design.

The domains of zero-energy and circularity are examined through the literature review. Their definitions, methodologies and main principles are presented. The reason for their inclusion and their importance is also analyzed. Alternative attempts on collective housing models are also part of the literature review, in combination with an analysis and presentation of multiple case studies. The thesis additionally investigates plans that conjoint sustainable, positive-energy and circular initiatives within collaborative and participatory housing models.

The case study of the refugee settlement of Alexandra's avenue, in Athens, Greece, is used to further analyze and evaluate the feasibility of the aforementioned concepts and to develop a strategy of actualization. The re-design process of the case study is divided in three parts: the energy transition, the circular adaptation and the operational scheme behind the renovation strategy.

Despite the fact that the complex consists of 8 similar buildings, the energy transition part is focused, indicatively, on only one of the buildings, assuming similar results for the rest. The steps taken here are: analysis of the energy use of the building and of the local climate, usage of a stepped approach to find the relevant energy measures, development of a net-energy concept for the building and calculation of the design's energy performance.

For the second part, the circular adaptation, all the available materials and building components are identified, according to the Shearing Layers concept by Frank Duffy and Stewart Brand, and the potential of applying any of the R strategies and in particular, reuse repair and remanufacture of building materials and components are documented.

In the third part, an operational scheme/business model is developed. The aim of this feature is to create a feasible operational plan for the application of an energy transition and circular adaptation of the case study, taking into consideration all the involved stakeholders, the state, the local community, the users and the design team. This thesis supports the idea that no innovation or progress (societal, economic, technological, environmental, etc.) can be achieved without the inclusion and cooperation of all the involved parties. In order to create successful, synergetic relations among them, the developed plan contemplates the obstacles and benefits of each party, as well as the potential conflicts between them, and the barriers and enablers of the applied concepts.

2.

The 3 Domains of Interest

Zero-Energy Design

Circularity

Barriers & Eneblers

Collective Housing Models

Zero-Energy Design

Even though buildings are a main responsible for global carbon emissions, they also play a significant role in the transition towards sustainability, as the sector with the greatest potential for reducing energy consumption with a cost-effective way. Since the 1970s, at least, energy and climate policies in the building sector began to emerge, in the EU and globally. Passive solar architecture, thermal and other regulations have kept being developed since then, towards the promotion of energy-efficiency and on-site renewable energy generation.

In order for the EU to achieve its goal for a carbon-neutral future, by 2050, the vast majority of its building stock needs to approach almost zero energy consumption. To do so, it must: a) apply strict specifications for new buildings regarding the envelope's energy performance and b) carry out a large-scale energy upgrade of the old buildings so that almost the entire old building stock that will remain in 2050 will be energy upgraded.

Greece, due to the relatively slow pace of construction of new buildings, which is expected to remain low in the future, is focusing more into the energy upgrade of existing old buildings (Hellenic Republic, 2020). The goal is to upgrade more than 800 thousands of residential buildings by 2050 (European Commission, 2020), with the support of EU.

The Zero-Energy concept is the most extreme version of a building's energy performance, though the only option for a carbon free future, and it can be applied in both, new and existing edifices. The European Commission defines the Nearly Zero-Emission Building (NZEB) as "a building that has a very high energy performance, while the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".

To tackle the dual challenge of climate crisis caused by the building sector and of the socioeconomic consequences of building depreciation, the EU has developed a Renovation Plan for the existing building stock. This plan targets on the improvement of buildings' energy efficiency and transition towards clean energy, as well as on the economic recovery of local businesses, related to the construction sector, after the COVID-19 pandemic. Additional to the emissions reduction and the creation of additional green jobs, these renovations can enhance the living quality of the users and inhabitants.

Zero-energy residential buildings can tackle energy poverty and the insecurity due to external factors. Low or no income families, cannot often afford the expenses for heating or cooling. In order to tolerate the low temperatures, they sometimes seek cheaper solutions, that are usually dangerous and unhealthy. Wood incineration, that is a common alternative, is not limited to dry, seasoned wood but includes also old furniture pieces that are coated or dyed and contain chemicals, and other unused items that are found in the apartment or in the streets. Except of air pollution, wood burning can also cause severe heart and lung diseases, and is a risky heating method, especially when the dwelling accommodates children or elderly. Furthermore, recent global circumstances have shown that the access to energy (electricity, gas, fossil fuels) is not guaranteed. The pandemic and the Russian invasion of Ukraine have increased the prices of energy carriers or have limited the access. Self-sufficient buildings provide access to affordable, clean energy and limit the dependency to other external, uncontrolled factors.

Strategies

There are different strategies for applying a deep energy renovation. Some of them focus more on the building cell, by prioritizing the improvements connected to the thermal properties of the building envelope through the use of high levels of thermal insulation and airtightness. Others focus on passive solutions that can significantly reduce the carbon footprint and result in ultra-low-energy buildings, requiring little energy for space heating or cooling. Some consider the building as an energy system that is composed by interdependent parts, where the features and performance of each component are strongly affected by the rest, and energy performance is considered a result of the whole system. Finally, the “insulate then generate” philosophy, first aims at reducing the energy demand from passive design strategies, and then tries to meet the remaining demand through the use of micro-generation technologies, (Cattani, 2016).

In the present thesis, the “stepped approach”, by Andy van den Dobbelsteen, which is similar to the “insulate then generate” philosophy, is applied. The “stepped approach” consists of 5 steps: 1. Research, 2. Reduce, 3. Reuse, 4. Produce and 5. Integrate. In the Research part an analysis of the building’s energy use and of the local climate is conducted in order to select the appropriate solutions. The Reduce step refers to the reduction of the building’s energy demands and consumption, usually by making use of passive solutions. Reuse is related to materials flow and waste management, by closing the loop of energy processes. The remaining energy demand needs to be cover by producing clean energy on-site. An integrated design, drive by the core steps of the approach – reduce, reuse, produce – results in the development of a net-energy concept for the building, including the appropriate energy measures. By calculating the design’s energy performance, the efficiency of the renovation can then be proven.

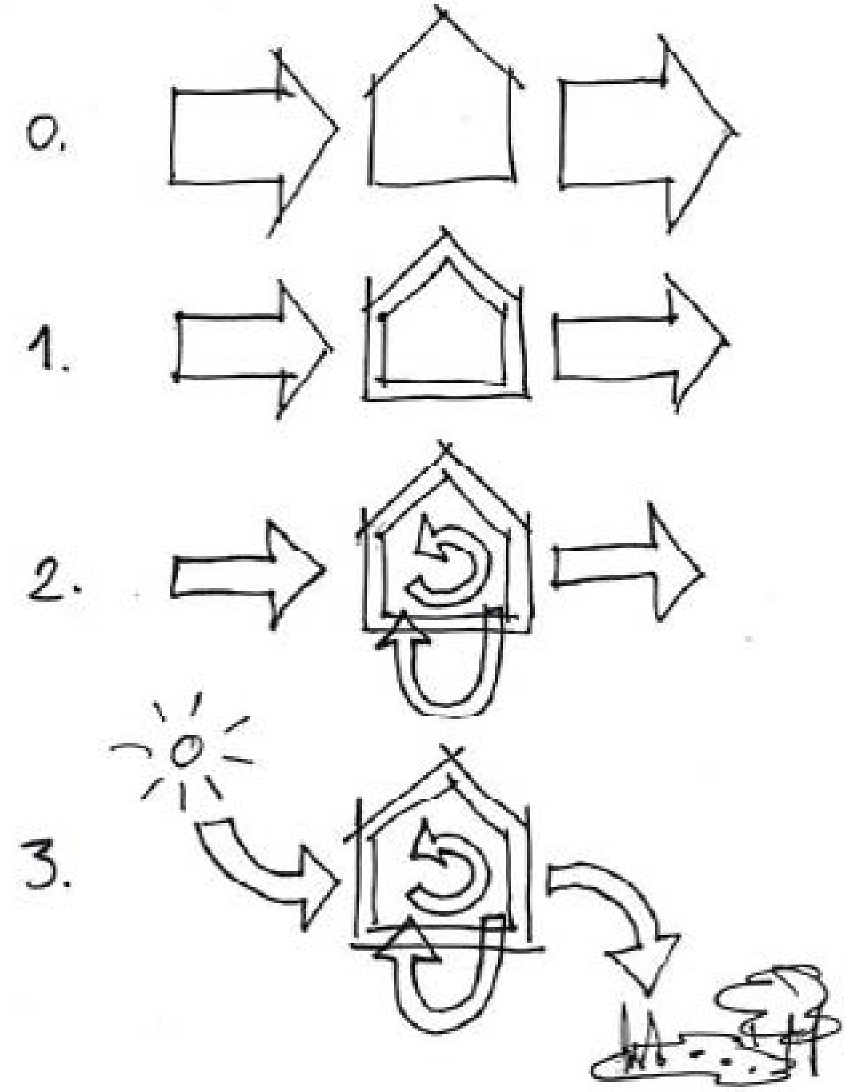


Image 2.1. van den Dobbelsteen, A. (xx). Stepped Approach [Sketch]. ProfEd: Advanced Zero-Energy Design

Go Zero in 8 Simple Ways

The following steps create a framework that can be applied to any renovation aiming to achieve zero-energy consumption and carbon neutrality. Prior to these steps, it is necessary to conduct: a) an energy audit of the existing building, including assessments of current insulation levels, window and door quality, water heater and HVAC systems, a year's worth of utility bills, and the efficiency of existing lights and appliances, and b) an energy model, in order to develop a zero energy retrofit plan that includes the degree of airtightness to be achieved, the R-value of insulation to be installed, the U-value of the windows, and the energy efficiency of the appliances, ventilation system, heating and cooling system, and lighting required.

1. Insulation: By installing insulation to the existing walls, basements and rooftops, a significant reduction on the energy demands can be achieved. The building envelop becomes more resistant to temperature changes and it is easier to regulate the interior comfortability.

2. Heating and Cooling: By replacing old inefficient or fuel based heating systems with geothermal energy systems or heat pumps that use electricity, reduction of carbon footprint and of energy bills can be achieved.

3. Windows: Old window frames and single paneled windows, with high U-values, are a main reason of heat losses, in the winter, and heat gains, in the summer. Replacing energy inefficient windows with high performance ones (with a U-Value close to 0.2) can contribute to more easily achieve a heat balance.

4. Ventilation System: The installation of an energy recovery ventilation system or heat recovery ventilation system can provide a continual supply of fresh, filtered air in the building.

5. Hot Water Production and Conservation: Domestic hot water requires big amounts of energy. A heat pump water heater of a solar thermal heater are energy-efficient solutions. Additionally, drain-water heat recovery systems can recover heat from the hot water used in showers, bathtubs, sinks, dishwashers, and clothes washers. Low flow showerheads and faucets can reduce hot water use.

6. Lighting and other Appliances: LED bulbs are more energy efficient, last much longer and contain no mercury. Replacement of any other existing energy inefficient appliances with the most energy efficient models can also save tones of energy.

7. Renewable Energy: Electricity will be the main energy carrier of the future, and in order to be sustainable it needs to be produces in sustainable means, that means from renewable energy sources. By installing PVs, PVTs or even micro-wind-turbines is possible to produce required kWh of electricity to power the remaining energy needs of the building, and be energy self-sufficient.

8. Go smart: Digitalization of the building's performance can work for the benefit of both the users and the planet. With or without the users interaction, smart systems can control the indoor environment and the energy use of the building for a more sustainable performance.

Circularity

The idea of circular flow for materials and energy is not new, appearing as early as 1966 in the book by Kenneth E. Boulding, who explains that we should be in a “cyclical” system of production. However, the term “circular economy” appeared for the first time in 1988 in “The Economics of Natural Resources” (Kneese, 1988) and soon after that was used by Pearce and Turner (1990) to describe an economic system where waste at extraction, production, and consumption stages is turned into inputs. From the early 2000s, China integrated the notion into its industrial and environmental policies to make them resource-oriented, production-oriented, waste, use-oriented and life cycle oriented (Zhu et al., 2019). The Ellen MacArthur Foundation (2012) was instrumental in the diffusion of the concept in Europe and America. The European Union introduced its vision of the circular economy in 2014, a New Circular Economy Action Plan having been launched in 2020 that “shows the way to a climate-neutral, competitive economy of empowered consumers” (European Commission, 2022).

Despite its long history, the definition of Circular Economy is broad and the debate is still open. Kirchherr, Reike, & Hekkert (2017), after a research analysis of 114 different definitions, conclude that Circular Economy is:

> an economic system that replaces the “end-of-life” concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers.

Circularity can be applied in everything around us; daily habits, fashion, food, water, data, services, energy, etc.. On a city scale, circular economy is closely connected to urban metabolism. Understanding the model of urban metabolism, results in awareness about the flows of materials and energy within the cities. With the growing concern of climate change and atmospheric degradation, the use of the urban metabolism model has become a key element in determining and maintaining levels of sustainability and health in cities around the world. Kennedy et al. (2007) define urban metabolism as:

> the sum total of the technical and socio-economic process that occur in cities, resulting in growth, production of energy and elimination of waste.

Consequently, circularity in the built environment offers opportunities against climate crisis and a unified approach for a sustainable future. The Circular Built Environment Hub (2017) defines the Circular Built Environment as:

> a system designed for closing resource loops at different spatial-temporal levels by transitioning cultural, environmental, economic & social values towards a sustainable way of living, thus enabling society to live within the planetary boundaries.

A Circular Built Environment expands in all different scales; from materials and components to entire buildings, and even neighborhoods and cities. For its accomplishment, aspects such as innovative technological solutions and management models, new design approaches, economic incentives, resources flows, as well as societal relations need to be examined. For the reason that, the transition towards a circular built environments affects and is affected by technological progress, culture, policies and regulations, economy, availability in materials and most importantly, multiple stakeholders and society as a whole. This complicated model that describes circularity in the built environment, can also be translated as a call for action through unified and holistic methods. Due to its complexity, action can be taken within a range of strategic decisions, from design to waste management.

From Linear to Circular Economy

The linear economy is a basic structured model that relies on the extraction of raw materials and their processing into products and potential by-products which, after usage, are treated as waste and mainly disposed into landfills or dumpsites (Taelman et al. 2018).

In the past, this model has been considered as a successful and effective approach, able to manufacture products at competitive prices, boosting the economies of developing and industrialized countries, and encouraging human consumption. However, concerns about the depletion of natural biotic and abiotic resources (coal, minerals, metals, wood, etc.), with consequent challenges in supply, have brought increased attention to the way we should manage the available resources. In this respect, waste disposal not only results in significant losses of materials but also incurs significant impacts on the environment finally reducing the quality of life (Ekvall et al., 2007). Ultimately, this may lead to exceed certain environmental thresholds or tipping points, defined as “planetary boundaries” (Rockström et al., 2009), by affecting the current ecosystem irreversibly. Therefore, waste should be managed so that it does not poses risks to air, water, soil, plant and animals e.g., by the release of methane or leachate, eventually leading to impacts on human health and well-being (European Commission, 2008). Therefore, changing this linearity of material flows is high on the agenda as it is one of the profound challenges the EU is facing today (Taelman et al. 2018).

The linear “take-make-dispose” model of economic growth we relied on in the past is no longer suited for the needs of today’s socio-economic European system. A shift towards a circular economy as an industrial system that is restorative or regenerative will increase resource efficiency and reduce waste significantly. Furthermore, the circular economy model aims to create secure jobs in Europe, to boost innovations giving competitive advantages to EU industry and to provide increased level of protection to humans and the environment. It should also provide consumers with more durable and innovative products that provide monetary savings in a life cycle perspective and a better quality of life (Taelman et al. 2018).

Image 2.2. Linear Economy

Image 2.3. Circular Economy

10R Strategies

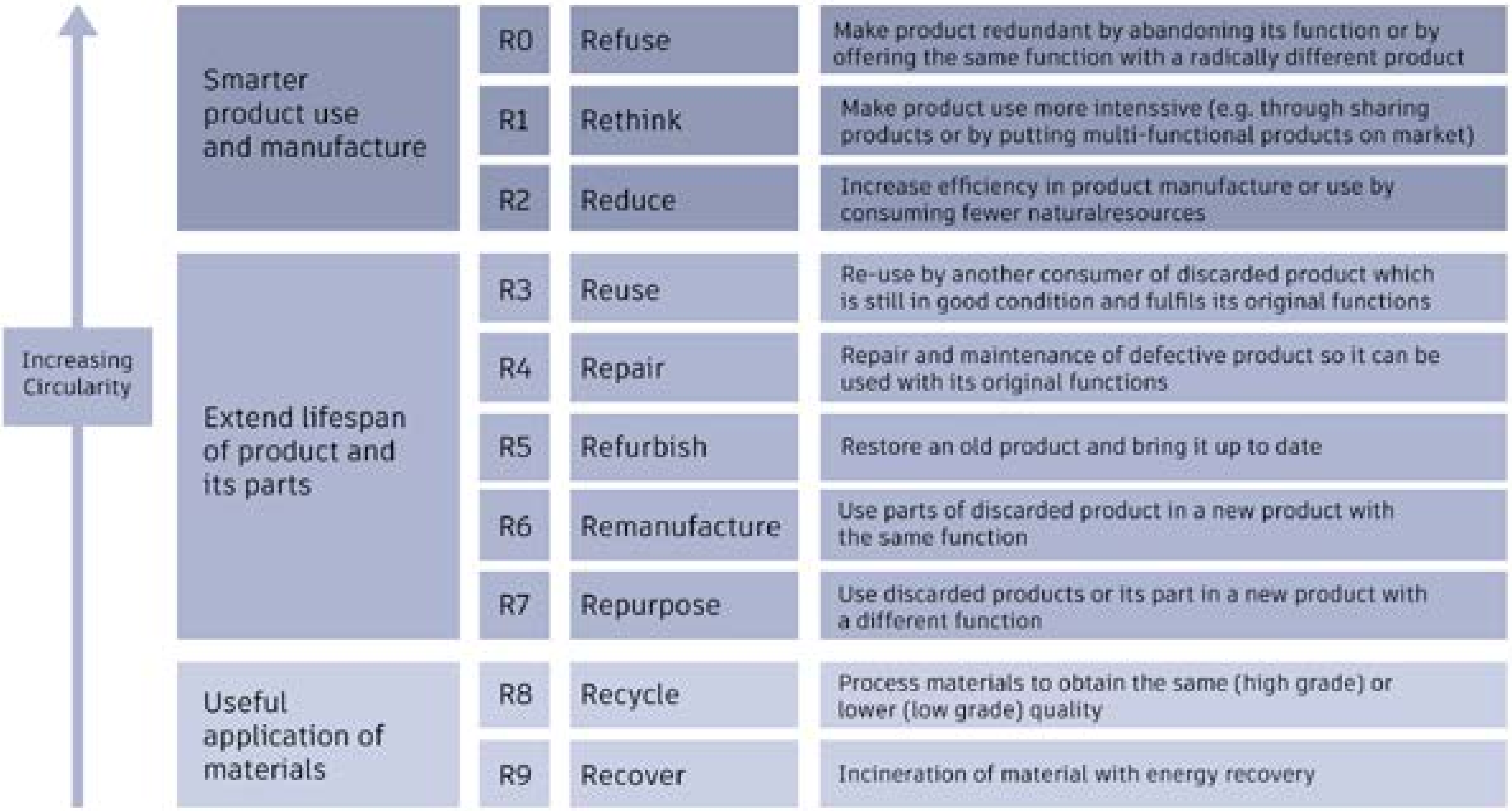
The two main perspectives in regards to circular economy that can be identified are: the value of materials and products and the essence of a proper waste management system (Taelman et al. 2018). Both contribute in enhancing the end-of-life processes, by preventing waste, prolonging the lifespan of products and postponing the end-of-life phase. For an impactful change, adjustments need to be made in all four stages of the process: production, construction, usage and end-of-life. Each phase is characterized by different circular strategies, that can contribute in closing, slowing or narrowing the loop. The "10R strategies", by Potting et al. (2017), are structured into three groups: a) useful application of materials; b) extend lifespan of products and their parts; and c) smarter product manufacturing and use. The order of the strategies (0-9) is related to the stage of the process they can be applied to. The earlier they are applied, the more the impact they have. So, the first strategies are connected with the design phase, are harder to apply, but are the most impactful ones, while the last are related to the waste management, they are more common, but not so effective.

Starting from the bottom up, this group of strategies (Recovery and Recycle) relates to solid waste otherwise destined for landfill, or burned without heat recovery. By processing this waste, energy (with recovery) or materials (with recycle) can be obtained. These strategies are related to the end-of-life phase and have relatively little influence on the system of production and consumption (Potting et al., 2017). Despite this, Recovery and Recycle is where most circular policies (and targets) are currently concentrated (Ghisellini et al., 2016; EPRS, 2017).

The second group targets on extending the lifespan of products and its parts and is closely related to the use stage, that is usually considered as the longest in the building life-cycle. This group (Reuse/Repair/Refurbish/Remanufacture/Repurpose) devises strategies to retain finished goods and their parts in the economy for longer, while maintaining or improving their value. To work, R3–R7 strategies require market receptivity, well-functioning reverse logistics, profitability for the parties involved, and the deployment of these strategies by varying business models. Products related to R3–R7 are stochastically uncertain in terms of their quantity/quality conditions (Guide, 2000). For CE governance, this poses challenges in innovation and requires adjustments to the revenue models and socioeconomic patterns. For example, prolonging the lifespan of product in certain cases can slow down innovation or prevent the development of new/evolved products that are more environmentally friendly (see Bressanelli et al., 2018). In other cases, regulations can impede R3–R7, imposing a phase-out of products or higher standards (e.g. for safety, energy efficiency).

The last group contains the most impactful strategies, that are closely connected to design and aim in narrowing the loop. This group encompasses Refuse, Rethink, and Reduce, which take place when products are conceived, designed, and developed. These strategies are precursory, enabling, and transformative. Precursory, because they occur before other CE strategies. Enabling, because they favor all other strategies. Transformative, because they can make the economic system a truly circular one if applied extensively. Accordingly, R0–R2 can lead the transition to a CE before production takes place (Morseletto, 2020).

Reuse, repair and remanufacture of building components are the strategies that are most commonly applied in heritage buildings' renovations. The 3 strategies target in expanding the elements' lifespan. Since the discussion is about existing



Increasing Circularity			
Smarter product use and manufacture	R0	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
	R1	Rethink	Make product use more intenssive (e.g. through sharing products or by putting multi-functional products on market)
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer naturalresources
Extend lifespan of product and its parts	R3	Reuse	Re-use by another consumer of discarded product which is still in good condition and fulfils its original functions
	R4	Repair	Repair and maintenance of defective product so it can be used with its original functions
	R5	Refurbish	Restore an old product and bring it up to date
	R6	Remanufacture	Use parts of discarded product in a new product with the same function
	R7	Repurpose	Use discarded products or its part in a new product with a different function
Useful application of materials	R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
	R9	Recover	Incineration of material with energy recovery

Image 2.4. Potting et al. (2017). 10R Strategy.

buildings, there isn't much to be done on design level (R0-R2), unless new parts are planned to be added. Additionally, listed buildings often contain components of value (architectural, economic, cultural or other) that are rarely treated as waste (R8, R9). Potting et al. (2017) describe the strategies R3, R4 and R6 as follows:

Reuse by another consumer of discarded product witch is still in good condition and fulfills its original function.

Repair and maintenance of defective product so it can be used with its original function.

Remanufacture. Use parts of discarded product in a new product with the same function.

The present thesis for its case study, mainly uses the following strategies: reuse (e.g. the basic element of the building envelope – limestone walls), remanufacture (e.g. old window frames) and repurpose (e.g. damaged plaster coating). Moreover, it includes waste management strategies, such as recycle (e.g. food waste to compost) and recovery (e.g. incineration of organic waste for biogas). For all the new components, it also considers the reduce of energy and natural resources consumption. More on the circular adaptation of the case study can be found in Chapter 3.

Shearing Layers

Buildings are ecosystems of different components and products. These elements are in constant friction; nonetheless of different speeds. As a result, wear of one element can conduce to the reduce of the whole building's lifespan. A framework organized by Frank Duffy (1992) and later modified by Steward Brand (1994) categorize these components in 6 bigger groups, also known as the "Six S's" or the "Shearing Layers", according to the longevity. The 6 Layers are: Site - Structure - Skin - Services - Space Plan – Stuff (Brand, 1994) and are meant to help describe buildings as "shearing layers of change".

Brand S. describes the Shearing Layers of Change as:

• Site - geographical setting, urban location, legally defined lot - can easily outlast the life of the building.

• Structure - foundation and load-bearing elements - can last 30-300 years although many buildings don't live that long for other reasons.

• Skin - the building envelope, consisting of frame, exterior finishes, glazing, etc. - can change for repair or appearances every 25 years or so.

• Services - the utility and HVAC systems and moving parts like elevators - may reach the point of major replacement every 7-15 years and can cause demolition of an entire building if their embedded-ness prevents alteration.

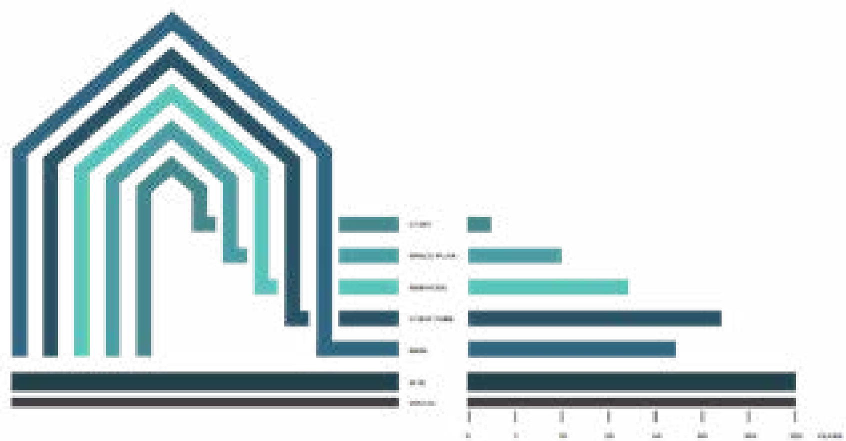


Image 2.5. Brand, S. (1994). Shearing Layers.

• Space Plan - division of space, cabinetry, interior finishes - can range widely from a commercial setting being overhauled every three years to a much longer life in a residential setting.

• Stuff - furniture, free-standing lamps, appliances, etc. - the things that change daily to monthly.

The faster changing layers such as the Space Plan are controlled by the slower changing layers such as the Structure, which are less flexible, thus creating friction between them. For example, an interior Structural element that can only be moved as a part of the whole building reconfiguration will dictate the limits of non-structural Space Plan changes. If the Space Plan configuration that is needed to optimize the function of the building cannot be accommodated because the Structure will not allow it, this high degree of friction could cause the premature obsolescence of the entire building.

In order to avoid these conflicts, both in use, and as a means to facilitate end-of-life disassembly, the consideration that building assemblies have cycles of use and wear can help designers plan for change with minimal building dysfunction, cost and waste (Ciarimboli & Guy, 2005). Thus, the concept of Shearing Layers can be a useful thinking approach for heritage building renovations, on circular terms.

Design for Disassembly (DfD)

Design for Disassembly is a practice highly related to circularity in the built environment.

Design for Disassembly – or Deconstruction - (DfD) is a design approach that facilitates the aforementioned R-strategies, reflecting the circular principles in the design, production, construction, usage and end-of-life phase. Ciarimboli & Guy (2005) define DfD as:

> the design of buildings to facilitate future change and the eventual dismantlement (in part or whole) for recovery of systems, components and materials. This design process includes developing the assemblies, components, materials, construction techniques, and information and management systems to accomplish this goal. The recovery of materials is intended to maximize economic value and minimize environmental impacts through subsequent reuse, repair, remanufacture and recycling.

Thus, DfD can provide a circular plan for the existing building stock renovation, on a components scale.

The benefits of Design for Disassembly are environmental, social, economic and cultural (Rios, Chong & Grau, 2015). DfD plans for the extension of the life of raw materials mines, the reduction of the materials' cost (depends on supply chain), the decrease of embodied energy and carbon emissions of the construction industry and reduces the disturbance of a site. It also contributes to a significant reduction of landfill areas and helps to produce more flexible and adaptable buildings, with components that are more easily maintained and repaired.

Additionally, the labor-intensive nature of deconstruction has huge potential in creating jobs for unskilled workers, including women in the construction sector. Design for Disassembly provides examples to the general public on the building materials reuse and recycling processes, raise awareness, motivates and contributes in the expansion of the market of sustainable buildings and products.

For the time being, DfD might be more expensive than traditional building methods, however there are potential savings (e.g. disposal fees, heavy equipment, re-sales value). It also stimulates the creation of a brand new market for the salvage materials, beyond the existent facilities, that, in the near future, could be highly profitable.

Disassembly finally conduces to the preservation of architectural history, by "rescuing" components that could be then used in other buildings.

DfD's principles are based on thorough planning, mindful material selection, specific methods of connections' design and human-oriented practicalities. For an efficient disassembly, it is essential to document materials and methods of deconstruction, label the connections and materials, and develop a detailed "deconstruction plan". Materials selection is a key to DfD. Materials that are chosen with consideration for future impacts and that have high quality will retain value and/or be more feasible for reuse and recycling. Furthermore, using materials and systems that exhibit principles of modularity, independence, and standardization will facilitate reuse.

Connections is a big chapter in Designing for Disassembly. Connections need to be accessible. Visually, physically, and ergonomically accessible connections will increase efficiency and avoid requirements for expensive equipment or extensive environmental health and safety protections for workers. Dry connections are preferable. Binders, sealers and glues on, or in materials, make them difficult to separate and recycle, and increase the potential for negative human and ecological health impacts from their use. Instead, use bolted, screwed and nailed connections. Using standard and limited palettes of connectors will decrease tool needs, and time and effort to switch between them. In the bigger scale, disentangling mechanical, electrical and plumbing (MEP) systems from the assemblies that host them makes it easier to separate components and materials for repair, replacement, reuse and recycling.

Deconstruction is usually planned to be achieved by humans and not machines. It is important, thus, to design human-scale components or conversely attuning to ease the removal by standard mechanical equipment. This will decrease labor intensity and increase the ability to incorporate a variety of skill levels. Moreover, allowing for movement and safety of workers, equipment and site access, and ease of materials flow will make renovation and disassembly more economical and reduce risk.

Adaptability

Adaptability is defined as the quality of being adaptable (The Century Dictionary, 1911), i.e. the ability to be flexible and adjust to changing factors, conditions or environments.

In the fields of city planning and architecture, adaptability of buildings is usually encountered with the theoretical concept of "adaptive reuse", which has been influential for at least the last thirty years. With "adaptive reuse", in these fields, a phenomenon that lies at the basis of each re-actualization of an architectural element is described. The concept of adaptive reuse is thus as old as architecture itself.

> The concept of reuse comprises four main aspects, viz. (1.) the involvement of at least one consciously acting agent, who, (2.) in order to achieve a certain purpose, (3.) resumes the usage (4.) of a clearly identifiable object

after an interruption in its being used. The attribute "adaptive" presupposes that the reusing person pursues a specific purpose by adapting something already existent to his or her specific needs. The reused object has to be identifiable as being reused, because otherwise the adaptation is not an instance of reuse, but of recycling (Freschi & Maas, 2017).

In city planning and architecture, adaptive reuse applies to the use of a building (often partially reconstructed) for a new function that differs from the purpose for which the building was originally erected. Adaptive reuse is an alternative to demolition and is employed for a wide range of aims, such as saving material resources, preventing urban sprawl, or preserving, at least to some degree, the appearance of townscapes. Thus, agency, finality and creativity are key elements in adaptive reuse (Freschi & Maas, 2017).

The potential effects of this strategy are linked to its integration of functions: preservation, restoration, reuse, redevelopment, reassigning a new meaning to an item while maintaining its form with regard to social benefits. It engages the community in the process of city making, creating a synergy between past and future. Adaptive reuse practices increase social cohesion and the sense of community. While on a larger scale it offers opportunities for investors and the local government, on a small scale it can help improve well-being and attract people, investors and activities.

The adaptive reuse of architectural heritage is about negotiating the transition from the past to the future to secure the historical transfer of heritage assets while also meeting the needs of the contemporary world (Chapman, 2004 & Li et al. 2021).

The long-lived, culturally relevant, and unique buildings of Europe's urban landscapes embody the values of the circular economy and sustainability. They are central to urban identities, generation after generation. Furthermore, adaptive reuse of cultural heritage buildings contributes to slowing down the extraction of natural resources, reducing energy for new buildings, and reducing construction and demolition waste and greenhouse gas emissions.

Other arguments for reuse/renovation/refurbishment/restoration over demolition and reconstruction are: the lifespan expansion of the building and its cultural heritage, the active revitalization of the cities, as well as the creation of social and economic hubs in them and the preservation of social, cultural and emotional and historical values of the building.

Additionally, the problem of vacant and abandoned properties and the degradation of the city centers is urban, economic, social and environmental. It leads to the gradual marginalization and ghettoization of parts of it that could be the most attractive, both, for housing and for activities in the tertiary sector (services). It deprives the city and the property owners of valuable financial resources. It degrades the lives of its inhabitants or alienates them from it, and makes it very difficult to deal with issues caused by climate change (Triantafyllopoulos, 2018).

Barriers & Enablers

Barriers

- Social and Cultural Barriers
    - Lack of awareness, knowledge, and interest
    - Difficulty in changing habits and accepting anything other than the “usual”

There are multiple barriers relating to awareness, information and technical expertise. Right and appropriate information is needed for the market to work well. This mainly refers to: availability in the correct energy advices, capability in delivering the appropriate measures by the energy efficiency service industries and guaranty of sufficient satisfaction levels for the consumer. If this is achieved, then the conversation about expanding this knowledge can commence.

- Organizational Barriers
    - Governments giving higher priority on other issues
    - Limited top management commitment and support for zero-energy and circularity initiatives

During the last decade more and more attention is given to sustainability related issues. However, there is still a gap, between existing policies and actual necessity, that needs to be bridged.

- Financial Barriers
    - High costs for materials and labor, especially when addressing to the social housing sector
    - Limited Funding on the sector
    - Limited knowledge on the available financial resources.

Undeniably, any investment in the construction sector, including the existing building stock renovation, requires money. This considerable capital has implications for policy making. Additionally, the initial investment costs can be high and this is often seen as an obstacle to consumer investment decisions. However, governments and local authorities, usually, provide funds for the energy transition of old buildings, that, more often than not, the interested parties are not aware of. Furthermore, the funds are usually limited and require specific criteria for the beneficiaries.

- Sectoral Barriers
    - Poor partnership formation with supply chain
    - Lack of standardization - especially for the design of buildings and end-of-life practices along with material passports is expressed as a significant barrier

The concept of the circular built environment is relatively new. As a result, there is still no unified database with materials, components and products. That incommodes the trade chain of building products between different parties, and makes it almost impossible to entirely close the loop. Fortunately, in the field of energy transition there is bigger and more organized flow of information.

- Technical and Technological Barriers
    - Absence of an information exchange system
    - Lack of design guidelines
    - Lack of measurement tools to assess the improvement

There is an immediate demand for guidelines, not only for design, but also for implementation, management, and measurement of the circular construction, energy transition, renovation, and maintenance of the future projects. This is essential in order to be able to calculate the impact of the transition and acheive the goal of carbon neutral future.

Enablers

- Social and Cultural Enablers
    - Pioneering Leadership - clear vision and commitment
    - Collaboration with other organizations, to share knowledge and experiences
    - Training, education and workshops, for a well-informed ecosystem creation
    - Inclusiveness – shift in user's preference and raise public awareness
- Organizational Enablers
    - Commitment and support from the top management

Increasing energy efficiency of the existing stock or transitioning towards natural-gas free homes have higher priority in the state's agenda. Therefore, is tough to prioritize circularity as an essential enabler.

- Financial Enablers
    - Lower costs
    - Carbon tax on materials – tax relief on sustainable initiatives
    - Sufficient funding for experimentation

In order for sustainable practices to become more attractive, it is important to become affordable. Additionally, for the long-term implementation, a successful business plan is needed. For this experimentation, evaluation and adaption are critical points, that need be encouraged and generoussly fundied.

- Sectoral Enablers
    - Best practice case studies platform: demonstration of best cases and experiences for the benefit of the rest of the sector
    - Better collaboration between different parties: work as an ecosystem around the same table - a network of partners–the partner ecosystem
    - Development of standards – for construction methods, procurement etc.

Sustainablity and circularity in the construction sector cannot succesfully work only on an individual level. Collaboration will be more beneficial than competition. For this, it is essential for the involved parties to communicate and operate as an ecosystem; to create a network of partners and share ideas and experiences.

- Technical and Technological Enablers
    - Development of methods, tools and guidelines

In order to help stakeholders to articulate and structure challenges and support transdisciplinary knowledge at an appropriate level for policy and decision making, it is critical to develop methods, tools and guideline that they can consultand use as references.

Collective Housing

Social Housing

The conversation on "social housing" begins with the assumption that there is no commonly accepted definition at a European level of what "social housing" is. The main difficulty in trying to come up with a single definition is related to the fact that social housing is very diverse from country to country and is one of the areas that primarily reflect the values of a state (Hansson & Lundgren, 2018). For this reason, when referring to "social housing", people from different countries do not understand exactly the same thing, in fact they may perceive something that changes over time (Ruonavaara, 2019).

Thus, in some countries, social housing is perceived as a public housing for rent in certain populations, while in others, subsidized property is also an option and even theoretically available to everyone (Goudis, 2020). At the same time, the size of the social housing sector, i.e. the part outside the free market, differs significantly across Europe, with the Netherlands being on top of the list with a social housing sector close to 30%, while Greece's corresponding percentage does not exceed 0% (Housing Europe, 2021).

From now on, in this thesis, the term "social housing" is used to render the concept of social housing that has historically been shaped in Greece according to the needs of the beneficiaries. That is specific groups of the population, like refugees, internal migrants, the working class and those who live in inadequate housing conditions and do not own any property.

The present thesis, proposes a transition from a zero social housing sector to an alternative, affordable, collective housing model.

Social Housing in Greece

The 1920s were the first historical period in which the Greek state systematically dealt with housing policy. After the Asia Minor Catastrophe (1922), more than 1.2 million people[1], relocated from Asia Minor, Eastern Thrace and Pontus to Greece. This massive influx of refugees created urgent housing needs of unprecedented scale and compulsorily pushed the Greek state towards the establishment of a housing policy. That constituted a difficult to accomplish challenge due to three factors: a) lack of previous experience in the field of housing rehabilitation, b) absence of public policy for the housing of vulnerable social groups and c) limited available financial resources, due to the preceding two Balkan Wars and the WWI (Myofa, 2021). The pressure to the all host places was significant and it would be impossible to solve this issue without the state's intervention in the housing sector for the first time.

Except of the temporary solution of placing the refugees in unorganised tent-like settlements, in or around open public spaces or buildings. The Greek state gave mainly 3 options. First, the Refugee Settlement Commission (EAP, in Greek, or Commission) developed the first refugee housing rehabilitation programs, that were, in fact, the first organized programs for production of social housing in Greece and helped decisively in the integration of refugees in the country. In the metropolitan area of Athens, where 20% of the relocated population was established, multiple settlements were built outside the existing urban tissue of Athens and Piraeus, after 1922 and until the end of the 30s.

[1] This number corresponded to about one fourth of the total population of the country at that time. The relocation was a result of the population exchange with Turkey, signed in the Lausanne Treaty (1923).

Meanwhile and despite the actions of the Commission, in collaboration with the Ministry of Social Welfare, the settlements were not enough to accommodate the constantly growing population. During the 1930s, landowners plotted their land and sold it to refugees, who, in most of the cases, through often arbitrary self-housing, accommodated their families. That was the beginning of the spread of home ownership in Greece (Goudis, 2020). At the moment, the Greek state just indicates the orientation of the cities' expansion.

Lastly, the less favored occupied empty lands in the city and around the already existing organized settlements and formed shack-like shelters in slum-like configurations. However, during the decades of 1930 and 1940, the Ministry of Social Welfare, demolished the shacks and instead constructed apartment blocks (Vasiliou, 1944). The beneficiaries of the apartments were the Asia Minor refugees who were the residents of the shacks.

The WWII creates a new reality in the country with housing needs in the foreground[2]. This situation is aggravated by the Civil War (1946-1949) which, in addition to further damage to the housing stock, causes national wounds at a social level with the division it brings.

The end of the WWII and the Civil War, constitutes for Greece a demanding restart at all levels and of course the housing sector is among the biggest challenges. An important parameter is the overall spatial organization since, after the war, urbanization continues but without a close connection with industrialization as in western countries. For example, "new cities" are not born like in England or France (Karydis 2008), as a result the housing stock has to be produced mainly in Athens and other already developed cities.

After the war, the value of residency occupied a prominent place in the public debate on development and national reconstruction as it was perceived as a necessary tool to facilitate the industrialization of the country by providing housing for workers and employees. In fact, in 1954, in this direction, the Autonomous Workers' Housing Organization (AOEK – later OEK, in Greek) was founded, by the Ministry of Employment and Social Security as an independent agency. This organization provided housing for private-sector employees who were not homeowners. The OEK was the first organization that its housing policy meant to be a more comprehensive, opposing to the state policy which, until that point, gave priority to the housing rehabilitation of refugees, slum residents and other residents affected by various natural or anthropogenic disasters. However, the most vulnerable social groups – such as the homeless and the unemployed – were excluded from OEK's social housing policy (Myofa, 2021 & Sapounakis, 2013).

There was literally a housing crisis, since, according to the 1940 census, 43% of the families were homeless or lived in unsuitable houses, whereas at the same time, is estimated that 409.000 Greek buildings were destroyed between 1940-1944 (Trixias, 2016, Zamani & Grigoriades 2013).

Worldwide, after 1975, concerning the social housing policy, the tendency was to replace the social housing system with a new model. The new one provided financial assistance for the construction or the individual purchase of a house produced by private companies (Bourne, 1998). This change, as well as the decrease of the Ministry of Welfare programs, also affected how policy was pursued in Greece (Vasilikioti, 1975).

[2] There was literally a housing crisis, since, according to the 1940 census, 43% of the families were homeless or lived in unsuitable houses, whereas at the same time, is estimated that 409.000 Greek buildings were destroyed between 1940-1944 (Trixias, 2016, Zamani & Grigoriades 2013).

The OEK was the main public agency that provided social housing from 1975 to 2011. However, only 10% of OEK's total activity was located in the metropolitan area of Athens. The Olympic Village was the last housing complex constructed by the OEK in Athens. This estate was constructed in order to temporarily house athletes during the Olympic and Paralympic Games held in Athens in 2004. After that, the dwellings were used for the housing rehabilitation of the OEK's beneficiaries (Aravantinos, 2007).

Since 2012, when the function of the OEK was terminated, no public agencies for accommodating housing of low-income households have existed (Zamani & Grigoriades, 2013). The housing needs of vulnerable groups are therefore resolved through emergency/temporary solutions rather than by established housing policies.

Apart from the public housing production (of secondary importance), after 1975, the social housing policy is largely absent (Emmanuel 2006), leaving the market to cover the housing needs of all classes mainly through the quid pro quo system that dominates the construction activity as well as in the 90s.

Ownership through quid pro quo system, except of its financial implications, also contributed to meeting the housing needs of a large part of the population (Patatouka 2010). It also prevented spatial-social divisions in the sense that in the same neighborhood and in the same building coexisted affluent and lower economic classes, young and old, etc. Filippidis (2005). In essence, social housing was identified with organized construction in Greece, but it quickly declined compared to private construction due to the financial advantages of the quid pro quo system, gaining an additional social stigma (Goudis, 2020).

This idiosyncratic housing production regime, which lasted for decades, found a very broad consent as it served all parties involved. The State had minimal resources for the housing of the working class while exploiting the tax revenues from the privately owned residence. The middle class, and not only, gained access to a good quality of life through home ownership. Finally, the construction industry, for a number of years, was one of the driving forces of the Greek economy. Thus, there has never been a significant social claim around housing policy (Goudis, 2020 & Varkas, 2015).

Nowadays, due to the long economic crisis, the augmented levels of unemployment and the latest refugee waves from the East, the access to affordable housing has become increasingly necessary. However, the social housing model developed in the 20's, cannot cope with the current needs of the dwellers. A collaboration between the state and the users needs to be established, in order to develop a new housing model that will benefit both of the parties, and will facilitate the confrontation of the current housing crisis in Greece.

Collective Housing

The economic crisis of the previous decade, in Greece, has not only affected the prices of the real estate, but also the activity of the building sector. The country is making a considerable effort to exit the crisis and revive the construction sector. However, the productivity remains low and the spatial configurations of the residential edifices are still relying on the same models as of 5 or 6 decades ago. Nevertheless, the target group, the needs of the occupants, and everyday life style have dramatically. The transition into a new way of living requires a reconsideration of the available housing models. Additionally, "the widespread housing shortage, the issue of affordability, the rise of single-person households and an ageing population prompt a re-evaluation of existing housing models in order to address a broader range of demographics and adapt to the changing needs of city dwellers", Cutieru A. (2021).

The term collective housing mainly refers to a block of apartments, lofts or residences (group of horizontal or vertical dwellings) that accommodate people who are not related to each other. These buildings often have common spaces, like entrance, garages, gardens, laundry rooms or even kitchens, living rooms and meeting spaces. These dwellings are usually located in central areas of the cities, with a wide range of services available in a walking distance. Moreover, the cost of collective housing is usually lower when compared to a traditional individual house. Changes in people's way of life, technological evolution and the need to increase population density in cities have favored the use of collective housing, among other residential types, because it implies a better use of the resources available, and reduces the costs of common services and supplies.

A main characteristic of collective housing is the need and willingness of the residents to use the common spaces to interact and spend time with each other. The tenants of a collective housing unit form a small community, that reflect all the problems and opportunities of the broader society.

Alternative Housing Models and Initiatives

Across Europe, there are already some examples of contemporary collective housing models that provide the framework for new dwelling experiences and support current lifestyles. More often than not, these models are also addressing to the contemporary problems of urban areas related to sustainability. These new housing models often include the concepts of participatory design, user-oriented design, collaborative and cooperative housing, shared homeownership, etc.

Despite of the building projects that accommodate collaborative ways of living, there are also groups that are supporting and expanding the research on sustainable, affordable, cooperative housing, in order to create alternative forms of coexistence in contemporary cities. Each of the following projects, research groups and housing cooperatives present a combination of a type of social/collective/cooperative housing model with the concepts of affordability, participatory design, shared homeownership, sustainability or circularity, in Europe.

Klaprozenbuurt
A neighbourhood designed by residents

Project name	Klaprozenbuurt
Type	Neighbourhood Mixed use spaces Transformation
Location	Amsterdam, Netherlands
Year	2018-ongoing

Klaprozenbuurt represents the first time ever that the City of Amsterdam has given local citizens and stakeholders the opportunity and responsibility for the design of an entire neighborhood. The aim is that, in the coming years, this industrial area will be transformed into a vibrant, densified part of the city with ample living, recreational and work opportunities.

The municipality of Amsterdam wanted to develop an one-of-a-kind participatory design process. Unlike the frequently used top-down planning approach, this approach preserves much of the existing land ownership structure. This creates conditions that make the redevelopment of each individual plot economically attractive for all those involved.

Image 2.6. Space & Matters (xx). Klaprozenbuurt [Photograph]. https://www.spaceandmatter.nl/

De Warren

An ultra-collective apartment building

Project name	De Warren
Type	Housing cooperative Circular construction Participatory Design
Location	Amsterdam, Netherlands
Year	xx-ongoing

De Warren is a housing cooperation, managed by future occupants, that plans to build for the city of the future. It proposes a social and affordable place, an ultra-collective building, where people live together and take care of each other; a small and open village, in the city. De Warren will accommodate a diverse group of people, from singles to families with children and will offer multiple common areas, including: a co-working space, a yoga futsal room, communal living room, silence room, maker space, music studio, communal garden, greenhouse and roof terrace, and a communal kitchen on each floor.

Additionally, the building will be made of biobased materials. The structure is drawn up from CLT (cross laminated timber), flax insulation and recycled wooden finishes. Reusing building products from demolished buildings is being researched. The building will be completely energy self-sufficient.

Image 2.7. Erik Loots (2022). De Warren under construction [Photograph]. https://dewarren.co/

Schoonschip

A sustainable floating neighborhood, developed by its residents

Project name	Schoonschip
Type	Neighborhood Sustainable community Self-sufficient
Location	Amsterdam, Netherlands
Year	2008-2021

Schoonschip is circular neighborhood initiated and developed by a group of enthusiasts with a shared dream, to build a sustainable, close-knit community on the water. The team consisted of multidisciplinary experts and future residents.

On a small scale, Schoonschip explores and applies innovative solutions to the pressing challenge of sea level rising due to climate change. Schoonschip's residents live in highly eco-efficient buildings that were remotely manufactured, and share everything from electric cars and cargo bikes to the clean energy they generate on the houseboat roofs. Built on a circular community model, Schoonschip's solar panels are connected to a smart grid where residents can trade energy with the help of blockchain technology. It contains decentralized and renewable solutions to water, energy, and waste systems, as well as submersed heat exchangers for heating and cooling.

Now that the project has been completed, members of the community work closely together to improve their residential area and achieve local loop closure. Its members connected in every conceivable way. Schoonschip demonstrates how circular neighborhoods can be created by people who take matters into their own hands.

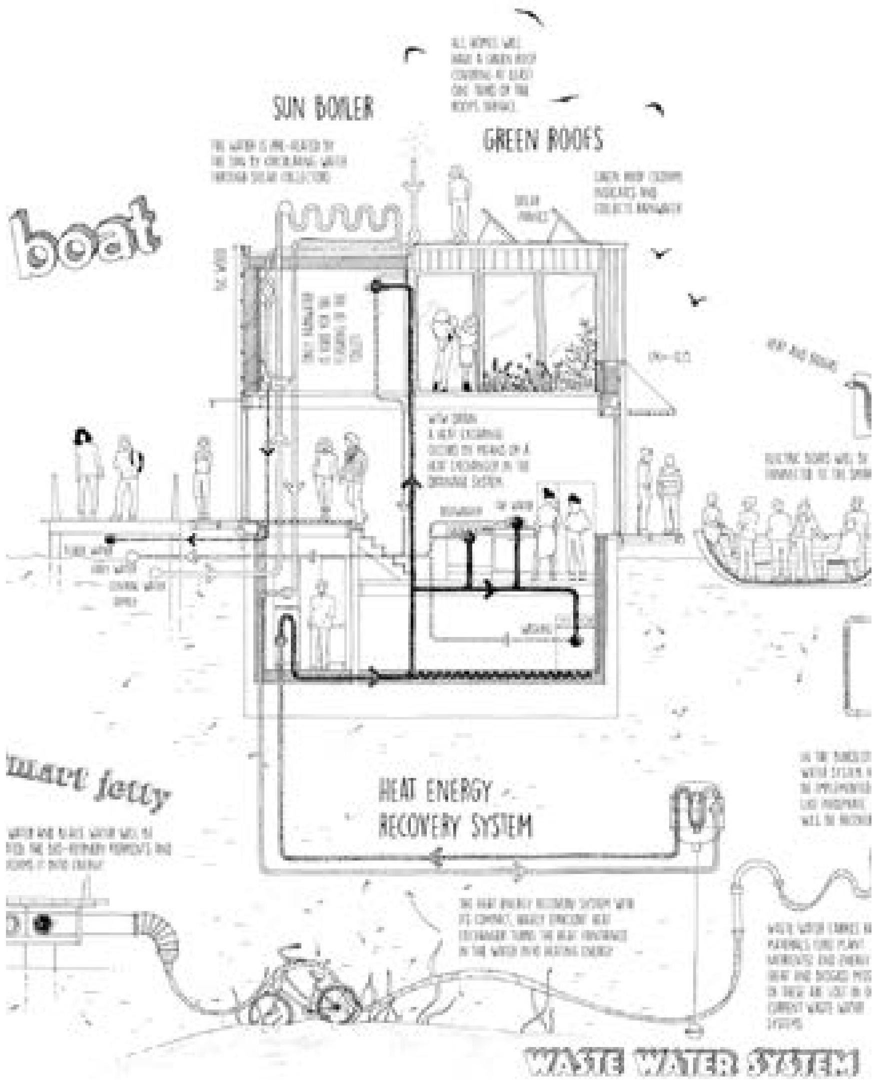


Image 2.8. Space & Matter (xx). Schoonschip [Sketch]. https://www.spaceandmatter.nl/

SUM
Symbiotic Urban Movement

Project name	SUM
Type	Renovation Sustainable community
Location	The Hague, Netherlands Wuppertal, Germany
Year	2008-2021

The Symbiotic Urban Movement (SUM), a student team from TU Delft, proposes a solution to the dual challenge of the Netherlands to become energy-neutral by 2050, and to add 1 million homes to the existing building stock by 2030. In order to achieve these goals, many post-war tenement flats are being demolished. SUM argues that with renovation and addition, a more sustainable and symbiotic renewal process should be possible. The prototype built for the Solar Decathlon Competition 21/22 showcases a renovation and densification plan for 847,000 underperforming tenement flats in the Netherlands, which represent 11% of the total housing stock.

Five are the main aspects of SUM's design: a public, interactive ground floor that enhances the feeling of community; a circulation core with technical and social spaces, which improves accessibility for all residents and invites people to meet each other and build a stronger relationships; a gallery for accessibility and spontaneous social interaction, prefab top-up apartments to densify the neighborhood and expand the range of housing types in the building; and energy productive roof and facade to provide the building with electricity and heat.

Image 2.9. SUM team (2022). SUM's prototye in Wuppertal, Germany [Photograph]. https://www.linkedin.com/company/team-sum/

NeNa1

A modern form of urban co-living

Project name	NeNa1
Type	Housing cooperative Neighborhood Sustainable community
Location	Zurich, Switzerland
Year	2012-ongoing

NeNa1 is a housing cooperative which supports that “neighborhoods make it easier and more attractive for individuals to live sustainably”. Therefore, they propose a neighborhood of 500 residents, who work together for the benefit of the entire community. They share from infrastructure for housework and leisure time to agricultural land, from tools and electrical devices to energy production to the Internet and computing power. In this way, one can use more while the consumption per capita is reduced. A pleasant side effect: more social interaction.

Electricity, water and heating consumption make up only a small part of the private ecological footprint. In order to create a holistic approach of sustainable living, NeNa1 also includes mobility, nutrition and consumer behavior as well as the gray consumption of resources in the design of the neighborhood.
NeNa1 suggests: “you can not only live, you also need to get involved, work and benefit from the common infrastructure. The cooperative is a connection that mainly aims to promote or secure certain economic interests of its members in mutual self-help”. The members of a cooperative have correspondingly far-reaching rights and obligations.

Image 2.10. NeNa1 (xx). Concept based on Oerlikon train station [Sketch]. https://nena1.ch/

Kraftwerk1

One roof: living, working, shopping, resting

Project name	Kraftwerk1
Type	Housing cooperative Co-living & Co-working Participatory & Inclusive
Location	Zurich, Switzerland
Year	xx-ongoing

The construction and housing cooperative Kraftwerk1 plans and implements ecologically and socially innovative residential projects of great density and diversity in and around Zurich. The greatest possible variety of people should have access to the apartments and commercial spaces, including people who have few opportunities on the regular market.

The cooperative is known for communal forms of living such as large apartments and cluster apartments and for the combination of living and working. The cooperative is characterized by high-quality and community-promoting architecture as well as diversity and participation. Around 700 people currently live in three settlements in 232 apartments.

Image 2.11. Kraftwerk1 (2022). Residents of the neighborhood and members of the cooperative during an architecture workshop [Photograph]. https://www.kraftwerk1.ch/

Co-Hab Athens
Urban habitat in common

Project name	Co-Hab
Type	Research group Collective ownership Community land bank
Location	Athens, Greece
Year	2016-ongoing

CoHab Athens is an open group, an exchange platform for urban researchers, activists and other, who run an applied research project on cohousing and collective ownership models for reclaiming affordable habitat quality in Athens. The research group was created due to the need of its members not only to understand and describe the crisis and the developments in the housing sector which has been taking place in Greece the past few years, but also to seek effective solutions to it. Drawing inspiration from successful cooperative housing models that have been implemented abroad, CoHab Athens is holding an ongoing participatory design workshop, in order to investigate local needs related to housing, as well as to explore the possibilities for the creation of the first project of cooperative housing/collective ownership in Athens. Aiming to the decommodification of urban land and active manifestation of the right to the city they seek and promote synergies with existing paradigms that have successfully been implemented and with similarly oriented ongoing projects.

Based on knowledge our team has acquired over the past four years through research, workshops, open discussions, informal talks, working groups and visits to housing cooperatives abroad, we describe what cooperative housing and collective ownership is and how it works, how it is organised and how it can be funded, and we propose two possible scenarios for its implementation in the city of Athens. We have worked with a range of possible scenarios, -dispersed cohousing, real estate market building, donated and exchanged buildings, publicly owned buildings- and we have tried to address a variety of needs in each economic and architectural model.

Image 2.12. Co-Hab Athens (xx). Concept based on Oerlikon train station [Sketch]. https://nena1.ch/

MOBA Housing SCE

A network of pioneering housing cooperatives

Project name	MOBA
Type	Housing cooperative Affordable housing Collective ownership
Location	Central and South-Eastern Europe
Pilot Projects	Serbia, Hungary, Slovenia, Czech Republic, Croatia
Year	2017-ongoing

MOBA opens a new possibility of housing for a wide range of people who currently cannot afford to buy an apartment, but would join in a more affordable approach to it. For example: young people who want to become independent, people without a permanent job, people with average or lower income, as well as those who are looking for a community in which they could live differently.

The MOBA model puts affordability of housing first, while taking away the pressure from individuals in resolving their housing condition. It is centered around a cooperative of inhabitants that collectively develops, finances, maintains and operates a multi-apartment building. Because it controls the entire trajectory (and does not need to make profit), the resulting apartments are much more affordable for the inhabitants.

The cooperative owns the real-estate as well as takes on the necessary loans to pay for its construction. Participating households or individuals (the members of the cooperative) thus collectively own their building. And keep it there, because individual members or households cannot speculate with their apartment – in that way it is not just a safe and affordable option for the first generation, but for many generations of its inhabitants to come.

As an inhabitant of a MOBA apartment, one pay a one-time entry fee (deposit) and a monthly contribution ("rent") that covers both the costs of the apartment as well as a predetermined amount for the utility costs (water, electricity, etc.) – so you always know what you are up to.

In addition, developing a building is a formidable challenge. However, more and more groups and initiatives emerge that want to realise affordable alternatives to the current offer (and economic reality) of housing. For, it is not just essential to get a detailed insight into the costs of the initial investment, but also the long-term costs of inhabiting such buildings. And breaking ground with such initiatives, in-depth insight into the financial aspects of housing is required when negotiating projects with future inhabitants as well as capital providers (friends, commercial banks, ...). Therefore, MOBA developed the Open Financial Review Model; a toolkit that gives insight into the financial aspects of multi-apartment buildings. It analyzes the costs of developing such a building, provides insight in the financial 'mix' required for the investment, and it indicates how much apartments cost (monthly contribution or "rent").

Image 2.13. NeNa1 (xx). Concept based on Oerlikon train station [Sketch]. https://nena1.ch/

INURA
International network for urban research and action

Project name	INURA
Type	Network Community Social housing provision
Location	Switzerland
Year	1991-ongoing

INURA is a network with a self-organizing, non-hierarchical, decentralized structure; a network of people involved in action and research in localities and cities. The Network consists of activists and researchers from community and environmental groups, universities, and local administrations, who wish to share experiences and to participate in common research.

Examples of the issues that Network members are involved in include: major urban renewal projects, the urban periphery, community-led environmental schemes, urban traffic and transport, inner city labor markets, do-it-yourself culture, and social housing provision. In each case, the research is closely tied to, and is a product of, local action and initiative.

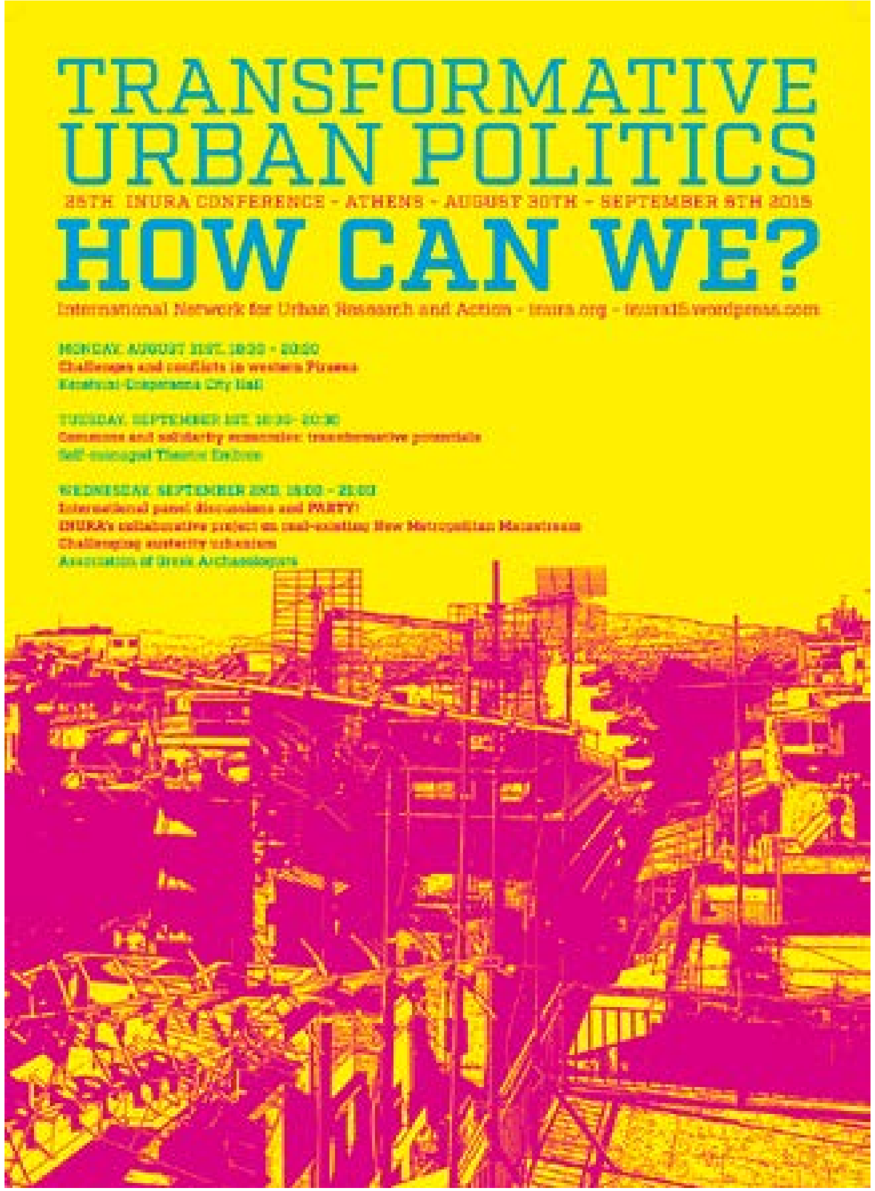


Image 2.14. INURA (2015). 25th INURA Conference 2015 Athens [Poster]. https://www.inura.org/v2/

SHICC
Sustainable Housing for Inclusive and Cohesive Cities

Project name	SHICC
Type	Sustainable housing Funding Inclusive & Cohesive
Location	North-West Europe
Year	2017-2021

The Sustainable Housing for Inclusive and Cohesive Cities (SHICC) project seeks to support the establishment of more successful Community Land Trusts (CLT) in cities across the North-West European (NWE) region. SHICC has already invested in four existing CLTs in Brussels, Ghent, Lille and London to prove the concept, create a supportive local, regional and national policy, funding and regulatory environment for CLTs and build a movement across the region. Now, it's expanding in the Netherlands, Germany, Scotland and Ireland, taking the work of creating a supportive funding environment further, and further strengthening the four initial pilot projects.

R50 - Cohousing,
A joint building venture project

Project name	R50 - Cohousing
By	ifau und Jesko Fezer + Heide & von Beckerath
Type	Collective housing Co-ownership Residents to developers
Location	Berlin, Germany
Year	2013

In Germany, the Baugruppen model is an alternative to investment-driven development in which residents become the developers, resulting in co-ownership of the communal space while residential units are individually owned. The R50 Baugruppen cohousing project in Berlin designed by Heide & von Beckerath and ifau with Jesko Fezer, is an enterprise where 19 households pooled funds for the project's construction. The architects and the group of residents collectively selected the site, and the building was developed through participatory design, with future residents reaching a consensus on everything from common spaces to finishings. The project features an array of shared spaces, including a rooftop terrace with a summer kitchen, a community room at group level, and shared balconies that envelope the entire building. Interestingly enough, by collectively deciding on the priorities, the cost ended up being lower than that of a typical apartment in the same area.

Van B Residence

a new housing form that reimagines the future of urban living

Project name	Van B Residence
By	UN Studio
Type	Urban living Multi-functional Community building
Location	Munich, Germany
Year	2018

As a prototype for modern city dwelling, Van B is designed to cater to changing demographics and multiple family constellations.

“The community aspect of housing is going to be much more important, alongside the further integration of technology”, says Ben van Berkel, founder of UNStudio, arguing that forms of community living reduce “the spatial needs compared to if everyone privately claims space for their amenities”. Indeed, while it takes on many shapes, from cohousing to co-living and any variants in between, the defining characteristic of community living is shared spatial resources. In recent years, forms of community living have gained traction as a viable answer to issues such as the housing shortage, the rising costs of living, the “loneliness epidemic”, and the changes within the social fabric.

Mass housing is being reconsidered from two perspectives simultaneously. On the one hand, domestic space is being redefined, and the boundary between private and public, individual and shared, is being redrawn. On the other hand, ownership and project development are also being reshaped, sometimes in opposite directions. With some versions of cohousing, residents reclaim the design and development process, giving rise to a new way of financing homeownership. At the same time, nomadic lifestyles have created the opportunity for a version of housing that resembles more a subscription-based service. These aspects represent the main framework for re-evaluating mass-housing.

3.

The Case Study

Energy Transition

Circular Adaptation

Operational Plan

The Case Study

“Prosfigika”[3] of Alexandra’s - Timeline

The refugee settlement complex of Alexandra’s Avenue was built by the Greek State to accommodate the refugees of Asia Minor, after a decade of them living in unorganized, often self-constructed, settlements. It is located in the heart of Athens, 2km away from the main square of Syntagma and only 300m away from the north entrance of Lycabettus hill (Image 3.1.). The southern boundary of the plot is bordering with Alexandra’s Avenue, which gave its name to the building complex.

The refugee settlement complex consists of 8 simple parallelepiped (Image 3.2.), strictly utilitarian buildings, following the line of German functionalism. Designed by Dimitris Kyriakou and Kimon Laskaris, the complex was built in two stages. In 1935, after two years of construction, the

Image 3.1. Google maps (2021). Map of Athens, Greece [Edited by Author]

Image 3.2. Unknown (2019). Aerial photo of the refugee settlements of Alexandra’s Avenue. Proto Thema.

[3] The long, descriptive term of “refugee settlements of Alexandra’s Avenue”, for the sake of brevity, will, from now on in this study, often be replaced with the terms “Prosfigika of Alexandra’s” or “Alexandra’s Prosfigika” or simply “Prosfigika”.

With the term “prosfigika” (in Greek: πρόσφυγας), we refer to the organized refugee settlements, built from the Greek State for the refugees. The term comes from the Greek “prosfigas”, which means “refugee”. It is the result of the words “pros” (προς), which means to/towards and “fevgo” (φεύγω), which is the act of leaving. “Prosfigas”, or refugee in English, is the one who is forced to leave the place of permanent residence for various reasons (war, persecution, natural disaster, etc.) and seeks refuge in a neighboring country or in his country of origin (Wikilexico, 2022).

The term “prosfigika” should not be confused with the recently (2015) born term of “hotspot”, which is referring to the site, set up by the refugee host countries with the assistance of the European authorities, for the refugees’ registration and sorting, even though, in practice, most of the hotspots often evolved into accommodation centers, i.e. refugee camps.

first 4 buildings, in the center of Athens, are ready to host 108 families. A year later, 4 more buildings were built at the same site, for another 120 families.

At the end of World War II, during the civil war, a series of armed clashes began in Athens between EAM-ELAS[4] forces and British and government forces. The battles lasted 33 days. During the street battles, many ELAS fighters found refuge in the "Prosfygika" of Alexandra's (Image 3.3). The marks from bullets and shells thrown by the British from the Lycabettus hill, remain untouched on the south facades of the buildings and are clearly visible to the visitor until today (Image 3.4.).

The "Prosfygika" of Alexandra's have been a topic for discussion for governments and institutions for many years. During the dictatorship (1967-74), a ministerial decision was issued stipulating the removal of the refugees and the demolition of the buildings, with the aim of building a courthouse, a decision, though, that was never implemented. Almost all the plans and studies prepared in the following years envisaged the demolition of all apartment buildings, with the aim of erecting modern buildings or the configuration of the outdoor space in a park, and even the creation of a parking space. The National Technical University of Athens also proposed a program of redevelopment of the area, aiming at the preservation of the buildings, with some contemporary interventions, the configuration of the open space, as well as the addition of an underground parking area.

In the 1990s the issue of "Prosfygika" was brought up again. This time, the demolition of six apartment buildings and the preservation of only two, as an example of architecture, were intensively debated. By 2000, the State's Real Estate Company

[4] The Hellenic People's Liberation Army (ELAS) was the military wing of the National Liberation Front (EAM) during the triple occupation of Greece.

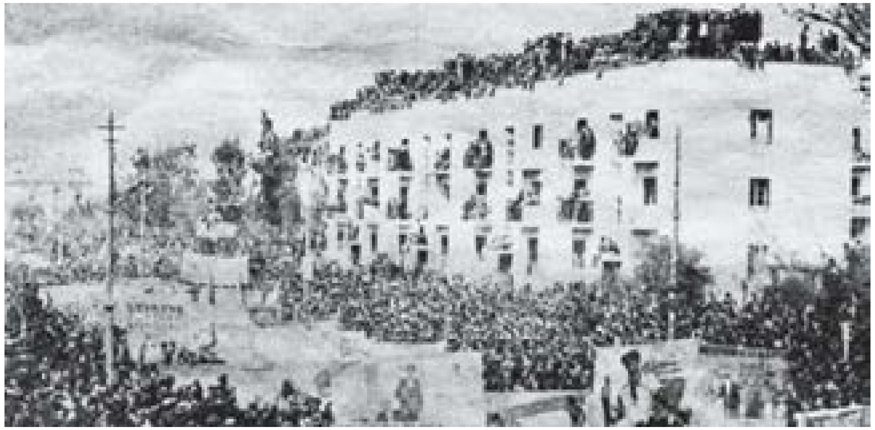


Image 3.3. Unknown (1944). The "Prosfygika" during the civil war. ERT Open.

Image 3.4. Unknown (2019). The marks from bullets and shells thrown by the British from the Lycabettus hill, during civil war, are visible till today. Lifo.

gradually expropriates 177 of the 228 apartments, with the aim of demolishing them and creating a “green space”. However, the remaining owners of the other (51) apartments were strongly opposed to that decision. Thus, a long protest began against their demolition, resulting in their gradual declaration as monuments of cultural heritage. Till 2009 all of the buildings in the complex of Alexandra’s were characterized as listed, due to their historical, social and architectural significance. For the sake of this decision, the apartment buildings can no longer be demolished, nor can their character be altered.

Today, 177 apartments belong to the Attica Region and 51 to individual owners, descendants of the first owners. During the last two decades, an image of abandonment has begun to dominate in the building blocks and the apartments acquired by the state began to be occupied by anti-authoritarians, refugees, homeless and drug addicts, while other still remain uninhabited. In 2019, the first step towards their protection and utilization seemed to happen, as a study of the company Athens’ Reconstruction S.A. (Ανάπλαση Αθήνας Α.Ε.) was approved by the Ministry of Culture, based on which many apartments would become social housing for the homeless, some others would be converted into temporary accommodation for patients of the neighboring hospital “Agios Savvas”, while other would host a museum exhibition of Asia Minor Memory. The duration of the reconstruction was estimated to three years. However, today, in 2022, still nothing has changed (Images 3.5., 3.6.).

The “Prosfygika” of Alexandra’s Avenue are buildings of exceptional importance, both historical and architectural. They are one of the few examples of Bauhaus in Greece and one of the few examples of modern architecture and urban planning in Athens, as they have been characterized as one of the 113 most important architectural monuments of the 20th century. It is also a place of memory and experience, and significant part of modern history.

Image 3.5. Author (2021). Current condition of the south/front facade of the first building of “Prosfygika” on Alexandra’s Avenue.

Image 3.6. Author (2021). Current condition of the nort facade of the last building of “Prosfygika” on Trixonidos Street.

Why this case study?

The refugee settlement complex in Alexandra's Avenue is part of the Greek heritage, with significant cultural and architectural value. All of the buildings are designated as listed and thus, they are protected and need to be preserved by the Greek State. The 8 simple parallelepiped buildings are oriented facing the south, that allows them to make good use of the sun light and solar radiation. The deciduous trees, planted in front of each building, allow the low winter sun to enter the buildings, but block out the hot summer sun. The 60 cm thick, limestone, exterior walls have high thermal mass that contributes in regulating the interior temperature, by absorbing, storing and releasing heat. Each apartment has openings in, at least, two sides (south and north), making cross natural ventilation feasible. These characteristics are a great example of an early passive solar design and an ideal basis to develop an advanced zero-energy re-design (Image 3.8.).

Each building covers an average area of 550 m2, in a site plot of 14.5 acres in total. This results in a 33% coverage factor, that leaves the rest two thirds of the plot free for open, public, circulation and/or green spaces. With only 3 floors elevation for each building, this complex has a plot ration of only 0.9. Meanwhile, in the neighboring site plots of today, the coverage factor often reaches 70% of the total area and the plot ration is 3.6 (4 times more than in the refugee settlement complex)- Image 3.7. This results in a building complex with a great ration between built environment and open spaces, in a, if nothing else, densely populated and densely built area. This layout is favorable for recreating the sense of neighborhood within the urban tissue and for developing a small but powerful urban lung.

Furthermore, despite their age (almost 90 years old), these buildings remain in a good structural condition and no damage have ever been reported during the big earthquakes. Thus only minor interventions need to be done, in order to keep up with the new, anti-seismic regulations. Let's not forget that Greece is recorded sixth in the list with the world's most seismogenic countries.

The abovementioned benefits combined with the multicultural character and the advantageous location of the complex form encouraging circumstances to develop a positive-energy, carbon-neutral district of collective social housing.

Image 3.7. Google maps (2021). Map of area around Prosfygika, Athens, Greece [Edited by Author]

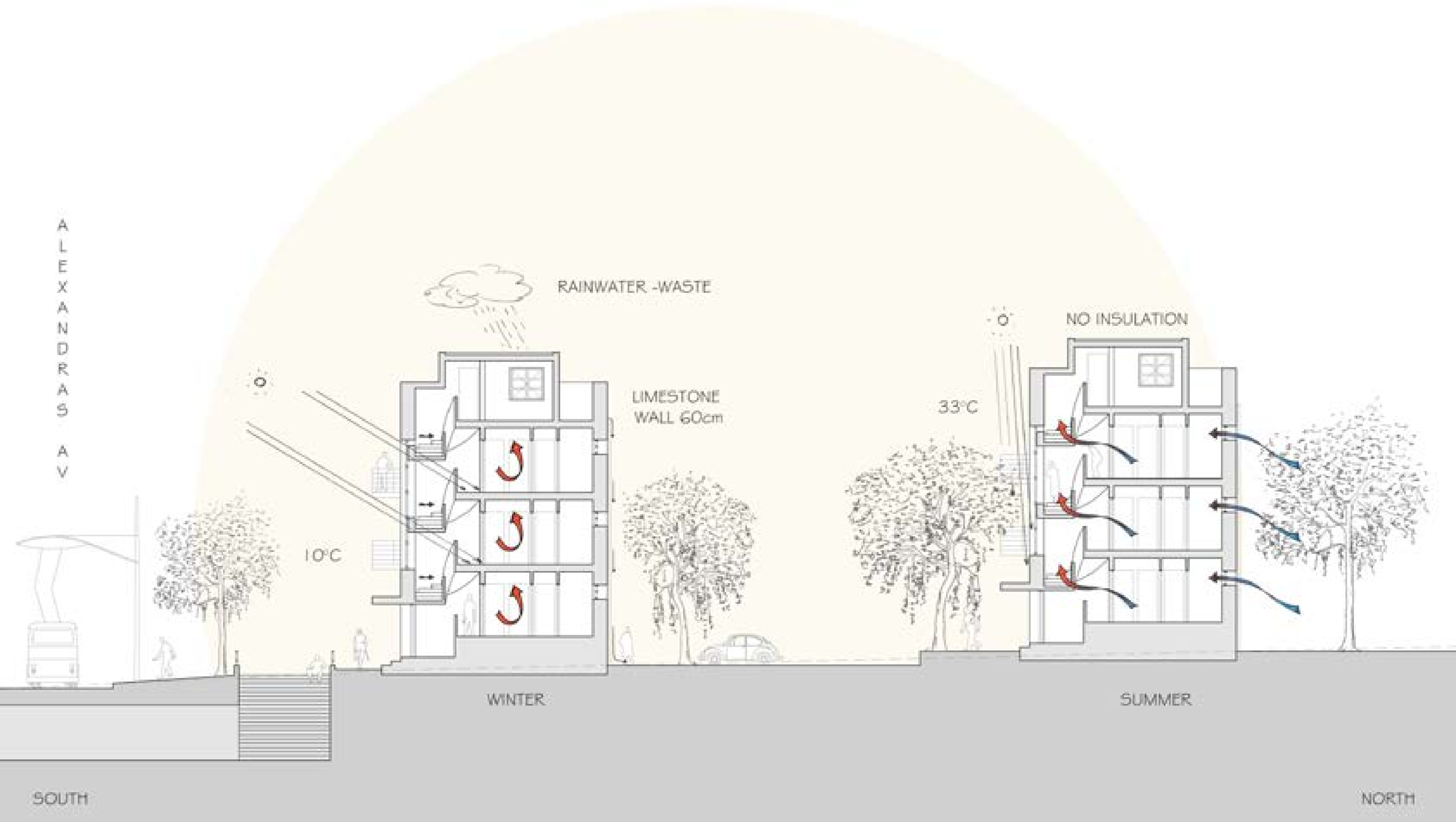


Image 3.8. Author (2022). Section of the front 2 buildings of Prosfygika - Current situation [Drawing].

Image 3.9. Author (2021). Plan and Facade of the 2 building types of Prosfygika - Current situation [Drawing].

Energy Transition

For the energy upgrade of the building, this study follows the “stepped approach”, by van den Dobbelsteen A., as it was previously described. The steps are briefly presented here and then applied and analyzed one by one through the case study of “Prosfygika”.

Steeped Approach:

1. Research:	• Analyze building’s energy use • Analyze local climate
2. Reduce:	• Passive measures to reduce energy demands
3. Reuse:	• Waste management
4. Produce:	• Energy generation with biomass or RES
5. Integrate:	• Choose the right energy measures • Develop a net-energy concept for the building

1. Research

Energy Generation and Consumption in Greece

The road towards climate neutrality involves eliminating all use of solid and liquid fossil fuels in the building sector. The “electrification” of thermal uses increases significantly in all long-term scenarios strategies. The “electrification” of thermal uses in the building sector is facilitated by the reduction of the cost of heat pumps in the future, the combination of heat and cooling allowed by heat pumps and ease of use of electricity. This trend is clearly more pronounced in the service sector buildings, as it turns to high-power central air conditioning units that meet the needs for heating, cooling and ventilation using electricity. However, it can be applied in all cases of buildings.

Currently, the main energy carrier, for heating and cooling in the residential buildings of Greece, is petroleum and solid fossil fuels. Other main carriers is biomass and renewable energy sources, as well as natural gas. In the future, Greece is aiming in the elimination of fossil fuel use and the increase of electricity and gas demand.

Electricity for heating and cooling can be the most sustainable solution, only if the generation of electricity is also a result of use of renewable energy sources. For the time being, only 25% of the electricity produced in Greece is generated by RES. However, the plan towards targets to 60% of production to come from RES by 2030, and more than 80% by 2050 (Hellenic Republic, 2020).

Estimating a 40% efficiency for the production by fossil fuels, for 1kWh of electricity we need: 1/0.4=2.5 kWh=9 MJ of primary energy.

In Greece, most of the energy, in the residential sector, is surprisingly consumed for heating purposes (more than 50%), while lighting and other appliances, as well as domestic hot water also have a relatively high energy demand. Nonetheless, the graph below depicts a relatively stable average consumption for the entire year, regardless of the temperature differences.

Energy Use of the Building

In order to reduce the energy demand of a building and to produce, in sustainable ways, the required amount of energy, it is important to know how much energy the building uses and which are the main energy carriers for heating, cooling, domestic hot water, cooking, lighting and other appliances.
The typical Athenian apartment uses petroleum for heating. However, the use of natural gas has been increased lately, for new and old dwellings. For cooling the use of electrical ACs is the most common. Electricity is also used for cooking, lighting and other appliances. For domestic hot water, it is common to use solar thermal collectors, usually combined with an electric boiler, for the cloudy days.

In the case of “Prosfygika” though, the one and only energy carrier is electricity. When it is needed, the residents use, for heating, electric radiators, air conditioners and sometimes wood for combustion. ACs are their only option for cooling. Cooking is achieved with electric stoves and no solar thermal collectors are installed for domestic hot water.

In terms of indoor thermal comfort, these buildings have 4 main design characteristics that contribute to passively regulate the temperature. The buildings are oriented facing south, with planted deciduous trees in front of the south façades, allowing the winter sun to enter the building, while blocking, at the same time the hot summer sun. The high thermal mass of the 60 cm thick exterior limestone wall absorbs the sun heat during the day, stores it and releases it into the building. While natural cross ventilation for cooling is easily achieved, due to the openings on both sides, north and south. Based on residents’ testimonies “the apartments maintain a stable indoor temperature for about one and a half months after an abrupt outdoor temperature charge. Despite the fact that the temperature starts dropping by the start of November, the apartments are getting colder at the end of December. And even though higher temperatures are being recorded in the city by the start of July, the indoor atmosphere begins to feel uncomfortable approximately a month later” (Eftaxiopoulos, 2022). As a result, a slightly lower energy consumption for heating and cooling is assumed, compared to a typical Athenian apartment.

A typical household in the refuge settlement has an average electricity consumption of approximately 4000 kWh per year. The consumption per square meter or per person contributes in the comparison of the energy demand between different types of apartments, for example a typical apartment that hosts a family of 5 doesn’t have the same footprint as a combined apartment of 110m2 occupied by 2 persons.

Counting Period	Consumption [kWh]	Total [kWh]
08.12.2020 - 08.04.2021	1,087	
08.04.2021 - 09.08.2021	1,413	
09.08.2021 - 09.12.2021	1,549	4,049

Table 3.1a. Author (2022). Electricity consumption of a 110m^2 household of 2 persons.

19.11.2020 - 22.03.2021	1,829	
22.03.2021 - 21.07.2021	1,041	
21.07.2021 - 22.11.2021	1,065	3,935

Table 3.1b. Author (2022). Electricity consumption of a 55m^2 household of 5 persons.

Yearly Average Total of a Household: **3,992 kWh**

3,992 kWh / 0.4 = 9,980 kWh_{prm} = **9.9 MWh_{prm}**
9.9 MWh_{prm} * 3.6 = **35.6 GJ_{prm}**

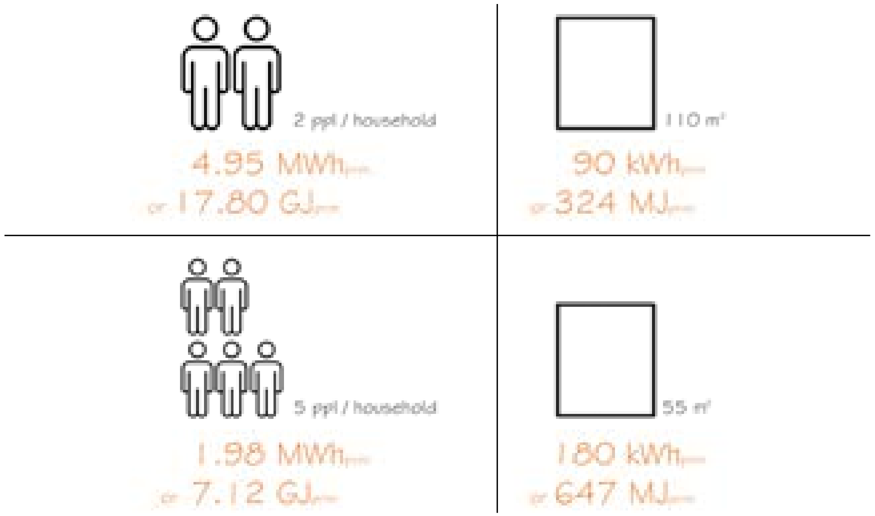


Image 3.10. Author (2022). Electricity consumption per person and per m² for the two examples

Annual solar energy output of a photovoltaic standard module:
E = A * r * H * PR

- E = Energy (kWh)
- A = Total solar panel Area (m2)
- r = solar panel yield or efficiency(%)
- H = Annual average solar radiation on tilted panels (shadings not included)
- PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)*
- 1.6x1753x0.20x0.90 = 504 kWhe /year/module

* Example of detailed losses that gives the PR value (depends on the site, the technology, and sizing of the system):

- Inverter losses (4% to 10 %)
- Temperature losses (5% to 20%)
- DC cables losses (1 to 3 %)
- AC cables losses (1 to 3 %)
- Shadings 0 % to 80% !!! (specific to each site)
- Losses at weak radiation 3% to 7%
- Losses due to dust, snow... (2%)
- Other Losses (?)

So what can 1 kWh power?
It varies a lot between appliances – some are more energy-efficient than others. Here are some estimated examples of what might use 1 kWh:

- Cooking in an oven (2,000 W) for 30 minutes
- Running a dishwasher (1,000-1,500 W) for less than an hour
- Keeping a fridge-freezer (200-400 W) on for about three hours
- Watching a 42” LED TV (80 W) for 12 and a half hours
- Using a laptop (20-50 W) all day

Based on the current electricity consumption of a 100 m2, 2 persons household, which was previously calculated to 4.049 kWh per year and the 504 kWh produced per year by one standard PV module: 12.8 m2 of PVs (8 standard PV modules) can cover the current energy demand of the household.

ZED Tool

To define the demand and consumption of energy in the building, as well as calculate the impact of the passive and active measures proposed, and estimate the overall performance of the design the Zero-Energy Design (ZED) Tool has been used. The ZED tool, developed by Leo Gommans and Siebe Broersma in TU Delft, uses the calculation model “Method5000”. The “Method5000 is developed by French architects in the 1980’s and forms the basis for current EPC models. It calculates a heat balance for space-heating of a building. Solar gains, internal heat-production, sunspaces/greenhouses and internal mass are taken into account. On the other hand, the heat losses caused by windows, walls, roofs, floors, thermal bridges and ventilation are calculated. Next to entering heated spaces, unheated buffer spaces can be taken into account, as well as sunspaces that preheat ventilation air. Method 5000 also can calculate open loop air collectors, open loop solar walls, Trombe walls and mass walls, however these features have not been used for the calculations of this project.

The ZED tool uses temperature and solar radiation numbers for the Greek climate (Athens). These are monthly average numbers. Based on the mass of the building and the desired average room temperature, Method5000 calculates the useful solar and internal gains of the heated space and the average temperature of the unheated space, for every month of the year. Subtracting the gains from the losses will result in an additional heat demand that has to be generated with a heater. Depending on the efficiency of the heater, there will be a certain additional energy demand left for space heating. The Method 5000 also gives an indication of the average comfort condition for every month of the year by comparing the average monthly temperature with a reference temperature. It also calculates the cooling demand to keep the heated space comfortable during the summer period. Next to the calculation sheet for space heating and cooling, a calculation sheet for defining the heat demand for the domestic hot water is made.

The following tables present the energy demand of the entire building, at its current condition. The first table refers to residential uses of the building, while the second one shows the demand of the building as if it was accommodating communal facilities. In both cases, the demand is high and the on-site production is zero. Nevertheless, the difference between the two numbers is not negligible. The residential facilities require 60% more energy than the common spaces, mainly due to the fewer demand in appliances and domestic hot water.

Electricity Demand	kWh	Electricity Production	kWh
Heating	72,898	PV-Systems	0
Cooling	50,594	Wind Turbine	0
Ventilation	0	Other	0
Appliances	54,330		
DHW	150,304		
MRE	0		
Other	0		
Total	328,126	Total	0
Net energy use	328,126 kWh		

Table 3.2a. Author (2022). Electricity demand and Production of existing situation as residential building [Calculations Results].

Electricity Demand	kWh	Electricity Production	kWh
Heating	72,898	PV-Systems	0
Cooling	50,594	Wind Turbine	0
Ventilation	0	Other	0
Appliances	36,180		
DHW	45,547		
MRE	0		
Other	0		
Total	205,219	Total	0
Net energy use	205,219 kWh		

Table 3.2b. Author (2022). Electricity demand and Production of existing situation as communal space [Calculations Results].

Analyze the local climate and select appropriate solutions

The climate in Athens is typically Mediterranean and is characterized by hot, dry, summers and mild, wet winters, and, in general, long periods of sunshine during most of the year. From a climatic point of view, the year can be divided mainly into two seasons: The cold and rainy winter period that lasts from mid-October until the end of March and the warm and dry season that lasts from April to October.

During the first period the coldest months are January and February, where the average minimum temperature ranges from 5-10oC in the coastal areas. The rainfalls, even in winter, do not last for many days and the Athenian sky does not remain cloudy for several consecutive days, as happens in other parts of the world.

During the hot and dry season the weather is stable, the sky is almost clear, the sun is bright and it does not rain except for rare breaks with heavy rainfalls or thunderstorms of short duration. The warmest period is the last ten days of July and the first of August when the average maximum temperature ranges from 29°C to 35°C. During the hot season, the high temperatures are mitigated by the cool sea breeze in the coastal areas and by the north winds (predominant annual).

Despite the relatively mild weather, there are some factors that sporadically affect the climate in Athens, and other parts of Greece. Climate change is causing, during the last years, really high temperatures in the summer, often over 40°C, as well as some unusually cold days, in the winter, when snow covers the entire city and its suburbs, from the north to the furthest south, coastal suburbs. Additionally, some areas of the city, like the city center, record higher temperatures due to the high building density and the low vegetation density. Furthermore, Athens is affected by the urban heat island effect

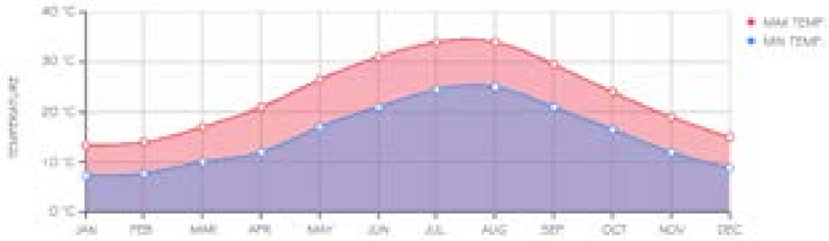


Image 3.11a. Weather and Climate (2021). Average min and max temperatures in Athens, Greece [Diagram]. https://weather-and-climate.com/

Image 3.11b. Weather and Climate (2021). Average monthly sun hours in Athens, Greece [Diagram]. https://weather-and-climate.com/

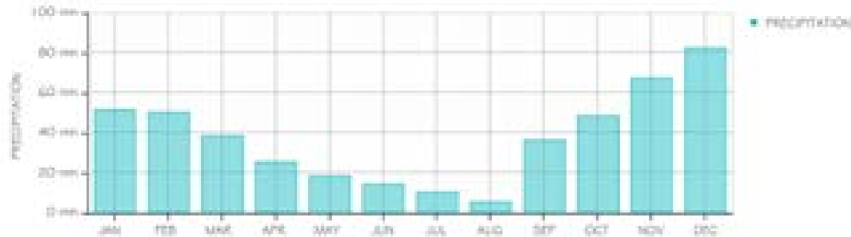


Image 3.11c. Weather and Climate (2021). Average precipitation (rain/snow) in Athens, Greece [Diagram]. https://weather-and-climate.com/

Image 3.11d. Weather and Climate (2021). Average relative humidity in Athens, Greece [Diagram]. https://weather-and-climate.com/

in some areas which is caused by human activity, altering its temperatures compared to the surrounding rural areas, and leaving detrimental effects on energy usage, expenditure for cooling, and health. The prolonged hot and dry period often gets worse with the dry and hot winds blowing from the Sahara desert, transferring massive amounts of dust particles.

Due to the high, bright sun and the large amount of sunny days during the year, Greece has a great solar energy potential. Athens has 1.753 kWh/m2 Global Horizontal Irradiation Yearly Totals.

Annual solar energy output of a photovoltaic standard module:
1.6x1753x0.20x0.90 = 504 kWhe /year/module

According to the ATES Suitability map (Image 3.12.), Athens has a low suitability for ATES (Aquifer Thermal Energy Storage) systems, resulting to ineffective beep, seasonal, underground, heat storage. On the other hand, due to the stable soil temperature of 17ºC (Image 3.13.) and the air temperature range from 10 to 35ºC, ground duct ventilation systems can be proven really efficient, especially in combination with an air to air heat pump and some air humidification (for the hot dry days of summer).
Based on the local climate and weather, described above, as well as the building's design and materials characteristics, the current situation of the "Prosfygika" can provide its users with 62.1% of comfortable hours without the use of any heating or cooling device, throughout an entire year, as it is depicted in the chart below[5]. A 100% of comfortability needs to be achieved, by choosing and applying mainly passive measures to the current condition, and later, by adding appropriate high performance heating and cooling systems (Image 3.14.).

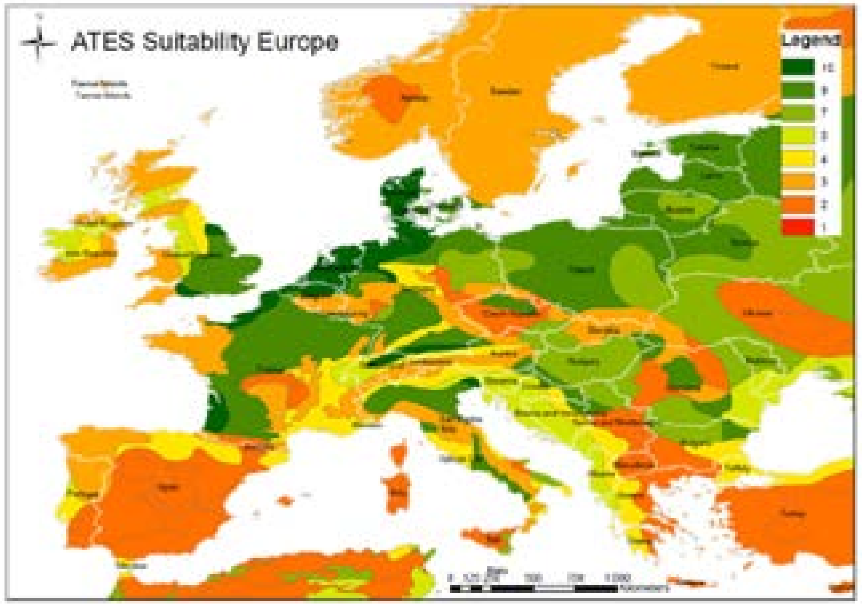


Image 3.12. Climate - KIC. (2018). ATES Suitability Europe [Map]. E-USE (aq)

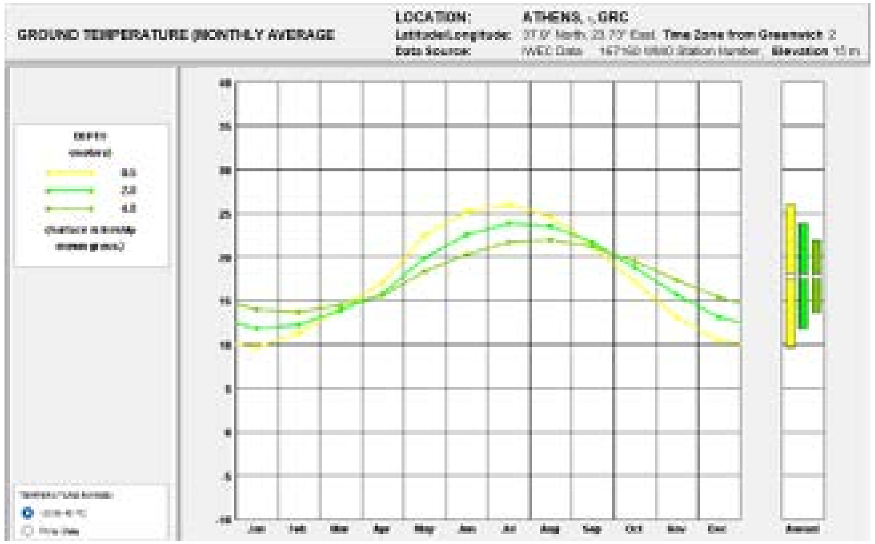
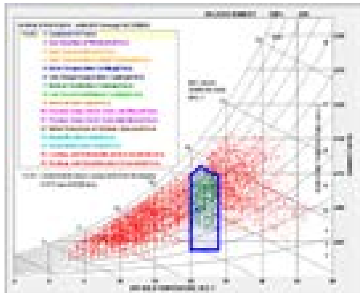
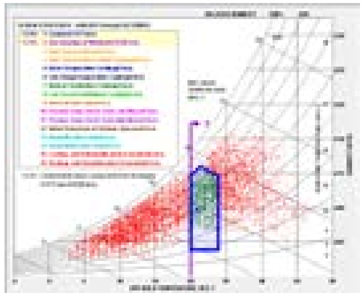


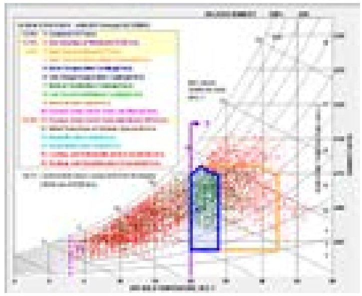
Image 3.13. Climate Consultant. (2022). Ground Temperature for Athens, Greece [Chart].



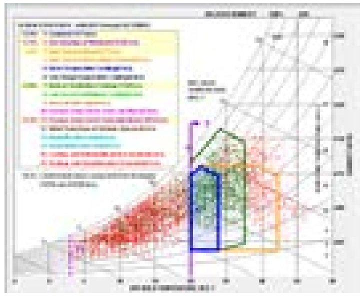
3.14a.



3.14b.



3.14c.



3.14d.

[5] The Psychrometric Chart is a representation of comfortable hours (dots) in a closed space, in relevance to the dry bulb temperature (axis x) and the humidity ratio (axis y) of the environment, in a defined location. The curved lines in between the two axis are the relative humidity, which is the present moisture until the air reaches saturation (at 100% there is precipitation).

For this chart, the Climate Consultant 6.0, by the University of California, is used. The latitude, longitude and elevation of the location of the “Prosfygika” of Alexandra’s avenue have been imported. Nevertheless, it is not an accurate representation of the exact building performance, is rather a generalization of how any building in the area could react in the specific climate. Thus it is only seen as a starting point.

There are some hours, when the temperature is between 20 and 24oC and the relative humidity is 20-80%, that the occupant can adapt to an indoor comfort zone, by just wearing the appropriate, according to the weather, clothing.

The windows of the “Prosfygika” are placed on the inner side of a 60cm thick wall. That is enough to provide sun shading during the summer, when the sun is right. However, in the chart, the comfortable hours related to the windows sun shading are not visible, because they overlap with already comfortable hours.

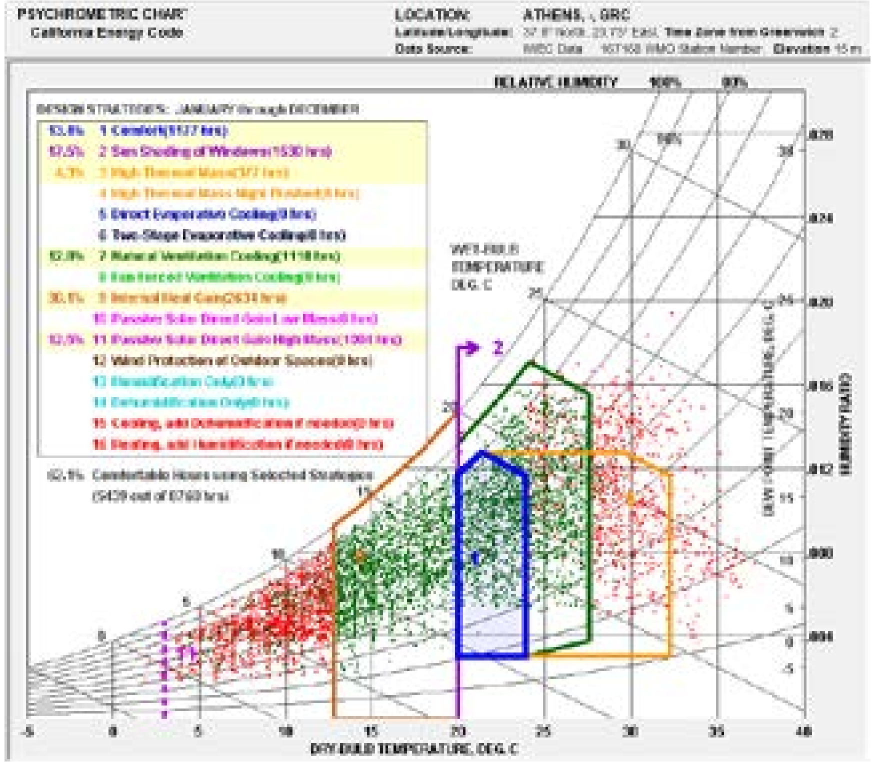


Image 3.14. Climate Consultant. (2021). Psychrometric Chart for existing situation of “Prosfygika”, Athens, Greece [Chart].

The high thermal mass of the 60cm thick limestone wall provides some extra 1088 hours of indoor comfort, by absorbing, storing and releasing the solar heat, throughout the year. The reason why all the dots in the designated areas did not turn green is because some of the hours represent overcast days or nigh hours when there is no sun.

Natural ventilation achieved due to the openings on two sides (south and north) of the building can significantly reduce the cooling demands during the hot season.

Internal heat loads from people, lighting and other devices, can be harnessed by e.g. adding insulation to the building envelope. This can minimize the heating demands for temperatures between 13 and 20oC.

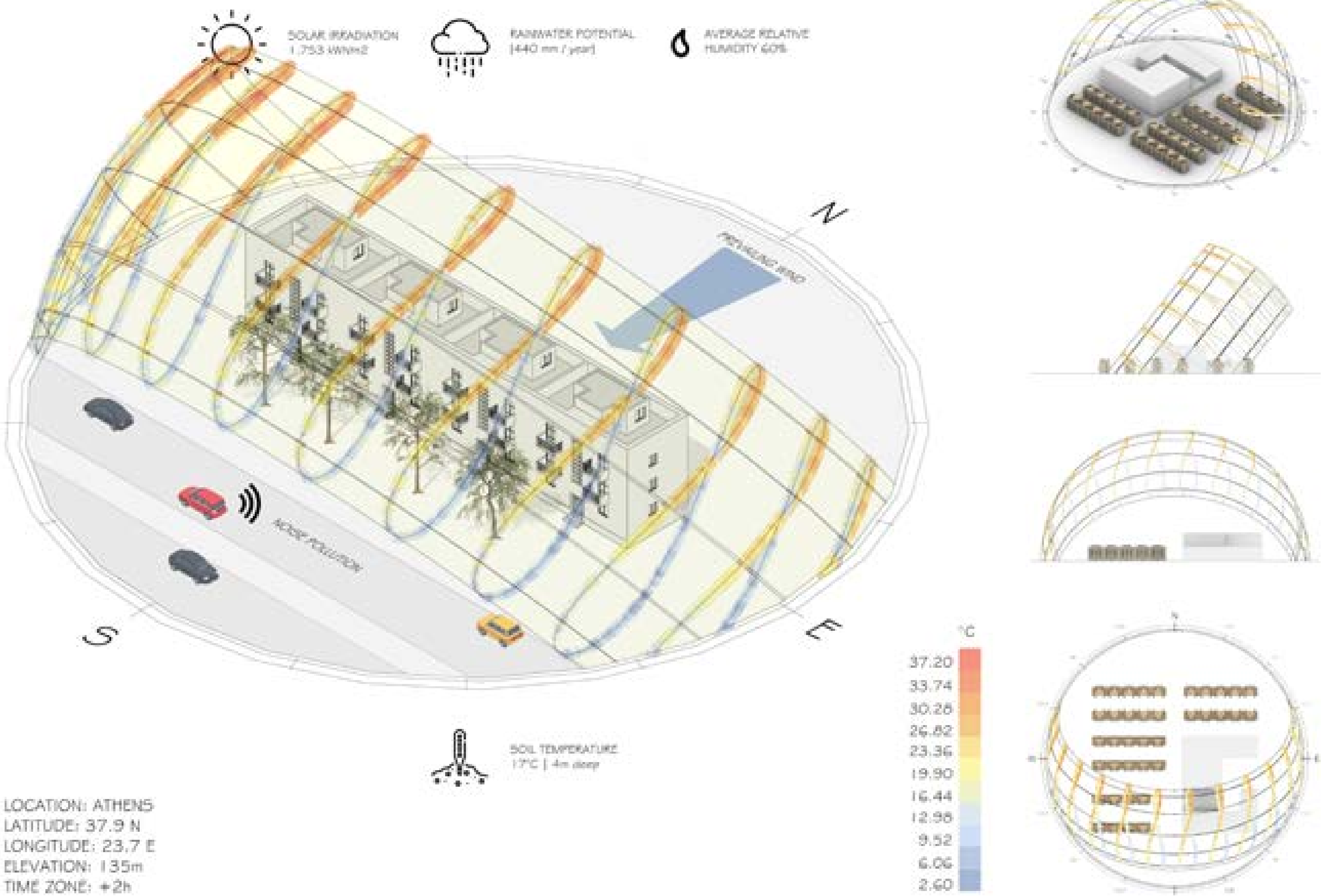


Image 3.15. Author (2022). Solar path and main local climate data representation - Current situation [Diagrams].

2. Reduce

The Reduce step refers to all the measures taken in order to decrease the heating and cooling related energy demands of the buildings. It mainly discuses passive actions like insulating the building envelope or harnessing the solar heat loads.

Existing characteristics that contribute in a passive solar design:

- The buildings are oriented facing the south. That allows them to make good use of the sun light and solar radiation.
- The deciduous trees, planted in front of the south facades, allow the low winter sun to enter the buildings, but block out the hot summer sun.
- Trees on the west minimize solar gains.
- The 60 cm thick, limestone, exterior walls have high thermal mass that contributes in regulating the indoor temperature, by absorbing, storing and releasing heat.
- Openings in, at least, two sides (south and north), in combination with a long narrow building floorplan maximize cross natural ventilation. Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes.

Actions taken for reducing the energy demand.

- Replacement of old, timber, single glazed windows (U-value=5.0 W/m2K) with new, double, high performance ones (U-value=0.9 W/m2K). Low-E for west, east and north façade, but clear on south for maximum passive solar gain. The design of the windows needs to be the same, since it is a listed building.
- For the west, east and north façade insulation is needed.
    - One solution is to add interior insulation. This way, the facades can remain untouched. On the other hand, the usable floor area is decreased and the works inside the building would probably require the temporary removal of the residents.
    - Another solution, a more preferable one, is to remove the damaged plaster and replace it with an exterior façade insulation. This way the disturbance of the occupants is less, the floor area remains the same and on the outside the facades will have a clean look, similar to when they were built. For this, EPS (Expanded Polystyrene) insulation boards can be used. They have excellent dimensional stability, compressive strength and water resistance. They are 100% recyclable and may also contain recycled materials. The total U-value of the wall will then drop from 1.5 to 0.5 W/m2K.
    - Additionally to the new insulation applied, on the west façade, colored PV panels for energy generation can be placed.
- Low vegetation is added on the roof tops, the benefits of which are multiple:

	U-value [W/m2K]	
Building Element	Before	After
Walls	1.5	0.5
Windows	5.0	0.9
Roof	0.8	0.3
Floors	0.8	0.8

Table 3.3. Author (2022). U-values of main building envelope's elements before and after renovatio.

- It insulates the roof (U-value=0.3 W/m2K).
- It adds up area for food growth.
- It can be part of a circular water management that purifies and reuses grey water.

- For the south façade other type of measures are required in order to preserve the image of the elevation and provide an adequate energy performance.

  - Vegetation: The most passive action is to add deciduous trees or vegetation in front of the south façade, allowing the low winter sun to enter the building and blocking out the hot summer sun. This can be achieved by either planting more trees or by building a green façade in front of the existing one.
  - Greenhouse: An attached to the south façade greenhouse can provide a protected passage for the visitors, while it protects and preserves the existing façade. It can also enhance the wall's high thermal mass performance, during the winter, by naturally preheating the air in between. In summer, with openable windows on the top, it can operate as a heat exhaust for the hot air trapped in the building. A given angle or an overhang is need to prevent from extensive solar gains in the hot season. Semi-transparent PV modules can be integrated in the top and front parts of the greenhouse. Additionally, this intermediate buffer zone can significantly reduce noise pollution from the traffic in Alexandra's Avenue.
  - Second skin façade: A second glass skin can be added in a small distance (approx. 40cm) from the existing south façade, turning that external wall into a Trombe-wall. In the winter the air is preheated in the cavity, absorbed by the limestone wall and released to the interior. In the summer, small openings on the top and bottom of its floor, allow fresh air to enter the room (bottom) and heat to escape (top). An overhang or inclination is required in this case too. This skin can be combined with installation of colored PV panels on the upper part.
  - Solar chimney: Another suggestion is to use the staircases as a solar chimney shaft. A double glazed window with integrated semi-transparent PV modules is placed on the long staircase opening. The window surface is exposed to the winter sun in order to heat up the air inside. An overhang protects the glass from the high summer sun, and the staircase becomes a shaft for the heat to exhaust, through an openable window on the roof.

After applying the aforementioned passive measures in the ZED tool, the building's energy demand is reduced by 40%. The impact of the proposed passive measures is a 10-times decrease in the heating demand and 30% reduction of cooling. However, there is still the need to generate the remaining amount of energy on-site, through renewable energy sources.

Electricity Demand	kWh	Electricity Production	kWh
Heating	7,110	PV-Systems	0
Cooling	35,727	Wind Turbine	0
Ventilation	0	Other	0
Appliances	36,180		
DHW	45,547		
MRE	0		
Other	0		
Total	124,564	Total	0
Net energy use	124,564 kWh		

Table 3.4. Author (2022). Electricity demand after the passive measures [Calculations Results].

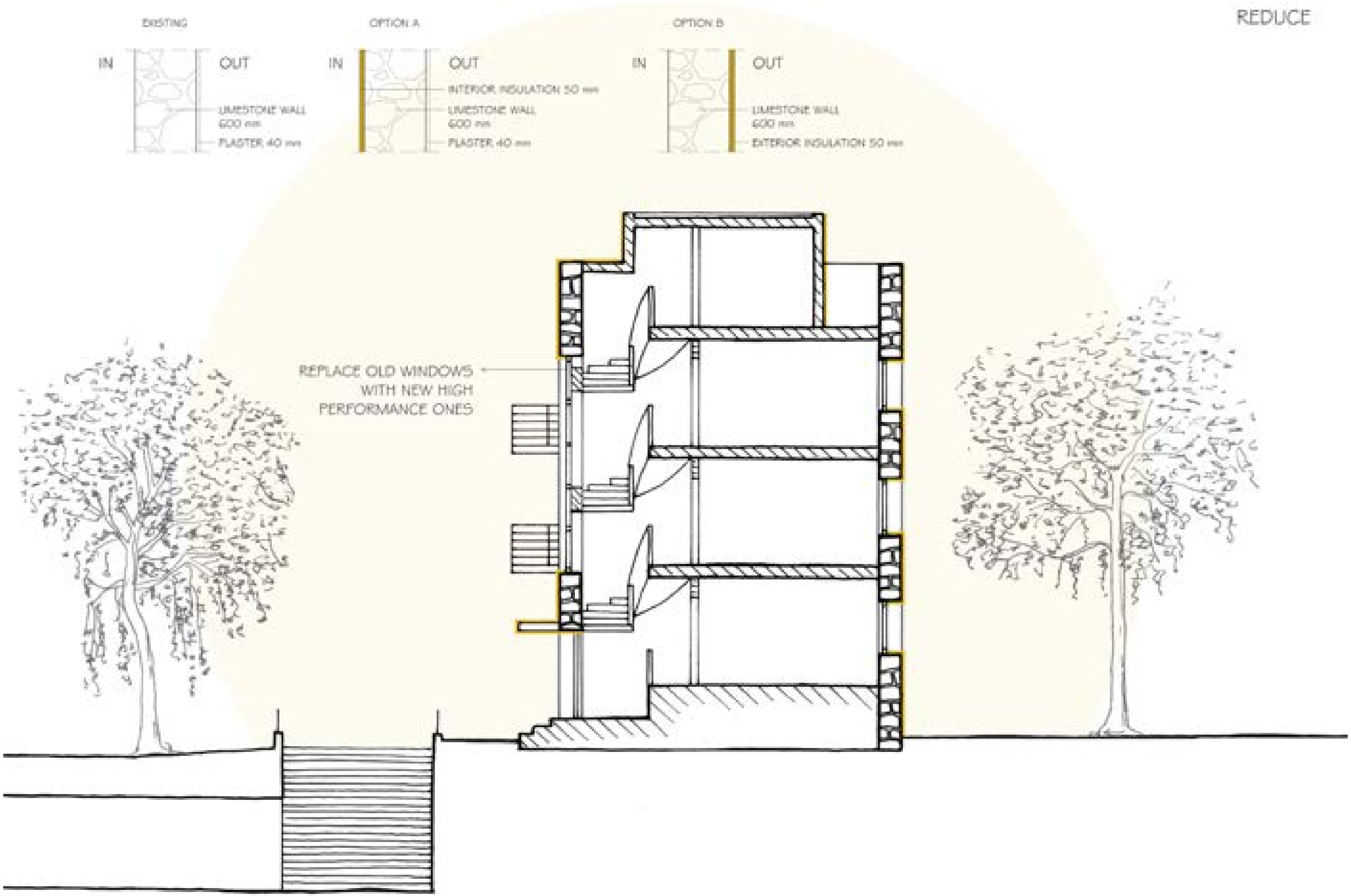


Image 3.16a. Author (2022). Section of the first building of Prosfygika - Reduce (windows & insulation) [Sketch].

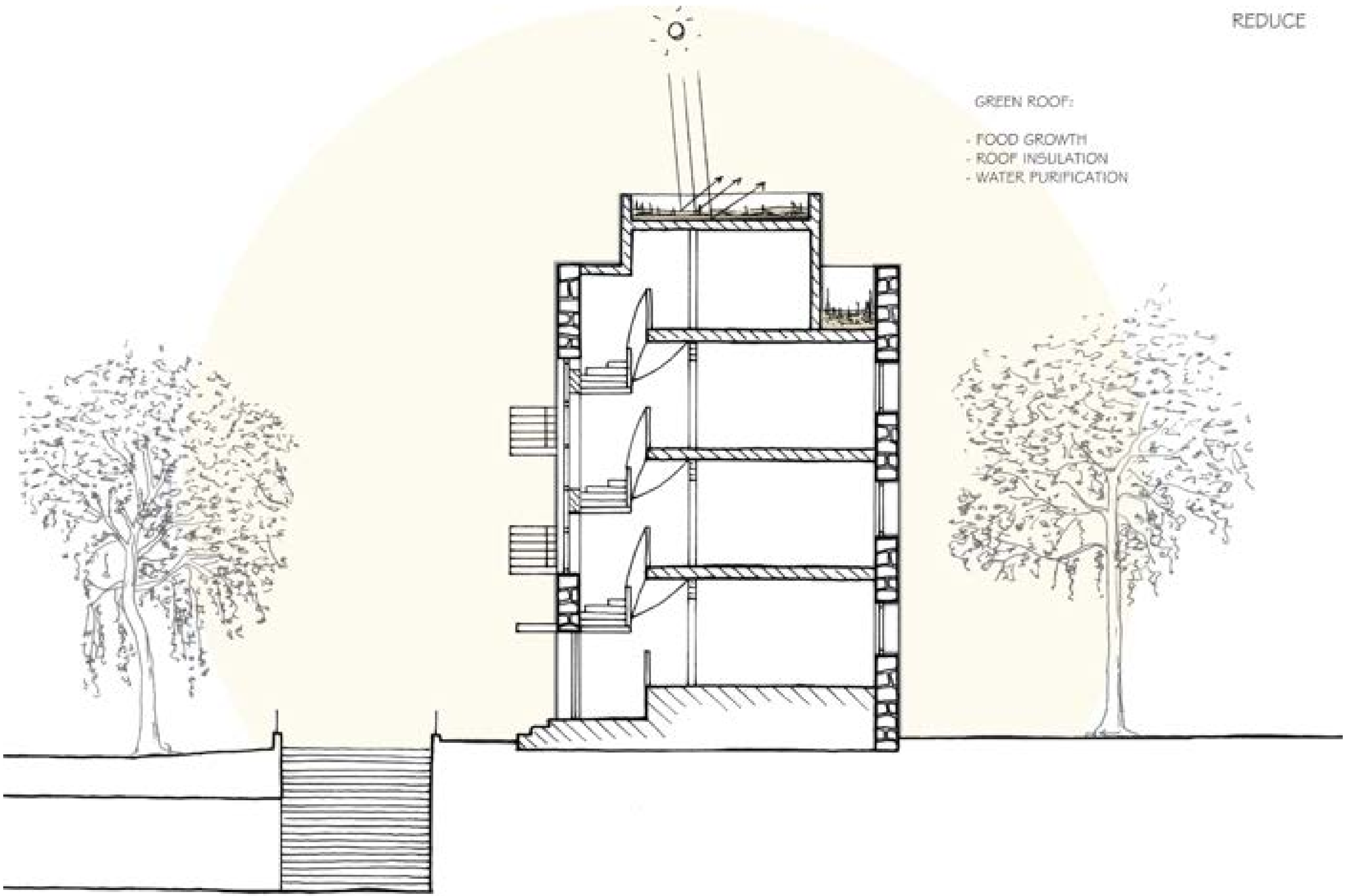


Image 3.16b. Author (2022). Section of the first building of Prosfygika - Reduce (green roof) [Sketch].

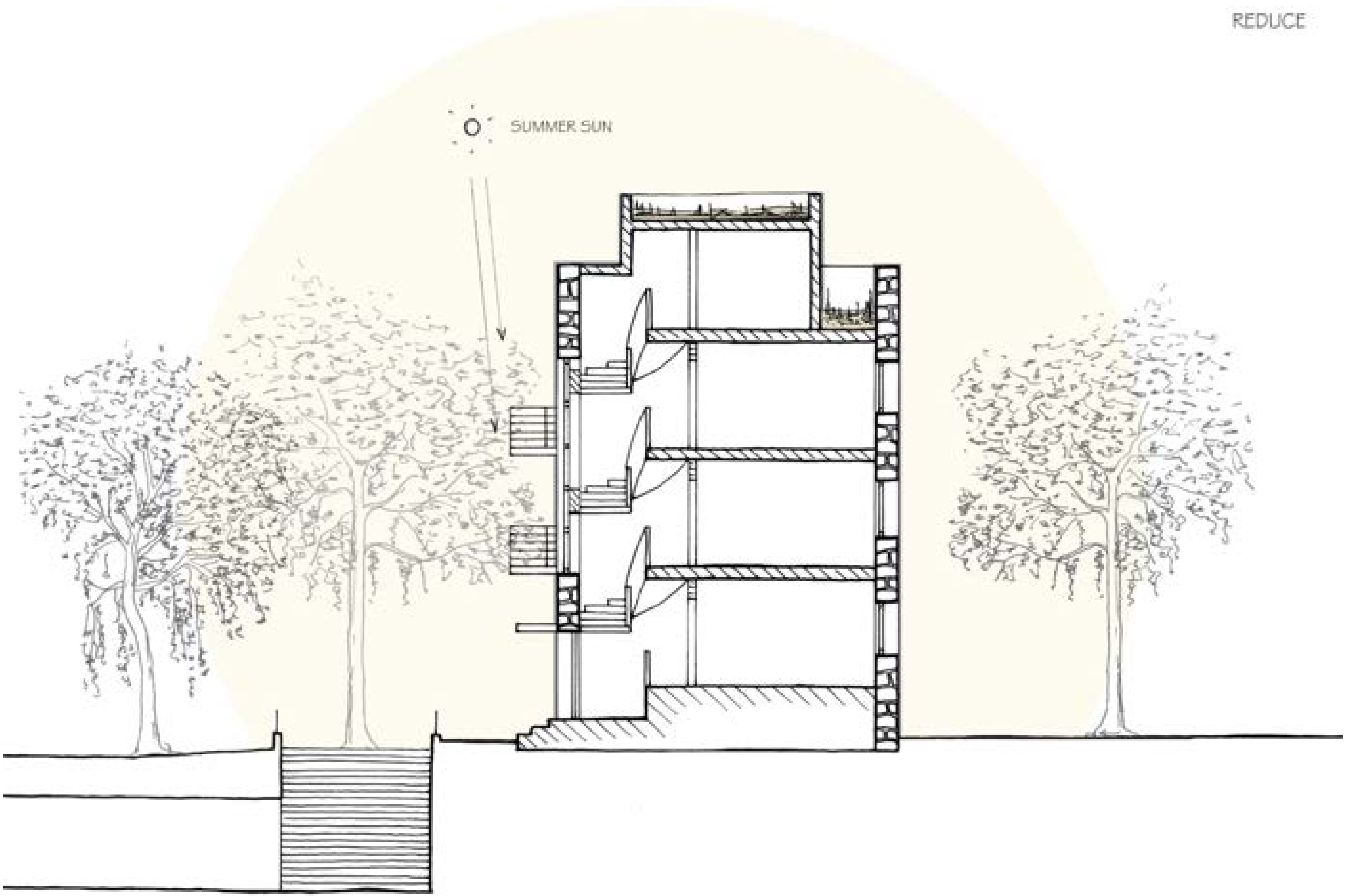


Image 3.16c. Author (2022). Section of the first building of Prosfygika - Reduce (green facade) [Sketch].

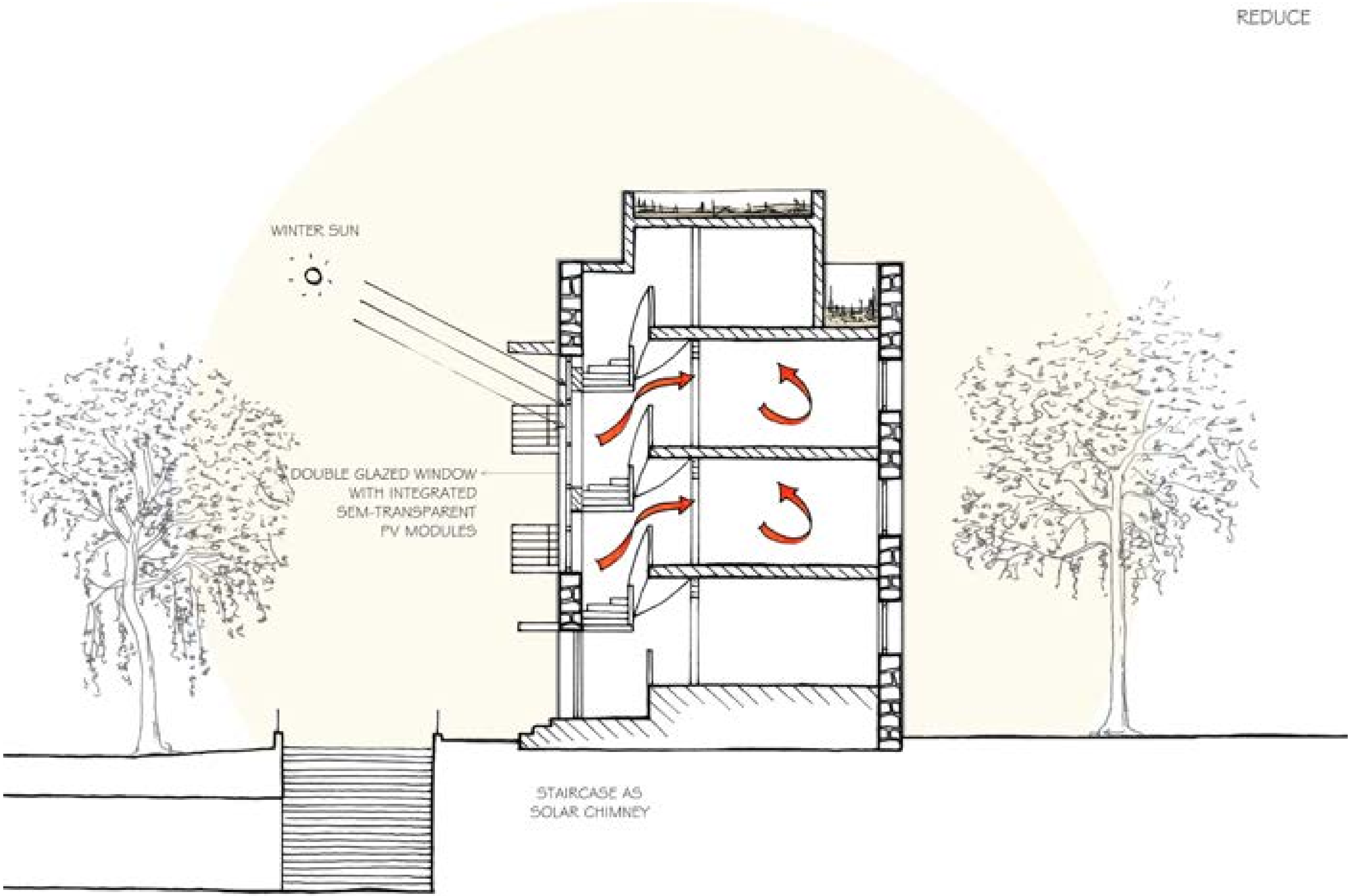


Image 3.16d. Author (2022). Section of the first building of Prosfygika - Reduce (solar chimney, winter) [Sketch].

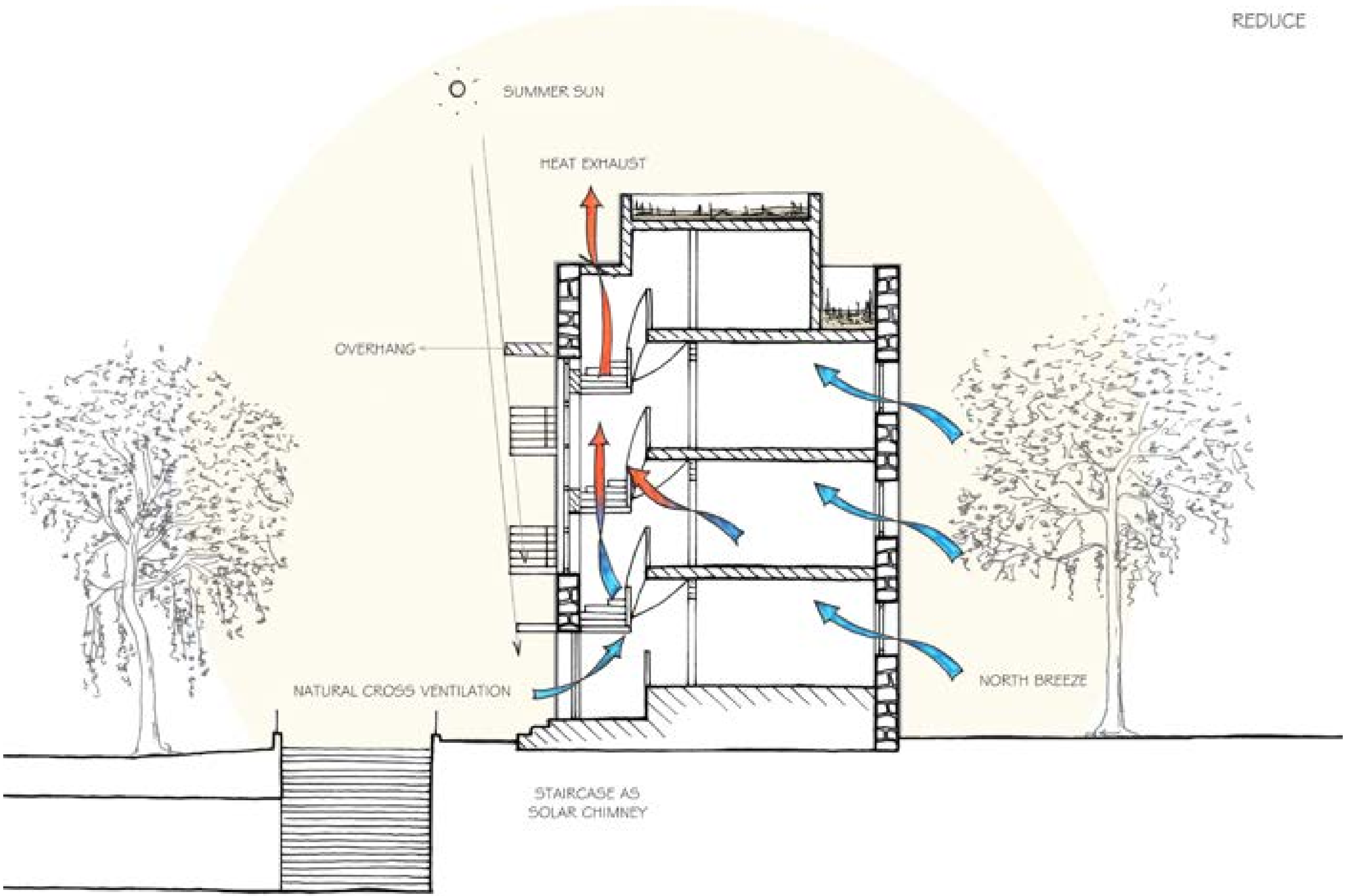


Image 3.16e. Author (2022). Section of the first building of Prosfygika - Reduce (solar chimney, summer) [Sketch].

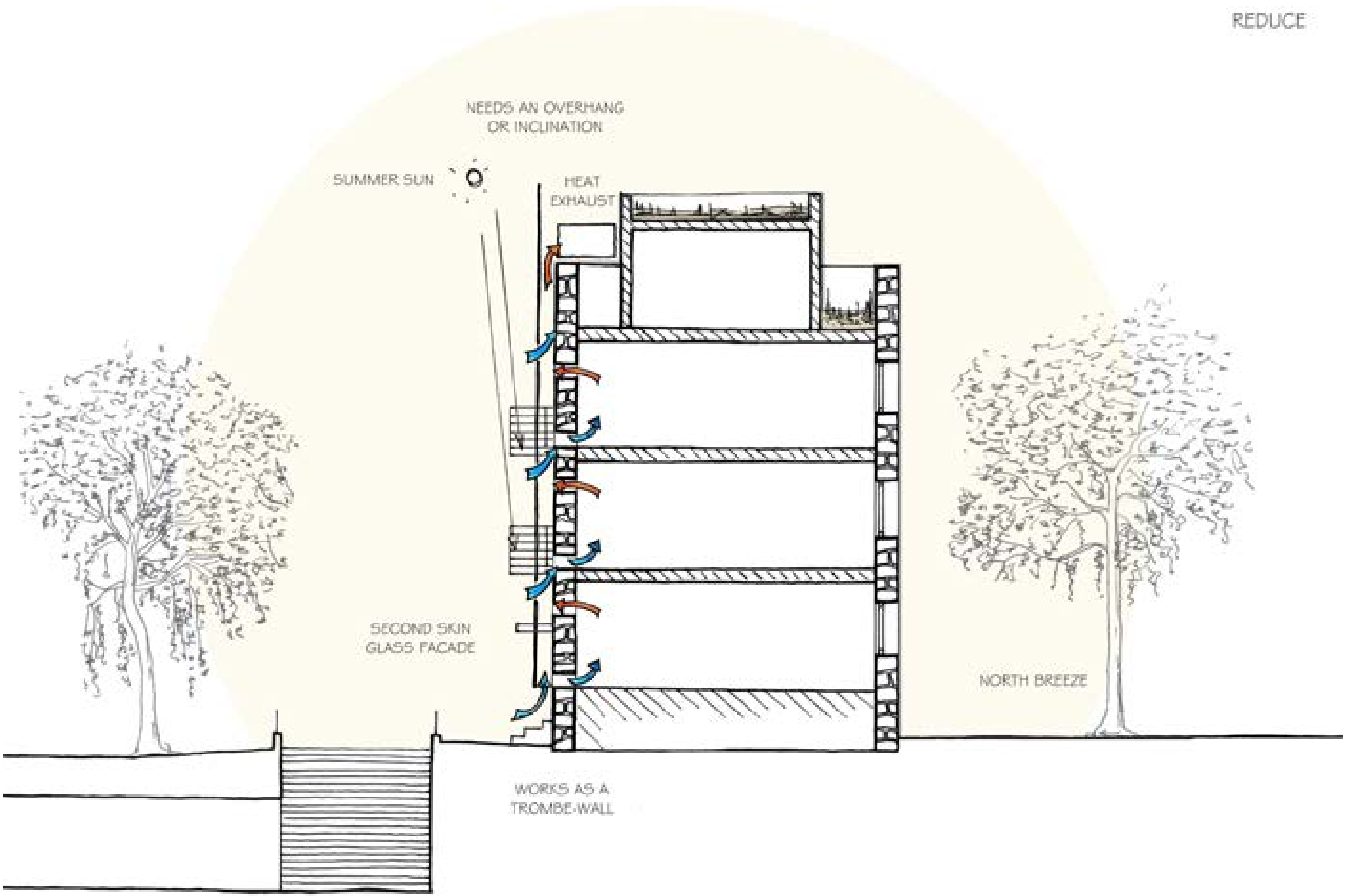


Image 3.16f. Author (2022). Section of the first building of Prosfygika - Reduce (second skin facade, summer) [Sketch].

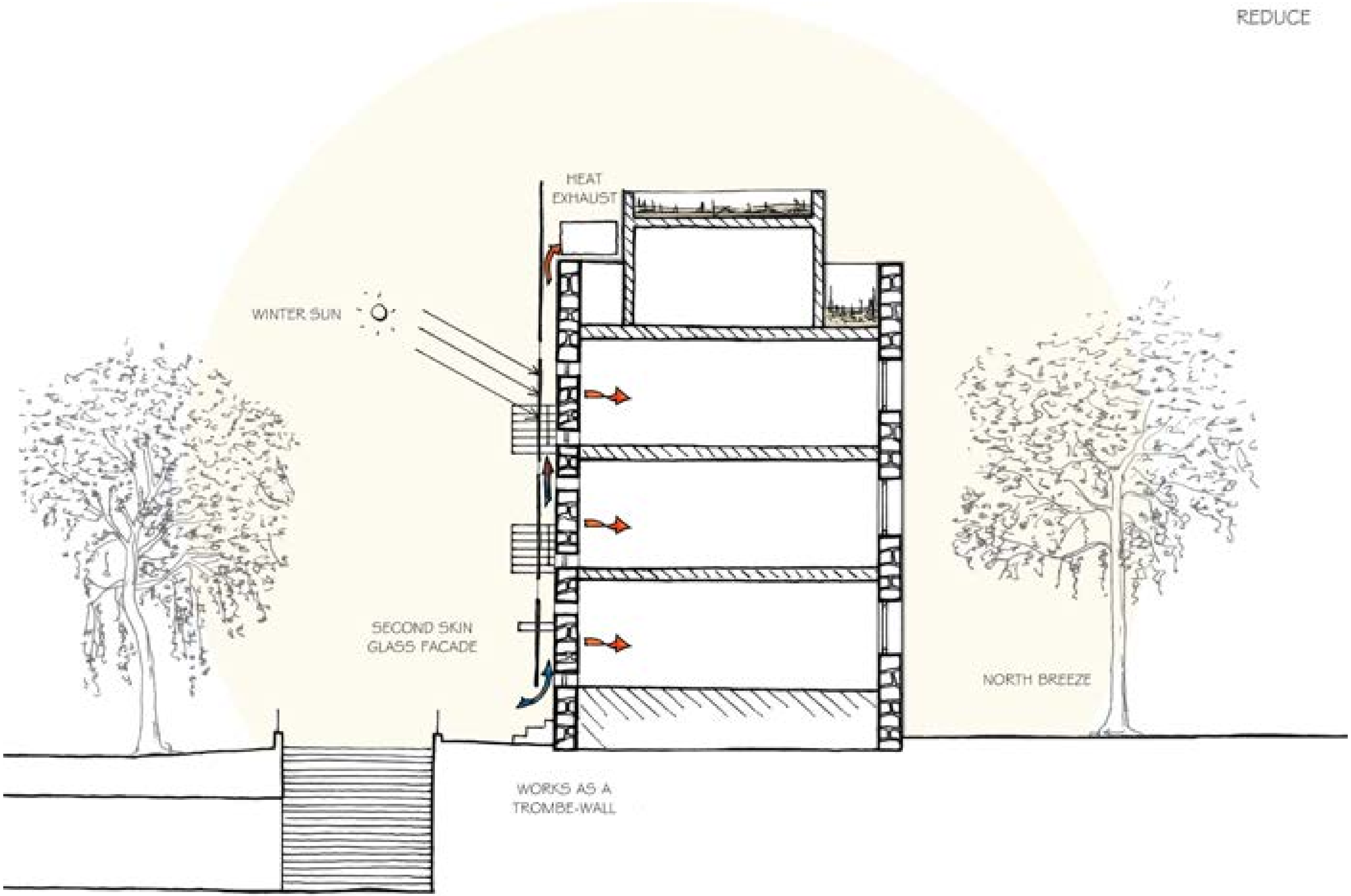


Image 3.16g. Author (2022). Section of the first building of Prosfygika - Reduce (second skin facade, winter) [Sketch].

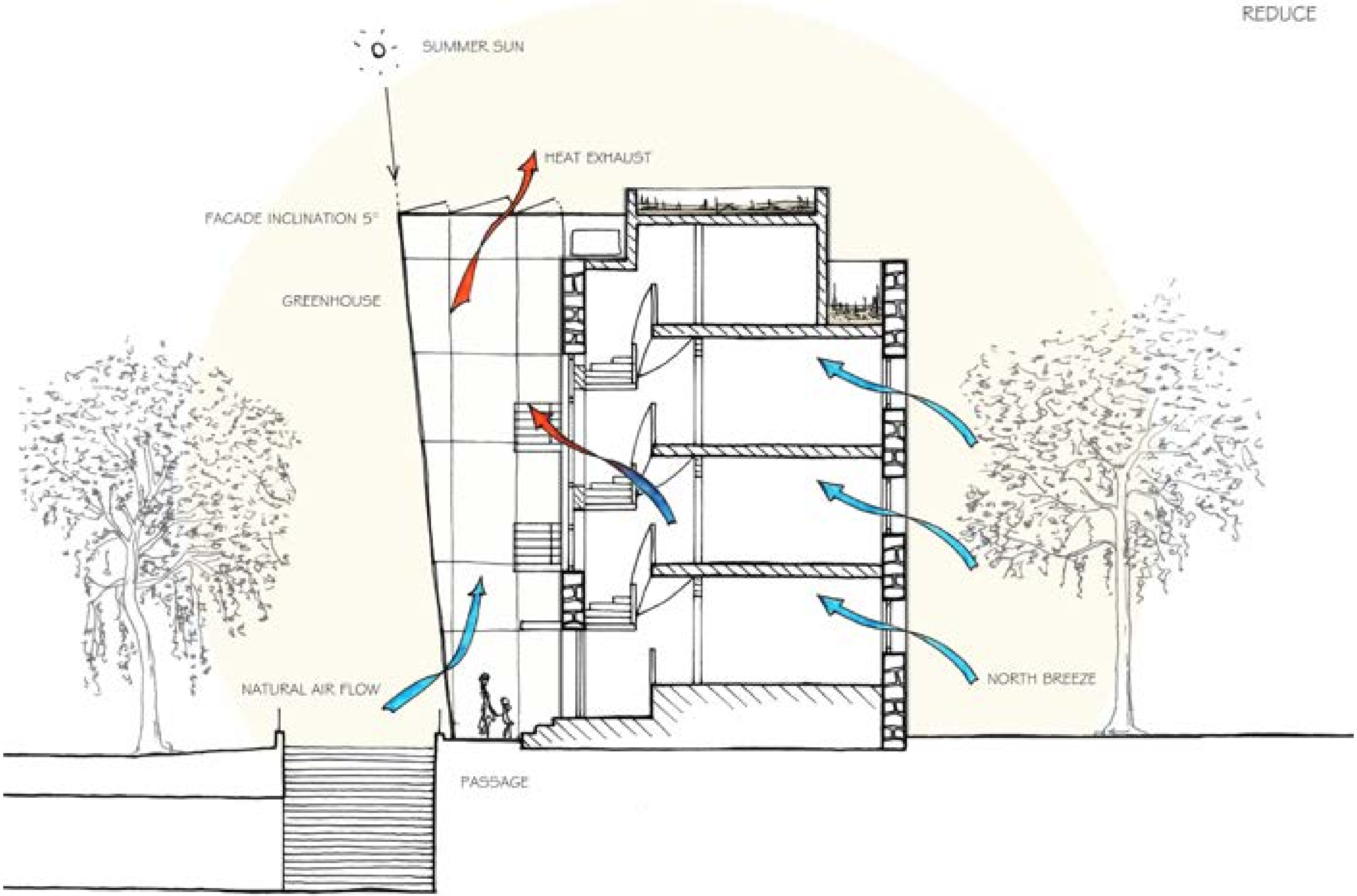


Image 3.16h. Author (2022). Section of the first building of Prosfygika - Reduce (greenhouse, summer) [Sketch].

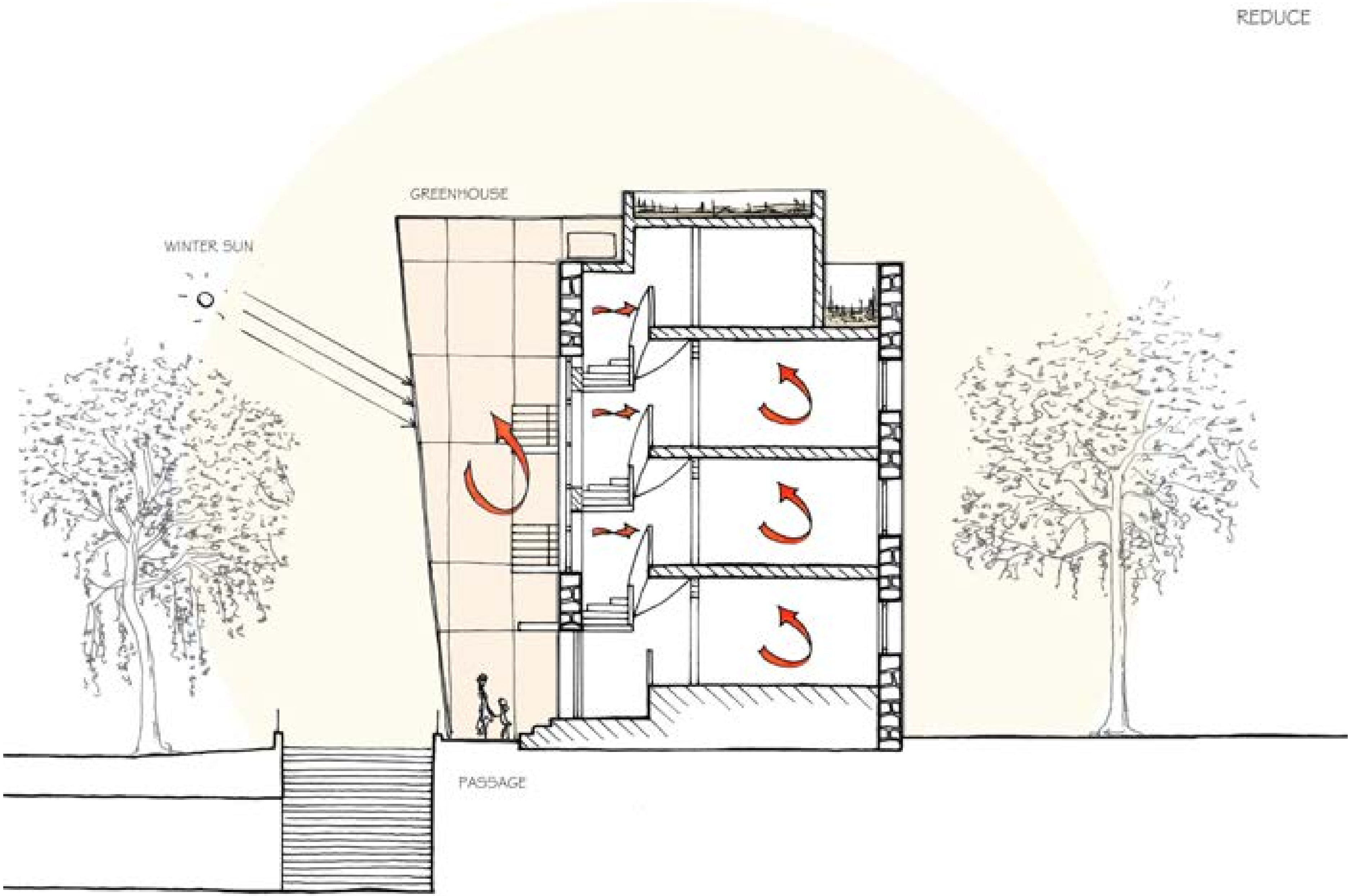


Image 3.16i. Author (2022). Section of the first building of Prosfygika - Reduce (greenhouse, winter) [Sketch].

3. Reuse

The “Reuse” step, as the world implies, discusses the reuse of natural resources, waste materials and other possibly usable flows, in order to close the energy loops.

Reuse measures:

- Water management: the waste water from the kitchen sinks and the showers can be collected, purified and then used to water the plants on the roof and around the building. The excess water, from heavy rainfalls, can be collected in water tanks and saved to flush the toilets, a service that currently consumes potable water.
- Organic waste management: food waste and human effluent can be collected and processed in an anerobic digestion. The main result of the digestion is biogas, that can be used for generating electricity. Whereas, a by-product digestion waste can be utilized as fertilizer for the greenery.
- Ground ducts: Ground ducts are the most suitable, sustainable mean of heating and cooling for the region of Athens. The soil has a stable temperature of 17oC, while the outdoor air temperature fluctuates between an average of 10 and 34oC. Additionally, an air to air heat pump can enhance the result of the outlet air, with a relatively small electricity demand.
    - During the winter the air travels through the ground ducts (about 4m depth). Because of the temperature difference, between air and soil, the air temperature rises. The heat pump further increases the temperature. The warm air travels through a mechanical ventilation system to reach every room.
    - During the summer the warm outdoor air travels through the ground ducts. Air humidification might be needed for the hot, dry days, to make the indoor environment more pleasant. Because of the temperature difference the air temperature drops. The heat pump further decreases the temperature. The air travels through a mechanical ventilation system to cool down every room.
- Natural ventilation and solar gains: The suggestions mentioned above for the south façade, all enhance the natural air flow in the building and correspondingly harness or avoid solar loads. Additionally, A heat collector can be installed on the upper part of each installation in order to catch the exhausted heat and reuse it as an inlet air for heating.

The reuse of organic waste as biogas results in generation of carbon neutral energy. Three tonnes of total organic waste are considered as the yearly average for the building. Processed in a moderate digester, a total amount of 7.200 produced kWh is assumed. One third is useable electricity, while the rest turns into heat, that can also be used for heating applications. Nevertheless, this depends on waste quality, digester design and proper operation of the system.

Electricity Demand	kWh	Electricity Production	kWh
Heating	7,110	PV-Systems	0
Cooling	35,727	Wind Turbine	0
Ventilation	0	Biogas	7,200
Appliances	36,180		
DHW	45,547		
MRE	0		
Other	0		
Total	124,564	Total	0

Net energy use 117,364 kWh

Table 3.5. Author (2022). Electricity demand and production after the reduce and reuse measures [Calculations Results].

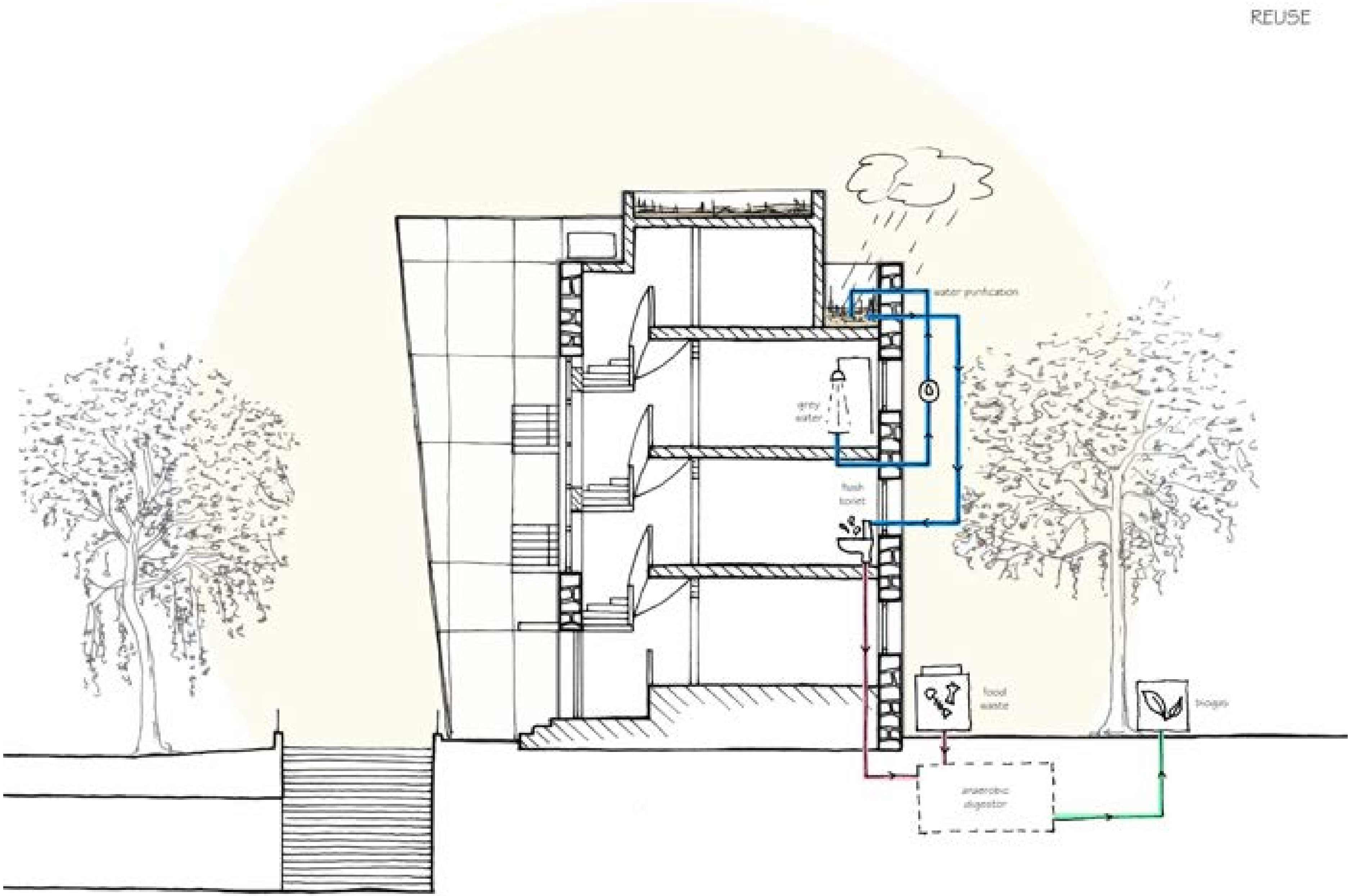


Image 3.17. Author (2022). Section of the first building of Prosfygika - Reuse (water & waste management) [Sketch].

4. Produce

Heating, cooling, cooking and domestic hot water will be achieved with electrified systems, so as to eliminated the use of fossil fuels. That will increase the electricity demands. To cover up the remaining energy demand, on-site electricity generation from renewable or sustainable sources is required, as much as possible.

Produce measures taken:

- PV modules installed on the roofs, facades and new envelope elements (see proposals for south façade) can generated electricity.
- PV-T modules installed on the rooftops can be used for electricity generation, as well as domestic hot water (DHW) production.
- Organic waste can be collected and used to produce biogas, that can then generate electricity, to support the operating appliances and the heat pumps.

More information can be found on the “Systems” section of step 5 – Integrate.

The addition of the greenhouse in the calculations of the ZED tool shows a significant reduction in the heating demand. Additionally, the proposed active measures for energy generation can not only produce enough energy to cover the building’s consumption requirements, but additionally create a surplus of energy, of more than 24.000 kWh per year. This energy excess can be either used for mobility reasons (electric bikes, scooters or cars), returned to the grid, saved in batteries for later use, or exchanged for financial reasons.

The tables and diagrams in the next pages present the results in more detail.

Electricity Demand	kWh	Electricity Production	kWh
Heating	3,782	PV-Systems	129.939
Cooling	35,727	Wind Turbine	0
Ventilation	3,810	Biogas	7,200
Appliances	24,180		
DHW	45,547		
MRE	0		
Other	0		
Total	113,046	Total	137,139

Net energy use	-24,093	kWh

Table 3.6. Author (2022). Electricity demand and production after applying the steeped approach [Calculations Results].

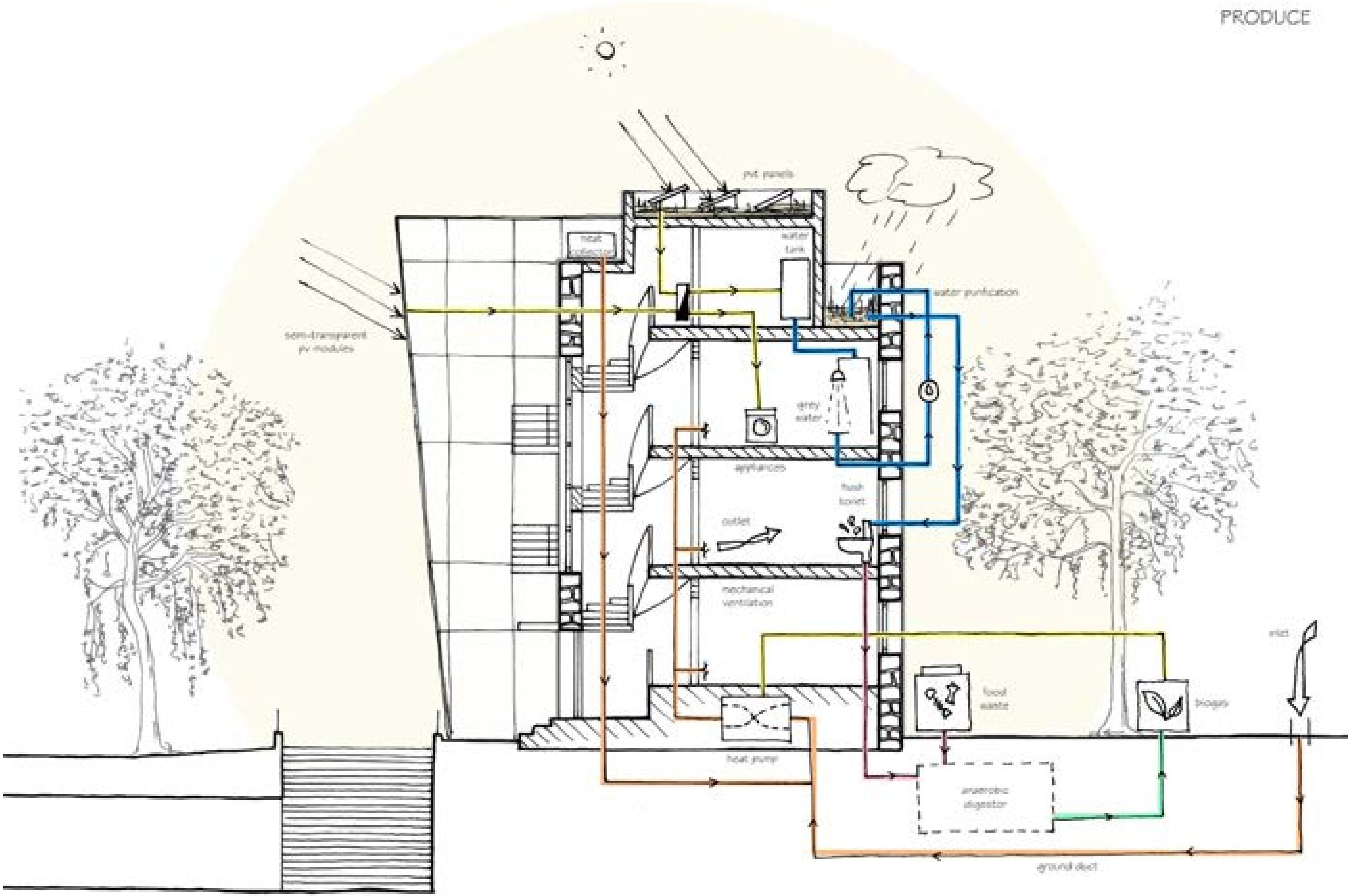


Image 3.18. Author (2022). Section of the first building of Prosfygika - Produce (biogas, PV systems, heating & cooling system) [Sketch].

	Heating	Cooling	Ventilation	Lighting & appliances	DHW	Total electricity demand	PV Panels	Biogas	Total electricity production
jan	782	0	318	2,015	4,270	7,384	3,644	600	4,244
feb	1,087	0	318	2,015	4,128	7,547	6,482	600	7,082
mar	0	163	318	2,015	3,843	6,339	11,499	600	12,099
apr	0	1,391	318	2,015	3,701	7,424	13,267	600	13,867
may	0	3,958	318	2,015	3,558	9,849	18,090	600	18,690
jun	0	6,206	318	2,015	3,416	11,954	17,397	600	17,997
jul	0	7,286	318	2,015	3,416	13,034	18,379	600	18,979
aug	0	7,815	318	2,015	3,558	13,706	15,931	600	16,531
sep	0	5,182	318	2,015	3,701	11,216	11,197	600	11,797
oct	0	3,206	318	2,015	3,843	9,382	7,214	600	7,814
nov	0	519	318	2,015	3,985	6,837	4,254	600	4,854
dec	1,913	0	318	2,015	4,128	8,373	2,586	600	3,186
year	3,782	35,727	3,810	24,180	45,547	113,046	129,939	7,200	137,139

Table 3.7. Author (2022). Total electricity demand and production by month [Calculations Results].

	Building related (excl. appliences)		
	Electricity demand from grid	Electricity autonomy	
jan	3,140	4,244	57%
feb	465	7,082	94%
mar	-5,760	6,339	100%
apr	-6,442	7,424	100%
may	-8,841	9,849	100%
jun	-6,042	11,954	100%
jul	-5,945	13,034	100%
aug	-2,825	13,706	100%
sep	-582	11,216	100%
oct	1,568	7,814	83%
nov	1,984	4,854	71%
dec	5,188	3,186	38%
year	-24,093	100,702	89%

Table 3.8. Author (2022). Building related, excluding appliances, elecricity demand from the grid and electricity autonomy by month [Calculations Results].

	Total electricity incl. appliences		
	Computer & Equipment	Electricity demand from grid	
jan	3,968	7,108	60%
feb	3,467	3,933	180%
mar	3,666	-2,094	-303%
apr	3,801	-2,641	-281%
may	3,968	-4,872	-202%
jun	3,499	-2,543	-470%
jul	3,968	-1,976	-660%
aug	3,817	992	1381%
sep	3,650	3,069	365%
oct	3,968	5,536	141%
nov	3,650	5,634	86%
dec	3,817	9,005	35%
year	45,244	21,151	476%

Table 3.9. Author (2022). Building related, including appliances, elecricity demand from the grid and electricity autonomy by month [Calculations Results].

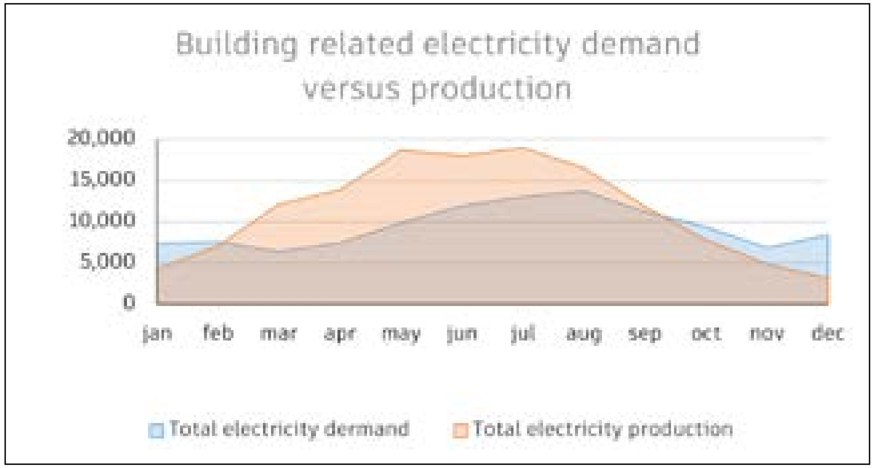


Table 3.10. Author (2022). Building related electricity demand vs production [Chart].

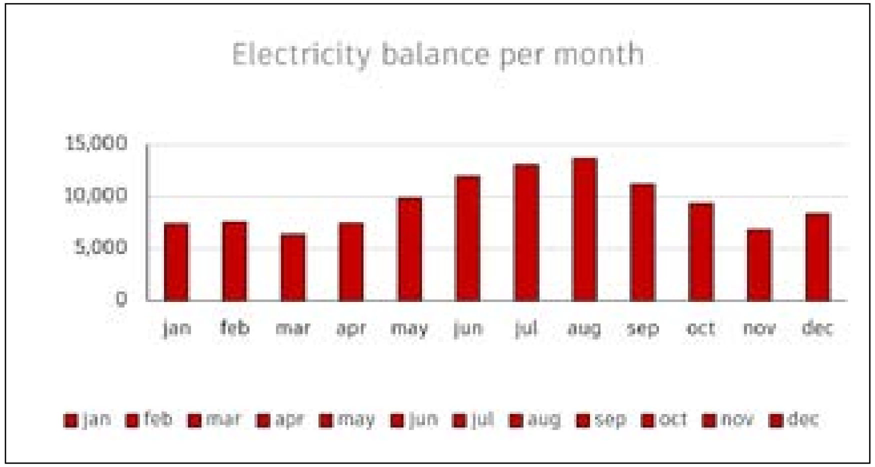


Table 3.11. Author (2022). Electricity balance per month [Chart].

The surplus energy produced during the months of March to August can be stored in batteries in order to be used from September to February.

5. Integrate

In this step, the goal is to select the most suitable measures from the ones described before, in order to develop a complete, unified design. The selected actions concern the front building, which borders with Alexandra's Avenue. This is the most important one in terms of heritage, for 3 reasons: a) it is the most exposed one to the public, b) it has suffered more damages during the civil war, and c) its south façade need to be preserved as it currently is. Thus, more restrictions are applied in its retrofit, regarding the interaction of the new interventions with the listed façade.

The building envelope offers multiple opportunities for refurbishment of all the components where heat losses occur. In table 3.12., the envelope's refurbishment matrix, the multiple options of measures, considered for this case study for the skin retrofit are briefly presented. The measures are listed from the less (top) to the most (bottom) efficient ones. The most efficient actions are supposed to also be the most expensive ones. Highlighted are the ones that were at the end selected.

Since the south façade is the most important element of the building, the arguments of the selection progress are also presented (Table 3.13.). The table elaborates on the advantages and disadvantages of the different retrofitting options for the south façade, regarding the heritage preservation and the energy performance. In terms of heritage, it is examined if the proposed solution protects the existing façade from weather conditions and other exogenous factors that can cause wear, if it allows visual contact with the old façade through, or not, a glass, and in what degree it affects the initial façade design and preserves its architectural value. In terms of energy, the degree of contribution to the reduction of energy demands for heating and cooling and to the production of energy required for all the systems' operation, is examined.

Based on these aspects, the addition of a greenhouse attached to the south façade is the selected measure, that forms a main element of the renovation.

The greenhouse enhances the thermal performance of the limestone wall. During the winter, the sun light enters the intermediate space and the air temperature rises. The high thermal mass of the limestone wall absorbs the heat, stores it, and later releases it inside the building. During the summer, air of lower temperature enters the greenhouse from the ground floor level. The heat exhausts from the top through openable windows. Shading of the glass elements is essential to avoid space overheating from the sun. The long south façade of the greenhouse has an inclination of 5o in order to avoid direct incidence of the sun light. Additionally, semi-transparent PV modules are integrated on the top windows, so as to partially shade the building during the intermediate seasons when the sun is still high, but to also contribute in the on-site electricity generation. Furthermore, the glass roof of the greenhouse is covered with rotating, solar blinds. The blinds' angle of rotation is determined by the sun altitude. In this way, they can prevent from excessive heat and they also constantly have the most efficient inclination for the PVs.

The greenhouse actively protects the heritage façade from deteriorations caused by weather conditions or other external factors. It creates a covered path, from where the people passing by can have unhindered visual contact with the listed building. From the outside it offers a new, contemporary look that can turn the building into a landmark and arouse interest. In terms of energy performance, is one of the most efficient measures proposed, contributing in reducing the heating and cooling energy demands, but also in generating part of the remain required energy.

	Building Envelope					
	Exterior Wall (South)	Exterior Wall (Rest)	Window	Balcony	Roof	Ground Floor
Existing Construction	masonry wall / no insulation	masonry wall / no insulation	single glazing	separate slab / no insulation	concrete slab / no insulation	slab on ground / no insulation
Retrofitting Measures	vegetation	internal insulation	upgrade	insulate balcony	insulate top floor slab	insulation on top of ground floor slab
	solar chimney	external insulation	secondary glazing	cut-off balcony	green roof	insulation under ground floor slab
	second skin façade	-	replace (double pane)	new balcony	photovoltaic	additional floor / basement
	greenhouse	-	adjustable or fixed shading	-	top-up floor	-

Table 3.12. Author (2022). Building Envelope Retrofit Matrix | Inspired from "The façade refurbishment toolbox matrix", by Konstantinou T. (2015). [Matrix].

	Heritage			Enegy Performance		
Option	Preserves Facade	Allows Visual Contact	Preserves Design of Facade	Reduce	Produce	Total
Green Facade	+	+ +	+ + +	+ +	+	9
Solar Chimney	+ +	+ + +	+ + +	+	+ +	11
Second Skin Facade	+ + +	+ + +	+	+ + +	+ + +	13
Greenhouse	+ + +	+ + +	+ +	+ + +	+ + +	14

Table 3.13. Author (2022). Renovation options for South facade and selection criteria [Matrix].

External façade insulation is chosen for the north, west and east façade, and the balconies. Expanded Polystyrene boards offer a relatively sustainable and significantly efficient solution to improve indoor comfort, while reducing heating and cooling costs. Furthermore, EPS can revive the image of the building.

The rooftop is divided in 3 areas. The part covered from the greenhouse, needs to be insulated and paved and it can operated as a leisure, sheltered, outdoor space for common activities. The rest will be turned into a green roof. The green roof provides thermal insulation, space for food growth and plays an important role in the water cycle. Part of the green roof will by covered with PVT panels that provide domestic hot water and electricity.

By applying these design strategies we can achieve 100% of comfortable hours, all year long (Image 3.19.)

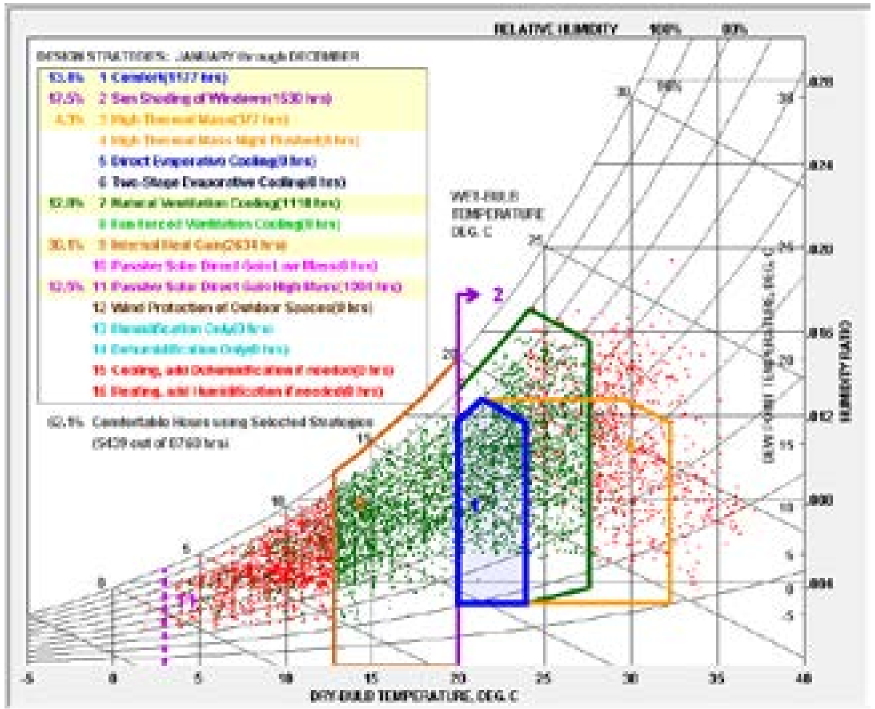


Image 3.19. Climate Consultant. (2021). Psychrometric Chart for “Prosfygika”, Athens, Greece, after the proposed renovation [Chart].

Image 3.20. Author (2022). Perspective section of the first building of Prosfygika - Proposal [Visualization].

Systems

In this section the systems used for the building's operation are described step by step.

PVT Panels: The PV Thermal panels on the roof absorb the solar heat and through a closed loop system, the heat is transferred to the water tank. The water tank is fed with fresh water from the city. The closed loop system contains anti-freeze fluid, which however does not get in touch with the fresh water. The hot water is transferred in a hot water tank, and from there it can be used for domestic reasons.

PV Panels: The PV modules of the PVT panels, the solar blinds and the semi-transparent ones in the glass panels of the greenhouse generate a flow of electricity. The charge controller regulates the amperage and voltage that is delivered to the loads and any excess power is delivered to the battery system. DC and AC (through an inverter) is then distributed for all the household appliances.

Water cycle and waste management: The waste water from the kitchen and bathroom sinks, the shower and the washing machines is purified and used to water the greenery on and around the building. The excess water from heavy rainfalls is collected in water tanks and used to flush the toilets. Human effluent from the toilets and food waste are processed in an anaerobic digestor. The main product of the digestion is biogas. However, by-products from the digestion waste are used as a fertilizer for the greenery.

Biogas: Biogas is converted to mechanical energy through an internal combustion engine. The mechanical energy rotates an electric generator which produces the electricity. The electricity is then used for the appliances. Alternatively, part of the produced biogas can be used as fuel.

Ground ducts: When heating or cooling is needed in the building, the outdoor air, fluctuating between an average of 10-34oC, travels through the ground ducts. The ducts are buried, approximately 4 meters, below the ground surface. The stable soil temperature of 17oC accordingly affects the air temperature. During the summer, some air humidification may be needed for the hot, dry days.

Heat Pump: An electric air to air heat pump further decreases or increases (depending the season) the air temperature. The outlet air travels then in the pipelines and it is released in the different spaces of the building through a mechanical ventilation system. The electricity required for the heat pump's operation is derived either form the PVs or from the biogas. Additionally, heat collectors, placed on the upper part of the greenhouse, collect the heat exhaust. The hot air is then transferred back to the heat pump to be reused.

All the plumbing systems are located into a shaft, that crosses all floors, and passes near the "wet" core (bathrooms and kitchen) of the building. The water tanks are placed in the auxiliary rooms of the roof. The waste collection and management is happening under the ground of the back yard.

The electrical installations pass through another shaft, closer to the circulation core. The central position of this shaft provides better air distribution via the ventilation ducts. The "wind catchers" for the ground ducts are placed on the north side of the building, facing the prevailing winds.

The location of the installations are shown in Imge 3.21, while Image 3.22 demonstrates the systems flow.

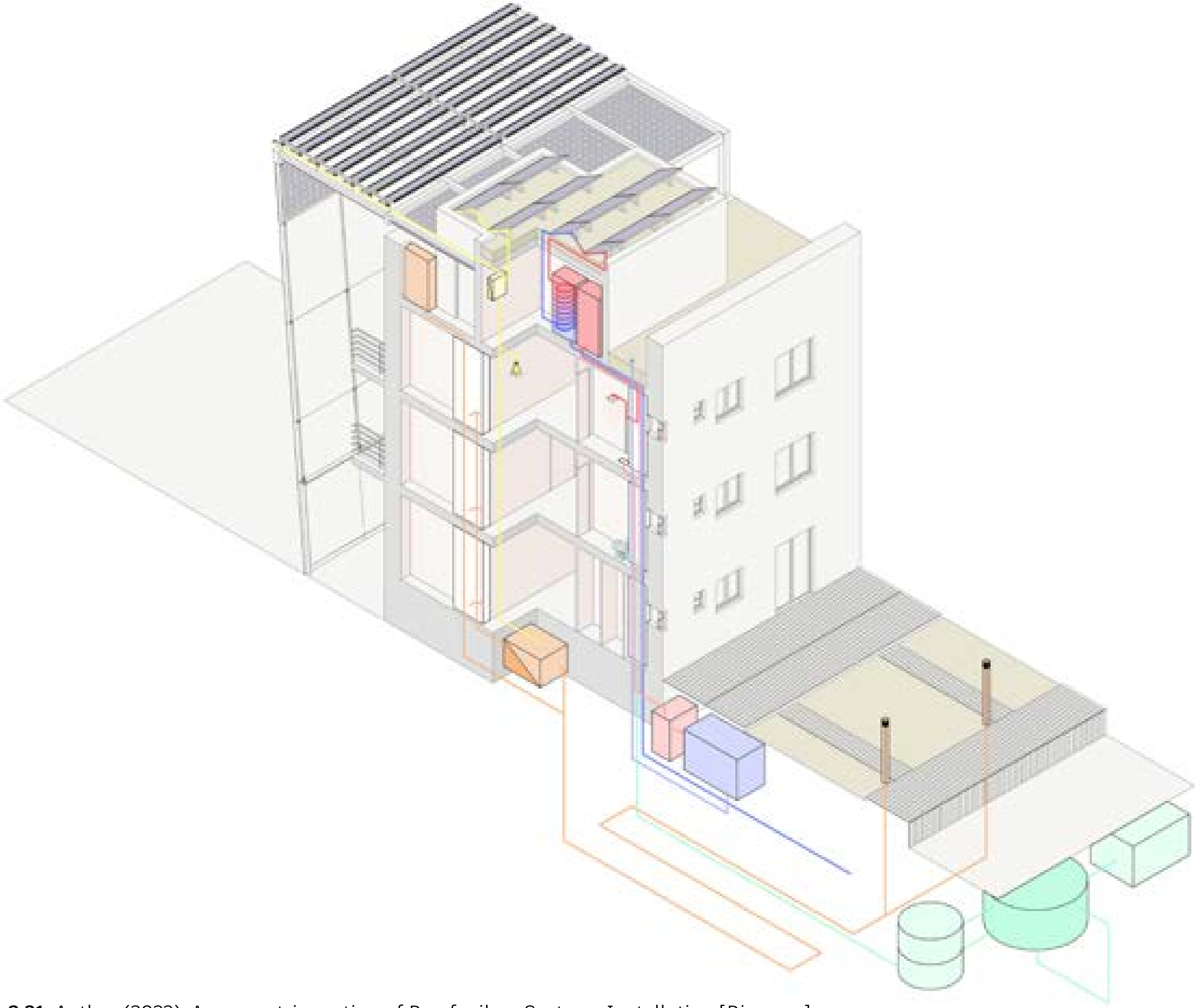


Image 3.21. Author (2022). Axonometric section of Prosfygika - Systems Installation [Diagram].

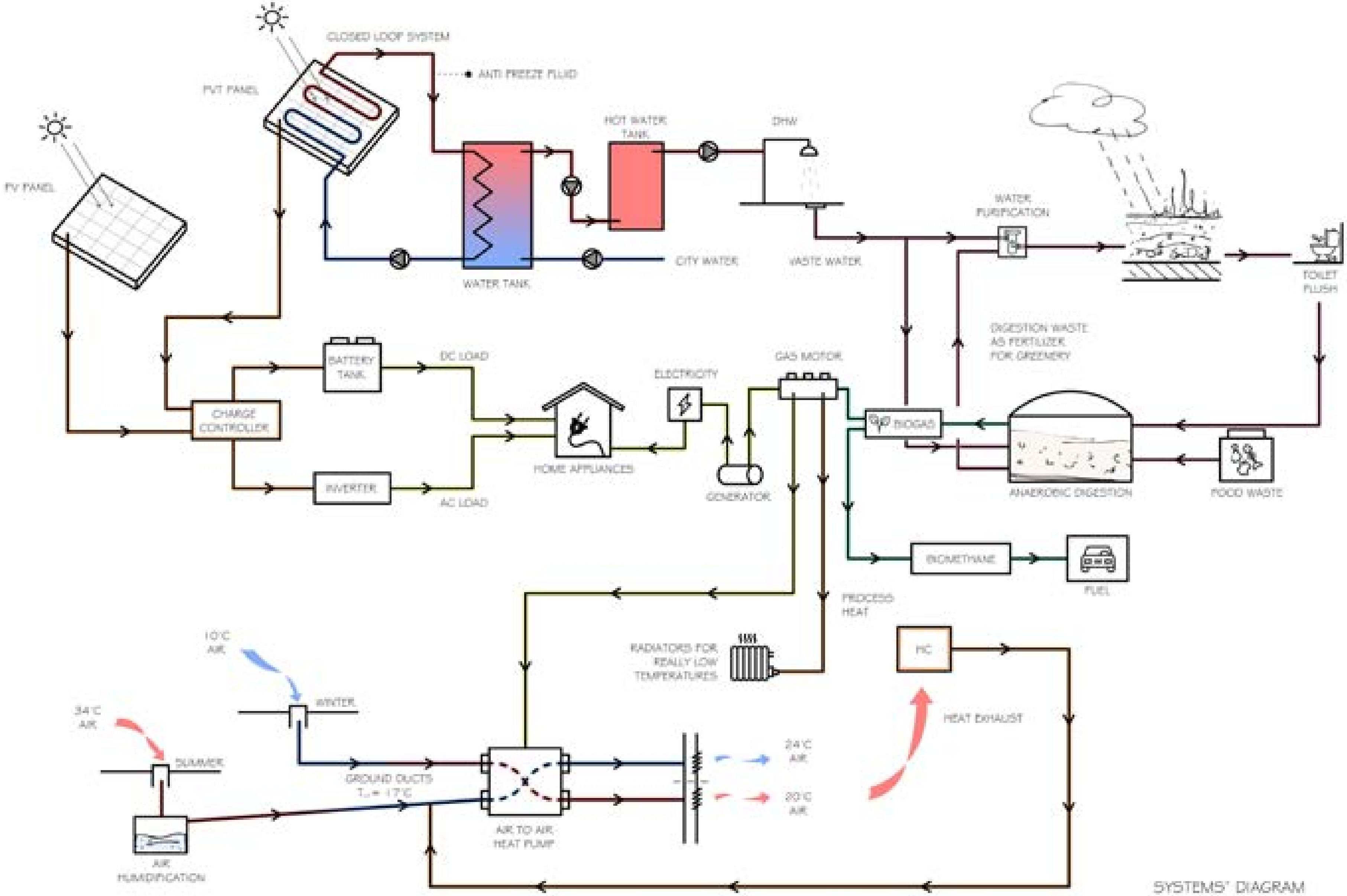


Image 3.22. Author (2022). Systems' Flow Diagram [Diagram].

Circular Adaptation

The building consists of 5 main elements:

- Exterior walls: 600 mm thick limestone walls, covered with 40 mm plaster
- Interior walls: 100 mm thick brick walls, plastered
- Floors: concrete slabs, without insulation
- Windows: timber frames with single glazing
- Balconies: concrete slabs, without insulation

However, the circular adaptation is processed by taking into consideration and by analyzing the building through the "Shearing Layers of Change", by Duffy and Brand.

Site

In the complex of "Prosfygika" only 33% of the plot area is built. That leaves the rest two thirds of the plot free for open, public, circulation and/or green spaces. However, the last decades, the once free, public space is being extensively occupied by parked cars. The removal of the cars will leave more space for vegetation, safe play zones, human interaction and will revive the neighborhood ambience of the old times.

The renovation is not only focusing on symbiotic relationships between humans in a neighborhood scale, but also between humans and the flora and fauna in their environment. By converting what is currently car occupied spaces into productive urban landscapes, it is possible to generate a microeconomy based on a collective urban farming system, that motivates healthy eating, sharing of goods and new occupations. Keeping in mind the international community living in the building, this activity promotes social inclusion, involves people to be responsible and improves the image of the overall

Image 3.23. Author (2022). Back yard [Visualization].

neighborhood. Moreover, it establishes a green sustainable intervention for the whole neighborhood.

Cutting out the car circulation though, requires a thorough urban planning study, in order to evenly distribute the traffic to other streets, and to find additional parking spaces. A previous study on the refurbishment of "Prosfygika" included the construction of an underground garage between the second and third building block. Nevertheless, this thesis is not focused on the urban planning of the area and further research hasn't been conducted.

Structure

The structural elements of the apartment blocks of "Prosfygika" have suffered minor damages during the years. Even after the big earthquakes, no damage have ever been reported. Thus only minor interventions need to be done, in order to reinforce the structure, keep up with the new, anti-seismic regulations and expand the buildings lifespan. However, this is not one of the research subjects of this thesis and will not be further analyzed.

Skin

The building envelope offers multiple opportunities for refurbishment of all the components where heat losses occur.

- Exterior walls

The most suitable measure for insulating the 60cm limestone walls is to first remove the damaged plaster and then add an external façade insulation, for the east, west and north side.

    - It is proven that the gypsum plaster waste (GPW) can be recycled continuously without significant changes in its composition, representing an elevated recycling potential. In addition, this practice prevents the contamination of the soil and the water, and it saves natural resources and landfill spaces, thus decreasing the negatives environmental impacts of natural gypsum plaster use (Geraldo et al., 2017).
    - The new exterior insulation system consists of EPS foam boards[6]. Expanded polystyrene is a cellular plastic material, composed of 98% air and 2% of a refinery by-product, naphtha, recently often made from renewable resources (biomass from organic or forestry waste). It is also 100% recyclable. It is, among other, an excellent thermal and thermo-acoustic insulator, water-repellent, lightweight, and retains all its properties over time. When applied EPS can improve indoor thermal comfort, reduce heat loss and heating costs and unlike internal insulation it does not reduce the habitable area.

For the south façade an extra intermediate space, a greenhouse, is added. The design of the greenhouse promotes modularity and disassembly. It is a system of elements subdivided in smaller parts that can be produced, used and later reused in different structures. The later removal of the greenhouse should also leave no trace or damage to the existing, listed façade. The structural elements can be made out of timber, that stores carbon for its entire life cycle, reducing the greenhouse effect. For the glass support a spider fitting system, with dry connections, can be used to allow disassembly and use of the glass panels for other purposes.

- Windows

The old, single glazed windows are removed, and they can be reused, refurbished or remanufactured for other buildings. Some of them can also be repaired and repurposed, as interior partition walls for the communal spaces of the same building. The new, double glazed, high performance window frames and panels need to be designed for disassembly, in order to allow repair and repurposing at the end of their use.

- Floors

The concrete slabs on the ground floor and the balconies are currently thermal bridges and they need to be properly insulted.

- Roof

Currently the roof consists of an uninsulated concrete slab. Part of it will be insulated, while most of it will be turn into a green roof, that provides thermal insulation and contributes to a closed water system. Additionally, a considerable amount of green roof will be covered with PVT panels, that will generated electricity and provide the households with domestic hot water.

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[6] EPS insulation can return up to 200 times the amount of energy required to produce it, and reduce emissions by up to 100 times the volume produced during the manufacturing process, representing an energy payback period of less than 17 months and a recapture of greenhouse gas emissions in less than 10 months (EPS Industry Alliance, 2022).

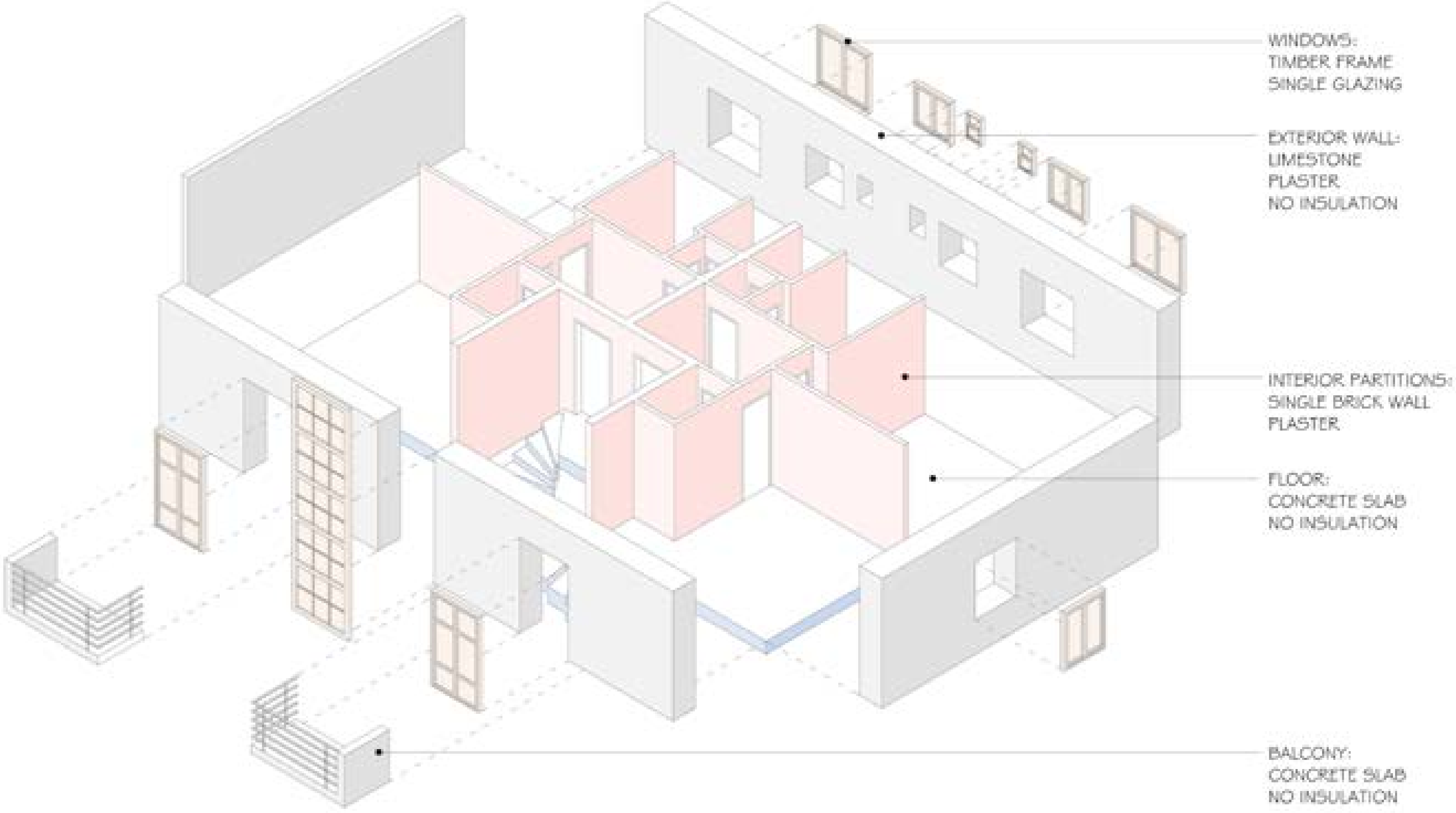


Image 3.24. Author (2022). Typical floor, Exploded axonometric view of main building envelope's elements [Drawing].

EXTERNAL FACADE INSULATION

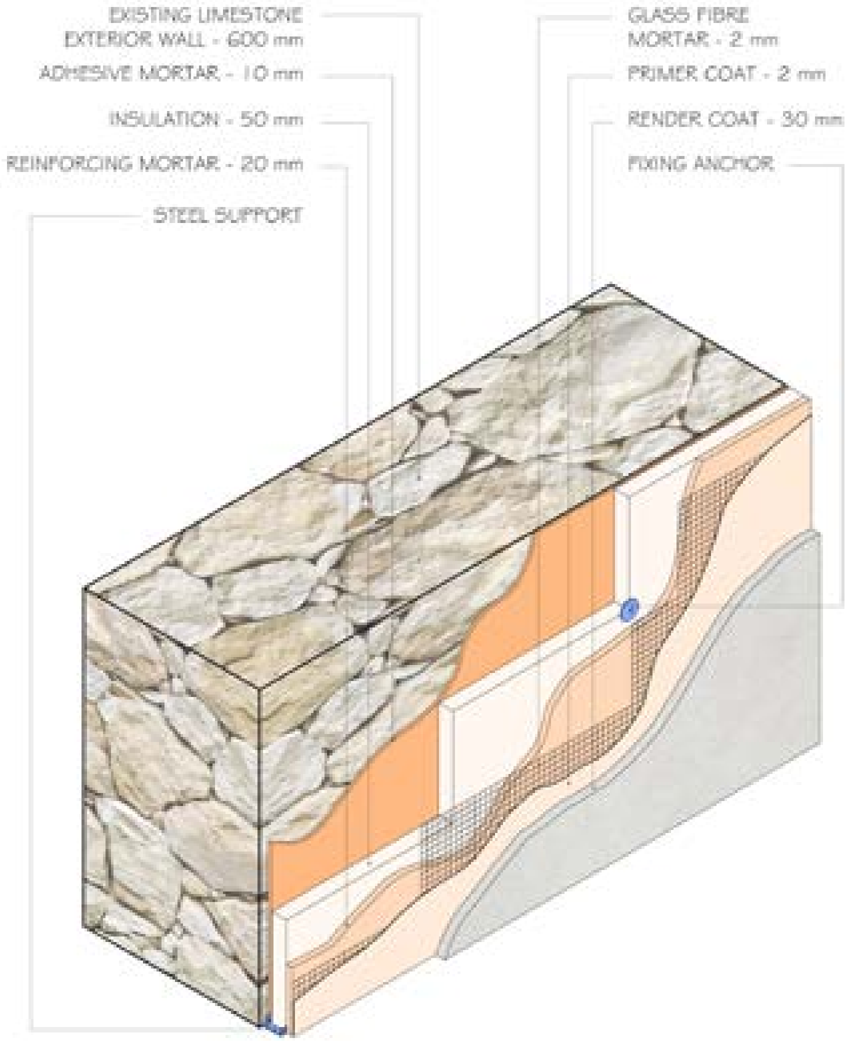


Image 3.25a. Author (2022). External facade insulation [Drawing].

NORTH FACADE: LIMESTONE WALL WITH PLASTER COAT

Image 3.25b. Author (2021). Current condition of north facade [Photograph].

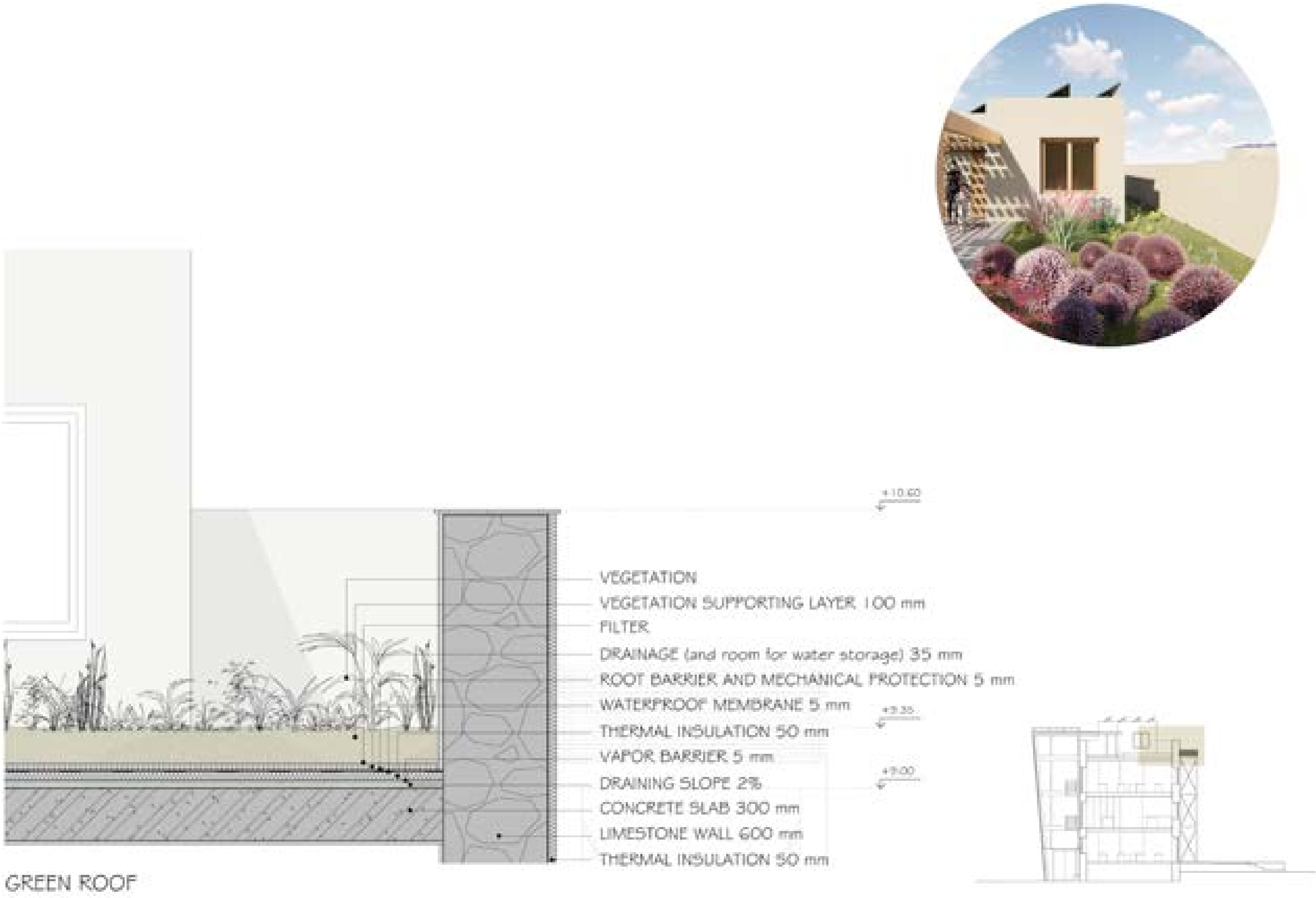
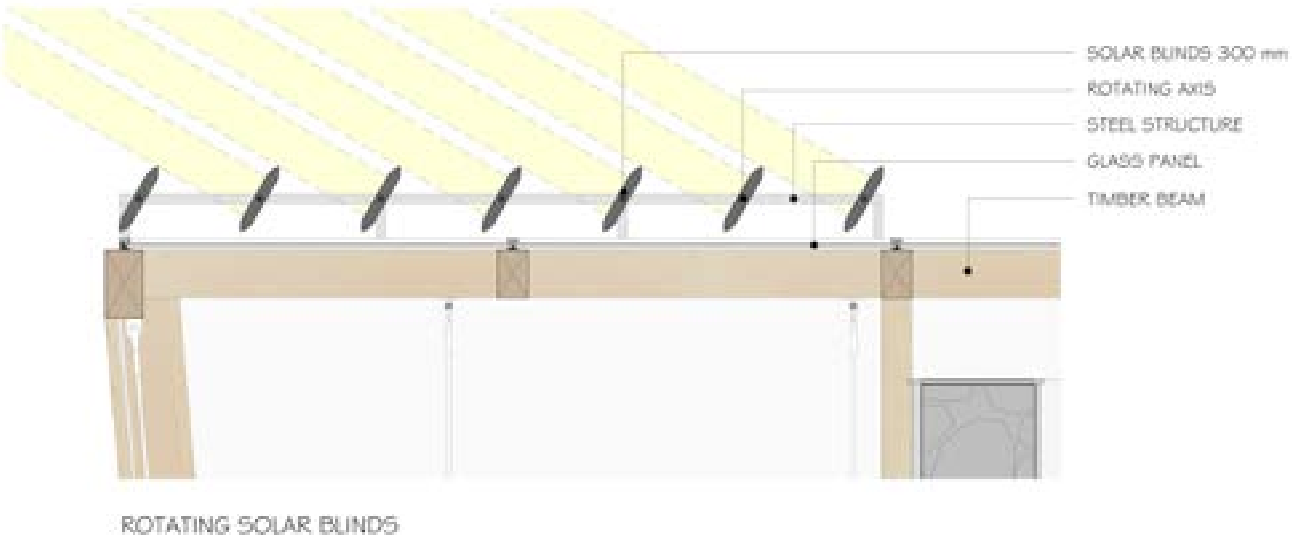


Image 3.26. Author (2022). Green Roof [Drawing].



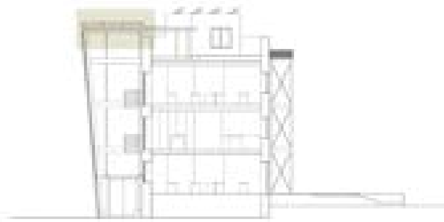


Image 3.27. Author (2022). Rotating Solar Blinds - Greenhouse [Drawing].

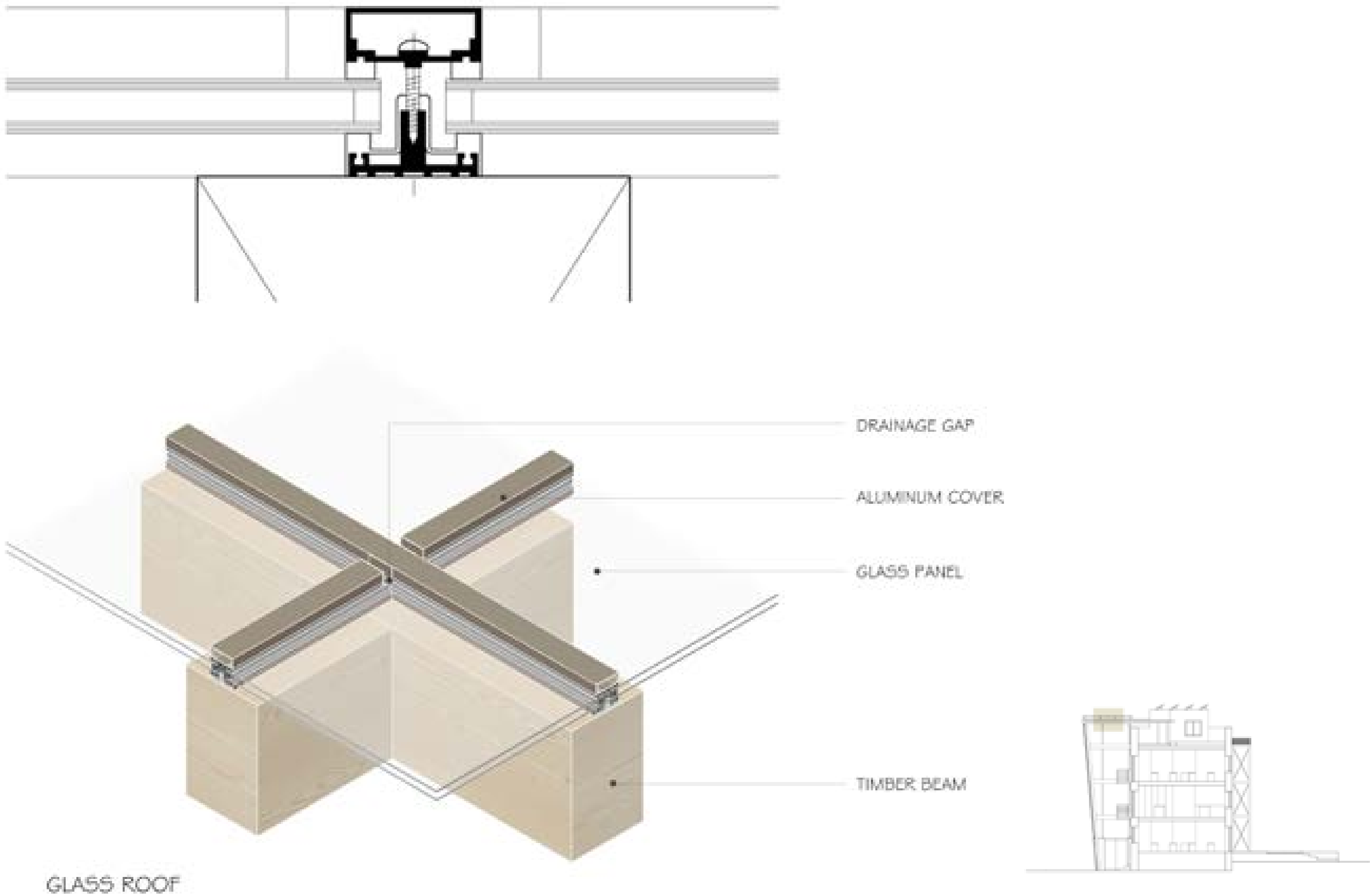


Image 3.28. Author (2022). Glass Roof Detail - Greenhouse [Drawing].

Services

The services include the utility and HVAC systems, as well as moving parts like elevators. It is essential for their good and quick maintenance, all the systems to be easily accessible, and separated from each other based on their function. The same applies for the added, external elevator.

Space Plan

Adaptability in the space layout is a fundamental requirement in a fast-paced world, where users and their needs change constantly. For this reason, space division in the new plans is limited, so as to provide a more flexible space configuration. Construction of new parts of walls should avoid traditional methods and seek for alternative, circular solutions in modular wall structures that can be quickly installed and repositioned countless times. At the same time, demolition waste of old brick walls can be recycled and used for cement, mortar, or again brick production.

Stuff

Stuff refers to all the furniture and other appliances occupying the building. The community program developed for the "Prosfygika" supports furniture repair, refurbishment and remanufacture through workshops and trade.

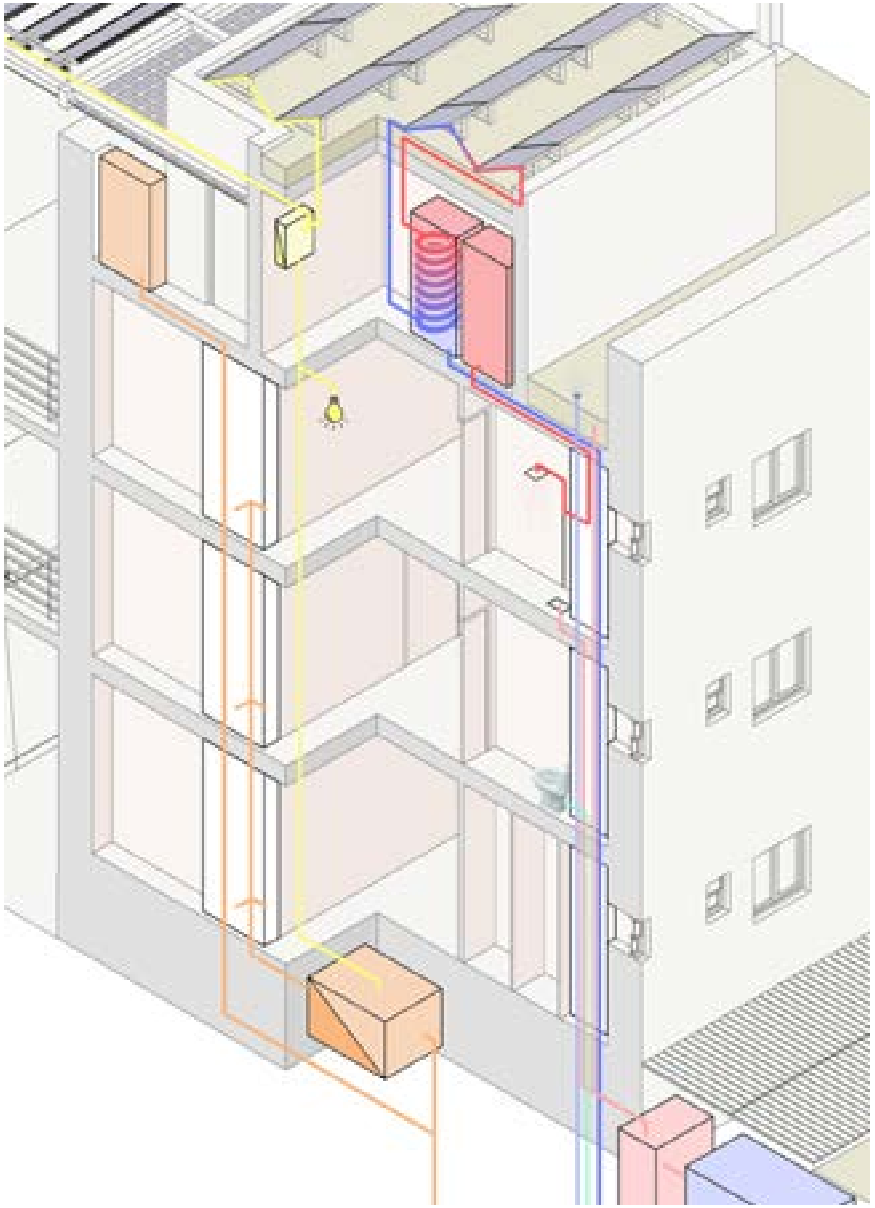


Image 3.29. Author. (2022). Axonometric section of Prosfygika - Systems Installation [Diagram].

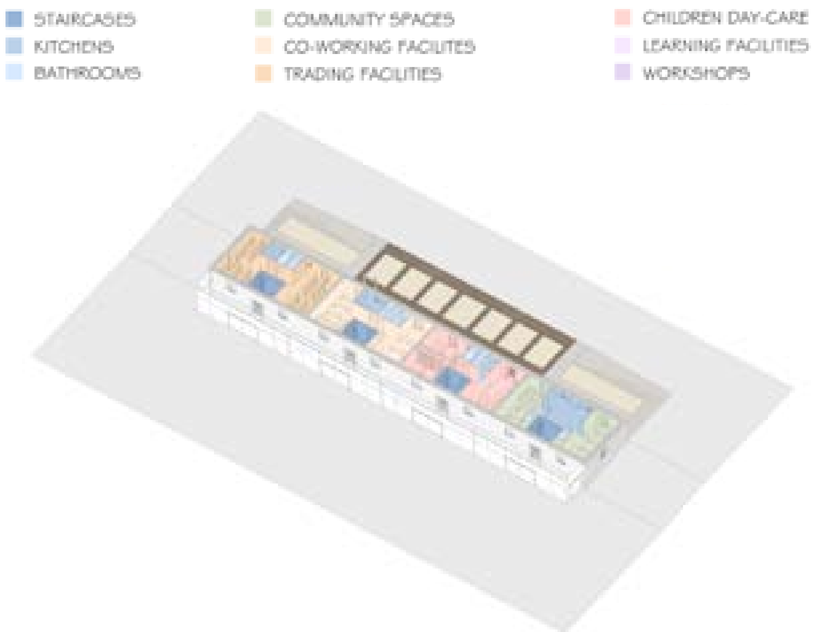


Image 3.30a. Author (2022). Space Plan & Facilities - Ground Floor [Drawing].

Image 3.30c. Author (2022). Space Plan & Facilities - 2nd Floor [Drawing].

Image 3.30b. Author (2022). Space Plan & Facilities - 1st Floor [Drawing].

Image 3.30d. Author (2022). Space Plan & Facilities - Rooftop [Drawing].

Operational Scheme

Circularity and energy transition in the built environment is more than a trend or a passing fashion. It is a promising approach that will help cities address the challenges they face. The approach has to be systemic and needs to create motivation for the industry to start the transition but it also requires a broad societal acceptance. Enabling people is crucial to mitigate the negative consequences that a transition might have.

New technologies and innovative ideas are constantly rising. Engineers know how to isolate the problem, set the requirements and find solutions. Thus, the technological answers are not the barrier towards a sustainable, carbon-free future. The real question is what else needs to be done to support this transition.

This thesis considers the lack of a developed holistic strategy, as the major reason for the failure of societies to apply contemporary, innovative, sustainable and inclusive solutions in the renovation of the existing building stock, in a bigger scale. A basic objective of this study is the development of such a strategy as a proposal for an efficient and effective application of these plans. In order to achieve a successful retrofit strategy, it is essential to identify the factors and barriers that affect decisions, specifically in the renovation of the existing building stock, given that these represent the vast majority of buildings and the biggest potential in energy savings.

A large number of people, such as owners or occupants, decision makers, developers and other stakeholders, are involved in the process of improving a building's energy performance. It is important to recognize all the involved stakeholders and understand their role, in order to "design and implement policies that will more effectively promote energy efficiency investments and actions, reflect the priorities and differ circumstances affecting implementation and improvements" (Economidou et al., 2020).

The homeownership-based system applied in Greece creates inequality in the ability of owners to pay for renovations (energy poverty), as well as groups (e.g. pensioners) that show no interest in the investment. Furthermore, in buildings where multiple owners and/or occupiers exist, as in the case of the refuge settlements of Alexandra's, various barriers apply. Ownership and responsibility can be opaque, while it can be very difficult to agree on energy saving investments if many different property owners have to either approve a decision or make a financial contribution. It is, therefore, essential to clarify the benefits of the investment in the long term, as well as the responsibilities of each party and the connection between the different stakeholders.

Three are the main involved parties in this plan; the state, the users and the companies of the construction sector. The following plan, even though it is user-oriented, it is an inclusive strategy that targets on every ones benefit. For the users the benefit is multifaceted and includes: participatory design of their neighborhood, craftmanship training, paid job opportunities, decent and affordable housing in a sustainable and circular community, social integration. The state provides the funds that are already available and in return gets relieved from the responsibilities of buildings that already belongs to it, but did not take advantage of them. Additionally, gets closer to its ultimate goal of carbon neutrality, and with its contribution initiates a pilot project that can later form the guideline for its renovation strategy. Finally the involved companies get the

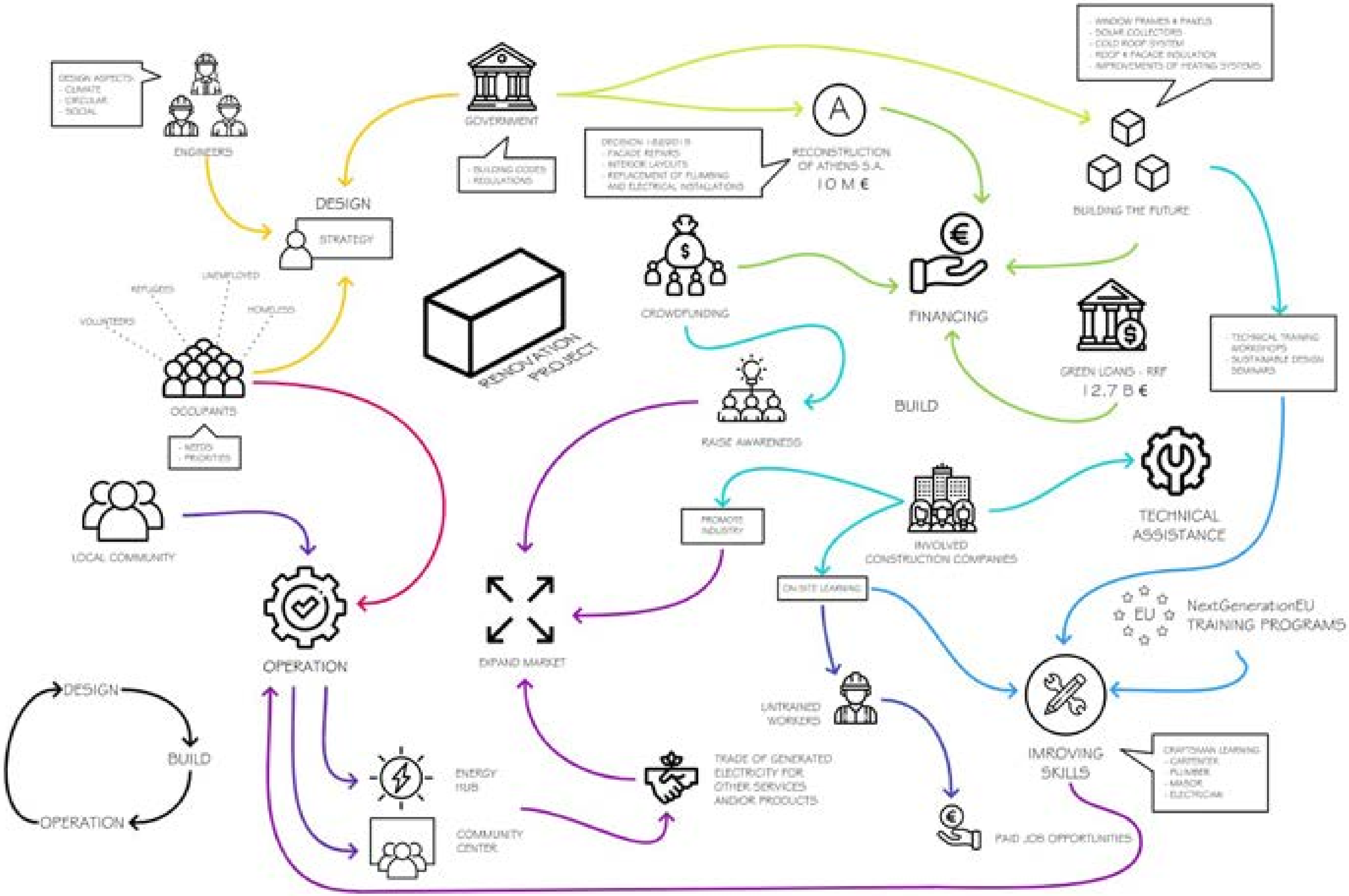


Image 3.31. Author (2022). Operational Scheme [Diagram].

chance to expand the market of sustainability and innovation, that will also lead to their individual development and attraction of more clients.

The plan

The renovation process includes three main stages, interconnected with each other in a loop-like sequence. These are: design, build and operation. The "design" stage is referring to a design strategy. The "build" stage includes funding solutions, technical assistance and skill improvement in the construction sector. The "operation" stage is referring to the maintenance and operation of the project after the end of construction, as well as the expansion of the market of sustainable buildings, products and services. To close the loop, evaluation and adaptation of the applied strategy is needed for future improvement.

Design: In order to plan the renovation project, a design strategy is needed. A team of engineers, the users and the government form the design team and each one contributes in a different way. The government requests for the building codes and regulations to be applied. These are often restrictions that define the strategy from the start. The future users of the project need to participate in the design process, to express their needs and priorities. This way, the result is inclusive and designed by and for the occupants. The team of engineers includes architects, urban planners, civil engineers, and other specialties, and define different design aspects of the project, such as climate, circular, social, economic, etc. The architect is usually the one to bring all these different ideas, aspects and restrictions into a coherent design strategy. At the end, the architect request from the local authorities the building permit so as to proceed with the construction.

Build: Financing: The construction work requires money. It is important to be aware of all the available funding resources, in order to minimize the cost for the occupants, tenants or owners and increase the chances of the investment realization. For this case study, there is already an approved grand (decision 182/2019) for the "Prosfygika" of Alexandra's. Athens Reconstruction S.A. is offering 10 million euros for façade repairs, interior layouts and replacement of plumbing and electrical installations for the 8 buildings of "Prosfygika" (Athens Reconstruction, 2018).

The project Building the Future aims to tackle the building related climate crisis and offers financial support for renovations and energy upgrade of old buildings, focusing on: the replacement of window frames with high performance ones and of single glazing panels with double, low-e ones, installation of solar panels and cold roof systems, façade and roof insulation and replacement of conventional heating and cooling systems with high efficiency ones. More than 1000 professionals in the field and 13 industry bodies have already signed voluntary agreements with Building the Future, in order to contribute to this effort (Building the Future, 2022).

Moreover, 12.7 billion € are available via "green" loans, since June 2021, from the RRF (Recovery and Resilience Facility Loans), a fund by the NextGenerationEU of European Union (Alpha Bank, 2021).

Additional financial support could be raised through crowdfunding, which also contributes in raising awareness.
Technical Assistance: The involved with the project companies need to provide technical assistance on and off site.

Improving Skills: In order to maximize the connection between the users and the project, it is important to include them not only in the design stage, but in all the stages of the process. The participation of the occupants, especially in the construction, increases their interest and dedication to it even after its completion. Additionally, by training and occupying the users, who are mostly unemployed, refugees or homeless, to work on-site, they get an income, plus working experience, knowledge and more chances for future paid job opportunities[7]. Their training can be achieved either through the involved construction companies and/or through programs offered by the state. For example Building the Future and NextGenerationEU also organize technical training workshops and sustainable design seminars.

Operate: After training the future users and improving their skills, they should be eligible for the maintenance and good performance of the project. This specific re-design results in a renewable energy hub and a community center. A trading network, between the involved residents and the local community, can then be developed, in order to exchange the renewable, on-site generated energy for other services and products. Through the trading network, the crowdfunding that targets in raising awareness and the involved companies that contribute in the promotion of the industry, it is possible to expand the market of sustainable buildings, products and services, and achieve results in a greater scale.

Finally, the evaluation and adaptation of the strategy is an essential step to recognize if the stated goals were achieved and identify areas of improvement, in order to scale up its application and impact.

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[7] It worth mentioning that an entire generation of women and men moved in Athens during the 50s, as internal immigrants, in the pick of urbanization, to experience the comfort that the big city and its technologies had to offer. Most of these men worked as untrained builders in the rising construction sector of Athens, which was struggling to accommodate the massive influx of people. Thus, Athens owes the bigger part of its postwar built environment and polykatoikias (apartment blocks) to the unskilled workers and their families, that moved in, worked hard, and integrated into the Athenian society.

Visualizations

This section includes a series of photos of the refugee settlement of Alexandra's Avenue in Athens, Greece, followed by visual representations of the proposed design, that facilitates the comparison between the current condition and a future possibility.

Image 3.32a. Author (2021). Current condition of the front (south) building of "Prosfygika [Photograph].

Image 3.32b. Author (2022). Proposal of renovation of the front (south) building of “Prosfygika [Visualization].

Image 3.33a. Unknown (xx). Current condition of the front (south) building of "Prosfygika [Photograph].

Image 3.33b. Author (2022). Proposal of renovation of the front (south) building of “Prosfygika [Visualization].

Image 3.34a. Author (2021). Current condition of the front (south) building of “Prosfygika [Photograph].

Image 3.34b. Author (2021). Current condition of the front (south) building of “Prosfygika [Photograph].

Image 3.34c. Author (2022). Proposal of renovation of the front (south) building of “Prosfygika [Visualization].

Image 3.35a. Author (2021). Current condition of the front (south) building and of the streets of “Prosfygika [Photograph].

Image 3.35b. Author (2022). Proposal of renovation of the front (south) building and of the streets of “Prosfygika [Visualization].

Image 3.36a. Author (2021). Current condition of the front (south) building and of the streets of “Prosfygika - north facade [Photograph].

Image 3.36b. Author (2022). Proposal of renovation of the front (south) building and of the streets of "Prosfygika - north facade [Visualization].

Image 3.37a. Author (2021). Current condition of the front (south) building and the back yardsd of “Prosfygika [Photograph].

Image 3.37b. Author (2021). Current condition of the front (south) building and the back yards of “Prosfygika [Photograph].

Image 3.37c. Author (2022). Proposal of renovation of the front (south) building and of the streets of “Prosfygika - north facade [Visualization].

4.

Conclusions

Reflection

References

Conclusions

The climate crisis related to the building sector, the buildings depreciation and the social issues related to homelessness are a combination of major problems encountered in the built environment in Greece and other European countries. The three sectors are strongly interconnected presenting very significant synergies and conciliations. Existing policies aiming to reduce the energy consumption of the buildings usually underestimate the importance of affordability and accessibility, and of a catholic, all-inclusive framework. Failure to consider all issues in an integrated and holistic matter may inevitably result in higher energy consumption and social inequalities. Innovating the built environment of Athens to zero in circular terms assumes a reduction of the energy consumption of buildings, utilization of the untapped existing building stock and reconstitution of the social housing policies. Such an objective, although it seems very ambitious, it is an explicit choice that will create substantial opportunities for future growth, will relieve the population from the consequences of these specific problems and will create short, medium and long term benefits and opportunities, while improving the quality of life of the citizens.

The developed framework suggests an approach that, if applied, will strongly contribute in the achievement of the Sustainable Development Goals. Specially, an enlarged application of the strategy will facilitate its evaluation and adaptation for greater results. The potential impact of this strategy on each sector and goal is presented in the following table.

By developing a plan that can provide decent, affordable housing for all, it is feasible to reduce the homelessness rates and empower vulnerable social groups to seek for job opportunities.

With local food production through urban farming and community kitchens, everyone can have access to healthy everyday meals.

By narrowing economic and social inequalities, reintegrating people in the community and creating a sustainable, less harmful environment, the life quality and well-being can be improved.

By creating and giving access to learning facilities, workshops and seminars, personal development and integration to the community can be accomplished.

5 GENDER EQUALITY

Through on-site work and education for women, and free children day-care facilities, we contribute to women empowerment.

6 CLEAN WATER AND SANITATION

With grey water infiltration and proper water management it is possible to achieve less use of potable water in secondary uses.

7 AFFORDABLE AND CLEAN ENERGY

On-site energy generation from RES and proper waste management can provide affordable and clean energy for everyone.

8 DECENT WORK AND ECONOMIC GROWTH

Paid job opportunities during construction and maintenance, and support through educational programs contribute in personal development and reinforcement of local economy.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

By developing a feasible plan for innovative solutions in the built environment, the creation of an exemplar neighborhood and the expansion of the sustainability market can be achieved.

10 REDUCED INEQUALITIES

The strategy is inclusive and aims in creating symbiotic and synergetic relations.

11 SUSTAINABLE CITIES AND COMMUNITIES

The development of a self-sufficient and climate adaptive neighborhood that operates as a renewable energy hub promotes and establishes the concept of sustainable cities and communities.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

The circular renovation principles followed in the project, and the applied waste management systems raise awareness regarding responsible production and consumption.

Climate action is supported by eliminating the use of fossil fuels, reducing the energy demands, closing the loops, generating clean energy, etc.

The urban farming initiative not only establishes a green sustainable intervention, but also promotes symbiotic relations between humans and the flora and fauna of their environment.

Integration of neglected populations and citizen-oriented policy making can contribute in a peaceful co-existence and an inclusive society.

Such ambitious goals will be achieved gradually. It is evident that the definition and the implementation of a clear, ambitious, holistic and multidisciplinary vision for the future of the built environment is an indispensable need for the future.

Reflection

The Green Light District project in Amsterdam was the starting point and a source of inspiration for this thesis. Innovative solutions are applied to decarbonize the neighborhood, while every citizen and stakeholder is involved with an important role. These ideas keep evolving and they are broadly applied in the Netherlands. On the other hand, in Greece, my country of origin, the situation is quite different. Economic, social, cultural, political and other factors affect the sustainable development of the construction sector and limit its beneficiaries to only some special cases.

The impact of the built environment in our climate is indisputable. However, when energy poverty, social discrimination, homelessness, unemployment, and other day-life issues are combined with the buildings depreciation and the construction sector related carbon emissions, the problem becomes more than environmental. If anything, the road to a sustainable future concerns everyone, and in order to be achieved it needs to involve everyone too.

Energy transition was from the beginning the axis which this thesis would have followed. The challenge was to find or develop the appropriate “tools” in order to make it accessible even for the most vulnerable social groups. Circularity in the built environment, not only adds on effect of the measures applied, but also makes the approach more inclusive. Research on these domains led to the need of developing a strategy for a renovation of the existing building stock, following zero-energy and circular principles, that is user friendly and user-oriented.
The selection of the case study is not random. This case study depicts all the problems that concern vulnerable social groups in the city of Athens, under the roof of 8 listed buildings. These buildings accommodate people, that with the current situation, will never get access to decent, affordable housing, clean energy, work opportunities and equality and who will not have the chance to escape (energy) poverty and discriminations.

As a result, the literature review was essential to find out what efforts have already been done, what are the methods, tools and principles applied, and what is missing. On the other hand, the analysis of the case study gave direction to the literature review. Research and design are closely related and interdependent. They derive input from and give feedback to each other. Thus, I consider this approach a useful and suitable method for the thesis, that despite the constant back and forth between research and design, indicated, together with my mentors, a focus area for the project.

Nevertheless, in my effort to include all the affecting factors and interesting to me aspects, the subject of the thesis got too broad. As a result, not all domains are equally analyzed in the research or evenly justified in the design. However, this resulted in a more generalized and inclusive approach. Even though the energy and circular measures proposed for the case study, as well as the developed strategy, are driven by and focused on a specific case study, they form a methodology can potentially be applied in other similar cases too. Nonetheless, the transition to integrated frameworks of renovation processes requires evaluation and adaptation of the proposed strategy, as well as further research and case study analysis.

Thesis relevance to BT track and MSc AUBS program.

The Green Light District Project was my initial project selection, that at the end, contributed in my graduation thesis as an early framework and inspiration. This thesis shares common principles with that project such as: restoration of the existing building stock, reduction of carbon emissions, reduction of energy demands, development of renewable resources, circular renovation techniques, energy and social upgrade and inclusion of the local community. This "regeneration plan" is highly related to the BT master track, since it analyzes techniques and principles of sustainability and circularity in the built environment. The design part concerns a transformation of an existing poor performing 30's building complex into a renewable energy, community hub. Energy transition of existing building stock, especially in densely populated urban areas, is a fundamental future construction challenge. Along with the above-mentioned, a socioeconomic aspect is added to the research, concerning vulnerable groups of people, social inequalities and new forms of affordable, collective housing, accessible to everyone, values clearly connected with Architecture, Urbanism and the Building Sciences.

Thesis relevance to the wider social, professional and scientific framework.

Recently more and more projects, like NeNa1, Kraftwerk1, Co-Hab Athens, Urbana Lab, SUM, De Warren, Schoonschip, Klaprozenbuurt, Almere Oosterwold, etc., explore the possibilities of participatory, inclusive design, in terms of sustainability, other more and other less successfully. An effort to develop alternative cooperative housing models and forms of coexistence in the city, under the umbrella of energy transition and circularity, is already a reality. For this reason, I want to believe that this project forms a realistic, feasible proposal, that if it is ever applied it would open up the horizons of utilization of the existing untapped building stock, of social housing policies, and of the urban living perception, in the city of Athens. I vigorously support that more proposals, that take into consideration technological innovations, environmental impact and the users' needs, are required in order to deal with the multifaceted challenges of the future.

The last 6 months have been for me a turbulent journey with ups and downs. Despite this, the knowledge I gained through the conducted research and the discussions with my mentors, is indisputable. Along the way, I had the chance to dive into topics that in my opinion form the future of the built environment. At the same time, I accomplished my need to not only include in the present thesis the social aspect of the subject, but to even make it an essential factor for the completion and integration of the project. I hope and expect that the combination of sustainability and social awareness will not only be the subject of this thesis, but also the substance of my future career as an architect.

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Planning for the regeneration of listed buildings for vulnerable social groups using Zero-Energy and Circular Principles | The case of the refugee settlements of Alexandra's Avenue in Athens, Greece.

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