PERFORMANCE OF ENERGY ANALYZING AND RETROFITTING TRADITIONAL HOUSING: THE ALBANIAN CLIMATE CASE

A THESIS SUBMITTED TO
THE FACULTY OF ARCHITECTURE AND ENGINEERING
OF
EPOKA UNIVERSITY

BY

ALEKSANDRA BEQIRI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ARCHITECTURE

JUNE, 2024

Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **"Performance of Energy Analyzing and Retrofitting Traditional Housing: The Albanian Climate Case"** and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

____

Assoc. Prof. Dr. Edmond Manahasa
Head of Department
Date: June,12 2024

Examining Committee Members:

Prof. Dr.Sokol Dervishi	(Architecture)	________________
Dr. Ina Dervishi	(Architecture)	________________
Prof. Dr. Pirro Thomo	(Architecture)	________________

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name Surname: Aleksandra Beqiri

Signature: ______________

ABSTRACT

PERFORMANCE OF ENERGY ANALYZING AND RETROFITTING TRADITIONAL HOUSING: THE ALBANIAN CLIMATE CASE

Beqiri, Aleksandra
MSc., Department of Architecture

Supervisor: Prof. Dr. Sokol Dervishi

Building energy consumption constitutes a significant portion of total energy usage. Over the past decade, there has been an increasing emphasis on the development of energy-efficient buildings as a crucial strategy for promoting sustainable development. This paper presents a research on the thermal efficiency of traditional residential houses constructed in Albania during the 18th and 19th centuries focusing on adaptation and improvement of current traditional buildings in order to meet the pressing demand to increase energy efficiency in the residential sector. Three distinct cities' energy efficiency and indoor thermal comfort levels were investigated; one traditional building is chosen for each city. By offering a new viewpoint on the relationship between thermal indoor comfort and energy consumption in traditional buildings. Using a thorough methodology that encompasses field data collecting, energy performance models, and retrofitting techniques this study uses building performance models based on energy bills to evaluate the patterns of existing energy use and identify the most efficient options. Moreover, the residences underwent dditional assessment using parametric simulation with Design Builder software. The outcomes of the simulation that was run provide a crucial basis for renovating traditional and historical buildings in climates with Mediterranean temperatures.

Keywords: *energy efficiency, simulations, assessment of thermal performance, façade, interior comfort.*

ABSTRAKT

ANALIZIMI I PERFORMANCËS ENERGJITIKE DHE PËRMIRËSIMI I SAJ NE BANESAT TRADICIONALE: RASTI KLIMATIK SHQIPTAR

Beqiri, Aleksandra
Master Shkencor, Departamenti I Arkitektures

Udhëheqësi: Prof. Dr. Sokol Dervishi

Konsumi i energjisë së ndërtesave përbën një pjesë të konsiderueshme të përdorimit total të energjisë. Gjatë dekadës së fundit, ka pasur një vëmendje në rritje për zhvillimin e ndërtesave me efikasitet energjetik si një strategji thelbësore për promovimin e zhvillimit të qëndrueshëm. Ky punim paraqet një kërkim mbi efiçencën energjitike të shtëpive tradicionale të ndërtuara dhe banuara në Shqipëri gjatë shekujve 18 dhe 19, duke u fokusuar në përshtatjen dhe përmirësimin e ndërtesave tradicionale aktuale në mënyrë që të plotësohet nevoja për të rritur efiçencën e energjisë në sektorin e banimit. Jane analizuar nivelet e efikasitetit energjetik dhe të komfortit termik të brendshëm të tre qyteteve të ndryshme duke u zgjedhur një ndërtesë tradicionale tipike për çdo qytet për të ofruar një këndvështrim të ri mbi marrëdhënien midis komoditetit të brendshëm termik dhe konsumit të energjisë në ndërtesat tradicionale. Duke shfrytzuar një metodologji të plotë që përfshin mbledhjen e të dhënave në terren, modelet e performancës së energjisë dhe teknikat e rikonstruksionit, ky studim përdor modele të performancës së ndërtesave të bazuara në faturat e energjisë për të vlerësuar modelet e përdorimit ekzistues të energjisë dhe për të identifikuar opsionet më efikase.

Për më tepër, rezidencat iu nënshtruan një vlerësimi shtesë duke përdorur simulimin parametrik me softuerin Design Builder. Rezultatet e simulimit që u krye ofrojnë një bazë thelbësore për rinovimin e ndërtesave tradicionale dhe historike në klimat me temperatura mesdhetare.

Fjalët kyçe: *fasada e ndërtesës, efiçenca energjitike, simulimet, vlerësimi i performancës termike, komoditeti i brendshëm*

.

Dedikuar plotësisht gjyshit tim, Demir Beqiri. E nisëm këtë rrugë bashkë, por fatkeqësisht po e përfundoj vetëm, për të dy!

ACKNOWLEDGEMENTS

I want to sincerely thank Professor Sokol Dervishi, my supervisor, for all of his assistance and encouragement in helping me to complete my master's thesis research. We could not have completed this project to its full potential without his unwavering cooperation. Working with him was an enormous honor and privilege.

I want to express my appreciation to Dr. Pirro Thomo for his assistance in the selection of buildings based on the criteria of our study as well as the proprietors of the three traditional houses. I am very grateful to the professors Ina Dervishi and Nerina Baci this initiative would not have been able to succeed without their hospitality, encouragement, and assistance. I want to thank Epoka University, my professors, my friends especially Samanta, thank you for making this journey much easier and full of unforgettable beautiful memories even on the days when we had to sleep at school to finish the project and everyone else whose help made this effort possible. Finally, thank you to my beloved family who have given me strength and support since the first day when I chose this challenging field and they never got tired of listening to my complaints about the hours of sleep I have missed for 5 years now. Nothing would be possible without you and your support!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Issues regarding traditional building approach towards energy consumption problem

In recent times, several governments have prioritized energy efficiency due to the fact that conserving energy is a more straightforward approach to help customers save money, lower carbon emissions, and lessen their reliance on fossil fuels.

Energy usage data has been gathered with the goal of increasing the rate of energy savings above a "business as usual" scenario by at least 32.5% by 2030 (Brockway et al., 2019). Reducing energy use and improving performance has become a key objective in the pursuit of extended energy efficiency, climate and environmental improvement goals, as households and public buildings are estimated to consume over 40% of energy and can produce over 35% of CO2 emissions (D'Agostino et al., 2019).

Therefore, it has been determined that setting strong energy efficiency tactics, in which hefty sums of money have been spent to create new materials and technology that increase energy efficiency.

To enhance energy saving in buildings, however, a number of human-related factors and behaviors need to be taken into account and adjusted (Mahapatra et al., 2018). To put it another way, more work has to be done to raise consumer knowledge of energy issues and encourage behavioral changes that will minimize energy waste (Alsalemi et al., 2019). Initiatives must also be progressively integrated into regular operations and have goals and targets that reflect the preferences of building owners and prospective users in order to be effective (Delzendehet al., 2017).

One of the most significant challenges in our nation, as well as the entire world, is the effective use and conservation of energy (Yılmaz et al., 2016) Making efficient use of the energy that is already available has been crucial to safeguarding and satisfying energy needs, which is one approach to lessen reliance on energy, particularly in nations like our own that rely on imported energy (Kalkınma et al., 2018)

Furthermore, by 2050, the global economy will have grown four times faster than it does now, requiring an additional 80% of energy and natural resources on top of today's energy use. This makes research on energy efficiency even more important.

The Albanian inhabitants lived in traditional individual houses in the village until the 20th century. These structures are among the most important in representing Albania's past. This local architecture aids in our reflection of the past and customs that are connected to Albania's social and economic life in addition to its history. The local climate in which these structures are situated is one of the primary variables that affected them. People construct their settlements in response to the real conditions that meet their requirements. According to (Bhandari et al., 2012), traditional structures frequently have a variety of clever design elements that developed as a result of societal functions and the local climate.

Despite their ability to link us to Albania's past and culture, historical homes are now extremely scarce and in inadequate state. The contribution of the study in this respect describes a systematic process for obtaining and assessing a simulation-based performance from traditional structures. The aim of this research is to evaluate and improve the energy efficiency of ancient residential buildings in Albania by retrofitting, while considering the climate of three distinct cities situated in the southeast of the country. The fact that these particular structures have a backstory and the designation of "protected buildings," making modeling and adaption difficult, is one of the most difficult aspects of this research.

1.2 Thesis Objective

The amount of CO_2 in the atmosphere has increased despite Albania's success in fulfilling the 2030 SDGs through the national strategy plan Albania 2030 and guaranteeing the adoption of sustainable practices in the building sector (Kamberi et al., 2021). 2019 saw the construction of almost 1 million m^2 of new structures, with

Tirana accounting for more than 60% of them (INSTAT, 2019). This resulted in a rise in stress and pollution in metropolitan areas.

Albanian cities were loud, with five exceeding the permitted noise levels in the centers occupied by 15-20%, and filthy, with Tirana ranking as the third most polluted city in Europe for 2019. There were also less green areas per inhabitant in Albanian towns. (Environment, 2017)

There are examples of vernacular household architecture in both urban and rural settings. Numerous investigations have shown that the rural home, which is often made up of a single room known as the basic cell, is the ancestor of the urban dwelling. As a result, we only examine urban housing in this work, which is located in the municipalities of Gjirokastra, Korça and Berat. This study will be focused on offering a recent perspective on the issue of energy use and thermal retrofitting in conventional and historic structures by analyzing important definitions made by different authors over the last century on the importance of preserving traditional buildings. Extended observation of the interior temperature environment in the chosen traditional houses throughout three Albanian regions. Analysis of the current state of energy efficiency and thermal comfort using data loggers in every conventional home. The creation of calibrated simulation models to enhance these historic structures' thermal performance. Comparing and evaluating potential thermal improvement scenarios for traditional dwellings using simulations based on various areas. Continuing with the creation of 7 different simulations for each building based on the real case of the building situation, base case and proposals on the application of insulating materials as well as their performance in the building. According to the simulation results, upgrading the buildings might enhance their thermal comfort and energy efficiency.

1.3 Motivation

Since buildings utilize 40% of all energy used annually, energy efficiency is a well-known issue these days, particularly with regard to the construction industry (EuropeanCommission, 2008). While the concept of energy efficiency has existed for some time, in different forms than they do presently, energy consumption became more of a concern in the 19th century when sciences began to diverge and take on their current form. Through national legislation, media, and standardization, the 20th century contributed to the increased importance of energy efficiency (Ionescu et sl., 2015) (British, 2013) states that between 1992 and 2012, there was a 52% rise in energy use due to population growth and technological advancements. These results highlighted the need for increased global energy conservation as well as the necessity to fund various energy-saving and energy-efficiency-promoting options (Sahin et al., 2015). A retrofit is defined as "the alteration of existing tools, systems, or structures to incorporate enhanced energy effectiveness, updated operation, or improved performance, or all three" (Webb, 2017). The Directive on Energy provides a number of guidelines and recommendations to minimize the energy in dwellings, as renovating the current building stock is one of the biggest issues of our day (European Parliament, 2012). (Ascione et al., 2011) concentrate on these regulations on expanding the refurbishment of these structures, upgrading the elements and appliances that are used, and highlighting the public buildings' energy efficiency. "Low energy buildings" are an excellent example that has been offered in recent decades. These buildings often have high insulation levels, energy-efficient windows, and little air leakage. Laustsen, who examined the development of low-energy structures, effectively explained this. Developing, designing, or retrofitting structures with higher energy efficiency performance than standard buildings is the aim of these low energy buildings. This typology frequently includes a mechanical ventilation system (Laustsen, 2008) . Refitting an old building might involve, according to Webb adding walls or sealing the roof, modifying the operational schedule, updating the HVAC system, and installing lights (Webb, 2017).

1.4 Aim and originality of the study

The preceding paragraph's analysis emphasizes the significance and advantages of energy retrofitting old and traditional buildings, particularly in Europe. In order to fill in the following knowledge gaps in the literature, this research can offer a unique addition to the field of energy retrofitting and point out possible areas for further simulation development.

Using onsite comprehensive inputs (electricity bills, in-site surveys, HVAC, occupancy and ventilation schedules, data loggers for temperature and humidity, and cost estimation), no prior study has created a building simulation model. Even though, some of these inputs such as precisely described building models and potential retrofitting interventions were taken into account in certain research. The case study of Albania highlights the differences in performance and requirements for each environment and typology.

No prior research helped compare and evaluate the energy and thermal efficiency of traditional dwelling typologies in distinct Mediterranean climates. Only a limited number of academics investigated retrofitting historical buildings in the Albanian environment in the past, and no research examined the energy retrofitting of different traditional buildings in light of climate and restoration legislation.

No research using simulations has provided a comprehensive framework for evaluating energy and interior comfort in historically significant traditional buildings built using vernacular construction techniques that are protected and maintained by Albania's Ministry of Culture.

Therefore, with Albania as a case study, the aim of this paper is to establish a comprehensive methodology using an analytical and quantitative approach that would greatly contribute to the field of energy retrofitting in Europe and the Mediterranean region. Based on an investigation of indoor comfort and energy performance, the research takes into consideration construction materials, WWR (windows to wall ratio), and climate. This scientific study's primary contribution is the design and proposal of several retrofit solutions that might enhance occupant comfort inside and lower annual energy consumption while taking preservation and restoration into account for historical and traditional structures. This paper can be considered as the first step in retrofitting Albania's conserved historic buildings with energy efficiency.

1.5 Organization of the thesis

Seven chapters comprise the thesis. The structure operates in this manner: The issue statement and thesis goal are provided in Chapter 1. The theoretical background is explained into phases in Chapter 2. Continuing with the literature review in Chapter 3 analyzing into different periods the impact and the solutions given by different authors. The study area is analyzed in detail for the three cities through their respective climatic context and a comparison between the three is made as well as the analysis of the traditional housing typologies in each city. This study's methodology is covered in Chapter 5 retrofitting measures considering energy efficiency and thermal comfort. The modeled outcomes are shown in Chapter 6, during the evaluation of the primary results it also presents the discussion session. Chapter 7 concludes with suggestions and conclusions for further research.

CHAPTER 2

THEORITICAL BACKGROUND

2.1 Definition of Vernacular

“We’re not proposing that you should go back and build like you did before architecture had technology. But maybe there’s a way you could build what we call Vernacular 2.0.” (Winston, 2018) Three fundamental factors that architecture must consider are people, location, and routes (Farmer, 1993). Rudofsky initially discussed the use of vernacular architecture in his groundbreaking book Architecture without Architects. "Architecture without Architects aims to breakdown our narrow perceptions of the art of building by introducing a foreign world of non-pedigreed architecture," he stated in defining the scope of his work (Rudofsky, 1964). “We don't even know the name of it because it is so poorly recognized. In the absence of a universal term, we will refer to it as vernacular, nameless, spontaneous, indigenous, or rustic, depending on the situation.” (Rudofsky, 1964).

A book release was co-located with an exhibition in New York featuring monochrome images of traditional structures from around the world. The popularity of the theme and the success of the book were both aided by this exhibition. In his scholarly curated Encyclopaedia of Vernacular Architecture of the World, Oliver provides a definition of vernacular architecture. (Oliver, 1997) In accordance with their resource availability and environmental circumstances, they are often owner- or community-built using conventional technology. Every type of vernacular architecture is created to fulfill a certain purpose, supporting the economics, values, and lifestyles of the civilizations that create it. "Architecture of the people, and by the people, but not for the people" is how vernacular architecture is defined. (Oliver, 2003). Oliver acknowledges that there isn't currently a particular field of study dedicated to studying vernacular architecture, but he says that if one did develop, it would include history, geography, anthropology, and architecture. As a result, indigenous knowledge and vernacular culture become extremely specific and localized, and they can be seen as particular responses made by people in the pre-industrial era to environmental, sociocultural, and economic challenges by utilizing the natural resources that were available to them in order to survive. According to Oliver, vernacular architecture may refer to a wide range of things, including handcrafted, traditional mansions, pre-industrial, and buildings that people have created or modified to suit their everyday requirements in any location or period. According to Oliver, a structure might be any of several types of traditional constructions, including turbines, straw warehouses, traditional homes, or village churches. However, he also saw vernacular architecture as a process of adaptation and change by the people in the particular circumstances, which may include the use of modern materials and structures.

This is why there is such variation in his views. (Cromley, 2008.) In order to establish a paradigm of control and authority over vernacular architecture, Bronner established the discussion of the selection, expectations, and transmission of architectural tradition (Bronner, 2006) while Noble made a distinction between folk, traditional, popular, and vernacular architecture (Noble, 2007). While traditional, this architectural expression should not be confused with vernacular architecture. Long before Rudofsky's book was published, architects researched and refined their designs using vernacular architecture. In this context, it is crucial to recognize Fathy's contribution, since he studied and incorporated indigenous architectural concepts, characteristics, and technology from Nubian settlements into his design for New Gourna in the middle of the 1940s (Fathy, 1976). This was the first project that addressed the socioeconomic and environmental realities of the users by utilizing the forms and construction techniques of the vernacular. This was the first project that addressed the socioeconomic and environmental realities of the users by utilizing the forms and construction techniques of the vernacular.

Table 1. Definitions of Vernacular Architecture

Author/researcher	Year	Definition
Eric Mercer	1975	*Buildings classified as vernacular pertain to a category of structures that were typical in a certain area and period of time. Stated differently, a structure is not deemed vernacular due to its attributes; rather, it is characterized by a value that is widely recognized. (Mercer, 1997)*
R.W. Brunskill	1981	*Vernacular buildings are kinds of constructions that are consciously sustained instead of temporary, have traditional inspirations instead of being academic, and designed to feed the simple, day-to-day activities of the people, their farm and their modest industrial business. They are gradually dependent on location and the use of local*
Camille Wells	1982	*A wide range of structures, such as industries, farms, and dwellings—as well as mills, fields around towns and commercial districts, schools, and individual homes with all of their features—are included in the category of vernacular architecture. (Wells, 1986.)*
Dell Upton	1985	*Vernacular buildings are ordinary buildings. (Upton, 1985)*
W.m. Heath	1988	*Vernacular architecture is a craft whose value is not in style but its capacity as cultural (Heath, 1988)*
Judith Roberts	1996	*Building employing local materials in accordance with regional customs, vernacular architecture refers to the shapes and forms of shelters and buildings that have come to record social and economic activities. We can now'read' these structures and comprehend them in our context thanks to their arrangement of shape, materials, patterns, and details. (Roberts, 1996)*
Paul Oliver	2000	*Vernacular architecture is defined as a structure created by the people for the people. Professionally planned and constructed buildings are not considered examples of vernacular architecture. (Oliver, 2000)*
Maria Philokyprou	2011	*In general, the term "vernacular architecture" refers to an unidentified, regional architecture that adapts its shape to the specific demands of the surrounding area. Vernacular communities lack beauty and embellishments, whereas official structures have both. They are important because people need to continue living and utilizing them in order to preserve vernacular traditions. (Philokyprou, 2011)*

Juan A.García-Esparza	2012	*When identifying historical artifacts in vernacular architecture, the subject makes use of his or her vision, memory, and lasting area. Each viewer's thoughts and feelings have an impact on all of this. (García-Esparza, 2015)*

2.2 Environmental aspects of vernacular architecture's sustainability

An ecosystem's ability to adapt to shifting environmental conditions by lessening its physical vulnerabilities is reflected in its environmental resilience. A community's physical susceptibility to natural disasters and its ability to adapt to changing circumstances and rebuild itself determine how vulnerable it is. In pre-industrial societies, climatic variability and the uncertain presence of water and other resources lead local communities to develop adaptive practices in order to respond to variability and change, making up in this way for the lack of modern technology, transports, and global market economy. Therefor traditional knowledge played a central role in responding to environmental crises: through processes of trial and error, practices and institutions have been developed to cope with changes and unpredictable events (Gómez et al., 2012).

2.3 Vernacular as a Crucial Component of Sustainability

Methods are applied in the creation of sustainable architecture models, which are also guided by practical and moral issues. In such a technical and practical context, these ideas are an external representation of a kind of functional utilitarianism and honesty, without pursuing stylistic concerns or artistic expression. Conversely, sustainable aspects were able to be more replicable and strongly associated with the preservation of regional history and social shared retention (Mahmoudi, 2008). The majority of the materials utilized in modern building come from the environment, or our immediate surroundings.

In addition to using a lot of energy and natural resources, construction projects often generate a lot of byproducts. This indicates that the pace of resource depletion on Earth is far higher than the rate of resource replenishment. Similarly, the production of tons of by-products pollutes the environment further by releasing unwanted elements into it. The modern world has several challenges, such as shortage of natural resources, pollution in many forms (air, water, land, and noise), and so forth. All of this emphasizes how important it is to employ sustainable architecture and design approaches as well as to save the environment for the future. (Nasir, 2021).

Environmental benefits: By increasing and safeguarding biodiversity and ecosystems, lowering waste streams, and improving air and water quality, sustainable building contributes to the conservation and restoration of natural resources.

Economic benefits include: lowering operational costs (fuel, for example); developing, growing, and enhancing the buildings' life-cycle economic performance and creating markets for green products and services.

Social benefits: Using environmentally friendly design techniques improves overall quality of life, reduces stress on nearby infrastructure, and improves occupant comfort and health. (Development, 2015)

2.4 Identity: Place, People, Culture, and Architecture

The question of cultural identity in contemporary design has gained prominence recently as a means of creating originality and local character in an increasingly competitive global market. "Identity" means "the fact of being who or what a person or object is; the qualities that determine who or what a human or item is" (Oxford dictionaries, 2017) in the Oxford English Living Dictionary. Identity, according to the Cambridge Dictionary, is defining or indicating who or what (someone or something) is, who a person is, or the qualities that distinguish a person or group from others (Abel C., 1980). In other words, identity is anything that makes a person, group of people, culture, nation, or even country stand out from the rest. An individual's "identity" is shaped by a combination of natural and man-made elements, including place (geography, landscape and the environment), people (social and organizational) and culture (traditions, customs, language, religion, and artifacts). It is crucial to talk about these components, how they interact, and how design reflects them.

Culture is one of the most important components in defining identity as it is a creation of the people who created it. Christian Norberg-Schulz is an architectural thinker, writer, educator, and architect who utilizes structures to reflect people and their environment and connect location and culture. Throughout Norberg-Schulz's writings, there is a common conviction that architecture has a unique "essence," an understanding of which is essential to the discourse and practice of architecture (Norberg-Schulz, 1996). As Norberg-Schulz Schulz puts it in "Genius Loci: Towards a Phenomenology of Architecture," "the uniqueness of place requires the identity of human identity." Therefore, the "essence" of architecture is defined as follows: Therefore, understanding the "vocation" of the site is the primary responsibility of architecture (Jina, 1996).

In particular, vernacular architecture is a result of people, place, and culture; it is among the several elements that comprise an individual's identity. Architectural symbols have relevance to the manifestation of social and human identities. "Architecture as identity" is now equivalent to "architecture as space" and "architecture as a language" as a result of this accumulation (McLennan, 2006). Every culture's most visible physical artifact is its architecture, which also has the greatest ability to adapt to and benefit from the distinctiveness of place **(**Curl, 2006).

2.5 Vernacular Conditions: Cultural Impact and Localization

Vernacular architecture is characterized by understated, traditional, native, and basic structures constructed from local resources using tried-and-true forms and layouts (Salman, 2007). Understanding the cultural significance of architecture in society's everyday practices and experiences is essential to understanding people's interactions with their natural and man-made environments (Winchip, 2011).

The constructed environment, which includes the city, the architecture, and the interior spaces, is what I refer to as vernacular architecture as it is created to meet societal demands. It is constructed in accordance with the natural environment (geography, terrain, site, climate, local building materials, labor experience, and construction techniques) in order to satisfy people's physical, economic, social, and cultural needs. Vernacular architecture serves as a "mirror" for a nation, reflecting its history, geography, and culture. It is a symbol of national identity. People design architecture for people, and it has changed throughout time and through trial and error to satisfy societal demands while maintaining environmental harmony.

Vernacular architecture was reliant on local resources and skills due to transportation limitations, which helped to preserve resources and gave each region's architecture a unique character (Fathy, 1976). Architectural technology was determined by the unique physical and aesthetic characteristics of each material.

Every society that has constructed building has also produced unique forms, including clothing, conventions, language, and mythology. Up to the dissolution of cultural boundaries in the twentieth century, architecture naturally reflected unique local shapes and features resulting from materials, technology, environment, and people's culture (Hidayatun et al., 2015). For instance, earth and lumber, one of the oldest and most often used materials in dry places like Ladakh, required specific techniques due to its size, shape, and endurance. It helped that most of the sun-dried earth blocks had proportions that fit the palm of a human hand, as the thickness of these vertical pieces varied according to their constructional location, height, and structural stresses.

Using the trunks of nearby poplar trees as beams was a creative way for builders to address the roofing problem while adhering to the physical requirements of brick. These cutting-edge designs worked well both aesthetically and practically with the regional environment and climate. These structural components developed a symbolic meaning throughout time that transcended their usefulness and aesthetic appeal, becoming ingrained in the "culture memory." The long, sunny days in the hot, arid weather brought out the distinctive beauty of brick. The light and a brilliant sky enhanced the visual attractiveness of the mud bricks by creating a contrast between shadow and shade. The aesthetic and creative aspects of these shapes were acknowledged, despite the fact that some of them were designed for structural and utilitarian reasons.

Regionalism, which in turn considers local characteristics like location, culture, climate, and technology in a certain age, produces architecture that is timeless (Rais, 2019). Architecture, as a location definer, will become disconnected from its surrounding environment and area if imported materials and cutting-edge technology are not employed effectively (Curl, 2006).

Ladakhi architects have assessed their own customs to identify their "own" set of principles and values.This method had a significant influence on the development of modern architecture and ultimately provoked a contentious discussion over how "localism" ought to be created in lieu of reusing old structures. Due to imported worldwide styles and practices that are incompatible with the local environment and do not accurately represent the uniqueness of each city/country, its people, and society, the majority of modern cities lack identity. "We have definitely lost our regard for place, as evidenced by the majority of our towns being built today," (Curl, 2006).

Ladakhn architects have been creating buildings that can reflect regional identity and take the possibilities of the area into account since the middle of the 20th century; this has resulted in a new take on regionalism in architecture. A lot of structures were finished during this trend of reclaiming identity via architecture, but most of them fell short of capturing the spirit and changing environment of regional identity. Generally speaking rather than closely examining regional identity and vernacular architecture, regionalism in architecture has been defined as an emotional interpretation of legacy through particular forms, architectural components, or materials.

2.6 Mediterranean vernacular architecture adaption to the climate

Mediterranean vernacular architecture is well-known for being a climatically and environmentally responsive architectural style that is useful, efficient, and sustainable (Oliver P, 2003). Builders had to experiment and create passively inventive systems that maximize indoor comfort and adapt to specific human demands and climatic conditions using the resources at hand in the past, when energy was scarce and active systems were nonexistent (Oliver, 1997). In this respect, the adaptation of vernacular structures to the local temperature and environment is the outcome of experience and customs (Tzikopoulos et al., 2005). In vernacular architecture, passive techniques help to generate a particular level of indoor comfort and appropriate microclimatic conditions. Mediterranean structures (Vissilia, 2009) clearly demonstrate this, with their emphasis on orientation, regulated openings, shading mechanisms, light-colored external coatings, high thermal endurance of the envelope, and use of natural ventilation.

The white hue of the external finishing layer is one of their most common features, yet one of the least researched. It is well recognized that solar radiation has an impact on thermal loads and building energy requirements (Stefanizzi et al., 2016) and cool materials with high solar reflection are becoming more and more popular in building envelopes to reduce cooling energy requirements and CO2 emissions (Levinson et al, 2007). Nevertheless, only a small number of writers examined the impact of exterior finishing colors on structures (Zinzi, 2016). This is a result of a dearth of information on materials' optical characteristics. This feature has a significant role in the energy requirements of structures and the interior microclimate of traditional Mediterranean architecture. The issue of urban heat islands is mitigated by bright, reflecting, and highly emissive exterior surfaces, as demonstrated by numerical research (Akbari, 2016).

2.7 Climate and vernacular architecture

An important fascination with spontaneous architecture has long been felt by anthropologists, sociologists, and historians of architecture. After the energy crisis broke out in the early 1970s, a different group of academics became interested in works of spontaneous architecture: those who promoted low-energy architecture, which the Americans later referred to "passive" and the Europeans "bioclimatic," possibly due to their better luck.

It was found that architecture without architects had always assumed the rules to build a comfortable envelope based on conscious use of the knowledge of the climatic characteristics of the place of the available materials, just as some precursors such as Rapoport (Rapoport, 1972) and (Olgyay, 1963) had already put in evidence.

It was found that identical or strikingly similar architectural solutions had been achieved in locations that were spread across different continents and inhabited by men from radically different cultures; these locations had never interacted, but they shared a similar climate.

A cultural current emerged that was predicated on the methodical and frequently unquestioning exaltation of the "perfection" of vernacular architecture from the perspective of bioclimatic, or climate adaptation. While some spoke of climate determinism, others denied it. It's not that long ago, so the tendency to elevate "the wisdom of the simple" is still very much present today. This mindset is heavily influenced by the romantic heritage of hyperbaton history, which situates us in an idealized "golden age" of past values that we ought to strive for in the future.

CHAPTER 3

LITERATURE REVIEW

3.1 Traditional/Ancient materials – modern applications and innovations

Classical construction materials like wood, stone, and clay are seeing a renaissance because they provide sustainability in situations where more labor-intensive and expensive materials like reinforced concrete, fiberglass, glass, and steel are unaffordable (Buchanan, 1985) . Traditional construction materials are still widely used at a time when cost and carbon foot printing are becoming important considerations, particularly in regions of the world where natural resource depletion is becoming a problem. There hasn't been much advancement in technology since the first farmers some 10,000 years ago, when most of the technology and material attributes employed in conventional building construction were created (Spence et al., 1983). Although clay, lumber, and stone are still used in building construction, their application requires years of study, testing, and alloying with other materials. In fact, but on a more industrial scale, the extraction, manufacture, and usage procedures for clay goods like brick remain the same. At its height in the 1970s and 1980s, British brick manufacturing reached up to 18 million bricks per week at Stewartby in Bedfordshire, England (Nash, 2009). Using clay as a construction material may provide a structure the structural integrity it needs to remain standing in addition as adding aesthetic value to a building's view.

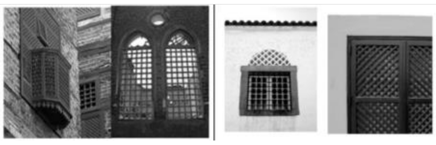
In terms of aesthetics, clay may be molded and curved to create elaborate facades and tiles. If it is polished and created to a specific quality, it can also be used to create terracotta pottery. Over the ages, the accessibility, geomorphological properties, and geographic distribution of clay have had a significant impact on building design and structural performance. Clay's plastic properties have made it possible for architects and builders to employ this amazing material in almost every facet of building over the millennia; it is used to make surface renders, wall tiles, flooring, roofing, and bricks (Hodder, 1998).

3.2 Climate-responsive strategies used in Mediterranean vernacular architecture

Mediterranean vernacular architecture is well-known for being a climatically and environmentally sensitive architectural style that is useful, efficient, and sustainable (Oliver P, 1998). On the past, architects had to experiment and create passively inventive systems that maximize indoor comfort and adapt to specific human demands and climatic circumstances using the resources at hand because energy was not easily accessible and active systems were nonexistent (Turan, 1990). *Table 2* compares a number of climatically sensitive vernacular techniques, demonstrating several adaptable passive solutions in both nations' Mediterranean areas.

Table 2. Climate-responsive design techniques seen in northern Egypt's and southern Portugal's vernacular architecture (Fernandes et al., 2014)

Strategy	Description	northern Egypt - southern Portugal
Urban design and building shape	• A compact urban design minimizes the amount of sun-exposed surfaces.	
	• Covered galleries and narrow streets shield people from the hot summer months.	
	• Patios are common in metropolitan areas, and buildings have compact forms. Buildings are oriented to maximize solar benefits in the winter and minimize them in the summer in the south quadrant.	

Utilizing natural ventilation and shade	• Adequate window shade when heat gains are not wanted, utilizing plants or screens (mashrabiya).	
	• In order to maintain thermal comfort and privacy, grids are used to promote cross-air circulation throughout the structure;	
Tiny openings	• Heat gains are decreased by reducing the size and quantity of apertures.	
Evaporative cooling	• Water evaporation from fountains and ponds, which are typically installed in patios and cloisters, cools the surrounding air.	
Vegetation usage	• The evapotranspiration process increases air moisture and provides shade for vegetation, which helps cool air streams before they enter buildings.	
Materials and thermal mass	• The local climate is ideal for using the resources that are available, mostly stone and soil. The temperature inside is stabilized by their strong heat storage capacity, which keeps the inside warm at night and cold during the day.	
Buildings' color	• By reflecting solar radiation, light colors are used on the building exterior, particularly on the roof, which receives the most sun exposure. This helps to minimize heat gains.	

3.3 Vernacular architecture studies and past research on Mediterranean areas

Galán-Marín et al. (2018) conducted one of the most current research on traditional and Mediterranean vernacular houses in Cordoba, southern Spain (Galán-Marín et al., 2018). This study examined the impact of shading one traditional element—the courtyard—by comparing its thermal efficiency to that of non-shaded courtyards in an effort to enhance it. This study demonstrated the thermal advantages of courtyards and how their beneficial effects may be amplified and incorporated into modern construction using a quantitative method. Fernandes and colleagues (Fernandes et al., 2014) discussed the value of researching vernacular architecture from a sustainability perspective. The study's foundation is a comparison of the vernacular architecture of southern Portugal and Egypt, two Mediterranean regions. The study came to the conclusion that similar vernacular strategies can be found throughout the Mediterranean regions. Mediterranean vernacular architecture was developed from a variety of perspectives and influenced by a wide range of factors, including climatic, environmental, and cultural aspects.

(Yannas et al., 2013) have noted the advantages of employing local materials and the superior thermal efficiency of vernacular structures in the setting of the Mediterranean climate. According to the study's outcomes, climate has a big role in building design and that passive cooling strategies utilized in Mediterranean vernacular architecture are useful considerations for creating energy-efficient buildings. Nevertheless, because mechanical equipment was assigned the primary responsibility in controlling the interior climate, the contemporary building design relies mostly on fossil fuels.

Few studies have been conducted in Palestine on various facets of vernacular architecture, particularly on how sociocultural values influence vernacular tactics employed in various residential building components and how they compare to modern residential structures. The majority of research focuses on a single area, such the preservation of the components of the possibility of repurposing traditional structures or researching the vernacular architecture. As an example, in order to provide a variety of examples of repurposed traditional structures (Ijla et al., 2015). In Palestine (Hadi, 2013), conducted a comparison between older and newer buildings with respect to the particular factor of thermal performance and came to the conclusion that older buildings are more cost-effective and have superior thermal performance than newer construction. Other research, as (Haddad, 2010), concentrated on traditional and vernacular construction techniques, emphasizing that these structures and solutions had to be researched, assessed, and improved rather than imitated.

In order to improve the living quality of future house designs in Palestine, (Hussein et al., 2010) emphasized the socio-environmental features of private outdoor spaces in modern Palestinian housing by contrasting it with traditional outdoor spaces. This comparative research was conducted in Jericho and Nablus, two distinct cities in two distinct climate zones in Palestine. The research focused on the notion of a courtyard and the importance of intentionally reinstating it in the design of residential structures, both new and old.

The survey that served as the basis for this study included 300 homes of various housing typologies, including multi-family and detached homes—the two most prevalent types of modern housing in Palestine. The primary finding of this study was that, in order to improve and achieve housing sustainability, private outdoor spaces are crucial, and that modern outdoor spaces are not made to accommodate the demands of their occupants.

By comparing modern and traditional typologies and determining how to employ historic housing's land characteristics to enhance contemporary housing in Palestine, another comparative research studied Palestine's high-density housing and the lack of land in the nation (Itma, 2014). Various types of housing, including attached, single-family, and courtyard homes, have all been examined in this study. Furthermore, it specifies the following construction typologies for Palestinians: i) courtyard housing; ii) highrise, high-density housing; and iii) low-rise, low-density housing. presented a comparative study stakeholders identify the vernacular architecture's guiding principles that can be applied to improve the sustainability of new urban areas.

An influential research of Middle Eastern vernacular architecture suggests that vernacular housing prototypes should be interpreted and studied within their particular setting (Meieret al., 2004). It seems unlikely that examining prototypes of vernacular housing as a setting tailored to the limitations of the natural world would produce the best results when it comes to suitable technologies and solutions in general.

In Table 3, a summary of similar projects on Mediterranean is made, highlighting through the analysis of the element taken in the study, its energy impact and the analyzed results of each study.

Table 3. Analysis of similar cases on Mediterranean cities

Study and climate location	Study based						Traditional element analyzed			Impact analyzed			Efficency impact			Research methods			Results
	Element analysis	Comparison of the v.a of Portugal and Egypt	Interior climate	sociocultural values influence	vernacular tactics	comparing modern and traditional housing typologies	Courtyard	Urban and façade elements	the preservation of the components	Shading element	climatic, environmental, and cultural aspects	passive cooling techniques	Repurposed traditional structures	thermal efficiency	Climate-responsive strategies	Quantitative data	Qualitative data	Design builder	
(Galán-Marín et al., 2018) **Cordoba, southern Spain**	•						•			•				•		•			Demonstrated the thermal advantages of courtyards and how their beneficial effects may be amplified and incorporated into modern construction.

(Fernandes et al., 2014) **southern Portugal and Egypt**		•						•		•					•		•		Similar vernacular strategies can be found throughout the Mediterranean locations, even if the culture is founded on Roman or Arab cultures Mediterranean vernacular architecture was developed from a variety of perspectives and influenced by a wide range of factors,including climatic,environmental, and cultural aspects.
(Weber, W.; Yannas, S. , 2013) **Mediterranean**			•					•				•		•			•		Climate is a significant factor in building design and that a few of the Mediterranean vernacular architecture's passive cooling methods were pertinent ideas to take into account when designing energy-efficient structures. Nevertheless, because mechanical equipment was assigned the primary responsibility in controlling the interior climate, the contemporary building design relies mostly on fossil fuels.
(Ijla, A.; Broström, T, 2015) **Palestine**				•					•				•			•			Adaptive reuse is a good way to improve the sustainability of the built environment. Compared to demolishing and rebuilding, adaptive reuse increases a building's long-term usefulness and is therefore a more sustainable choice.
(Abdel Hadi, 2013) **Palestine**	•							•			•			•				•	Older buildings are more costeffective and have superior thermal performance than newer construction.
(Hussein et al., 2010) **Palestine**	•					•	•	•						•		•			In order to improve and achieve housing sustainability, private outdoor spaces are crucial, and that modern outdoor spaces are not made to accommodate the demands of their occupants.

3.4 Historical studies of Mediterranean regions and vernacular architecture

In Italy, an experimental construction site was recently established between 1992 and 1993 in Sperate, in Sardinia, in accordance with the provisions of April 10, 1991, law n.125, which deals with "Beneficial actions for the achievement of equal working conditions for female employees." For more than two years, a sizable number of academics and specialists from various age groups and socioeconomic backgrounds have been active in educating the local female population about social emergency protocols as well as the proper and responsible upkeep of earthen homes (Mongiu, 2004).

Another experimental project in Spain was completed at the village of Navapalos. It was completely constructed of rammed earth, but it was abandoned following an earthquake. The architect E. Rohmer provided funding for the Association InterAcciòn (ONGD) to promote the event in 1985. The construction site was intended to serve as a place where educators and learners could coexist as a cohesive community, moving from tents to homes once the structures were completed, and cooperating. (Navapalos, 1994). Throughout the Euro-Mediterranean region, traditional earth architecture is defined by walls constructed primarily of tapia, or tapial atop a stone foundation including bands of three rows of baked bricks spaced every 60 to 90 cm, enticing with slaked lime mortar (henceforth referred to as encintados), and linked to vertical constructions constructed in a similar fashion. from conservation to knowledge for sustainable usage.

Given that the area is seismic, strengthening the earth walls with six sturdy pillars is essential (Uzal, 1996). They have porches on the minor sides and narrow, enlarged patios that are oriented N-S (even in rural locations, in accordance with the customary sun orientation shared by the urban tissues of many Mediterranean cities) in order to achieve the maximum thermal comfort. This orientation has been used since ancient times (Orsini et al., 1802).

CHAPTER 4

STUDY AREA

4.1 Overview

The process of life of a nation continues to be one of the most obvious markers of its cultural heritage. Buildings are seen to be among the first examples of culture, and ethnologists believe that this makes them the ideal medium for recording history (Muka, 2004). Regarding space and building materials, Albanian architecture has a deep relationship with the natural world. Albania's architectural legacy is a significant part of the Albanian people's patrimony, having evolved over ages and starting from ancient times. Due to its history and foreign invasions, Albanian architecture has been influenced by many civilizations over the ages. Because traditional Albanian homes were not the work of educated artisans but rather demonstrated a logical answer for their time of construction, Ali Muka refers to Albanian architecture as "vernacular architecture" (Muka, 2004).

Albanian cities began to expand in the 19th century, particularly in terms of urban planning. Cities with flat topography, such as Shkodra, Elbasan, Durres, saw an extension of architecture in this century, moving away from the castle, which became completely defunct in the middle of the 19th century. However, because of their steep geography, places like Girokastra and Berat have maintained their urban traits. The majority of Albania's traditional architectural legacy is found within its homes. All parts of the nation have traditional homes, albeit they range in typologies according to geographic, climatic, and cultural influences from surrounding nations (Pashako, 2012). Hilly topography restricted architectural design; nonetheless, as these topographies were viewed as natural barriers, the towns situated on these locations had a significant impact on the development of forced-oriented architecture, in which every structure was constructed according to an organic plan.

Urban centers and communities situated on level ground, including expansive structures encircled by towering walls for security, are another type of landscape.

Seldom is the house close to the roadways; it is encircled by a lot of vegetation and has a straightforward design (Thomo et al., 979). New concepts for residences emerged throughout Albania between the 19th and the first half of the 20th centuries, reflecting historical significance linked to the growth of the national bourgeoisie, which strove to adorn their homes to demonstrate their wealth and affluent lifestyle. Traditional Albanian homes served as the foundation for both residential and economic-social activities (Meksi et al., 1979).

Albania is located in southeast Europe, in the western region of the Balkan Peninsula, between the Adriatic and Ionian Seas. 77% of the country's land is made up of hills and mountains due to its rugged environment. Strong tectonic movements and diverse landscapes have resulted from this position, especially in the southern half of the region.

4.2 Site Selection

Albania is located in southeast Europe, in the western region of the Balkan Peninsula, between the Adriatic and Ionian Seas. 77% of the country's land is made up of hills and mountains due to its rugged environment. Strong tectonic movements and diverse landscapes have resulted from this position, especially in the southern half of the region.

Gjirokastra, Korca, and Berat are typical Mediterranean cities (*Figure 1*) chosen for this research, all of them located in the southeast part of Albania (*Figure 2*). In terms of historical context and influences. Gjirokastra, a UNESCO World Heritage Site, is renowned for its exquisitely maintained Ottoman-era architecture, whilst Korca has a blend of Ottoman and Neoclassical architectural elements. Comparing Korce to Gjirokaster and Berat, Korce is better organized urbanally and is recognized for its cultural and educational significance. Berat, another UNESCO World Heritage Site, is well-known for the castle quarter and its white Ottoman homes. Known as the "City of a Thousand Windows," it features a distinctive architectural design with lots of windows and a tasteful fusion of old and new.

Figure 1. The selected locations in the Mediterranean region

Figure 2. The selected locations in Albania map

4.2.1 Gjirokastra

Situated in a valley between the Gjerë Mountains and the Drino River (*Figure 3*), Gjirokastër is a UNESCO World history. About 300 meters above sea level is the elevation at which the city is located. The rugged, hilly landscapes that define the city's topography operate as a natural barrier (Gjirokastër, 2020). City that is renowned for its well-preserved Ottoman-era architecture and its role in symbolizing the cultural history of the region known as the "City of Stone." Ottoman architectural styles, which are typified by towering stone walls, ornate wooden balconies, and stone homes with characteristic roofs, are a major impact on Gjirokastër's architecture. (Jacques, 1995) These buildings, which are a dominant feature of the cityscape, are examples of Ottoman workmanship and design ideas.

The traditional houses, referred to as "kulle," are mostly made of stone, with wooden accents and slate roofs. These tall houses are both beautiful and useful, with broad eaves that offer insulation from the harsh winters and summer heat. (Riza,2009)

***Figure* 3.** Beqiri, A. (2024), Gjirokaster Location in Albania map

4.2.2 Korca

The city of Korça is located in southeast Albania on a plateau that is about 850 meters above sea level. It is among the most significant hubs for both culture and the economy in the area. The Morava Mountain range encircles it, and it is located close to the Greek border as illustrated in *Figure 4*. Since ancient times, people have lived in Korça, which saw substantial growth throughout the Byzantine and Ottoman eras. (Çuka & Gjeta, 2017). Korça's architecture, which combines Ottoman, Neoclassical, and contemporary elements, is a monument to its rich past. Numerous ancient structures in Korça include Ottoman architectural characteristics, such timber balconies, stone masonry, and elaborate embellishments. Several neoclassical structures, influenced by European architectural styles, were built in the late 19th and early 20th centuries (Hoxha, 2019). These structures frequently have ornate facades, columns, and symmetrical forms. Modern architecture has swept through Korça in recent decades, with new public, commercial, and residential structures that showcase modern style and practicality (Çuka & Gjeta, 2017).

Figure 4. Beqiri, A. (2024), Korce Location in Albania map

4.2.3 Berat

Situated 120 kilometers south of Tirana and on the right bank of Osum in southern Albania (*Figure 5*), the city of Berat is 53 meters above sea level and encircled by mountains, including the recently designated Morr National Park. One of the earliest towns in the Balkans and Europe, the city was fortified with castles, medieval roadways, and walls as early as the 4th century BC. The Ottoman Empire, which ruled the city for five centuries, is one of the foreign invasions that are represented in the architectural and historical traits that the city of Berat has managed to maintain (Pashako, 2012).

Berat is renowned around the globe as "the city of 1000 widows" because of the numerous big windows situated on the town's ancient, elaborately adorned façade. In 2008, Berat's distinctive architecture was inducted into the UNESCO globe Heritage List. With 444 cultural monuments preserved, Berat is a historical gem of Albanian culture (Pashako, 2012).

Figure 5. Beqiri, A. (2024), Berat Location in Albania map

4.3 Climate context of the selected sites

Albania is a country in Southeast Europe that is bordered by the Ionian and Adriatic Seas. Its latitude, closeness to the Mediterranean Sea, and diverse topography which includes plains, hilly areas, and coastal areas all affect its climate.

Coastal Mediterranean Climate:

- **Temperature**: The coastal areas of Albania experience a typical Mediterranean climate. Summers are hot and dry, with average temperatures ranging from 25°C to 30°C. Winters are mild and wet, with temperatures averaging 8°C to 10°C (Tota & Bajraktari, 2020).

- **Precipitation**: The coastal region receives significant rainfall, especially during the winter months. Annual precipitation averages between 1,000 mm and 1,500 mm, with the wettest months being November and December (Tota & Bajraktari, 2020).

Inland and Continental Climate

- **Temperature**: Inland areas exhibit more continental characteristics. Summers are warm to hot, with temperatures ranging from 20°C to 25°C. Winters can be cold, with temperatures often dropping below 0°C, especially in higher altitudes (Lika & Sulçe, 2019).

- **Precipitation**: These regions experience substantial precipitation, particularly in the mountainous areas where annual precipitation can exceed 2,000 mm. Snowfall is common in winter (Lika & Sulçe, 2019).

Mountainous Alpine Climate

- **Temperature**: The mountainous regions, including the Albanian Alps and the Pindus Mountains, have a more alpine climate. Summers are cooler, with temperatures around 20°C, while winters are cold, often dropping below -10°C in the highest peaks (Marku & Tashko, 2018).

- **Precipitation**: These areas receive the highest precipitation in the country, with annual amounts often exceeding 2,500 mm. Snow is prevalent and can persist for several months in the highest elevations (Marku & Tashko, 2018).

Climate Change Impact

Albania is experiencing notable effects of climate change, which are influencing its weather patterns, ecosystems, and socioeconomic conditions.

- **Temperature Rise**: Average temperatures in Albania have been rising, with a significant increase in the frequency and intensity of heatwaves during the summer months.

- **Changes in Precipitation Patterns**: There has been a shift towards more erratic rainfall patterns, including heavier rainfall events and prolonged dry periods, affecting agriculture and water resources.

- **Sea Level Rise**: Coastal areas are increasingly at risk of flooding and erosion due to rising sea levels, which also threaten freshwater resources through salinization (Zeneli, 2021).

4.3.1 Climate context of Gjirokastra

Southern Albania include the region of Gjirokastra, which is characterized by a warm and moderate temperature (Climate-Data, 2024). The graph (*Figure 6*) shows the monthly changes in Gjirokaster's temperature and sun irradiation. The temperature (°C) is represented by the left Y-axis, which ranges from -5°C to 30°C. The average monthly temperature is shown by the red line, the minimum monthly temperature is shown by the dotted grey line, and the maximum monthly temperature is shown by the dotted orange line. Light orange bars on the right Y-axis indicate the sun irradiation in watts per square meter (W/m2), which is measured on a horizontal plane and ranges from 0 to 350 W/m². The months of the year, from January to December, are represented by the X-axis. During the summer, the maximum temperature peaks at roughly 30°C, while the average temperature peaks at or above 20°C in July and

August. The minimum temperature is still below average; in January and February, the lowest readings are often close to -5°C. The highest levels of solar irradiance, which can reach up to 300 W/m², occur in June, July, and August, while the lowest levels, which fall below 50 W/m² in December and January. The seasonal fluctuations in Gjirokaster's temperature and sun irradiance are depicted in this graph.

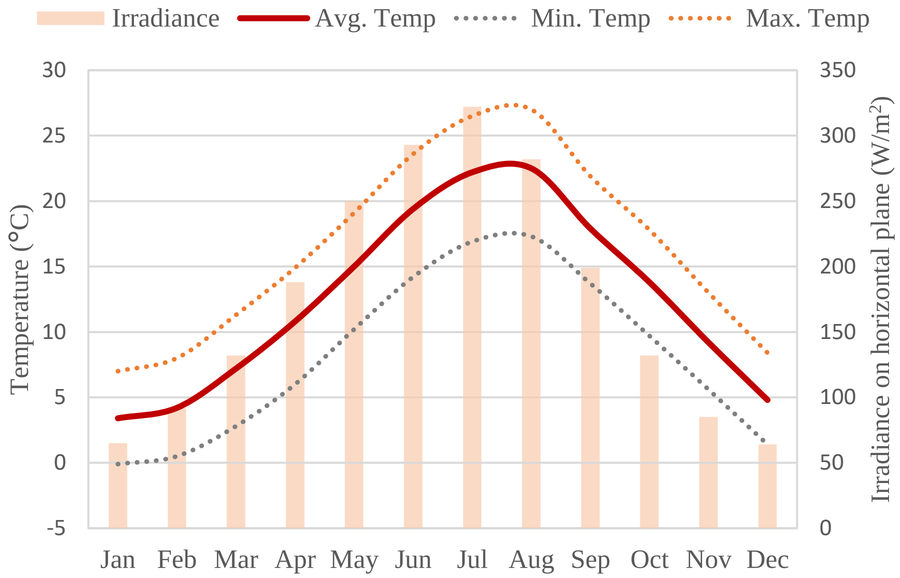


Figure 6. Annual temperatures and average solar irradiance on horizontal plane for the city of Gjirokaster (Meteonorm 2024)

4.3.2 Climate context of Korca

The town of Korça lies in southeast Albania and has a moderate, temperate climate (Climate-Data, 2024). The temperature and sun irradiance variations for the city of Korca can be observed on the graph (*Figure 7*). The temperature is represented by the left Y-axis in degrees Celsius, with a range of -10°C to 30°C. The average monthly temperature is shown by the red line, the minimum monthly temperature is shown by the dotted grey line, and the maximum monthly temperature is shown by the dotted orange line. Light orange bars on the right Y-axis indicate the sun irradiation in watts per square meter (W/m2), which is measured on a horizontal plane and ranges from 0 to 250 W/m². The months of the year, from January to December, are represented by the X-axis. During the summer, the maximum temperature peaks at roughly 30°C, while the average temperature peaks at or above 20°C in July and August. In January and February, the lowest minimum temperatures are often close to -10°C, which is below the norm. The highest levels of solar irradiance, which can reach up to 200 W/m², occur in June, July, and August, while the lowest levels, which fall below 50 W/m² in December and January.

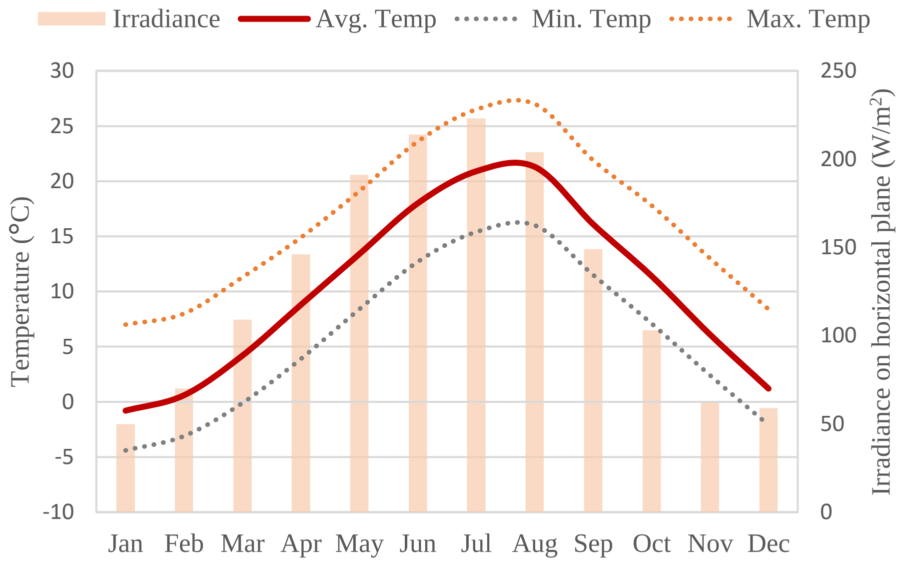


Figure 7. Annual temperatures and average solar irradiance on horizontal plane for the city of Korca (Meteonorm 2024)

4.3.3 Climate context of Berat

With a Mediterranean mild and moderate climate, Berat is situated in central Albania, in the southern region of the nation (Climate-Data, 2024). The temperature and sun irradiance variations for the city of Berat are displayed on the graph (*Figure 8*). The temperature is represented by the left Y-axis in degrees Celsius, with a range of -10°C to 30°C. The average monthly temperature is shown by the red line, the minimum monthly temperature is shown by the dotted grey line, and the maximum monthly temperature is shown by the dotted orange line. Light orange bars on the right Y-axis indicate the sun irradiation in watts per square meter (W/m2), which is measured on a horizontal plane and ranges from 0 to 250 W/m². During the summer, the maximum temperature peaks at approximately 30°C, while the average temperature peaks at or above 20°C in July and August. January and February saw the lowest minimum temperatures, which are still below normal and nearly at freezing. The highest levels of solar irradiance, which can reach up to 300 W/m², occur in June, July, and August, while the lowest levels, which fall below 50 W/m² in December and January.

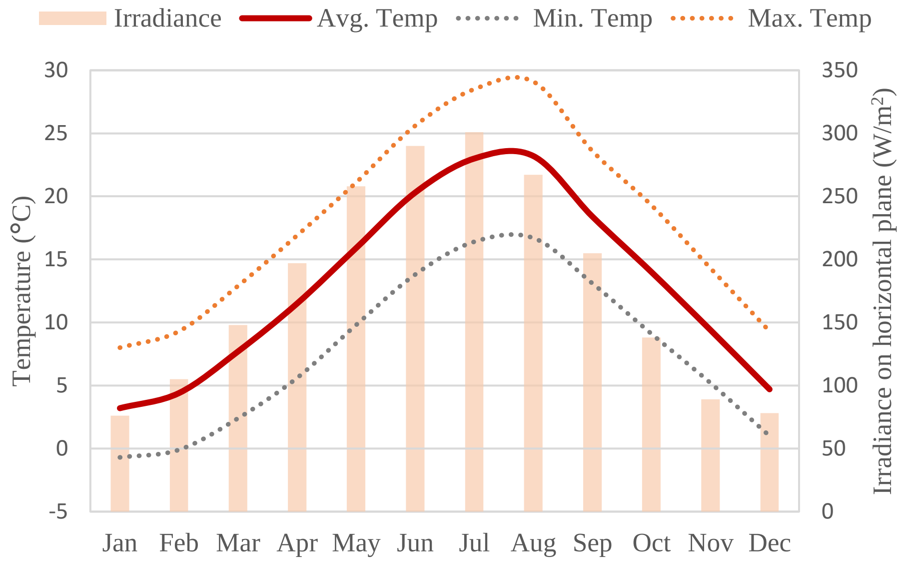


Figure 8. Annual temperatures and average solar irradiance on horizontal plane for the city of Berat (Meteonorm 2024)

4.3.4 Climate comparison

The monthly temperature variations for three cities—Korçë (KOR), Berat (BER), and Gjirokaster (GJIR)—are depicted in *Figure 9*. The months of January through December are represented by the X-axis, while the temperature in degrees Celsius (°C), ranging from 0°C to 30°C, is represented by the Y-axis. The weather of Gjirokastër is Mediterranean, with hot, dry summers and warm, rainy winters. Summer temperatures typically reach over 30°C, while winters are pleasant with very few below-freezing days. As shown in Figure 9 due to its greater altitude, Korçë has colder winters and cooler summers, with an average summer temperature of 25–28°C and more snowfall. Because to its closeness to the shore, Berat has slightly milder temperatures than inland cities; it has hot summers and mild winters similar to those of Gjirokastër. Winter brings most of the rain to Gjirokastër; summers are dry and there is sporadic snowfall in the nearby mountains. All three cities have similar seasonal temperature patterns overall, with warmer summers and colder winters; however, Korçë is generally colder all year round, whereas Berat and Gjirokaster enjoy warmer temperatures, especially in the summer.

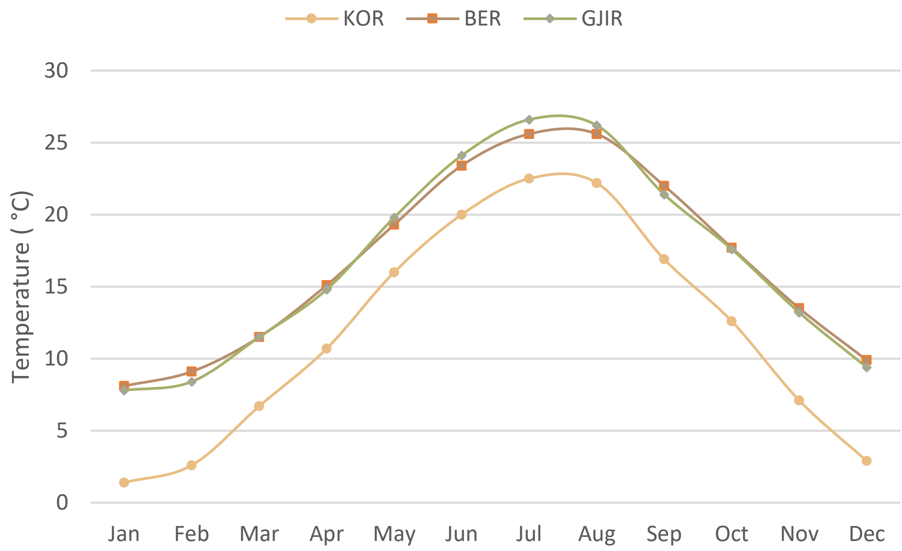


Figure 9. Climate Temperature Comparison for the three cities (Meteonorm 2024)

Precipitation in Korçë and Berat is more evenly distributed year-round, (*Figure 10*) with somewhat higher amounts in the spring and fall. Similar to them Gjirokastër experiences its most rainfall in the winter but but at a higher value, with intermittent showers brought on by the impact of the coast in the spring and fall. The yellow line, Korçë (KOR), depicts comparatively constant precipitation levels throughout the year, with greater values during the winter. With values about 140 mm, the precipitation peaks in January and then progressively declines to its lowest point during the summer, especially in July and August, before rising once more near the end of the year. Compared to Korçë and Gjirokaster, Berat (BER), represented by the orange line, shows a continuous trend of lesser precipitation throughout the year. The months with the most precipitation are November and December, when up to 80 mm of precipitation is recorded; July has the least amount of precipitation, about 20 mm. The green line depicting Gjirokaster (GJIR) demonstrates a clear pattern with noticeably more precipitation in the winter. December sees the peak, which can reach a height of 180 mm. Precipitation in the city decreases sharply from April to August, reaching its lowest point in July (like in Berat and Korçë), and then begins a considerable rebound in September. Overall, the comparison illustrates that Berat has lower, more consistent precipitation with a slight increase towards the end of the year, Gjirokaster has the highest and most variable precipitation, especially peaking in the winter months, and Korçë has more stable, moderate precipitation throughout the year. This demonstrates how these three cities' different climates have different effects on precipitation patterns.

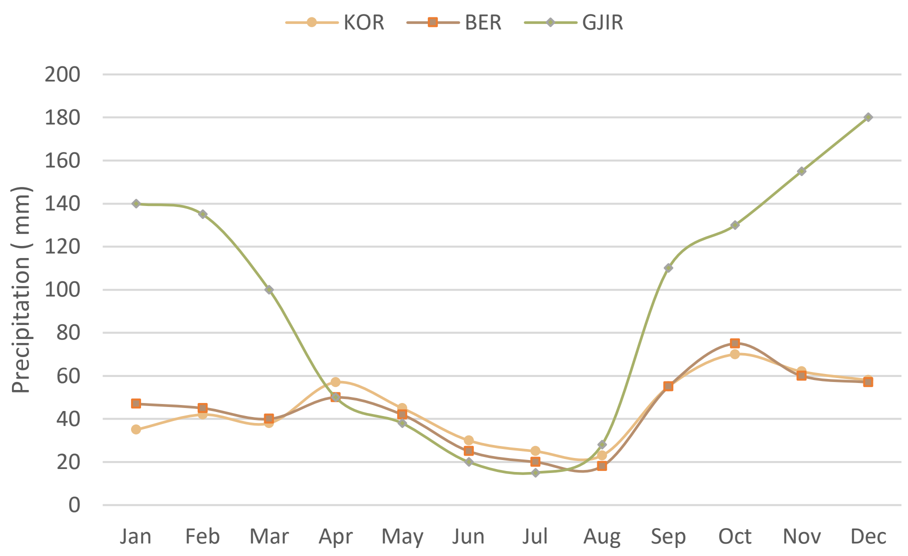


Figure 10. Precipitation Comparison for the three cities (Meteonorm 2024)

4.4 Traditional Housing Typologies in Albania

Although the origins of these structures may be traced back to the fourteenth century, the expansion of traditional Albanian houses occurred throughout the nineteenth century. Traditional housing in Albania served as the foundation for both residential and economic-social activities (Meksi et al., 1979). Traditional Albanian homes come in a variety of typologies, but they always have the same spatial distribution pattern and number of spaces. The majority of these homes are two stories, with the living quarters on the first level and the service rooms and barns for livestock and agricultural goods always located on the bottom floor. The first-floor inner wall and, in rare instances, the facades were created using a mix of yarn and wood, although the constructions were based on enormous stone masonry. Load-bearing walls were made of stone, whereas floors, roofs, and secondary walls were made of wood (Pashako, 2012).

Researchers from Albania (Riza, 2009) divided traditional housing into five categories: houses with porches called "hajat" (derived from the Turkish word hayat), houses with side galleries called "çardak," houses with Tirana houses, also called "shtepi zjarri" (fire houses), houses with galleries called "qoshk" and "kulla" (tower houses). The oldest style of vernacular architecture is the "hajat" house, which dates back to the early 1700s. Examples date as early as the 17th century. The area that is exposed on the front façade or one of the two sides is called the porch, or "hajat". It has several wooden columns supporting it from the front, and an extended roof covers it. This porch served as a living area in addition to serving as a link between all the rooms in the house.

The porch of the home served as a working place for agricultural goods in addition to being a communication unit. Large gardens and tall walls were typical features of this style, which was prevalent among wealthy households (Riza, 2009). The 15th through the 19th century saw the construction of "çardak" houses in Albania. According to Meksi, this home typology with "cardak" is prevalent in Shkodra, Berat, Elbasan, Korge, Durres, Kruje, Lezhe, and other villages in Albania. The Persian language is where the word "çardak" (which meaning "five columns") originates. This sort of home has a distinctive spatial arrangement called the gardak, a sizable room that functions mostly in the summer and resembles a gallery (Meksi et al., 1979).

Main facades of houses with Çardak facing south are where you will mostly find them. Prior to its usage as an eating area or lounging area, particularly on hot summer days, this area was utilized for the refinement of agricultural goods. The first room you see when you go into the home is called Çardak. It is connected to the main staircase and has a hardwood floor with just wooden roof pieces for shade instead of ceilings. Cardak faces either the south, south-east, or south-west, or the sunny side of the horizon (Riza, 2009). Through its vernacular architecture, this type captures the spirit and personality of the local area. Homes with "çardak" have a horizontal floor layout and are arranged in two floors (Meksi et al., 1979). The first level is used for residential quarters and the çardak serves as the main entrance. The ground floor is utilized as a barn and communication hall. The extent of internal design varied according to the owner's social status; rich households had ornate doors, windows, and other interior features (Riza, 2009).

With the exception of Berat, where this type of building is also found on sloppy ground with little to no garden, this type of residence was often located on plain terrain, surrounded by a garden, and a high defensive wall. "Qoshk" houses are the third kind of traditional Albanian homes. This particular typology is often referred to as the "house with side gallery," as it features a space that protrudes from the frontal facade's contour and is typically placed in the middle or on either side. A section utilized for a living was the side gallery, also known as the "goshk" (Meksi et al., 1979). Homes with "qoshk" were constructed as one- or two-story structures with a straightforward design made up of three main sections: the dwelling blocks on either side and the middle portion housing the stairs and connection area.

In terms of architectural furnishings and ornamentation, this home typology is simpler than the two preceding forms (Riza, 2006). The tower buildings, or "kulla," which were mostly constructed in the late 19th century, are another unique kind of Albanian vernacular architecture. Compared to the others, this type has a distinctive composition and design. A kulla is a type of fortification that is mostly located in northern Albania. Typically, tower homes were two-story structures with both an exterior and an interior made of stone masonry (Riza, 2006).

4.4.1 Traditional Houses in Gjirokaster

The main traditional dwelling typology found in Gjirokaster is the "Kulle" or "tower house". This typology has a unique spatial composition that incorporates utilitarian and cultural factors (Heritage, 2005).

Spatial composition

Kulle buildings are distinguished by their verticality, frequently reaching multiple floors. The lack of level soil in the untamed region of southern Albania is reflected in the vertical design, which is driven by the necessity of protection against invaders. Typically, native stone is used in the construction of these dwellings, which offers superior durability and insulation. The building's defensive qualities and structural stability are enhanced by the massive stone walls. Their small size allows for a compact layout (Robert, 2017). Usually, the lower floor has animal stables, storage spaces, and occasionally a kitchen. The top levels are used by living quarters, with communal areas and bedrooms centered around a central courtyard or staircase.

A "hajat," or center courtyard, is a common element in kulle homes. It provides natural light and ventilation while also acting as an outdoor living area. The courtyard can be utilized for social events or domestic chores like cooking. It frequently has a well for water supplies (Torresi, 2001). Kulle homes were historically built with defensive elements to shield occupants from harm. These include fortified doors, tiny windows high on the wall to reduce projectile susceptibility, and occasionally even gaps in the wall where an attacker can be shot. Usually flat, they have stone slab roofs or wooden beams covered with stone tiles. During battles, the strong roof can sustain defensive positions and acts as an extra line of defense (Lamprakos, 2010).

Construction Techniques

The primary traditional home type in Gjirokaster, referred to as the "kulle" or "tower house," is built using a blend of regional materials, skilled workmanship, and architectural ideas that are specific to the area's rocky topography and rich historical background (Robert, 2017). Kulle dwellings are mostly built from locally available stone, either granite or limestone. Expert stonemasons meticulously cut, shape, and arrange the stones to create substantial walls that offer security, insulation, and protection from outside dangers as shown in *Figure 11.* Stacking stones without mortar is a common method of building dry stone walls for kulle dwellings (Riza, 1984). This method depends on the stones fitting together precisely to form a solid structure. In order to create sturdy walls that can survive earthquakes and other natural difficulties, skilled artisans carefully choose stones of different sizes and shapes to interlock them firmly. The main building material for kulle homes is stone, but timber components are also essential. Floors, ceilings, and roof systems are structurally supported by wooden beams, joists, and lintels. Wooden components are shaped and joined using traditional carpentry techniques, which guarantee their structural integrity and lifespan (Riza, 1984). Kulle homes often have flat or gently sloping roofs made of wooden beams covered with tiles or stone slabs. The timber structure offers weather protection and bears the weight of the stone coating. To guarantee appropriate drainage and avoid water penetration, which might jeopardize the structural integrity of the building, roof construction demands meticulous attention to detail. Kulle homes frequently have carved lintels, elaborate doors, and ornamental motifs gracing their facades, among other wood- or stone-crafted decorative components. These components add to the structures' visual attractiveness while showcasing the builders' artistic expression and workmanship (Riza, 1984).

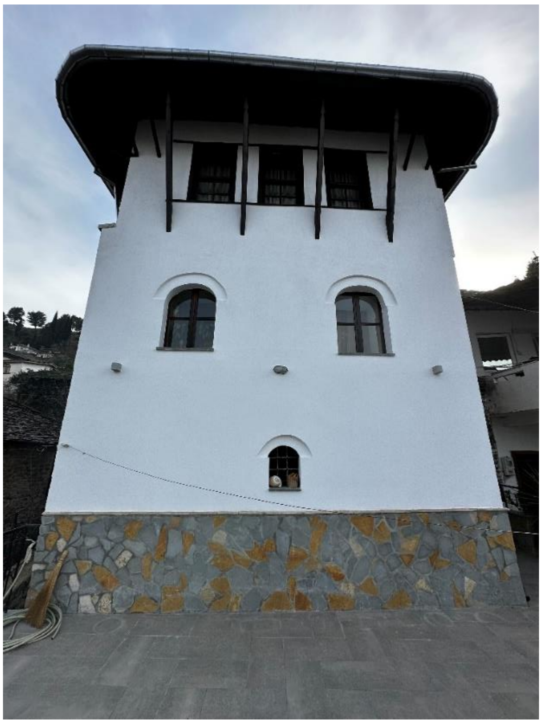


Figure 11. Beqiri, A. (2024). Adem Zeko House, Gjirokaster

4.4.2 Traditional Houses in Korce

The spatial arrangement, materials, and decorative aspects of traditional homes in Korçë, Albania, are a combination of Ottoman and indigenous architectural traditions. The main building materials are wood and stone from the area (Aliaj, 2003). Usually, the top stories are constructed of wood, allowing for elaborate ornamental embellishments and lighter construction, while the ground level is composed of stone, which offers structural stability and moisture protection. Terracotta tiles adorn the gabled roofs of traditional homes (Riza, 2014). The precipitation and snow are shed by the steep grade. Better light and views are made possible by the top floors' prominent bay windows or erker, which project out from the front. Wooden embellishments are frequently used to frame these windows. For privacy and security, the ground level windows are often smaller and blocked. Wooden components are frequently finely carved, particularly the eaves, balconies, and internal ceilings. The cultural legacy is reflected in the interior design, which includes vibrant carpets, painted ceilings, and fabrics.

Spatial composition

The center point of the home is the central hall, or hayat, which is usually found on the top floor. Encircled by private rooms, it functions as a shared space for family gatherings. The geography and the demands of the occupants dictate the layout of Korçë dwellings, which is frequently asymmetrical in contrast to Western symmetrical forms. Stables, a kitchen, and storage areas are located on the ground level. It is less ornamented and has more functional uses (Aliaj, 2003). A wooden staircase extends from the entry hall to the upper stories. The primary living areas, which include the central hall, bedrooms, and reception areas, are located on the upper levels. These rooms have bigger windows that let in plenty of natural light and have more ornate décor. Rooms provide a variety of purposes, including dining, sleeping, and socializing. Most furniture is movable to accommodate various applications. Terraces and balconies create more living area while providing vistas and fresh air. The main rooms or central hall are frequently the points of entry. Many homes include an enclosed courtyard that gives the family a private outside area. It frequently has an outdoor kitchen, a well, and a garden (Riza , 2014).

Construction Techniques

Stone Foundations: Sturdy stone foundations support the traditional Korçë dwellings as shown in *Figure 12*. In addition to provide stability, these foundations shield the building from damp and shifting earth. Stone Masonry: Usually, huge, coarsely cut stones are used in the construction of the ground floor walls, and they are held together with lime mortar. Thermal insulation and longevity are guaranteed by this technology. Timber Framing: A timber frame construction is frequently seen on the upper floors. The framework is built from timber beams and posts and filled with a combination of smaller stones and wattle and daub mortar (Aliaj, 2003).

Wooden Floors: Typically, wooden beams and planks are used in the construction of upper floors. The use of wood facilitates simple construction and provides for design versatility. Decorative Ceilings: Ottoman and regional artistic influences may be seen in the elaborate wooden carvings and painted designs that adorn the ceilings of reception rooms and major halls. Gabled Roofs: Traditional homes often have gabled roofs with terracotta tile coverings. The roof's high slope facilitates effective snow and rain removal. Wooden Roof Structure: The tile covering is supported by rafters and beams made of wood.

Bay Windows (Erker): Prominent bay windows that protrude from the front are frequently found on upper stories. These provide the rooms more light and space and are supported by wooden frames.Tiny Ground level Windows: For security reasons, the ground level windows are frequently adorned with iron bars. The purpose of these windows is to provide ventilation and interior protection.Ornate Doors: Decorative wooden doors with metalwork and carvings typically decorate main entrances (Aliaj, 2003).

Plaster andd paint: Plaster is frequently used to finish interior walls, which are then painted with vibrant patterns and motifs. Stone walls on the outside can be preserved or painted white. Wooden Decorations: Wooden components, such as interior ceilings, balconies, and eaves, are frequently beautifully carved and have both structural and ornamental functions (Riza , 2014).

Figure 12. Beqiri, A. (2024) Andromaqi Melko House

4.4.3 Traditional Houses in Berat

The uneven topography of Berat makes its traditional homes distinctive. The three old neighborhoods of Berat (Kala, Mangalem, and Gorice) are all characterized by rocky topography and sloping terrain. This element has an impact on the house's composition, design, and construction method. The presence of stone within the city allowed for the construction of load-bearing masonry. These stones were either gathered from the river or during the excavation of the building's foundation. Wood was a common building material in Berat in addition to stone (Pashako, 2012). In Berat, there are three different types of houses: the first is the "cardak" home. The second type of home is one with "half floors." This type of habitation arises from the interaction between the house and the steep terrain. This typology is distinct in that it features a first floor that is larger than the ground level and is easily identified by its projecting wooden front, which features bow windows that were influenced by Ottoman architecture. Finally, nineteenth-century homes with rows of huge windows framed in wood and timbers (Pashako, 2012).

Spatial composition

The terrain of the area determines the traditional dwellings' spatial distribution in Berat (*Figure 13*). The layout of the design is in two-story horizontal planes. According to Riza (1972), the first story served as a living area for the occupants, while the bottom floor served as a barn and place to store cattle or agricultural goods. Three functional zones—open areas, semi-open areas, and closed areas—are separated among the spaces. The "çardak" and "hajat" are semi-open spaces, but the "odas' rooms, guestroom, fire room, service areas, restrooms, hallways, and kitchen are closed spaces (Pashako, 2012).

Figure 13. Beqiri, A. (2024), Gorice, Berat

Construction Techniques

The availability of natural resources located close to the city and socioeconomic growth are the primary factors influencing the building technology adopted. As a result, these building materials indirectly influence construction and typology by dictating certain criteria like the size of the stairs, the span of the rooms, etc. For every type of house in Berat, the same construction method is used (Riza, 2009). While light constructions like "çatma" wood walls can be used to build the first floor, the first level (basement) is always enclosed by bearing walls. One of the most recognizable features of the home is the massive wooden roof, which stands out due to its many folds and the size of the eaves' overhang.

The bearing walls may be constructed completely of stone, partially of wood, or partially of both. The stone walls are typically composed of dry stones and have a thickness ranging from 60 to 120 cm. Load-bearing masonry may be used to finish the upper stories, however the breadth may be up to 10 cm less than on the ground level. Wooden "catma" walls can be partitions or load-bearing (Riza, 1981). Catma is constructed in two stages: the first involves building the wooden skeleton, and the second involves filling it in with a mixture of materials, such as straw and lime sand. The partition walls are 12–18 cm thick, but the "çatma" wall technology has a width of 18–22 cm (Pashako, 2012). The upper level is supported by the ground level beams and slab, which rest on the masonry walls, while the bottom floor is situated on the masonry foundations. In this type of building, the roof was built using brick tiles and a timber framework. The wooden beams in the ceiling were joined to the roof. was first covered with a layer known as "patravat," or roof felt, and then roof tiles. The roof was typically spaced apart from the outside walls of the homes by up to 2 meters (Riza, 1972).

CHAPTER 5

METHODOLOGY

5.1 Selection Criteria

This study examines the key characteristics and potentials of historic buildings in Albania that date back to the 18th and 19th centuries. Additionally, it simulates prospective retrofitting actions meant to reduce energy consumption and improve indoor comfort in addition to analyzing the buildings' current energy use. The cities that have been chosen are Gjirokaster, Korça and Berat representing the climate conditions in the southern region of Albania. The three domestic traditional structures are the study's target samples. Despite belonging to distinct building typologies, these structures have common architectural features such as the materials used in construction, the way spaces are distributed, the number of floors, and their designation as "protected buildings" despite being in regions with varying temperatures.

The cities that met the requirements for climatic variety were chosen because they had similar climates, which allowed the study to offer a range of retrofitting options for climate alternatives. viewpoint of tourism, since the chosen towns serve as the primary centers for travel to Albania and the Balkan areas. Therefore, there may be a chance to boost tourism by upgrading existing structures. The traditional residential structures were chosen, one for each city, using the list of "protected residential buildings" supplied by the Albanian government.

5.2 Case study Description

5.2.1 H 1- Adem Zeko House

The building is two storey residential with a change in development planimetric first floor, which goes out to the side and back with three pocket on the bottom of the right arm. The apartment is of the variant with two arms, with a closed sofa (*Figure 14*). There is under the sofa the grain barn was built, with separate for types different cereals as shown in (*Figure 15*).

Figure 14. Beqiri, A. (2024) Adem Zeko House Exterior view

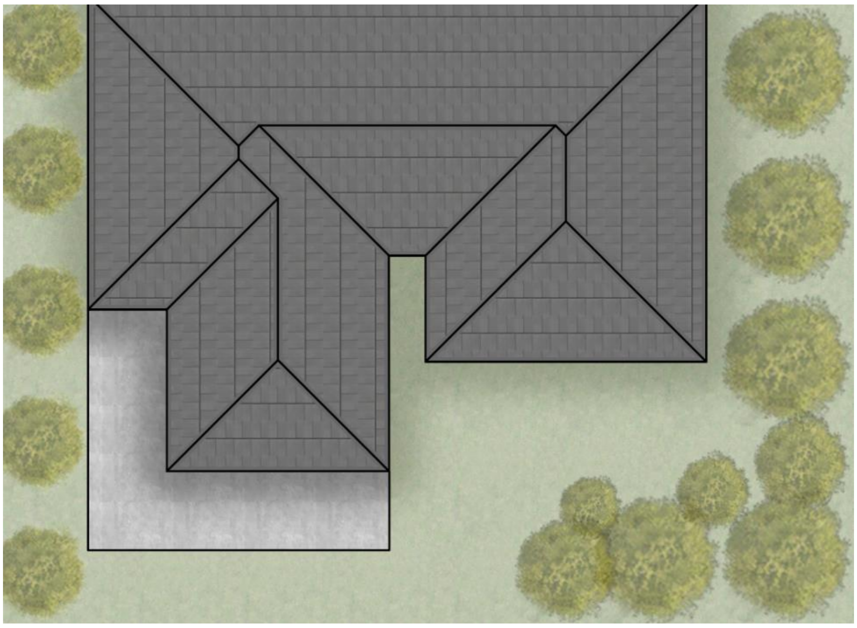


Figure 15. Beqiri, A. (2024). Adem Zeko House Top View

The residential floor has the usual scheme of this variant, with some changes on the right side. Chamber of friends comes out more than the other arm, leaning on the broken arcade characteristic of these solutions. Right arm takes place in the front, beyond the contour of the ground floor going out to bay window shape. The relatively small size of the premises as well their limited number shows that she belonged to the strata of medium. The ground floor (*Figure 16*) could also be used from the entrance of the chamber. Katoi has internal connections with the environment on it. Both residential floors are connected by stairs internal. On the first floor (*Figure 17*), there is an intermediate wall that separates it from a space where the environment is sanitary and not furnished. Special solution, it seems placing three spaces and on this wall that is difficult (*Figure 18*). As illustrated in Figure 19, the stone wall has a thickness of 65 cm covered by both sides of 2 cm mortar and 0.5 cm white paint.

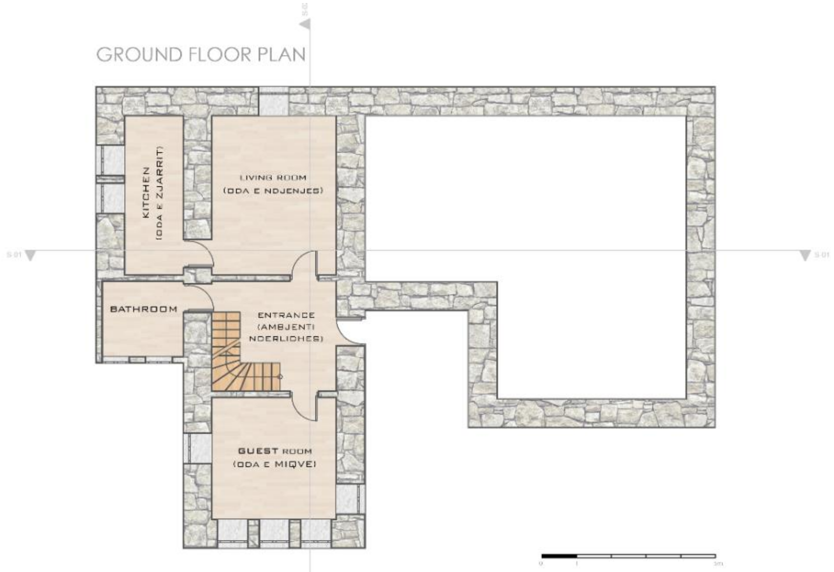


Figure 16. Beqiri, A. (2024). Adem Zeko House Ground floor

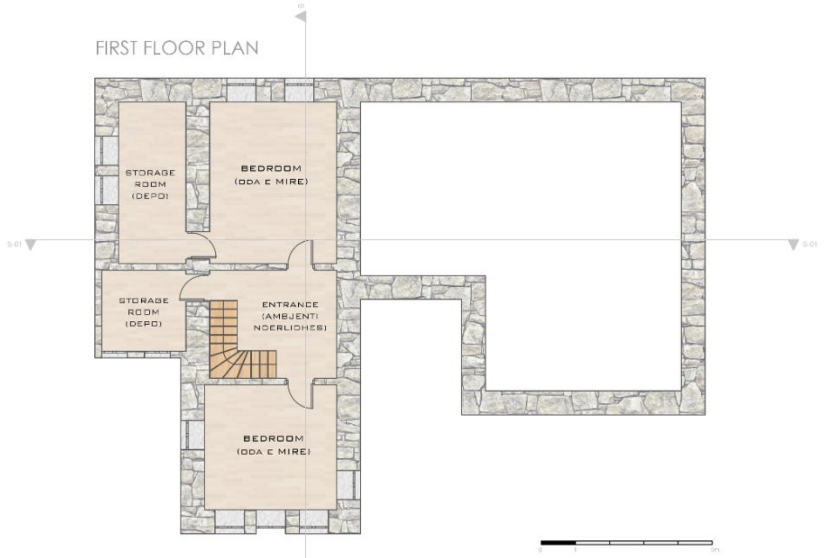


Figure 17. Beqiri, A. (2024). Adem Zeko House First floor

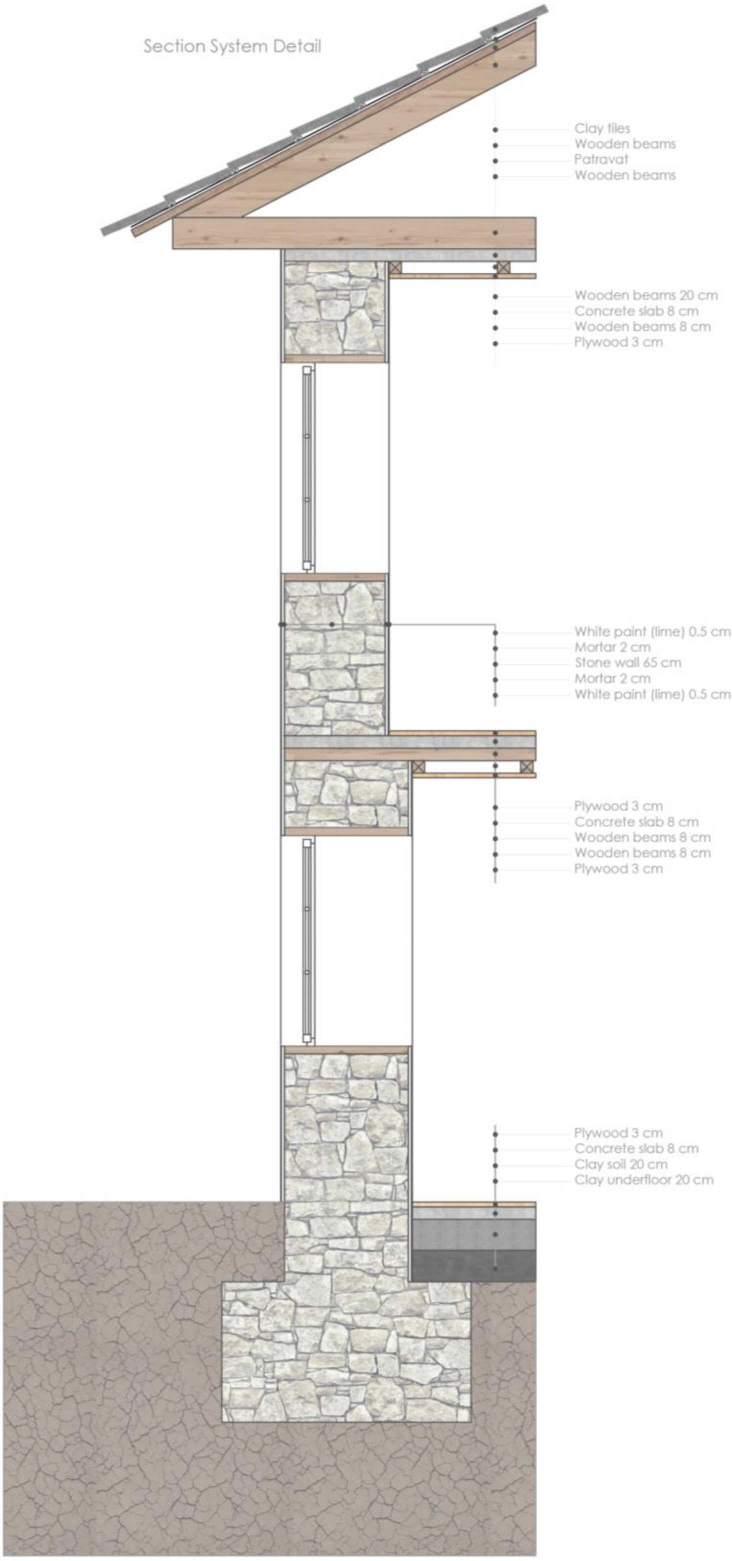
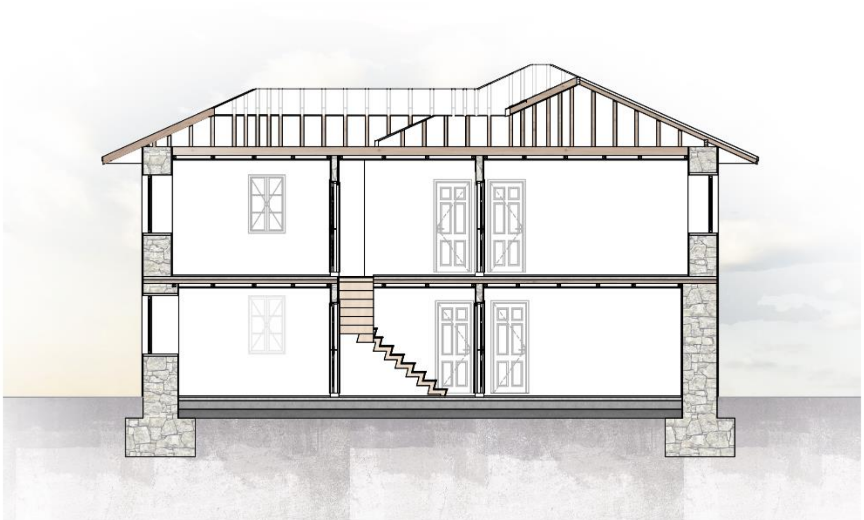


Figure 18. Beqiri, A. (2024), Adem Zeko Section System Detail

SECTION 01



SECTION 02

Figure 19. Beqiri, A. (2024), Adem Zeko House Sections

The apartment has a turret at the front of the floor, the sanitary environment of the room on the first floor, in the back as and on the side wall, in the direction of the main entrance to the courtyard and valet. Figure 20 illustrates the main typical facades of the building. The connection of the apartment with the chamber in this form a unique case is presented among the old houses that are preserved in the city. There are many unique and traditional construction details present in the building which are shown in Figure 21 while in Figure 22 are selected some important solutions made inside the building. A 3D model is made as shown in Figure 23 as well as a 3D section showing all the layers of the building elements' construction.

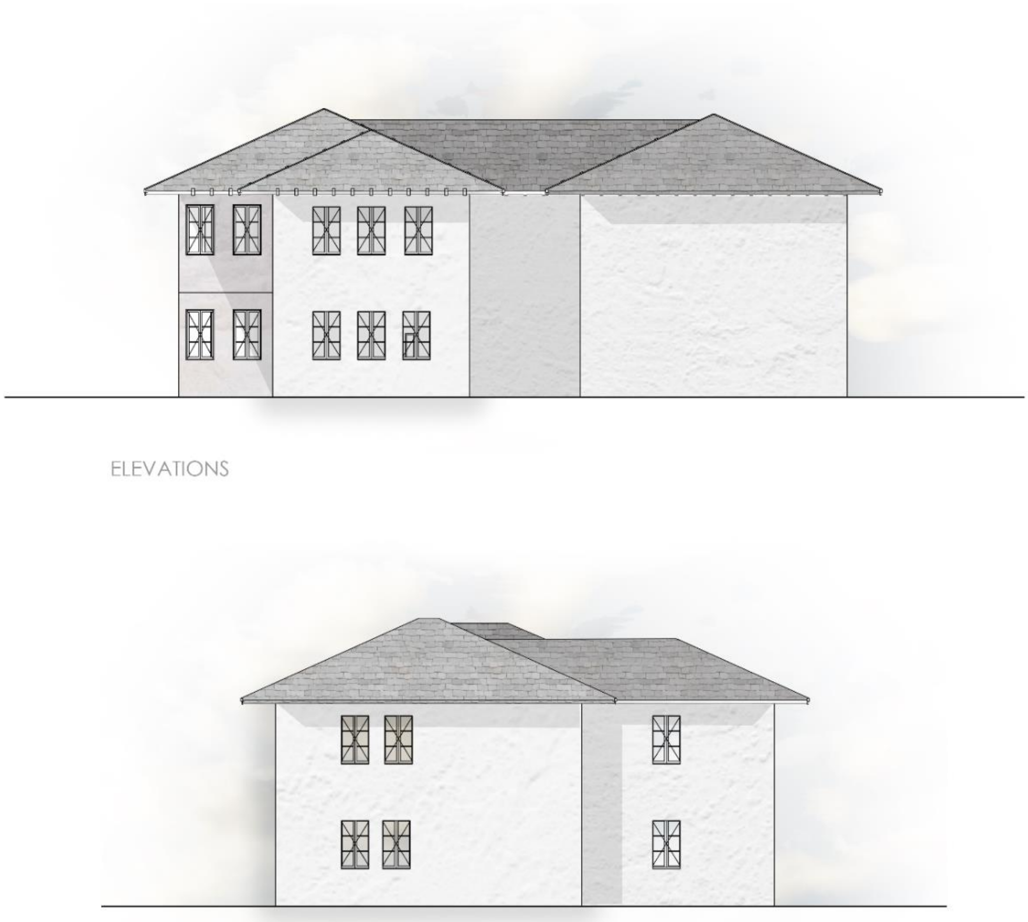


Figure 20. Beqiri, A. (2024), Adem Zeko House Elevations

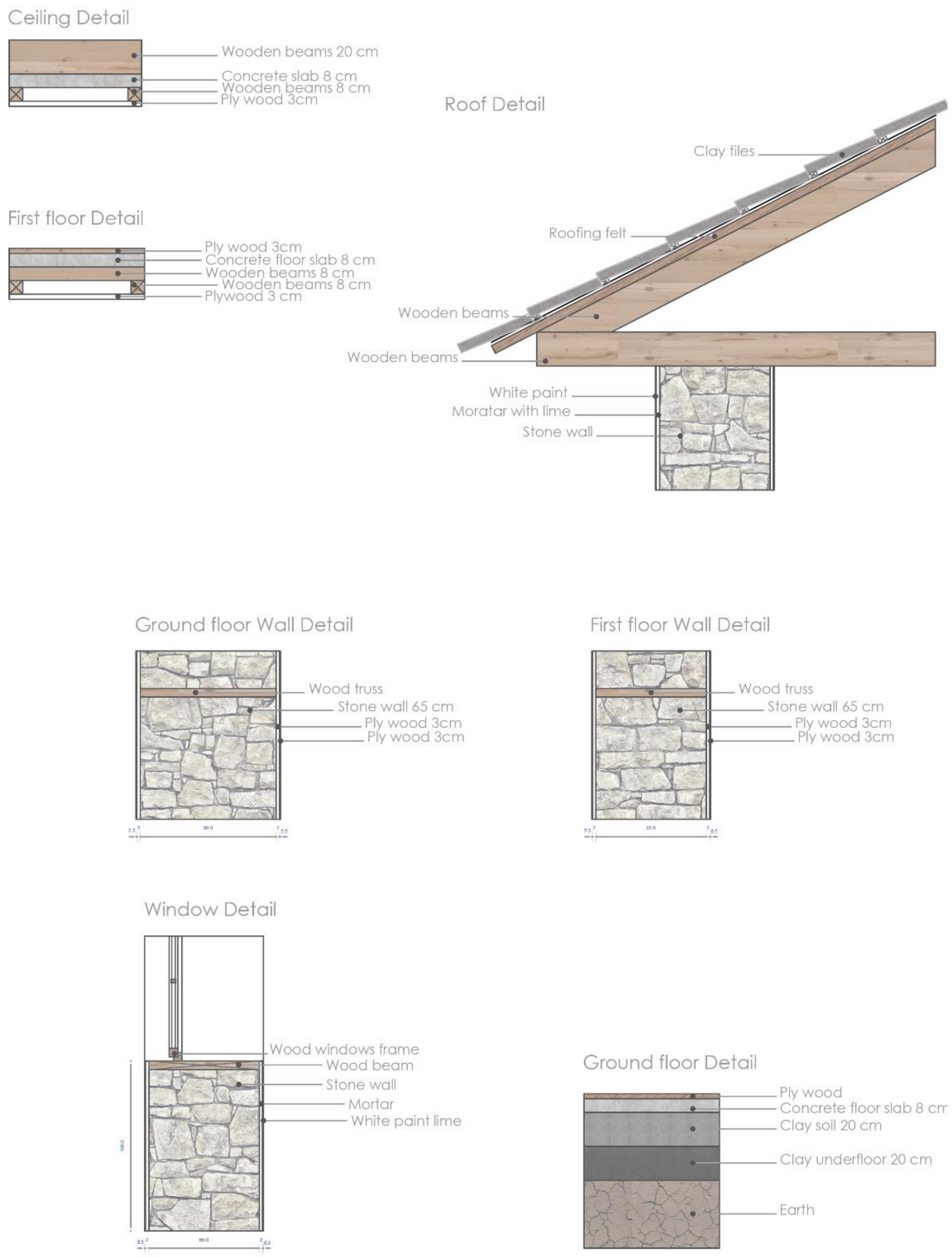


Figure 21. Beqiri, A. (2024), Adem Zeko Construction Details

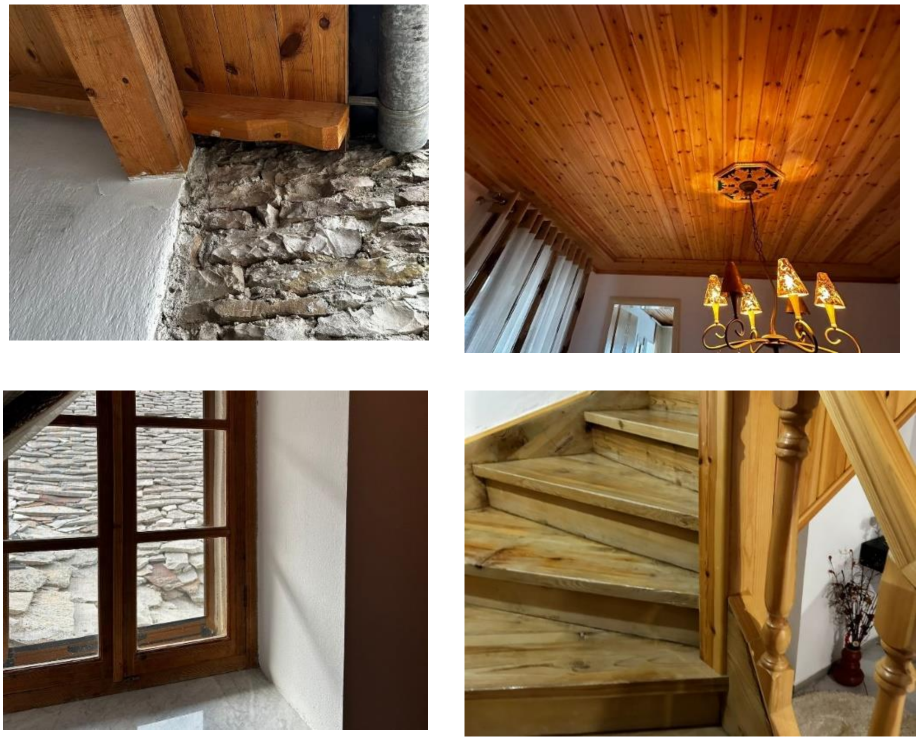


Figure 22. Beqiri, A. (2024), Adem Zeko Interior Details

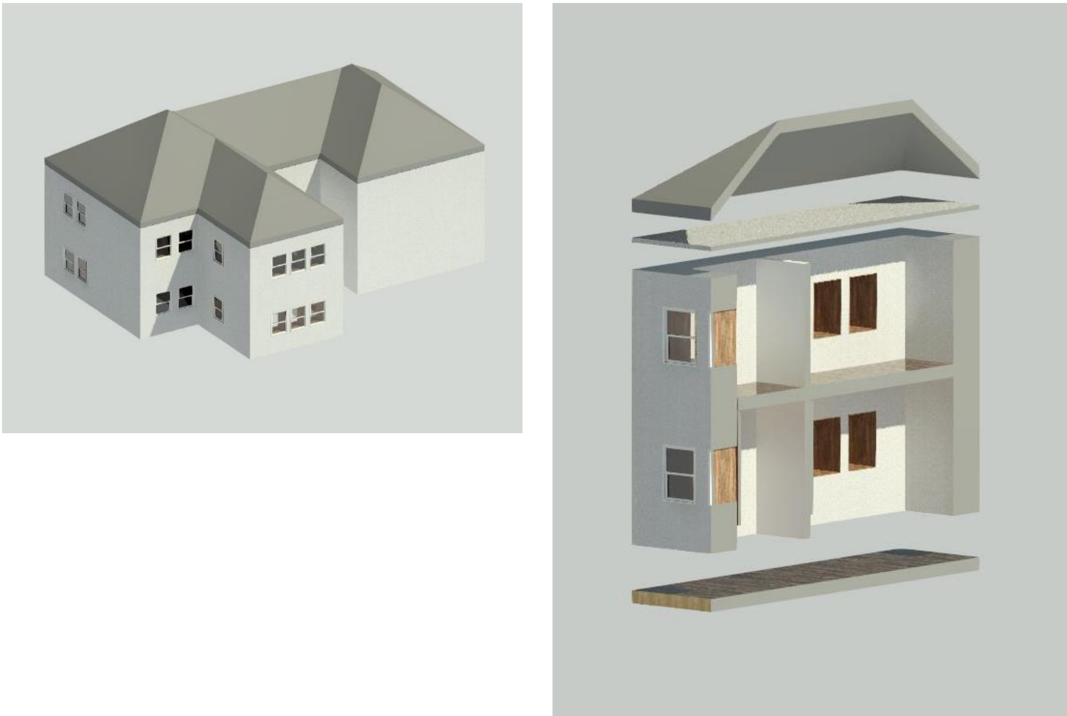


Figure 23. Beqiri, A. (2024), Adem Zeko 3D model (left) 3D section (right)

5.2.2 H 2 – Andromaqi Melko House

Andromaqi Melko's house is a monument of cultural heritage in the district of Korça (*Figure 24*). The fact that this home is situated at the intersection of the two streets that its side facade and rear facade face (*Figure 25*) allowed for the maintenance of a balance in the treatment of both facades.

Figure 24. Budini, S. (2019) Andromaqi Melko House Main interior entrance (left) exterior entrance (right)

The ground floor (*Figure 26*) functions as a pantry (food deposit), the living and reception rooms are situated there, and the bedrooms are on the first floor. This further clarifies the layout's utility. The first floor (*Figure 27*) is used as a single place for family rituals. The console piece known as the "Erker," which protrudes from the house's perimeter, is also composed of "çatma," but it has a more elaborate ornate design. The upper level has been plastered, allowing the differential of techniques between the two floors to be seen through a stone belt, while the ground floor has not been plastered, allowing the stone masonry to remain visible.

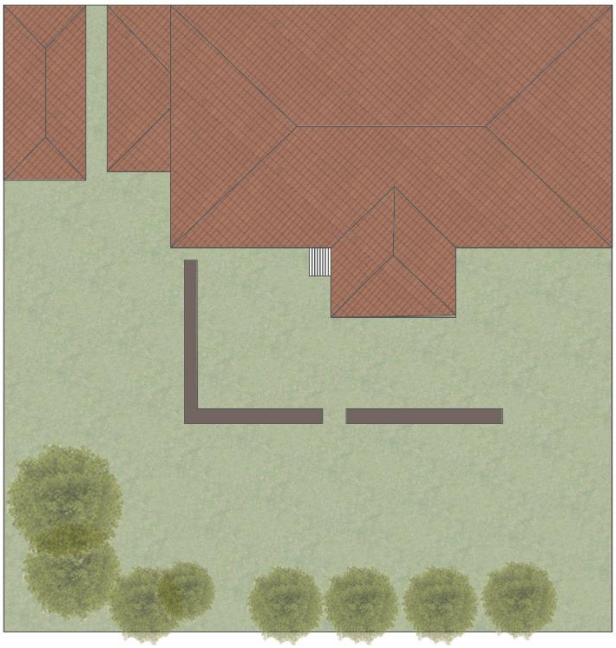


Figure 25. Beqiri, A. (2024) Andromaqi Melko House Top View

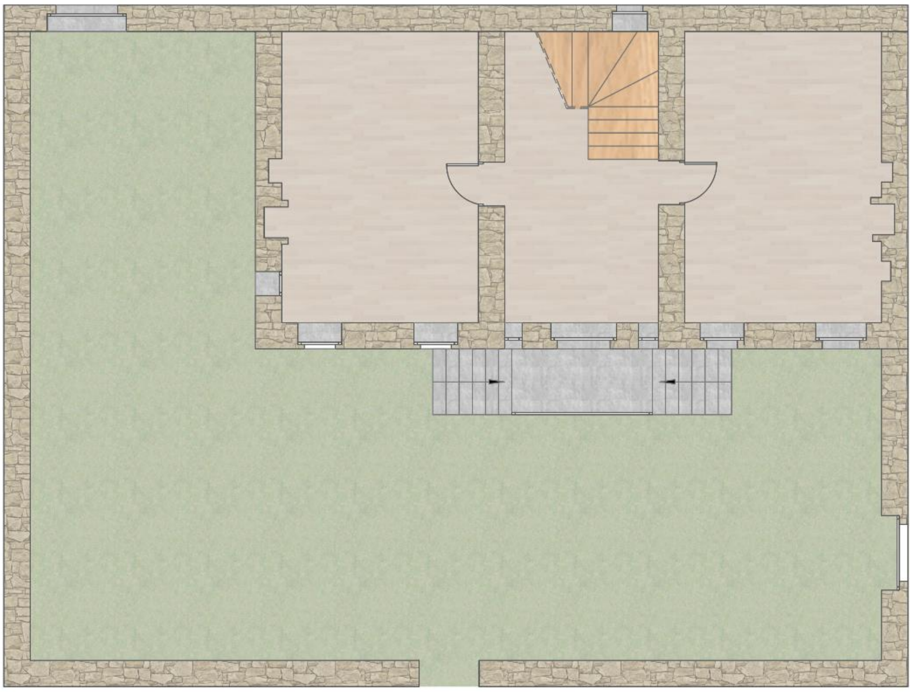


Figure 26. Beqiri, A. (2024) Andromaqi Melko House Ground Floor

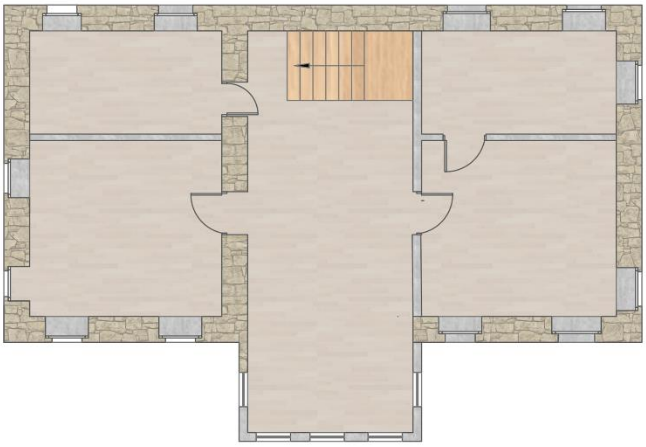


Figure 27. Beqiri, A. (2024) Andromaqi Melko House First Floor

The front yard façade (*Figure 29*), features aspects that are more specifically treated architecturally. The main entrance (*Figure 28*) and the two parade-staircases that connect to the porch highlight the center volumetry. This one, which supports the corner known as the "erker" above, was constructed with the help of stone pillars. The inclusion of "sobalka" living quarters, which are musandras, a sort of closet, enhances its arrangement.

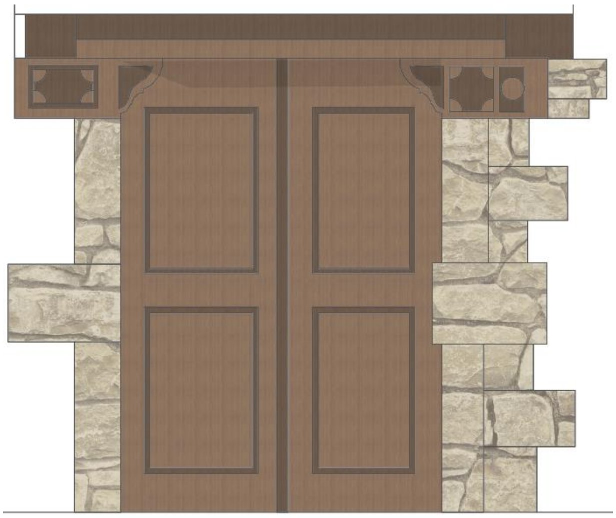


Figure 28. Beqiri, A. (2024) Andromaqi Melko House Main Entrance Detail

Figure 29. Beqiri, A. (2024) Andromaqi Melko House Elevations

The corners of the top level, which is covered in white plaster, are embellished with carved red stone pilasters that rest on the stone partition frame.
It is a first-class monument. Following the 1960s, a further earthquake led to more modifications in the waiting area. This space is split into two halves. There's an entrance above that allows you to get to the roof. *Figure 30* illustrates the section

system detail of the residence as shown in *Figure 31* the stone wall has a thickness of 57.5 cm, it does not have a layer covering the stone wall in the exterior while in the inner parts has a 2 cm layer of mortar and a 1cm layer of white paint.

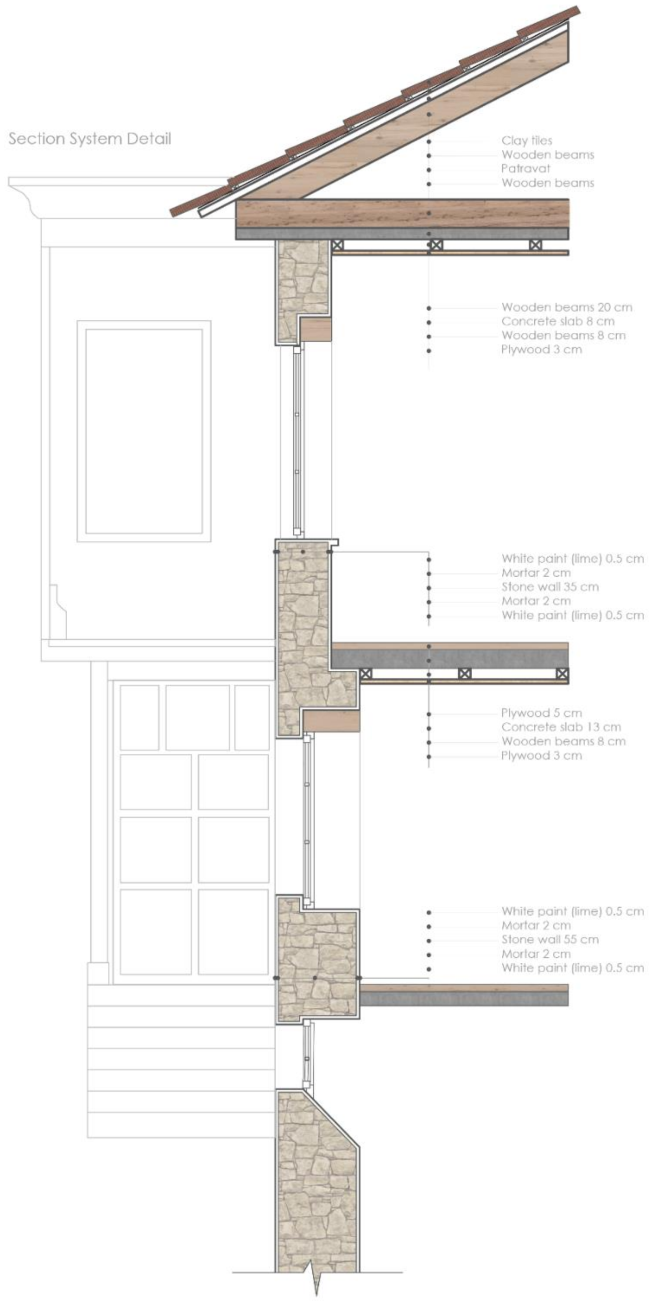


Figure 30. Beqiri, A. (2024) Andromaqi Melko House Section System Detail

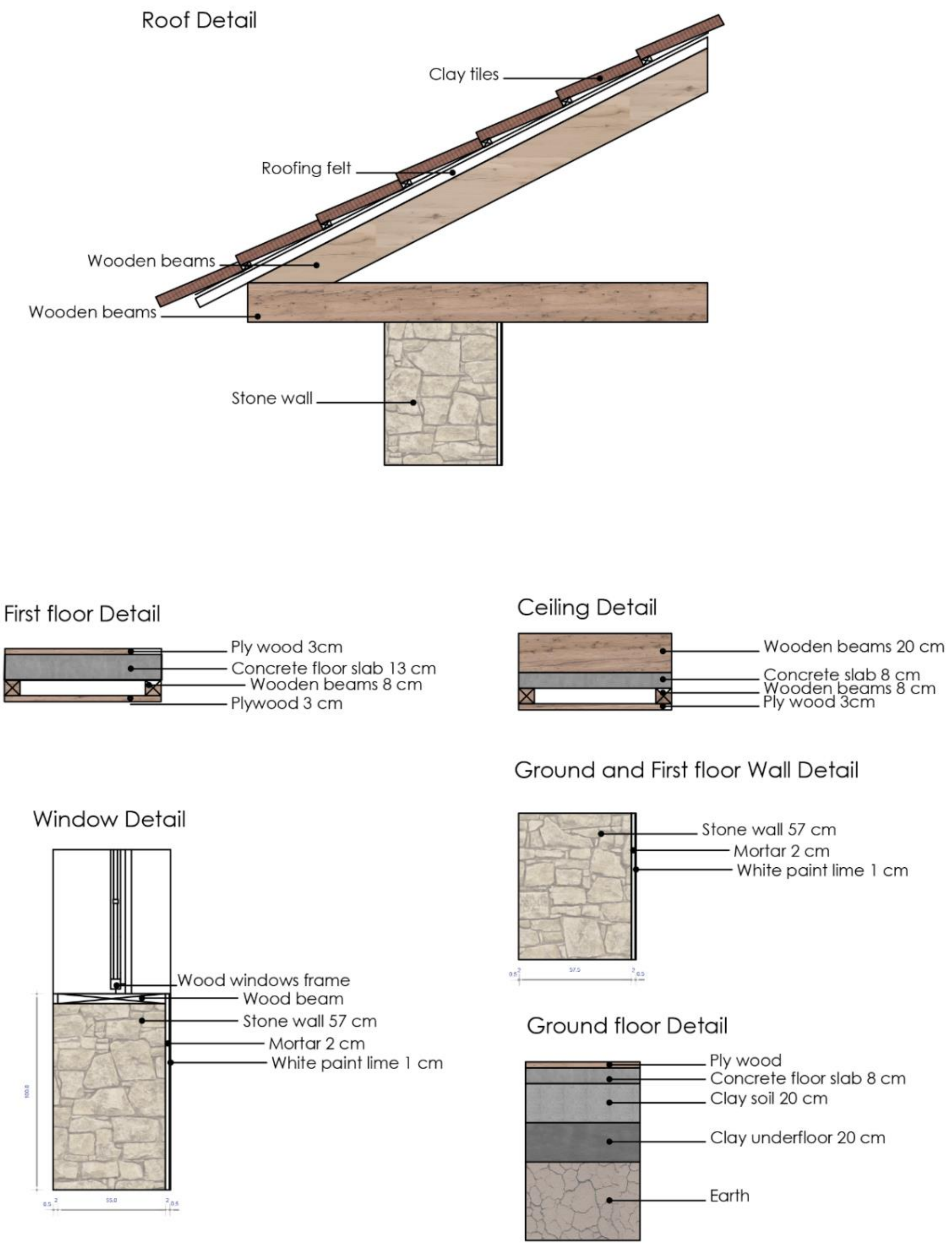


Figure 31. Beqiri, A. (2024) Andromaqi Melko House Construction Details

Figure 32 illustrates the cross section of the building showing also the position of the single glass windows placed mainly on the outer parts of the wall. Some exterior views of the residence are showing in *Figure 33* while in Figure 34 a 3d model of the building is made as well as a 3D section (*Figure 35*) demonstrating its actual physical apparence.

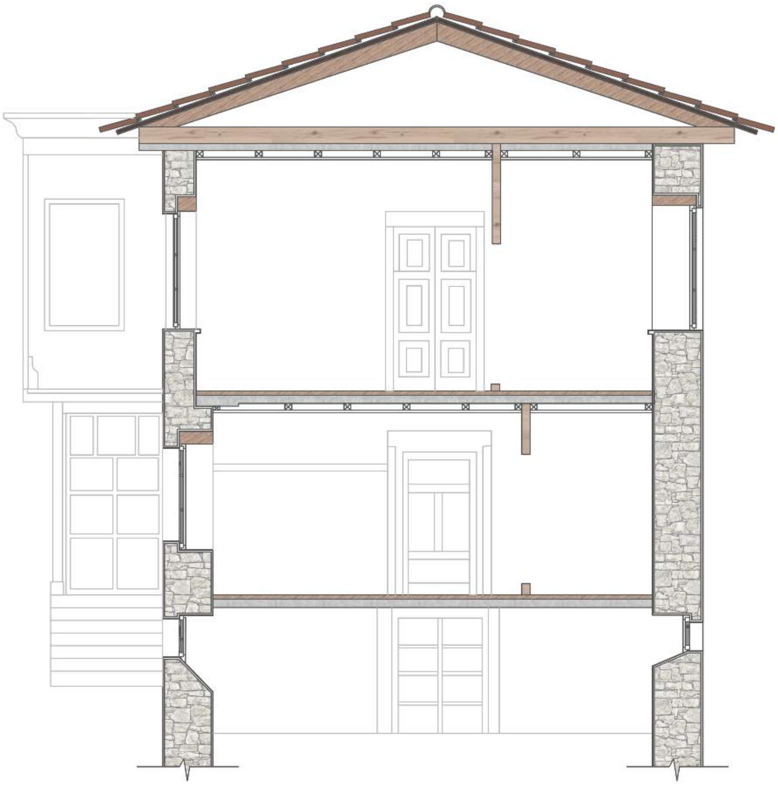


Figure 32. Beqiri, A. (2024) Andromaqi Melko House Section

Figure 33. Beqiri, A. (2024) Andromaqi Melko House Exterior Views

Figure 34. Beqiri, A. (2024) Andromaqi Melko House 3D model View

Figure 35. Beqiri, A. (2024) Andromaqi Melko House 3D Section detail

5.2.3 H 3 – Lluke Zanati House

In the city of Berat, Albania, which is well-known for its rich historical and cultural legacy, the Luke Zanati House (*Figure 36*) is a noteworthy example of typical Ottoman architecture. Often referred to as the "City of a Thousand Windows," Berat is renowned for its exquisitely maintained Ottoman homes, which have expansive windows providing a view of the town below.

Figure 36. Beqiri, A. (2024) Lluke Zanati House Exterior View

Like many other houses in Berat, the Luke Zanati House (*Figure 37*) exhibits the region's unique architectural style, which is defined by sloping roofs, large, symmetrical windows, and construction made of wood and stone. These multi-level residences, with the top floors utilized as living rooms and the lower levels frequently used as work facilities or storage, were usually built to house extended families.

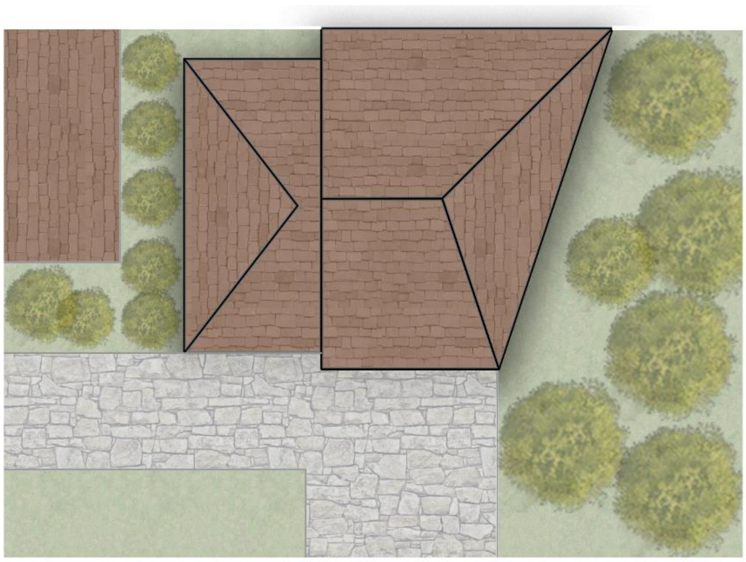


Figure 37. Beqiri, A. (2024) Lluke Zanati House Top View

The fundamental layout of the home is two levels, which is indicative of traditional Berat housing. While the inner walls of the second floor (*Figure 39*) are made of wood, which allows for more flexibility and extension, the ground floor (*Figure 38*) is built of stone, which offers solidity and insulation.

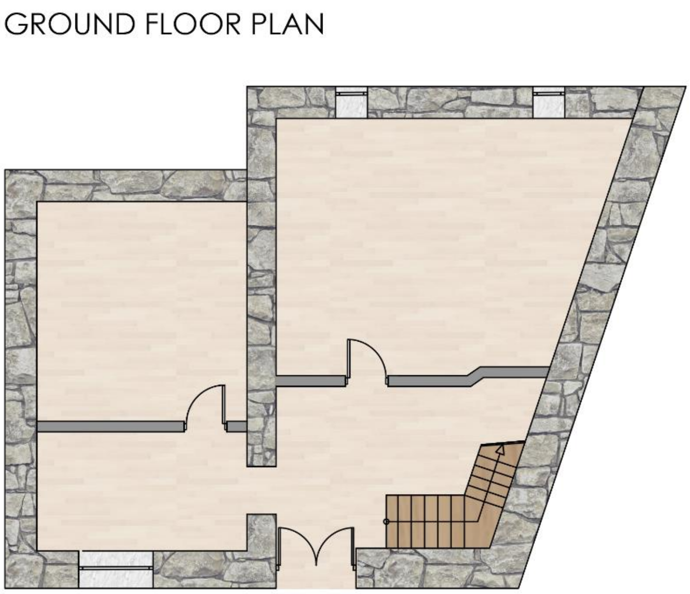


Figure 38. Beqiri, A. (2024) Lluke Zanati House Ground Floor plan

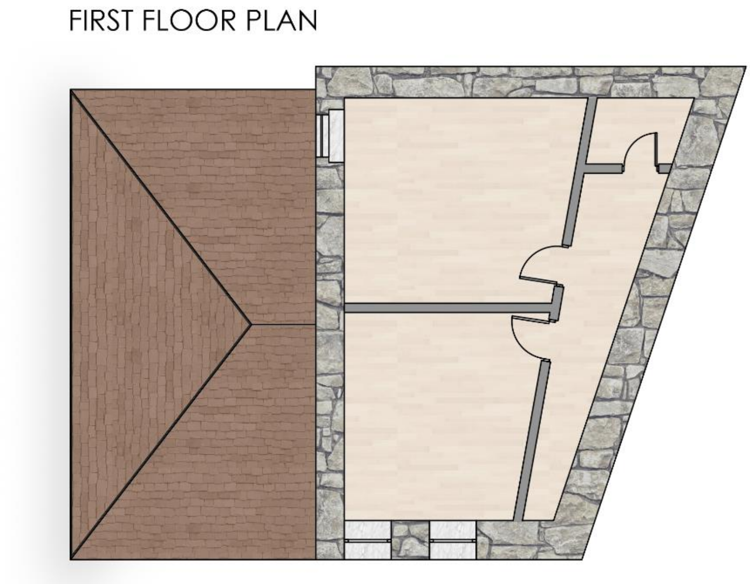


Figure 39. Beqiri, A. (2024) Lluke Zanati House First Floor plan

Wide eaves and big windows are two characteristics of the Ottoman era that are evident in the house's façade (*Figure 40*). Clay tiles cover the roof, which slopes gently to efficiently shed rainfall (*Figure 41*). The whitewashed stone exterior walls of Berat's ancient sections add to the building's overall harmonious look (*Figure 42*).

Figure 40. Beqiri, A. (2024) Lluke Zanati House Facade

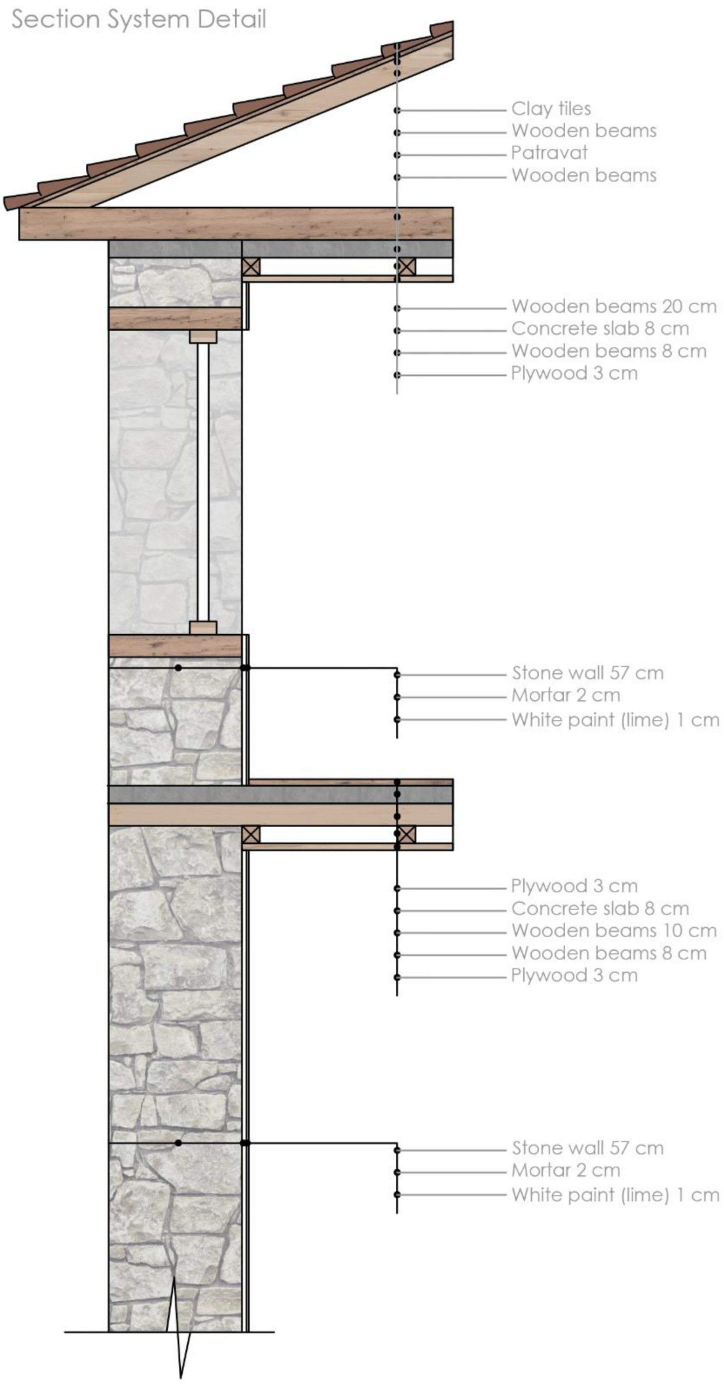


Figure 41. Beqiri, A. (2024) Lluke Zanati House Section System Detail

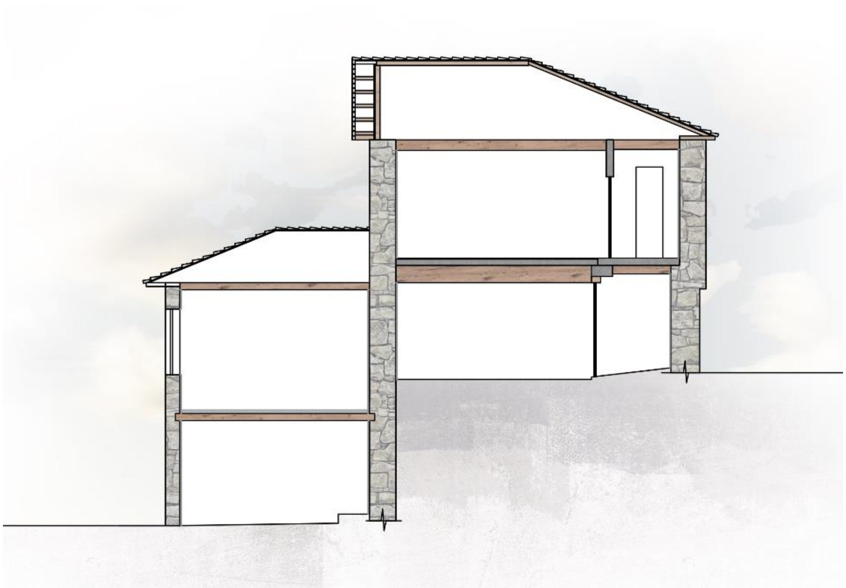


Figure 42. Beqiri, A. (2024) Lluke Zanati House Section

The residence has ornamental aspects that capture the historical and cultural milieu of the era. This features elaborately painted ceilings, carved wooden beams, and ornate doors (*Figure 43*).

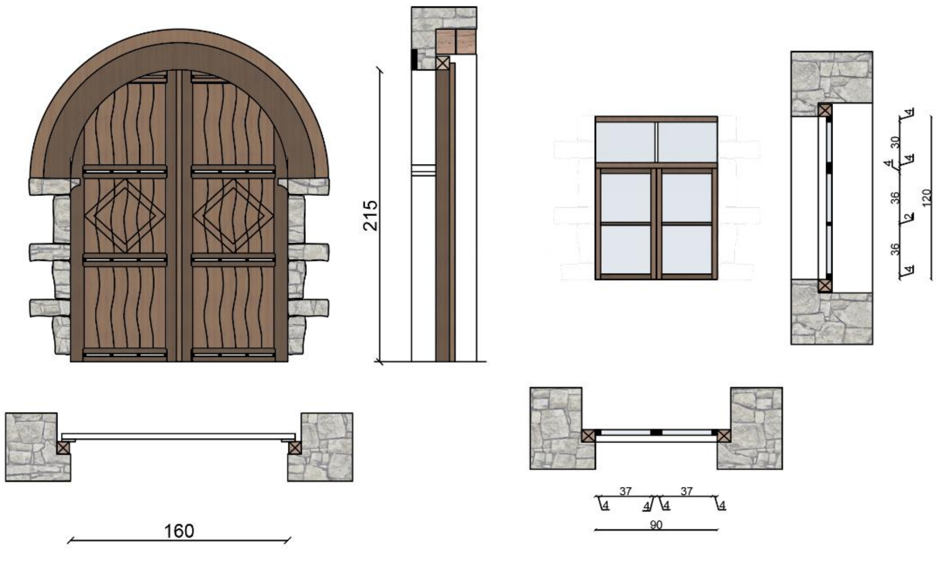


Figure 43. Beqiri, A. (2024) Lluke Zanati House Ornate door (left), typical window (right)

Figure 44 illustrates the traditional Berat windows used in the building in plan,section and elevation. Some interior views and details of the building are demonstrated through actual photos made by the author in the residence (*Figure 45*). *Figure 46* shows different construction details while *Figure 47* illustrates a 3D model of the building is made as well as a 3D section (*Figure 48*) demonstrating its actual physical features.

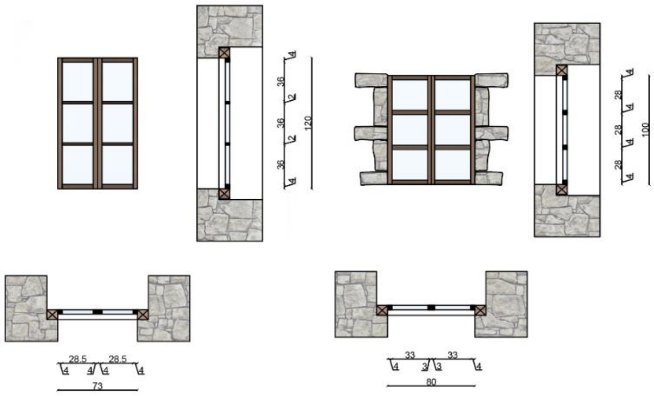


Figure 44. Beqiri, A. (2024) Lluke Zanati House Window Detail

Figure 45. Beqiri, A. (2024) Lluke Zanati House Interior Views and details

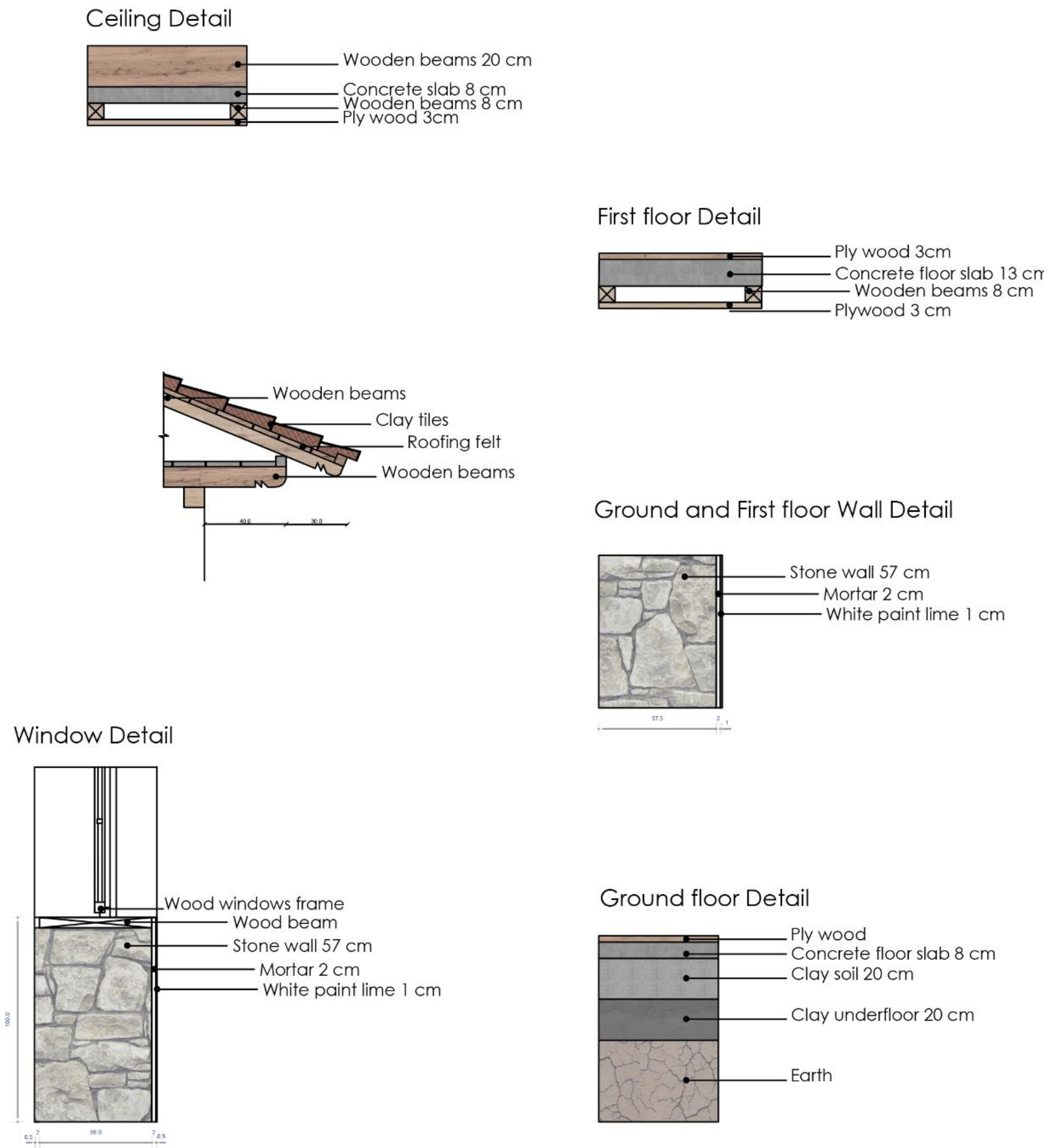


Figure 46. Beqiri, A. (2024) Lluke Zanati House Construction Details

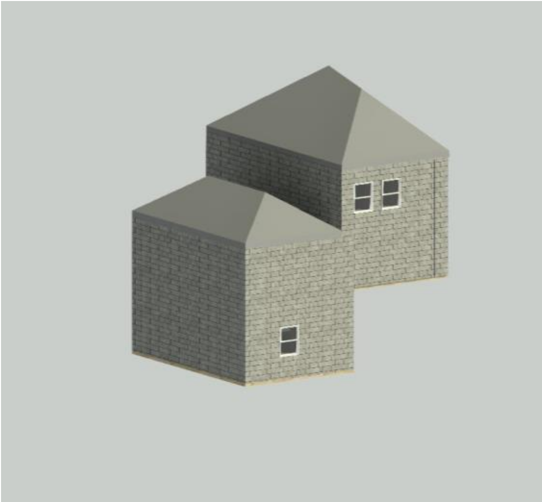


Figure 47. Beqiri, A. (2024) Lluke Zanati House 3D View

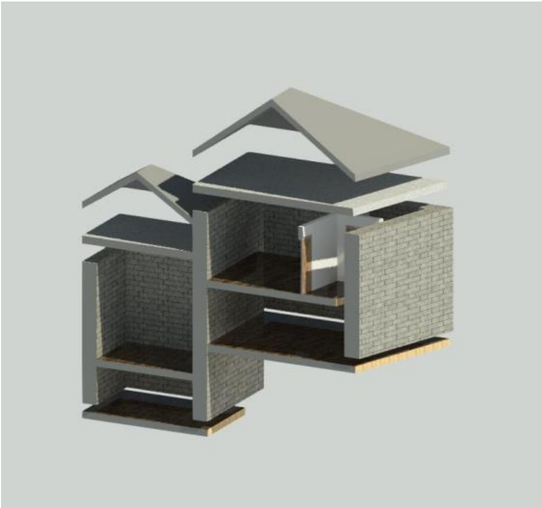


Figure 48. Beqiri, A. (2024) Lluke Zanati House 3D Section

5.3 Computation and Simulation

Building performance simulation (BPS) software Design-Builder interface version 6 (Ltd., 2020) for EnergyPlus (Energy, 2020)is used to design and construct energy-efficient buildings in several Albanian climate scenarios. The process is made by modeling the building's geometry using information from thorough building surveys, construction materials, occupancy schedules, operation control, ventilation hours, and the monthly/annual data collection for indoor comfort, heating, and cooling. By creating particular weather data using the Meteonorm program (Meteonorm, 2020), DesignBuilder energy modeling is created.

5.3.1 Simulation Real Case Study Inputs

The tables below give comprehensive explanations of the building materials and the corresponding U-values for different building components, assuming that the three houses are similar in material selection. Layers of firm dry stone and cement/lime plaster are used as materials for external walls, providing a balance between structural integrity and insulation. Clay tiles, an air gap, and roofing felt are used in roof construction to improve heat resistance and weather resistance. Windows with 3 mm single glazing have the highest U-value, which is indicative of less effective insulation. Brick and cement/lime plaster are used to build interior walls, which helps control interior temperature. Radial oak wood, limestone cement, and plywood—all selected for their longevity and insulating qualities—are used to construct floors. Like flooring, ceilings are constructed with limestone cement and radial oak wood to provide insulation and structural stability.

Table 4. Description of R1 construction material with associated U-value assumptions

Construction Element	*U-Value (W.m2K-1)*	*Description*
External Wall Properties	U-Value= 1.42	Cement/lime plaster=0.025m Hard Dry stone= 0.75m Cement/lime plaster=0.025m
Roof Properties	U-Value= 2.93	Clay tile=0.025m Air gap=0.02m Roofing felt= 0.005m
Window Properties	U-Value= 5.89	Window- 3mm single glazing
Internal wall properties	U-Value= 1.64	Cement lime/plaster=0.05m Brick wall=0.1m Cement lime/plaster=0.05m
Floor Properties	U-Value= 0.25	Radial oak wood=0.1m Limestone cement=0.08m Plywood=0.03m

Ceiling Properties	U-Value= 0.25	Radial oak wood=0.1m Radial oak wood=0.1m Limestone cement=0.08m

Table 5. Description of R2 construction material with associated U-value assumptions

Construction Element	***U-Value (W.m2K-1)***	***Description***
External Wall Properties	U-Value= 1.74	Cement/lime plaster=0.025m Hard Dry stone= 0.65m Cement/lime plaster=0.025m
Roof Properties	U-Value= 2.93	Clay tile=0.025m Air gap=0.02m Roofing felt= 0.005m
Window Properties	U-Value= 5.89	Window- 3mm single glazing
Internal wall properties	U-Value= 1.64	Cement lime/plaster=0.05m Brick wall=0.1m Cement lime/plaster=0.05m
Floor Properties	U-Value= 0.25	Radial oak wood=0.1m Limestone cement=0.08m Plywood=0.03m
Ceiling Properties	U-Value= 0.25	Radial oak wood=0.1m Radial oak wood=0.1m Limestone cement=0.08m

Table 6. Description of R3 construction material with associated U-value assumptions

Construction Element	***U-Value (W.m2K-1)***	***Description***
External Wall Properties	U-Value= 1.70	Cement/lime plaster=0.025m Hard Dry stone= 0.75m Cement/lime plaster=0.025m
Roof Properties	U-Value= 2.93	Clay tile=0.025m Air gap=0.02m Roofing felt= 0.005m
Window Properties	U-Value= 5.89	Window- 3mm single glazing
Internal wall properties	U-Value= 1.64	Cement lime/plaster=0.05m Brick wall=0.1m Cement lime/plaster=0.05m

Floor Properties	U-Value= 0.25	Radial oak wood=0.1m Limestone cement=0.08m Plywood=0.03m
Ceiling Properties	U-Value= 0.25	Radial oak wood=0.1m Radial oak wood=0.1m Limestone cement=0.08m

5.4 Scenarios for the proposed changes

The T*able 7* lists the various combinations of suggested modifications to building features that were employed in the simulations conducted in three separate dwellings wile fully explained and described in *Table 8*. S1 is concerned with changing the windows, S2 with the roof, and S3 with the walls. Combination situations include S4, which deals with both glazing and roof modifications; S5, which focuses on wall and glazing alterations; and S6, which deals with adjustments to the roof and walls. Changes to the walls, roof, and glazing are included in scenario S7. These simulations aid in the evaluation of the effects of different building modifications on the effectiveness and performance of the residences.

Table 7. Scenarios for the proposed changes

Scenario	
S 1	Glazing
S 2	Roof
S 3	Wall
S 4	Glazing + Roof
S 5	Glazing + Wall
S 6	Roof + Wall
S 7	All scenarios

Table 8. Scenarios description

CODE	***SCENARIO***	***DESCRIPTION***
GJ_S1	Replacement of Glazing	Replacement of Single Glazing with Double low E=1 (Arg =13 mm)
GJ_S2	Roof insulation	8cm Glass Wool
GJ_S3	Wall insulation	8 cm Glass Wool + 1.25 cm Ply Wood
GJ_S4	S1 + S2	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool
GJ_S5	S1 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8 cm Glass Wool & 1.25 cm Ply Wood
GJ_S6	S2 + S3	8cm Glass Wool + 8 cm Glass Wool & 1.25 cm Ply Wood
GJ_S7	S1 + S2 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool + + 8 cm Glass Wool & 1.25 cm Ply Wood
K_S1	Replacement of Single Glazing	Replacement of Single Glazing with Double low E=1 (Arg =13 mm)
K_S2	Roof insulation	8cm Glass Wool
K_S3	Wall insulation	8 cm Glass Wool + 1.25 cm Ply Wood
K_S4	S1 + S2	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool
K_S5	S1 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8 cm Glass Wool & 1.25 cm Ply Wood
K_S6	S2 + S3	8cm Glass Wool + 8 cm Glass Wool & 1.25 cm Ply Wood
K_S7	S1 + S2 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool + + 8 cm Glass Wool & 1.25 cm Ply Wood
B_S1	Replacement of Single Glazing	Replacement of Single Glazing with Double low E=1 (Arg =13 mm)
B_S2	Roof insulation	8cm Glass Wool
B_S3	Wall insulation	8 cm Glass Wool + 1.25 cm Ply Wood

B_S4	S1 + S2	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool
B_S5	S1 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8 cm Glass Wool & 1.25 cm Ply Wood
B_S6	S2 + S3	8cm Glass Wool + 8 cm Glass Wool & 1.25 cm Ply Wood
B_S7	S1 + S2 + S3	Replacement of Single Glazing with Double low E=1 (Arg =13 mm) + 8cm Glass Wool + + 8 cm Glass Wool & 1.25 cm Ply Wood

Figure 49 illustrates the scenarios and the changes that are going to be made to the House 1, respectively Replacement of Single Glazing with Double low E=1 (Arg =13 mm), roof insulation with 8 cm thick Glass wool and wall insulation the combination of 8 cm glass wool and a layer of ply wood as its interior finish. Respectively *Figure 50* shows the same scenarios for the second house as well as *Figure 51* demostrates the same scenarios for the Lluke Zanati House, the third house. The improvements are detailed in 3D views accordingly *Figure 52* for the Adem Zeko House, *Figure 53* showing the detailed section and 3d view of Andromaqi Melko house in Korca and *Figure 54* the Lluke Zanati House in Berat.

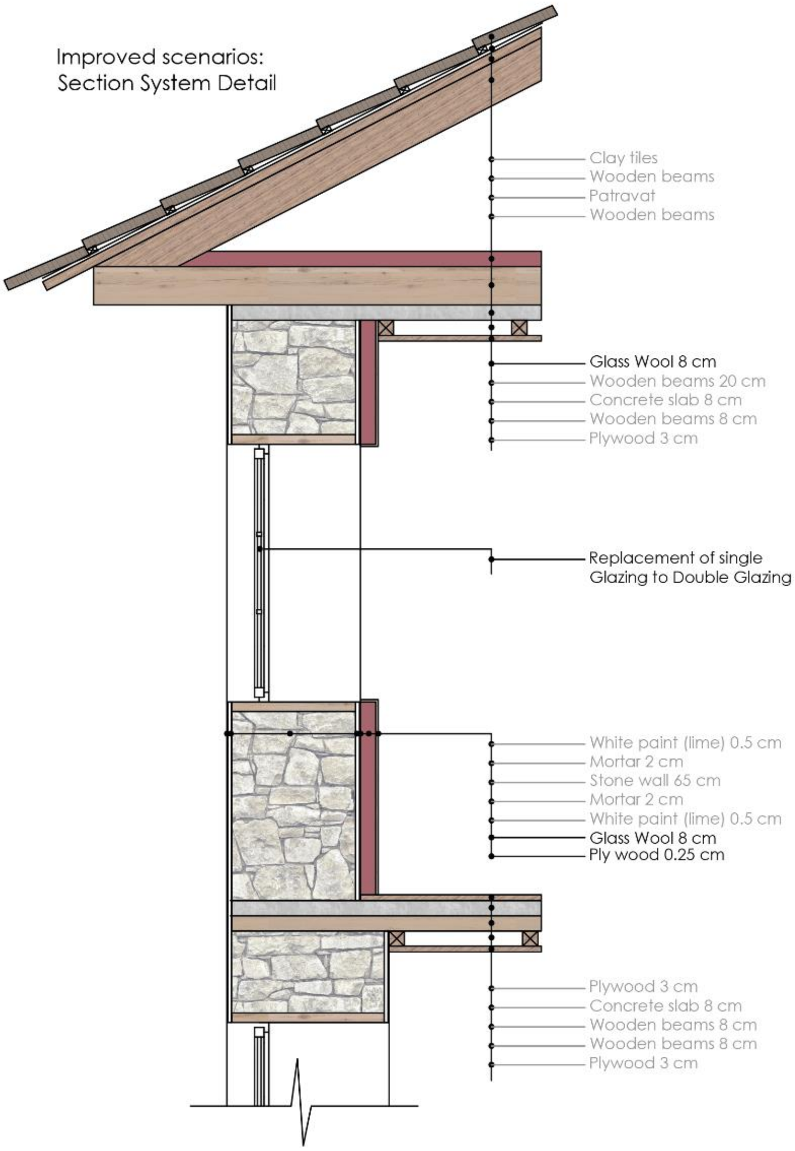


Figure 49. Improved scenarios for House 1

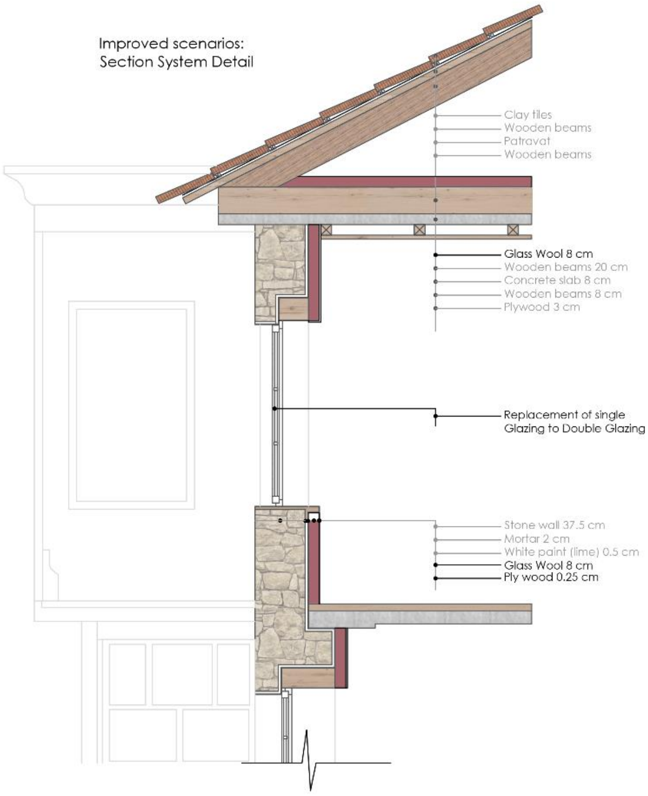


Figure 50. Improved scenarios for House 2

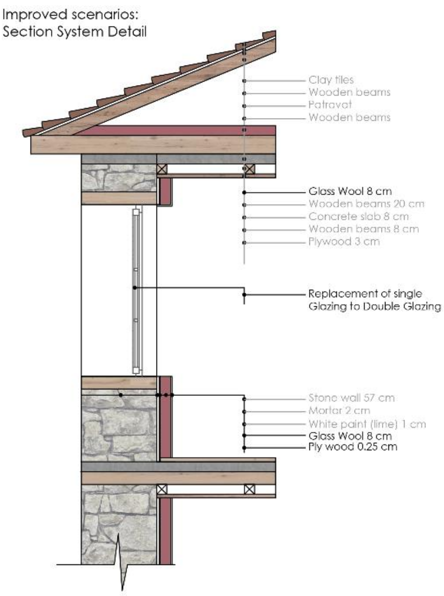


Figure 51. Improved scenarios for House 3

Figure 52. Improved scenarios for House 1 3D view

Figure 53. Improved scenarios for House 2 3D view

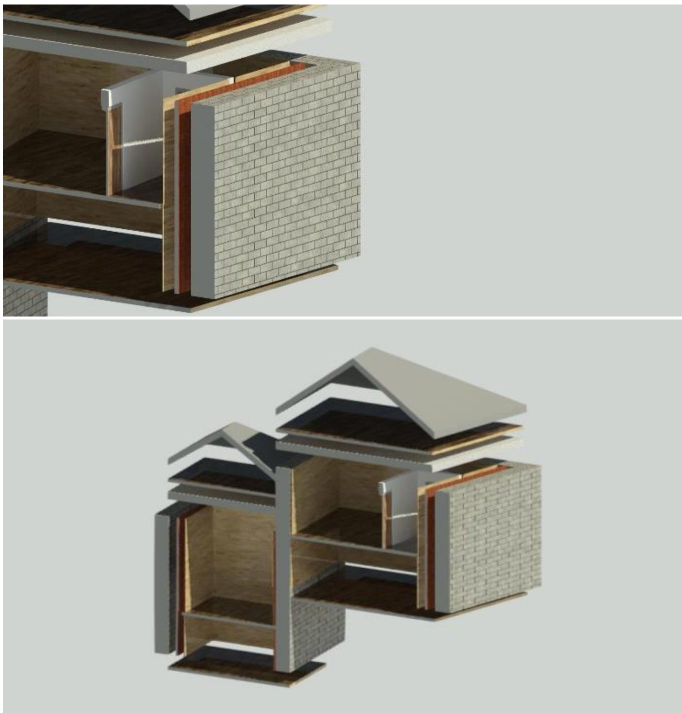


Figure 54. Improved scenarios for House 3 3D view

5.5 Questionnaire on Indoor Thermal Conditions and Energy Use

Over the course of a year, calculations were made regarding the indoor environment parameters of temperature, humidity, and energy consumption of the buildings (1 January–31 December). Data loggers and Design Builder software are used to assess the current interior temperature and relative humidity (Design Builder, 2019). Furthermore, on-site personal conversations with the occupants of the chosen historic houses provide information about their present energy performance. While *Table 10* shows the daytime and nighttime ventilation patterns *Table 9* included questions about cooling, heating systems, and other information. Each case house's technical details are displayed in *Table 11*.

The outputs were obtained from site visits and the questionnaire that was given to the residents. In the meanwhile, data loggers and (Meteonorm, 2020) software collected information on temperatures and building materials. Design Builder software was used to create a comprehensive thermal performance simulation model based on the data collected (questionnaires, site inspections, and Meteonorm files).

Table 9. Presents the results of the questionnaire, the temperature, energy use, lighting, heating, and cooling of the selected residences (R1, R2, R3)

Questions	**R1**	**R2**	**R3**
Thermal insulation	No	No	No
Thermal comfort/ Summer	Slightly cold	Neutral	Neutral
Thermal comfort/ Winter	Slightly cold	Cold	Cold
Humidity	Neutral	Low	Low
Energy Usage	Cooking-Heating Cooling-Lighting	Cooking-Water Lightning	Cooking-Water Lightning
Heating Equipment	Wood charcoal	Wood charcoal	Wood charcoal
Cooling Equipment	Air conditioner	-	-
Lamps	Economical	Non-economical	Non-economical

Table 10. Questionnaire outputs, ventilation in the selected residences (R1, R2, R3)

Ventilation Period	**R1**	**R2**	**R3**
Summer	8.00.00-23.00.00 AM	8.00.00-23.00.00 AM	8.00.00-23.00.00 AM
Winter	8.00.00-11.30.00 AM	9.00.00-11.00.00 AM	8.00.00-11.30.00 AM
% of opening	20%	30%	35%

Table 11. Technical aspects of the selected houses (R1, R2, R3)

Technical imformation	**R1**	**R2**	**R3**
Building Area (m2)	232m2	257 m2	177 m2
Density (People/m2)			
No. Facades	4	4	4
Orientation of main Facade	South	South	South
No. Of floors	2	2	2
Height a.s. 1	2.9m	2.7m	2.55m
WWR	20%	30%	35%

CHAPTER 6

RESULTS & DISCUSSIONS

6.1 Overview

These results are conducted using Design Builder Software where the three houses in Gjirokaster, Korce and Berat are designed based on the renovation plans. There are conducted a series of 7 simulations including the base case simulation for each house. The first scenario S1 shows the changes in energy demand for heating and cooling when the windows are changed from their actual condition to double glazing thermal windows. S2 shows the changes in energy consumption when 8cm glass wool insulation is added to the roof of the houses. S3 shows the changes in energy consumption when 8cm of glass wool insulation is added to the interior of the walls of the houses covered by wooden boards in the innermost layer of the exterior walls. S4, S5, S6 are a combination of changing two variables in the same time, respectively glazing change and roof insulation, glazing change and wall insulation, roof and wall insulation. The last scenario S7 is conducted by implementing all the changes in previous scenarios in the same time to have a more visible change in energy heating and cooling energy consumption.

6.2 Residence 1 (R1) Adem Zeko House, Gjirokaster

The graph (*Figure 55*) illustrates a comparison of Adem Zeko House heating and cooling energy consumption, expressed in kWh/m2, between the base case and the real case. The building's actual energy consumption is 3.21 kWh/m² for cooling and 15.12 kWh/m² for heating. On the other hand, according to the base scenario, the building should ideally utilize 6.33 kWh/m2 for cooling and 19.01 kWh/m2 for heating. This comparison shows that the building's actual energy consumption for heating and cooling is lower than the base case projections. With a difference of 3.89 kWh/m², the heating energy usage is significantly reduced, while the cooling energy usage is almost half that, with a difference of 3.12 kWh/m².

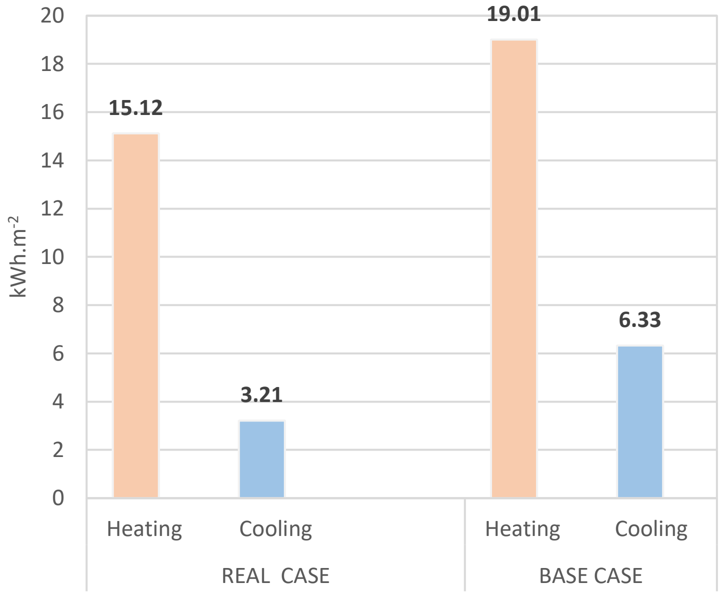


Figure 55. Comparison of Adem Zeko House heating and cooling energy consumption

Figure 56 illustrates a comparison of a building's total energy usage, expressed in kWh/m2, between the base case and the real situation for the building designated R1. While the basic scenario predicts a consumption of 25.34 kWh/m², the building actually consumes 18.33 kWh/m². This shows that, with a difference of 7.01 kWh/m², the actual energy usage is substantially less than the predicted demand. However reduced energy consumption may appear beneficial at first, this disparity indicates that the building is using less energy than expected. Because of this under-consumption, the building may not be sufficiently heated or cooled in accordance with the design standards, which likely prevents the residents from living in the most comfortable conditions. As a result, even though the building uses less energy, it still needs to be optimized to balance energy use with user comfort, making sure that reduced energy use doesn't impair living conditions.

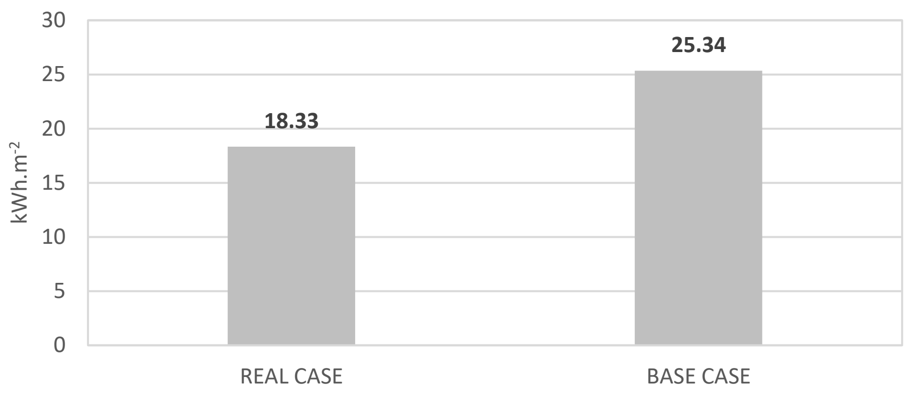


Figure 56. Comparison of Adem Zeko House total energy consumption

6.2.1 R1 Base Case Analysis

The base case of R1's monthly energy use for heating, expressed in kWh/m2, is depicted on *Figure 57*. At about 5 kWh/m², energy consumption peaks in January and stays high in February and March. From April onwards, it drastically drops, reaching almost nothing from May to September. October and November see another spike in use, with December seeing a particularly large increase to roughly 4 kWh/m². This pattern represents normal seasonal heating requirements, using less energy in the warmer months and more in the winter.

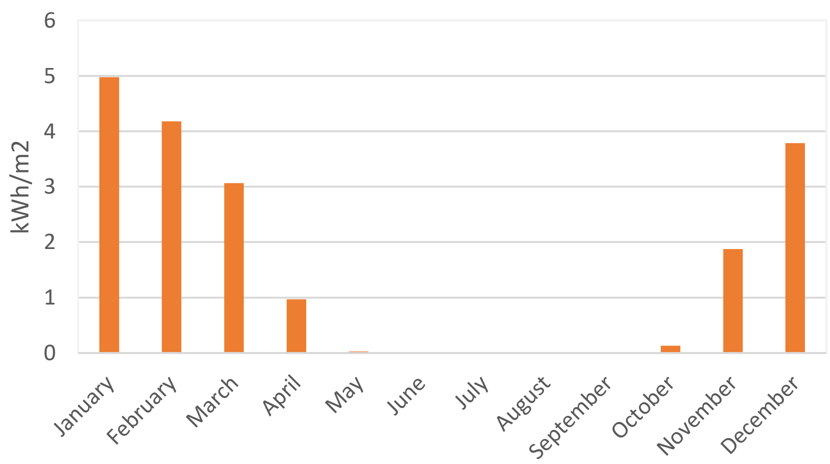


Figure 57. R1,Base case energy consumption for heating (monthly)

On the other hand, *Figure 58* represents the kWh/m² monthly energy usage for cooling in the R1. Summertime is when energy use is at its highest, reaching a peak in August of about 2.5 kWh/m², closely followed by July. June sees a substantial increase, followed by a significant reduction after September, and from October through May, there is little to no cooling energy usage. The aforementioned pattern suggests that cooling energy use occurs mostly in the summer, coinciding with normal seasonal cooling requirements for preserving indoor comfort.

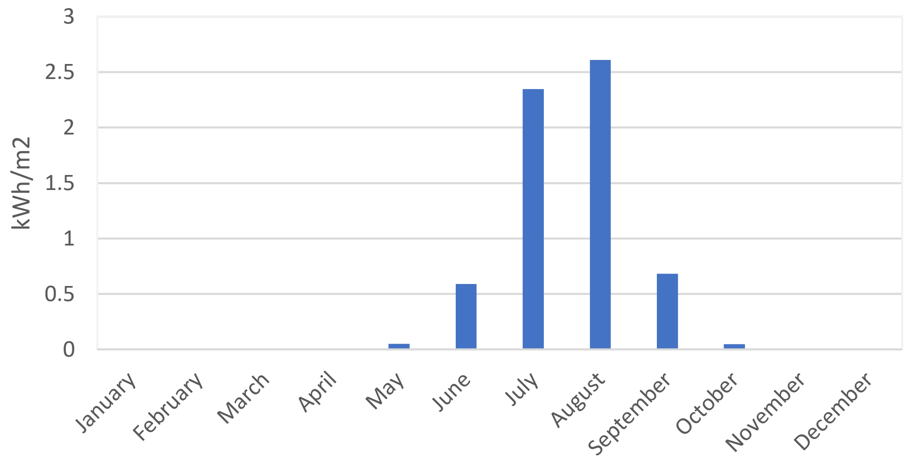


Figure 58. R1,Base case energy consumption for cooling (monthly)

The building designated R1's annual total energy usage, expressed in kWh/m2, is illustrated on *Figure 59*. January sees the largest energy demand, reaching a peak of about 5 kWh/m². February and March see quite high energy usage as well. April is when there is the biggest drop, while May and June see the least amount of use. Due to the demand for cooling, energy consumption increases once more in July and August before declining in September. December sees another notable increase, indicating a demand for heating. This graph shows that, with moderate usage in the transitional months, the building's energy consumption is mostly driven by heating during the winter and cooling during the summer.

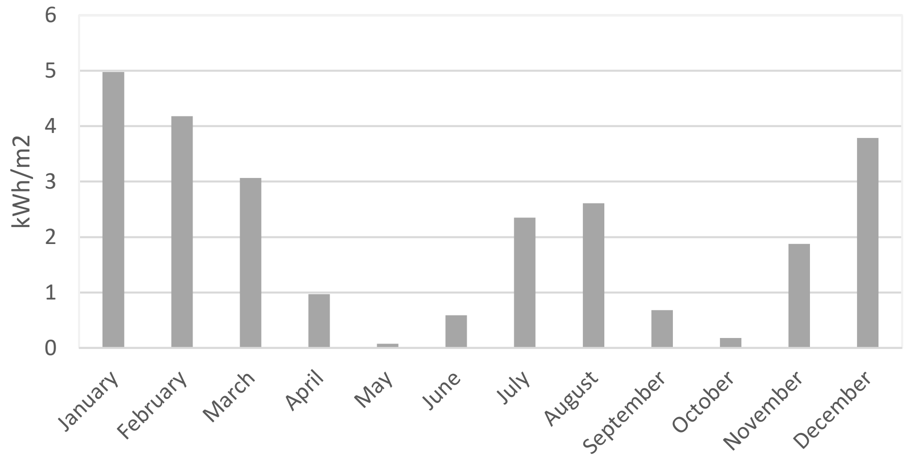


Figure 59. R1,Base case of the total energy consumption (monthly)

6.2.2 Scenarios for R1

The graph (*Figure 60*) compares the base case (BS) with different improvement scenarios to show the total energy usage for heating in Residence 1 (R1), measured in kWh/m². The base case, which depicts the building's existing state, has the highest energy use (19.01 kWh/m²). The following are the possible outcomes: The scenarios with the lowest energy consumption are S7 (all scenarios) at 9.67 kWh/m², S5 (glazing + wall) at 10.33 kWh/m², S6 (Roof + Wall) at 10.42 kWh/m², and S1 (glazing) at 18.37 kWh/m², S2 (Roof) at 17.86 kWh/m², S3 (Wall) correspondingly at 17.86 kWh/m². This suggests that the most effective way to increase the energy efficiency of the building is to adopt all of the suggested adjustments (S7), as this leads to the largest reduction in heating energy usage.

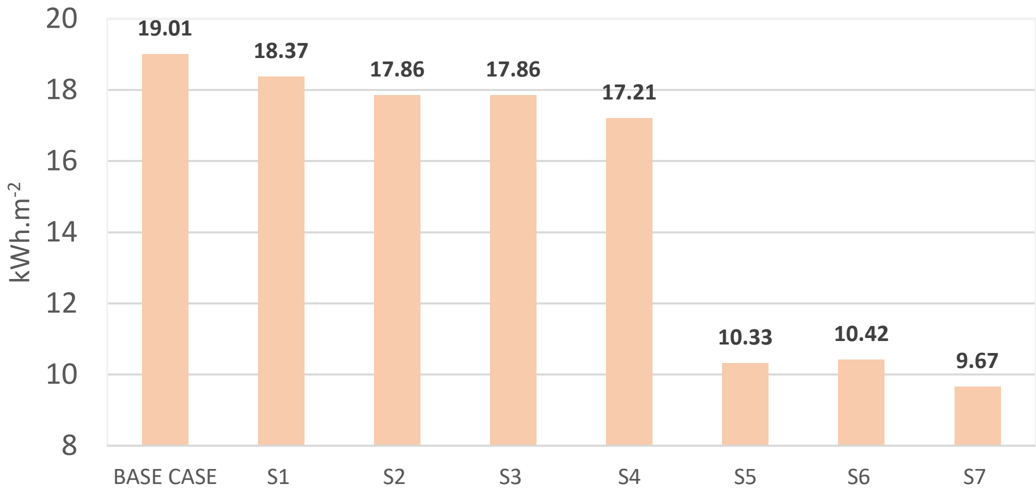


Figure 60. R1-Gjirokaster scenarios impact on Heating energy consumption performance

Figure 61 shows the total energy used for cooling in Residence 1 (R1) as a comparison of different improvement scenarios and the basic case (BS), expressed in kWh/m². The base case, which depicts the building's existing state, has the largest energy use (6.33 kWh/m²). The following are the possible outcomes: The scenarios with the lowest energy consumption are S7 (all scenarios) at 4.14 kWh/m², S5 (glazing + wall) at 4.69 kWh/m², S6 (Roof + Wall) at 4.54 kWh/m², and S1 (glazing) at 6.04 kWh/m², S2 (Roof) at 5.83 kWh/m², S3 (Wall) likewise at 5.83 kWh/m². This suggests that the best way to increase the energy efficiency of the building is to adopt all of the suggested adjustments (S7), as this leads to the largest decrease in the amount of energy used for cooling.

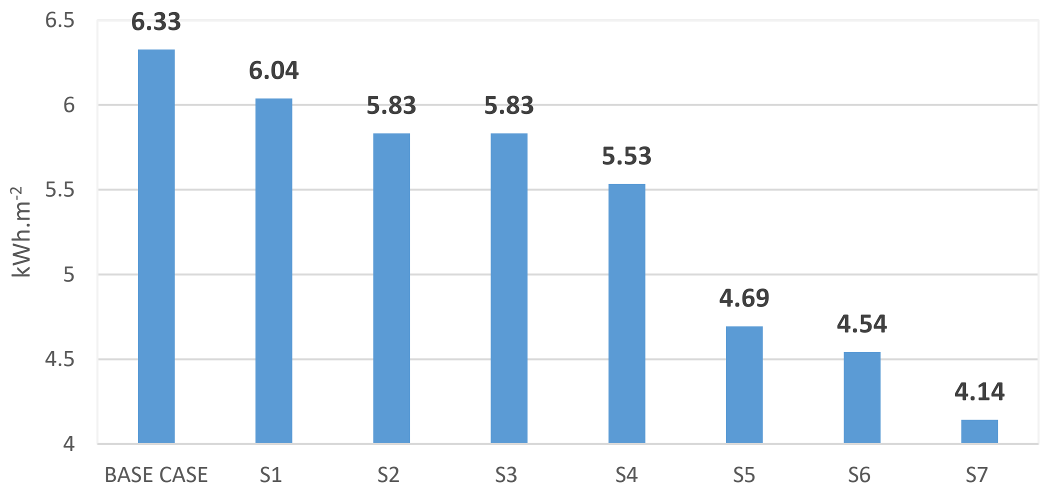


Figure 61. R1-Gjirokaster scenarios impact on Cooling energy consumption performance

Figure 62 illustrates Residence 1's (R1) overall energy use under various scenarios. At 25.34 kWh/m², the base case—which represents the actual energy usage—shows the highest consumption. The glazing scenario (S1) somewhat lowers this to 24.41 kWh/m². S3 (Wall) and S2 (Roof) both attain a usage of 23.69 kWh/m². When roof upgrades and glazing are combined in S4, the demand is reduced to 22.74 kWh/m². S5 (Glazing + Wall) and S6 (Roof + Wall) exhibit more significant decreases in energy consumption, with respective values of 15.03 kWh/m² and 14.97 kWh/m². S7 exhibits the greatest reduction, incorporating all suggested modifications and resulting in an overall energy consumption of 13.81 kWh/m². This illustrates that the greatest energy savings come from a holistic approach to building modifications.

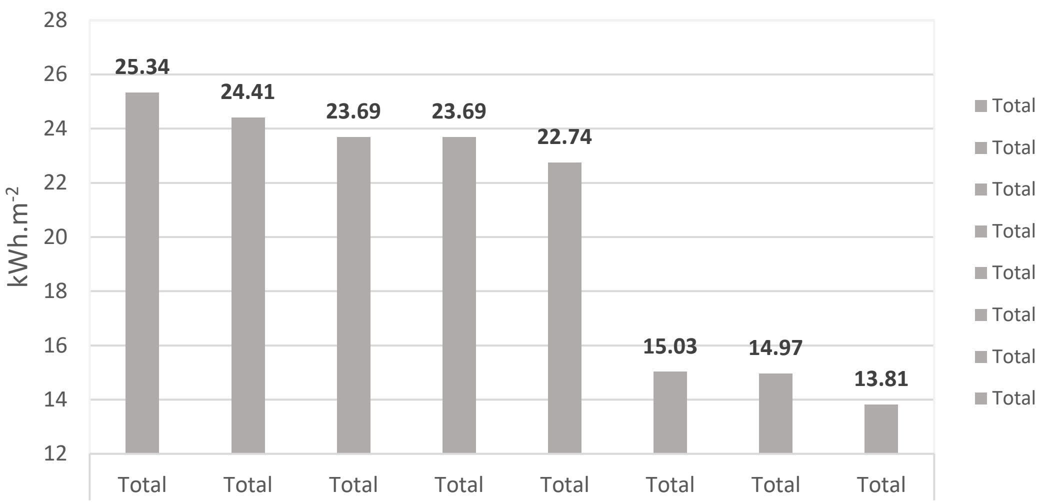


Figure 62. R1-Gjirokaster scenarios impact on the Total energy consumption performance

6.3 Residence 2 (R2) Andromaqi Melko House, Korce

The graph (*Figure 63*) shows the amount of energy was required for heating and cooling the Andromaqi Melko house (R 2) in Korçë in the base case compared to the actual situation. The building's actual energy consumption is 4.14 kWh/m² for cooling and 37.55 kWh/m² for heating. As opposed to this, the basic scenario estimates that the building will require 6.17 kWh/m2 for cooling and 56.14 kWh/m2 for heating.

The comparison shows that real energy use is less than base case projections for both heating and cooling. In particular, the real instance has a significant reduction in heating energy consumption of 18.59 kWh/m² and cooling energy consumption of 2.03 kWh/m².

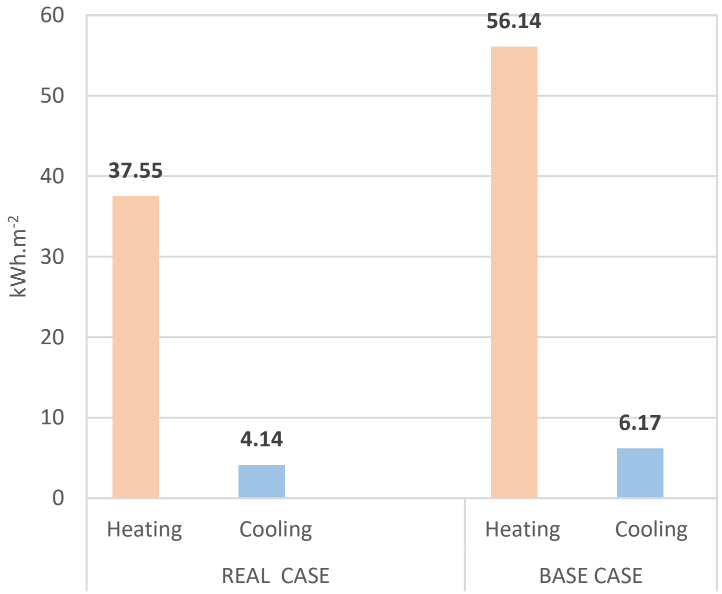


Figure 63. Comparison of Andromaqi Melko House heating and cooling energy consumption

Figure 64 shows the difference in total energy usage between the base case and the real case for Residence 2 (Andromaqi Melko House) in Korçë. The building uses 41.69 kWh/m2 in the real scenario, while the base case predicts a greater consumption of 62.31 kWh/m2. With a difference of 20.62 kWh/m², this shows that the real energy usage is far less than the predicted demand. While the building may not be utilizing enough energy to ensure the highest levels of comfort for its occupants, this lower energy usage may look advantageous. The notable decrease in energy use suggests that adjustment is required to guarantee that energy efficiency does not compromise indoor comfort.

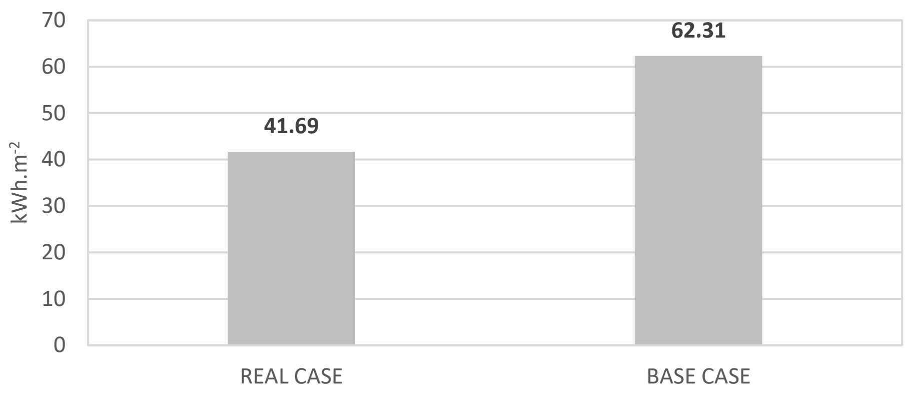


Figure 64. Comparison of Andromaqi Melko House total energy consumption

6.3.1 R2- Base Case Analysis

Figure 65 shows the monthly energy usage for heating in R2 in Korçë. Wintertime is when energy use peaks, with January reaching approximately 16 kWh/m², and continues to be high in February and March. There is a noticeable dip in April and very low use from May to September, suggesting that there is little to no need for heating in these warmer months. October sees the start of another increase in energy use, which picks up speed in November and December and reaches about 12 kWh/m² in December. In order to maintain indoor comfort, this pattern represents average seasonal heating needs, with the coldest months requiring the most energy use.

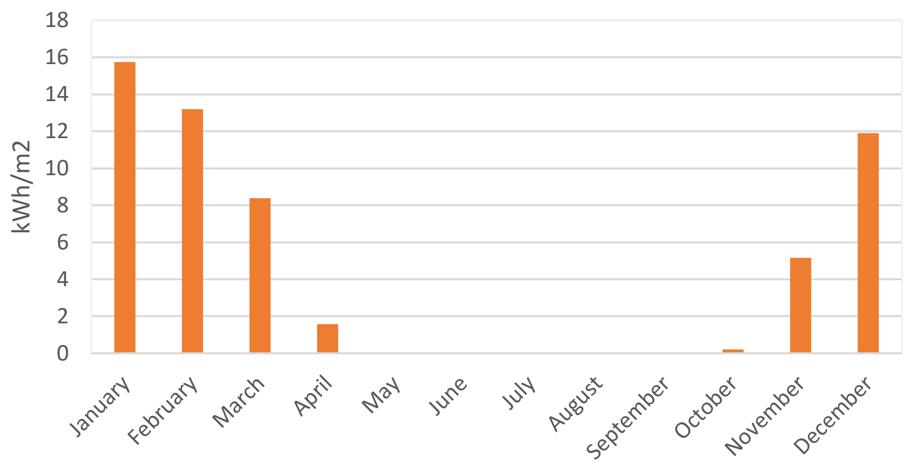


Figure 65. R2,Base case energy consumption for heating (monthly)

Figure 66 displays the monthly energy use in R2. The summer months experience the highest energy demand for cooling, with a notable increase beginning in June and reaching a peak of approximately 2.5 kWh/m² in August. July likewise exhibits near-peak consumption at a high level. September sees a discernible decline, and by October, cooling energy use reaches very low levels, which persists for the remainder of the year.

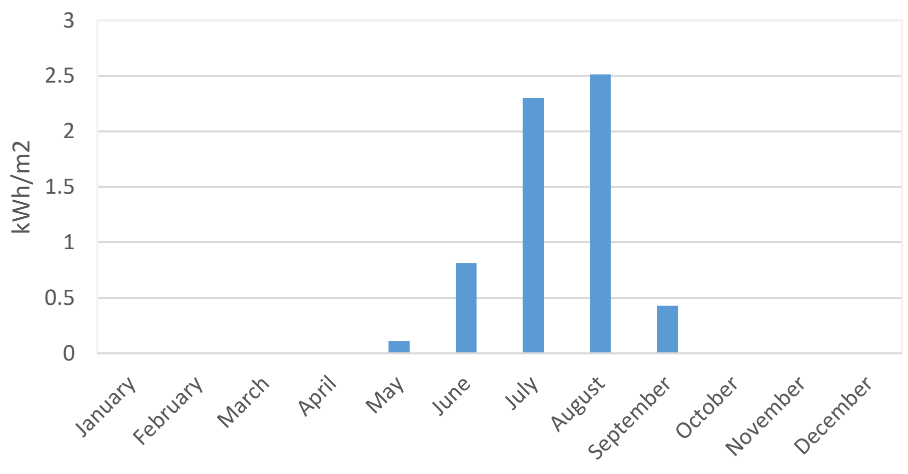


Figure 66. R2,Base case energy consumption for cooling (monthly)

The annual total energy consumption of R2 is shown on *Figure 67*. Wintertime is when energy use peaks, with January reaching a high of about 16 kWh/m², with February and March having high values after that. With only slight increases in July and August, which suggest some cooling demands, energy usage only slightly increases in April and stays low throughout the summer, from May to September. October sees the beginning of the consumption spike once more, which continues through November and December, reaching a notable peak of almost 12 kWh/m². With heating accounting for the majority of energy use during the coldest months and cooling accounting for a significantly smaller portion during the warmer months, this trend illustrates the building's seasonal energy needs.

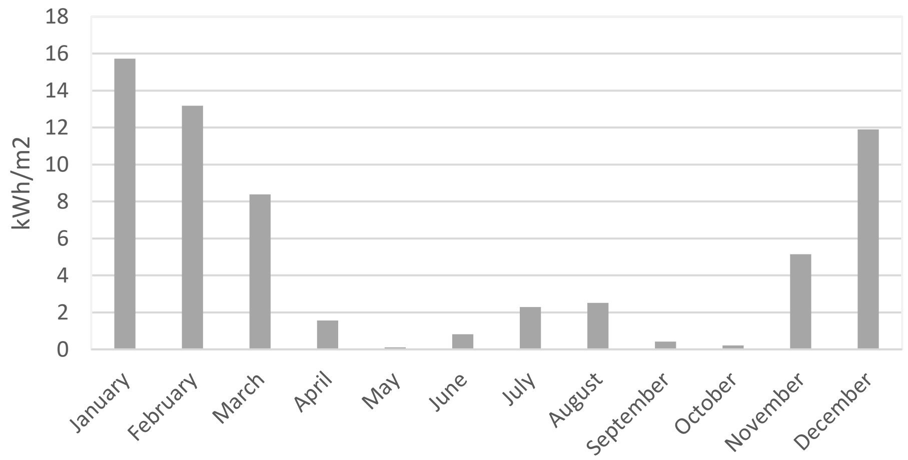


Figure 67. R2,Base case of the total energy consumption (monthly)

6.3.2 Scenarios for R2

The graph (*Figure 68*) compares the base case (BS) with several improvement scenarios to show the total energy used for heating in Residence 2 (R2). At 56.14 kWh/m², the base case exhibits the highest energy use. Scenario S2 (Roof) lowers consumption to 54.96 kWh/m², while Scenario S1 (Glazing) marginally raises consumption to 56.67 kWh/m². The energy usage is significantly reduced to 24.68 kWh/m² by Scenario S3 (Wall). The usage in Scenario S4 (Glazing + Roof) is 51.45 kWh/m². The energy usage is further decreased to 26.19 kWh/m2 and 24.82 kWh/m2 in scenarios S5 (Glazing + Wall) and S6 (Roof + Wall), respectively. Scenario S7 (All scenarios) yields the best performance and uses the least energy, at 22.41 kWh/m². This suggests that while putting all suggested modifications into practice results in the largest decrease, concentrating only on wall improvements (S3) also has a significant positive influence on lowering heating energy usage.

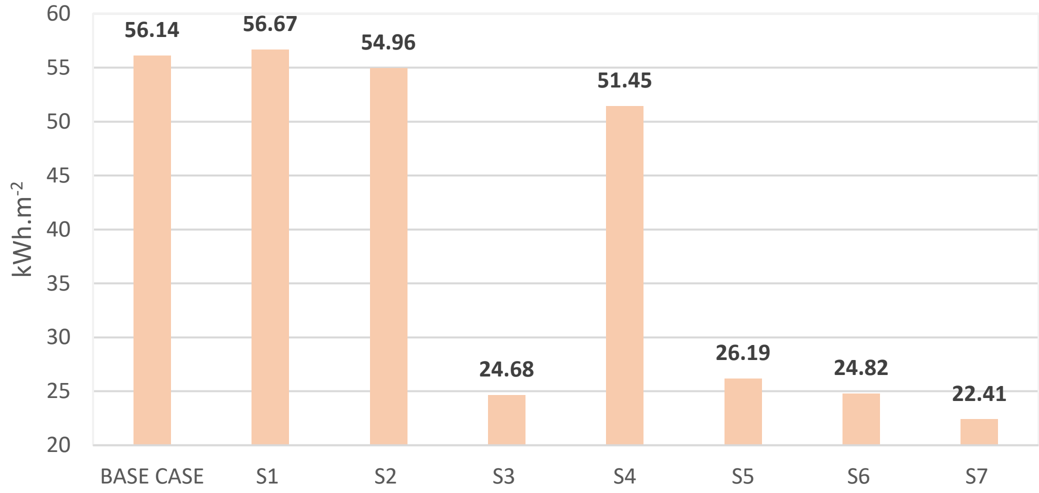


Figure 68. R2-Korce scenarios impact on Heating energy consumption performance

Figure 69 shows how much energy Residence 2 (R2) uses overall for cooling. With 6.17 kWh/m², the base case exhibits the highest energy consumption. This is decreased to 5.08 kWh/m² in Scenario S1 (Glazing) and 5.89 kWh/m² in Scenario S2 (Roof Insulation). With wall insulation, scenario S3 lowers consumption to 5.03 kWh/m2, and with glazing and roofing, scenario S4 further lowers consumption to 5.53 kWh/m2. With its substantial impact, Scenario S5 (Glazing + Wall) reduces the energy usage to 3.88 kWh/m². 5.13 kWh/m² is the consumption achieved by Scenario S6 (Roof + Wall). Scenario S7 (All scenarios) has the highest performance, lowering the cooling energy consumption to 3.52 kWh/m². This suggests that while S5 has a very good influence on reducing energy use, S7 produces the largest reduction when all suggested modifications are implemented.

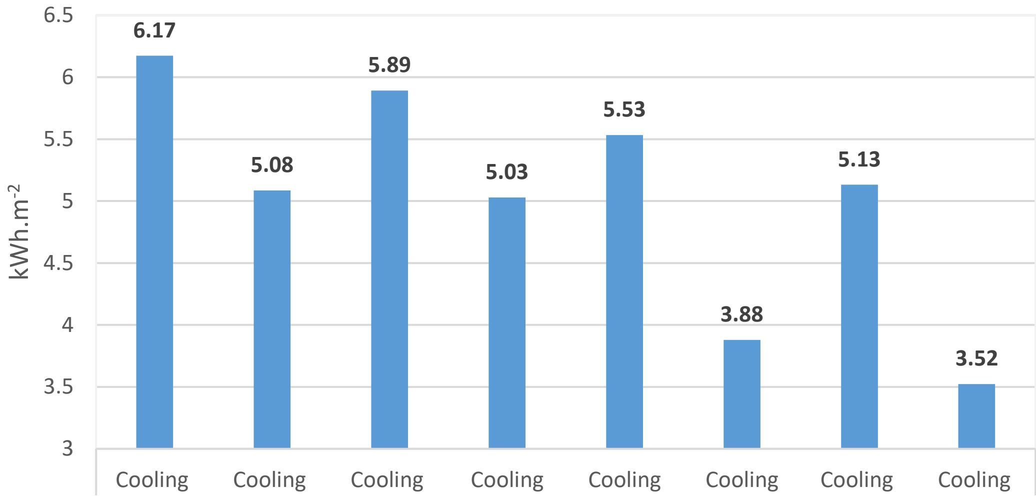


Figure 69. R1-Korce scenarios impact on Cooling energy consumption performance

Figure 70 displays Residence 2's (R2) overall energy consumption and contrasts the base case (BS) with several alternatives for improvement. At 62.31 kWh/m², the base case has the highest energy consumption. This is reduced to 61.75 kWh/m² by Scenario S1 (Glazing), and to 60.85 kWh/m² by Scenario S2 (Roof). With regard to the Wall scenario, the drop to 56.98 kWh/m² is more notable. Significant decreases may be observed in S4 (Roof + Wall) at 29.95 kWh/m², S5 (Glazing + Wall) at 30.07 kWh/m², and S4 (Glazing + Roof) at 29.71 kWh/m². Scenario S7 (All scenarios) yields the best results, reducing the overall energy use to 25.93 kWh/m². Even while each scenario has a good effect on lowering energy consumption, the greatest notable reduction is achieved when all suggested improvements in S7 are put into practice, proving how successful they are in raising the building's energy efficiency.

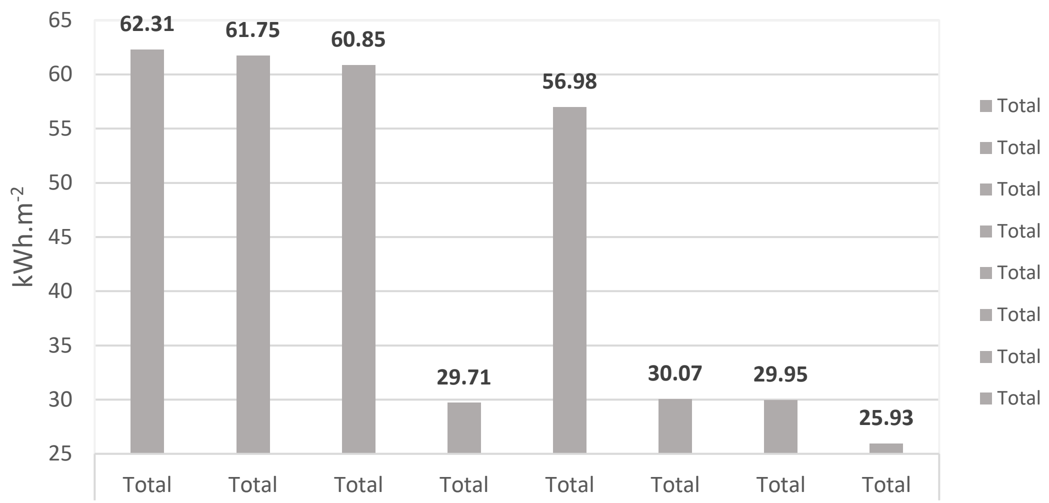


Figure 70. R2- Korce scenarios impact on the Total energy consumption performance

6.4 Residence 3 (R3) Lluke Zanati House, Berat

Figure 71 shows the difference in heating and cooling energy usage,in kWh/m2, between the real and base cases for the Luke Zanati House (R3) in Berat. The building's actual energy consumption is 4.86 kWh/m² for cooling and 10.97 kWh/m² for heating. On the other hand, the basic scenario predicts that the building will require 6.97 kWh/m² for cooling and 17.23 kWh/m² for heating. This comparison shows that, for both heating and cooling, the actual energy consumption is far less than the estimated figures. In comparison to the base case, the real case's heating energy consumption is decreased by 6.26 kWh/m² and its cooling energy consumption is decreased by 2.11 kWh/m². These variations show that the structure is operating more economically than anticipated, consuming less energy to keep temperatures pleasant. But the lower-than-expected energy use may also indicate that the residents of the facility may not be as comfortable as they may be, perhaps as a result of inadequate winter or summer cooling. As a result, even though the building has efficient energy-saving features, it can be necessary to optimize energy use to guarantee that occupant comfort is not jeopardized.

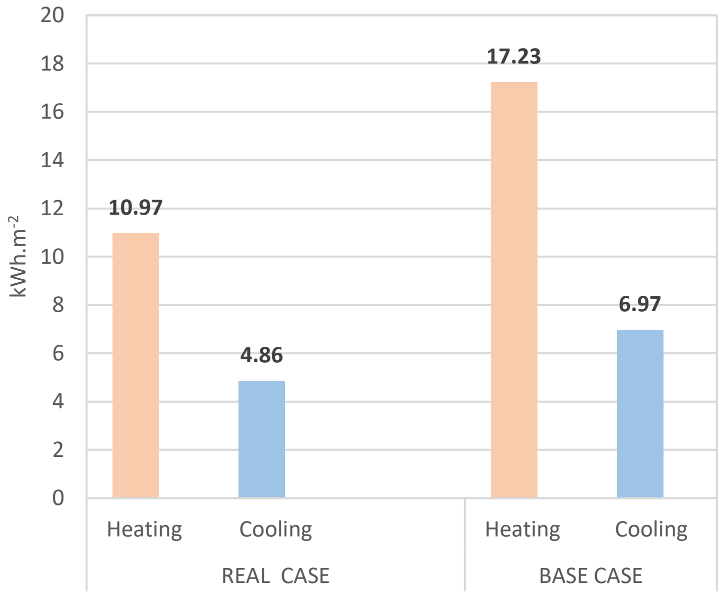


Figure 71. Comparison of Lluke Zanati House heating and cooling energy consumption

Figure 72 illustrates the difference in total energy usage, expressed in kWh/m2, between the base case and the actual scenario for R3 in Berat. The building uses 15.82 kWh/m2 in the real scenario, while the base case predicts a greater consumption of 24.19 kWh/m2. This shows that, with a difference of 8.37 kWh/m², the actual energy usage is far less than the predicted demand.

Due to the notable decrease in energy use, the building's occupants may experience discomfort if it is underheated in the winter or undercooled in the summer. As a result, even with the apparent energy efficiency, energy usage needs to be optimized to fulfill occupant comfort requirements while preserving efficiency.

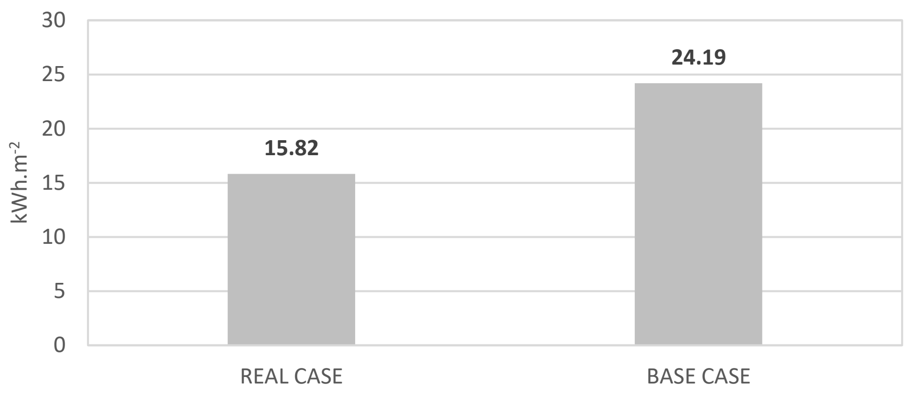


Figure 72. Comparison of Lluke Zanati House total energy consumption

6.4.1 R3-Base Case analysis

The monthly energy usage for heating in Residence 3 (R3), expressed in kWh/m2, is shown on *Figure 73*. January and February see the highest energy demand, which is approximately 5 kWh/m². The months of March and April witness a decline in heating consumption, but the months of May through September exhibit low usage, suggesting that there is little demand for heating during these warmer months. October sees a return to higher use, which rises noticeably in November and December to reach about 4 kWh/m² in December. This pattern shows that the necessity to preserve indoor comfort during the colder months is reflected in the highest heating energy use throughout the winter.

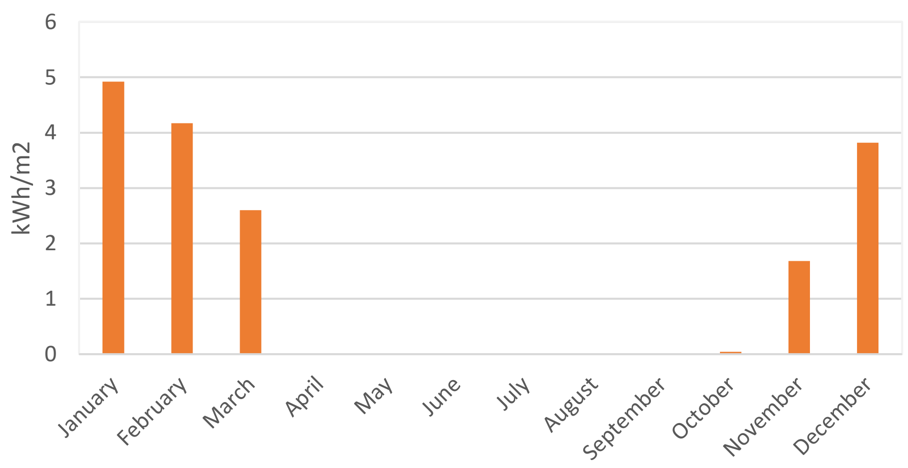


Figure 73. R3,Base case energy consumption for heating (monthly)

The monthly energy usage for cooling in R3 is shown on *Figure 74*. The amount of energy used for cooling starts to climb in May and really picks up in June. The consumption peaks in July and August, when it reaches approximately 3 kWh/m², demonstrating that during the warmest months of the year, there is a greater demand for cooling. September sees a considerable but beginning reduction in energy usage. Because there is less need for cooling during the cooler months, there is little to no energy use for cooling from October to April.

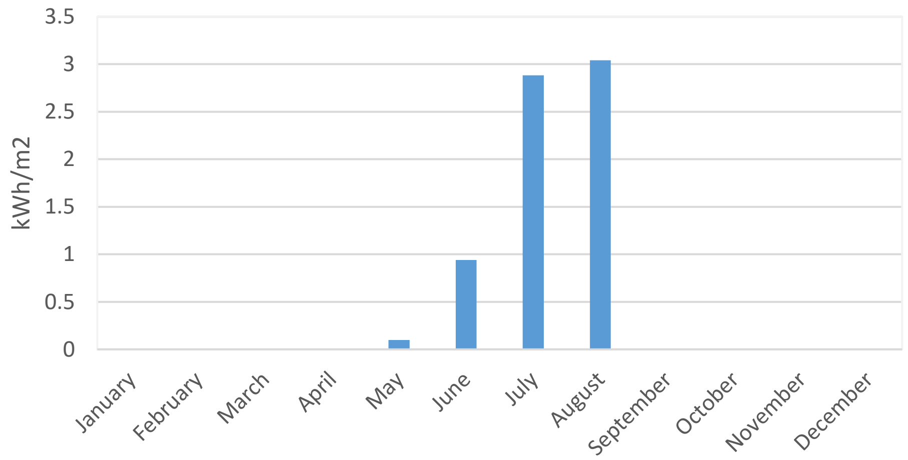


Figure 74. R3,Base case energy consumption for cooling (monthly)

Figure 75 represents R3's annual total monthly energy use. Wintertime is when energy use is at its maximum, peaking at about 5 kWh/m² in January and February. March and April are the low-energy months of the spring, and this trend continues into May and June. Due to the necessity for cooling, there is a discernible spike in July and August throughout the summer, with consumption of about 3 kWh/m². The amount of energy used decreases once again in September and October before increasing somewhat in November and significantly in December to a total of about 4 kWh/m². This pattern suggests that throughout the winter and summer, the building's heating and cooling needs drive its energy usage, with lesser consumption during the transitional months.

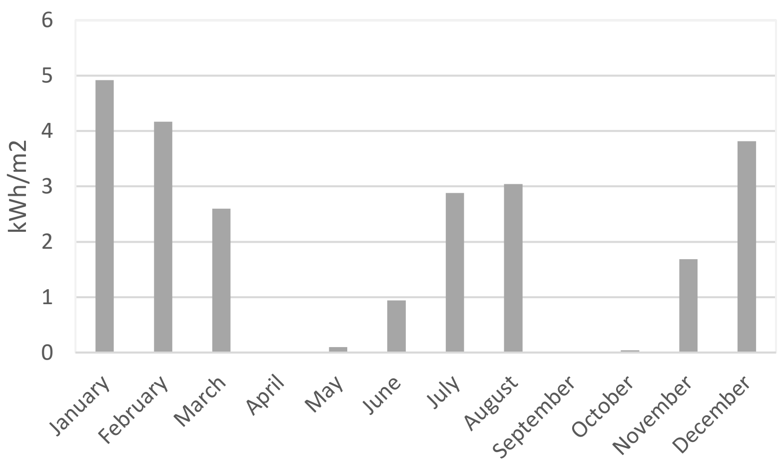


Figure 75. R3, Base case of the total energy consumption (monthly)

6.4.2 Scenarios for R3

Figure 76 compares the base case (BS) with several improvement scenarios to show the total energy used for heating in Residence 3 (R3). 17.23 kWh/m² is the energy consumption in the base case. This is lowered somewhat to 17.04 kWh/m² by scenario S1 (Glazing), and even lower to 16.63 kWh/m² by scenario S2 (Roof). With its substantial influence, Scenario S3 (Wall) lowers consumption to 7.20 kWh/m². The energy usage in Scenario S4 (Glazing + Roof) surprisingly rises to 22.56 kWh/m². Additional savings are realized in scenarios S5 (Glazing + Wall) and S6 (Roof + Wall), where consumption is 7..00 kWh/m² and 6.48 kWh/m², respectively. Scenario S7 (All scenarios) provides the best results, reducing the energy use to 6.28 kWh/m². This suggests that although S7 exhibits the largest decrease in energy usage, S6 also makes a noteworthy contribution, proving their efficacy in raising the building's energy efficiency.

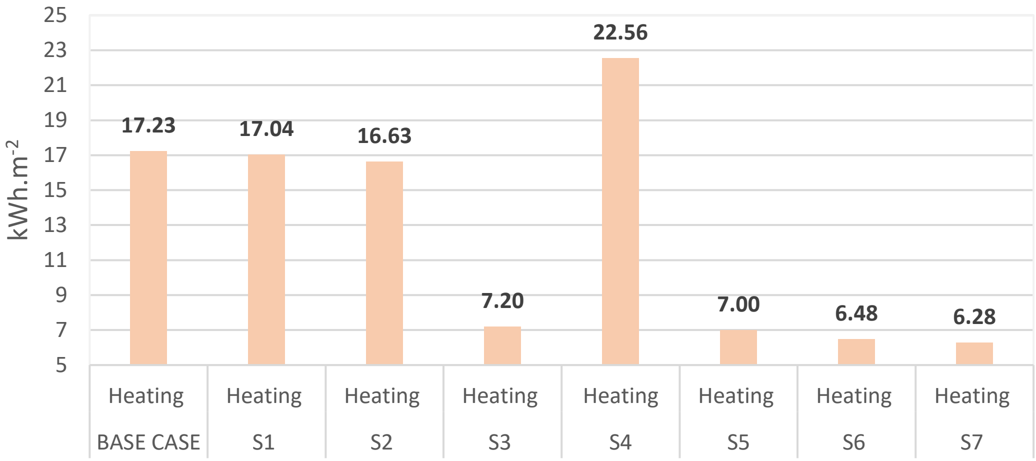


Figure 76. R3-Berat scenarios impact on Heating energy consumption performance

Figure 77 shows the total energy used for cooling in Residence 3 (R3) in comparison to different improvement scenarios and the basic case (BS), with measurements in kWh/m². 6.97 kWh/m² is the energy consumption in the base case. This is lowered somewhat to 6.88 kWh/m² in Scenario S1 (Glazing), and even more to 6.60 kWh/m² in Scenario S2 (Roof). A greater impact is seen in Scenario S3 (Wall), where consumption is reduced to 4.11 kWh/m². Scenario S4 (Glazing + Roof), however, results in an increase in energy usage to 7.25 kWh/m². Further reductions in consumption are achieved in scenarios S5 (Glazing + Wall) and S6 (Roof + Wall), with corresponding usage of 3.97 kWh/m² and 3.65 kWh/m². Scenario S7 (All scenarios) exhibits the best performance, lowering the energy use to 3.50 kWh/m². It demonstrates that while a number of scenarios result in considerable reductions in the amount of cooling energy consumed, S7 offers the largest reduction, proving its efficacy in raising the building's energy efficiency.

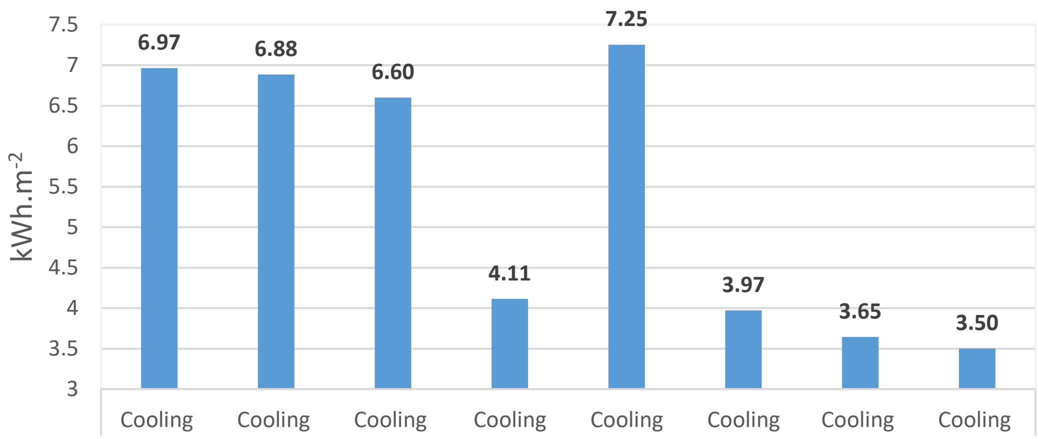


Figure 77. R3-Berat scenarios impact on Cooling energy consumption performance

Figure 78 demonstrates Residence 3's (R3) total energy consumption and contrasts the base case (BS) with several alternatives for improvement. The energy usage in the base case is 24.20 kWh/m². This is lowered somewhat to 23.92 kWh/m² by scenario S1 (G), and much lower to 23.24 kWh/m² by scenario S2 (R). With a major impact, scenario S3 (Wall) lowers consumption to 11.31 kWh/m². The energy usage in Scenario S4 (G+R) surprisingly rises to 29.81 kWh/m². Further reductions in consumption are achieved in scenarios S5 (G+W) and S6 (R+W), with corresponding usage of 10.97 kWh/m² and 10.12 kWh/m². It indicates that while a number of scenarios result in considerable reductions in the amount of cooling energy consumed, S7 offers the largest reduction, proving its efficacy in raising the building's energy efficiency.

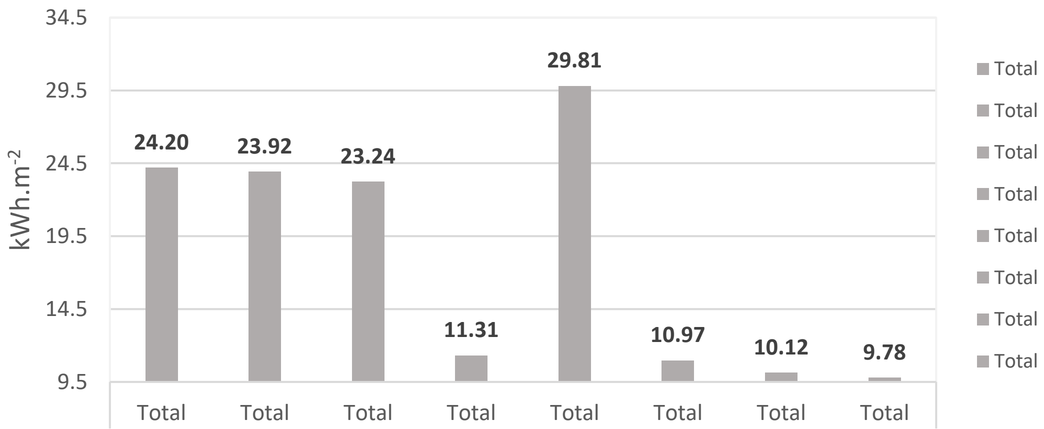


Figure 78. R3- Berat scenarios impact on the Total energy consumption performance

6.5 Comparison Total Energy consumption for the three Residences (R1,R2,R3)

The graph (*Figure 79*) compares the base case (BS) with different improvement scenarios to show the total energy usage, measured in kWh/m2, for three dwellings in three cities (Gjirokaster, Korçë, and Berat). All three cities show significant energy usage in the base case; Korçë peaks at about 60 kWh/m². Slight reductions are observed when glazing (S1) is improved in all cities, suggesting a moderate influence. Similar slight decreases are shown by roof upgrades (S2 and S3), indicating that roofing by alone does not significantly reduce energy use. Wall improvements (S4) show significant decreases, particularly for Berat. Improvements to roofing and glazing combined (S5) produce observable decreases in all cities and are more successful than each strategy alone. Improvements to the walls and roof (S6) result in significant decreases, especially in Korçë. Scenario S7, which combines all of the suggested modifications, shows the biggest reduction in energy usage and the greatest efficacy in raising total energy efficiency in Gjirokaster, Korçë, and Berat. S7 is the most effective method, offering the largest reduction in energy usage and optimizing energy efficiency in all three cities, even though some scenarios show notable reductions.

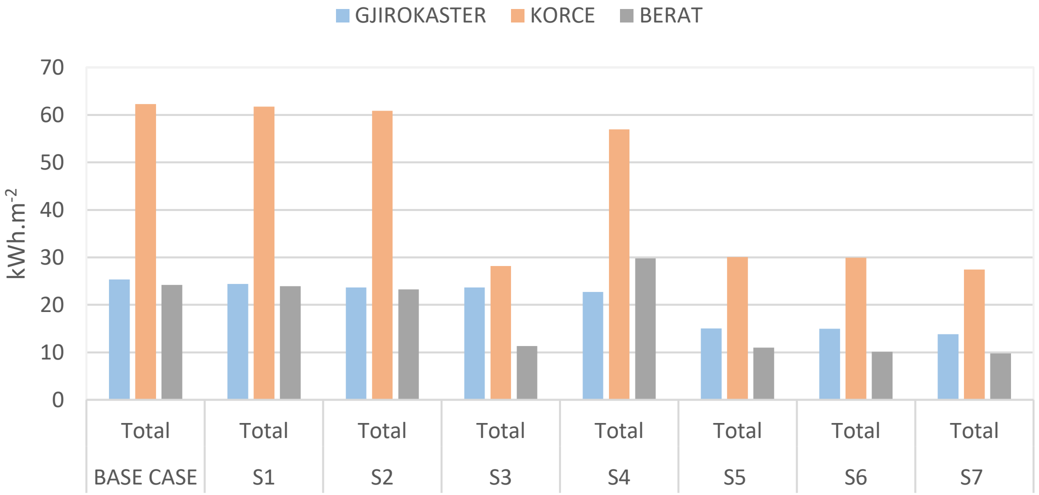


Figure 79. Comparison of the total energy consumption values for the 3 Houses

6.6 Morphological effectiveness

The annual energy demands for Gjirokaster (GJ), Korçë (K), and Berat (B) as well as the total energy demands are shown in *Figure 80*. The morphological effectiveness of each scenario is assessed in order to ascertain the effects of various energy-saving strategies.

Base Case for **Gjirokaster (GJ):** The entire amount of energy used is 25.33 kWh/m².

S1 (Glass replacement): Displays an 8.5% increase in heating efficiency and a 4.5% increase in cooling efficiency, for a 3.6% total energy gain.

S2 (Roof insulation): Displays a 7.75% improvement in cooling and a 6% improvement in heating, for a total energy improvement of 6.47%.

S3 (Wall insulation): Equivalent to S2, but with a 7.75% cooling gain and a 6% heating gain, yielding a 6.47% total energy improvement.

S4 (G+R): Displays improvements in cooling of 12.5% and heating of 9.47%, resulting in an overall energy improvement of 10.38%.

S5 (G+W): Reports a noteworthy 45.6% increase in heating and a 25.7% increase in cooling, for an overall energy improvement of 40.7%.

With a 45.15% improvement in heating and a 28.1% improvement in cooling,

S6 (R+W) has an overall energy improvement of 40.93%.

With a 49.1% improvement in heating and a 34.49% improvement in cooling,

S7 (All Scenarios) shows the greatest improvements, yielding an overall energy improvement of 45.47%.

Korçë (K): Base Case: 62.31 kWh/m² is the total energy consumed.

S1 (G): Indicates a marginal -0.9% decline in heating efficacy but a 17.66% increase in cooling, translating into an overall energy improvement of 0.89%.

S2 (R): Displays a 2.34% total energy improvement with a 2% improvement in heating and a 4.53% improvement in cooling.

S3 (W): Displays a noteworthy 18.63% improvement in cooling and a noteworthy 60% improvement in heating, for a total energy improvement of 55.96%.

S4 (G+R): Displays an improvement in heating of 8.3% and a cooling improvement of 10.37%, resulting in a total energy improvement of 8.57%.

S5 (G+W): Displays a 51.74% total energy improvement with a 53.3% improvement in heating and a 37.27% improvement in cooling.

S6 (R+

W): Displays an improvement in cooling of 16.85% and heating of 55.79%, resulting in an overall energy improvement of 51.94%.

With an improvement of 56.03% in heating and 42.94% in cooling, S7 (All Scenarios) shows the highest improvements, with an overall energy improvement of 34.11%.

Berat (B): Base Case: 24.19 kWh/m² is the total energy consumed.

S1 (G): Displays 1.16% and 1.14% increases in heating and cooling, respectively, for a 1.11% total energy improvement.

S2 (R): Displays improvements in cooling of 5.17% and heating of 3.48%, resulting in a total energy improvement of 3.96%.

S3 (W): Displays a noteworthy 58.27% increase in heating and 40.94% increase in cooling, for a total energy improvement of 53.28%.

S4 (G+R): Displays a drop in cooling efficiency of -4.16% and a fall in heating effectiveness of -30.87%, resulting in an overall energy reduction of -23.19%.

S5 (G+W): Displays a 42.95% improvement in cooling and a 59.37% improvement in heating, for an overall energy improvement of 54.65%.

S6 (R+W): Displays a 47.7% improvement in cooling and a 62.44% improvement in heating, for a total energy improvement of 58.16%.

With a 63.55% improvement in heating and a 49.71% improvement in cooling, S7 (All Scenarios) shows the greatest improvements, yielding a total energy improvement of 59.56%.

		Annual heating demand			**Annual cooling demand**			**Annual energy demand**		
	Scenarios	Total heating [kWh]	Total heating [kWh/m^2]	**Morphology effectiveness [%]**	Total cooling [kWh]	Total cooling [kWh/m^2]	**Morphology effectiveness [%]**	Total energy [kWh]	Total energy/ conditioned area [kWh/m^2]	**Total Morphology effectiveness [%]**
GJ	Base case	4410.16	19.00	**-**	1467.78	6.32	**-**	5877.94	25.33	**-**
	GJ_S1	4262.72	18.37	**8.5**	1400.97	6.038	**4.5**	5663.7	24.41	**3.6**
	GJ_S2	4143.056	17.85	**6**	1353.11	5.83	**7.75**	5496.1	23.69	**6.47**
	GJ_S3	4143.05	17.85	**6**	1353.11	5.83	**7.75**	5496.17	23.69	**6.47**
	GJ_S4	3992.29	17.20	**9.47**	1283.784	5.53	**12.5**	5276.07	22.74	**10.38**
	GJ_S5	2396.90	10.33	**45.6**	1089.18	4.69	**25.7**	3486.09	15.02	**40.7**
	GJ_S6	2418.17	10.42	**45.15**	1053.89	4.54	**28.1**	3472.07	14.96	**40.93**
	GJ_S7	2243.82	9.67	**49.1**	961.09	4.14	**34.49**	3204.92	13.81	**45.47**

	Base case	14427.89	56.13	-	1586.32	6.17	-	16014.21	62.31	-
	K_S1	14563.3	56.66	**-0.9**	1306.72	5.08	**17.66**	15870.02	5.08	**0.89**
K	K_S2	14124.95	54.96	**-2**	1514.32	5.89	**4.53**	15639.28	60.85	**2.34**
	K_S3	5761.63	22.41	**60**	1292.68	5.02	**18.63**	7054.318	27.44	**55.96**
	K_S4	13221.9	51.44	**8.3**	1421.66	5.53	**10.37**	14643.57	56.97	**8.57**
	K_S5	6731.77	26.19	**53.3**	996.97	3.87	**37.27**	7728.75	30.07	**51.74**
	K_S6	6378.14	24.81	**55.79**	1318.71	5.13	**16.85**	7696.86	29.94	**51.94**
	K_S7	6343.45	24.68	**56.03**	905.58	3.52	**42.94**	7249.03	28.2	**34.11**

	Base case	3049.71	17.23	-	1232.82	6.96	-	4282.54	24.19	-
	B_S1	3015.86	17.03	**1.16**	1218.52	6.88	**1.14**	4234.38	23.92	**1.11**
B	B_S2	2944.32	16.63	**3.48**	1168.31	6.6	**5.17**	4112.63	23.23	**3.96**
	B_S3	1273.59	7.19	**58.27**	728	4.11	**40.94**	2001.6	11.3	**53.28**
	B_S4	3992.29	22.55	**-30.87**	1283.78	7.25	**-4.16**	5276.07	29.8	**-23.19**
	B_S5	1239.22	7	**59.37**	703.23	3.97	**42.95**	1942.46	10.97	**54.65**
	B_S6	1146.72	6.47	**62.44**	645.18	3.64	**47.7**	1791.91	10.12	**58.16**
	B_S7	1111.65	6.28	**63.55**	619.61	3.5	**49.71**	1731.27	9.78	**59.56**

Figure 80. Morphology effectiveness for the 3 Houses

Scenario S7 consistently exhibits the highest increases in morphological effectiveness for lowering overall energy consumption among the three cities. There is an improvement of 45.47% in Gjirokaster, 34.11% in Korçë, and 59.56% in Berat. Not notable gains are also noted in S6 and S5, especially in Berat and Korçë, suggesting that combinations of wall and roof or glazing and wall upgrades have a significant effect. However, implementing all suggested adjustments in Scenario S7 results in the most extensive gains.

6.7 Thermal performance analysis

6.7.1 Thermal performance in R1 (Girokaster) during a typical day in summer and winter

Measured in degrees Celsius (°C), *Figure 81* shows the gains in indoor temperature performance for Residence 1 (R1) in Gjirokaster over the course of a typical summer day (24 hours) under different circumstances. The indoor temperature in the Base Case (BC) begins at roughly 27.8°C at 1:00 AM, rises steadily throughout the morning, peaks at about 28.8°C between 4:00 PM and 5:00 PM, and then falls back to 28°C by midnight. In the early morning, Scenario S1 (Glass) displays somewhat lower temperatures than the BC; nevertheless, it maintains a temperature closer to 28.5°C until the afternoon peak, suggesting a moderate improvement. Compared to S1, Scenario S2 (Roof) performs better, exhibiting a more notable decrease that begins at 27.3°C and peaks at 28.5°C in the afternoon. While S3 (W) peaks slightly higher at 29.2°C, it exhibits a similar early-morning trend to S2, suggesting less significant improvement throughout the hottest part of the day. The majority of the day, Scenario S4 (G+R) keeps temperatures at or around 28.5°C; however, in the late afternoon, it peaks at or around 30°C, indicating less success in regulating peak temperatures. The lowest temperatures are consistently seen in S5 (G+W) and S6 (R+W), with morning highs of about 27°C and afternoon lows of less than 28°C. While S6 peaks slightly higher at 28.4°C, S5's peak temperature is approximately 28.2°C. Both show a notable increase in temperature regulation. With a beginning temperature of 27.5°C and a generally steady temperature throughout the day, culminating at around 28.2°C in the afternoon, Scenario S7 (All Scenarios) performs the best.

In conclusion, scenarios S5, S6, and S7 show the most effective temperature improvements for (R1) in Gjirokaster on a normal summer day. These conditions result in much cooler interior temperatures, especially in the afternoon when people are most comfortable. The usefulness of the proposed adjustments in enhancing thermal performance is demonstrated by Scenario S7, which consistently displays the lowest peak temperature and better overall performance.

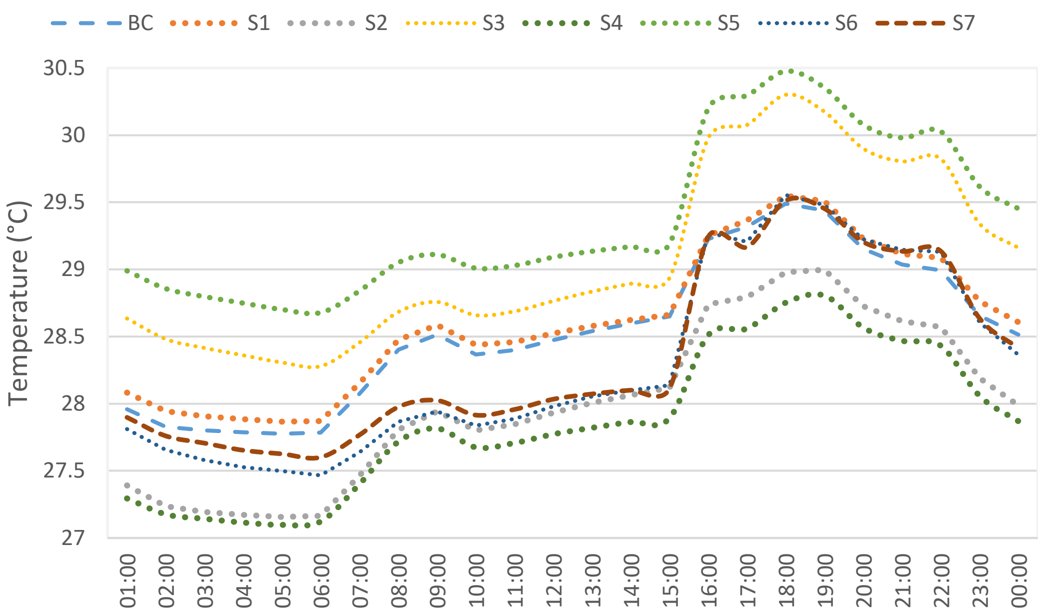


Figure 81. R1-Gjirokaster: Temperature improvement inside in a typical summer day

The graph (*Figure 82*) demonstrates, in degrees Celsius (°C), the improvements in indoor temperature performance for Residence 1 (R1) in Gjirokaster throughout a typical winter day in February (24 hours) under different situations. Under the Base Case (BC), the temperature inside the building begins at around 8.5°C at 1:00 AM, rises steadily through the morning, peaks at about 10.5°C between 4:00 PM and 5:00 PM, and then falls to about 9.5°C by midnight. Temperatures in Scenario S1 (Glass) start at roughly 9.5°C and peak at roughly 11°C in the afternoon, which is a slight improvement above BC. A more notable improvement may be seen in Scenario S2 (Roof), which starts at roughly 10°C and peaks in the afternoon at about 11.5°C.

The Wall insulation (S3) has a comparable pattern to that of S2, with morning temperatures hovering around 10°C and afternoon highs marginally above 12°C, signifying notable enhancements in insulation. While maintaining temperatures around 10°C throughout the day and peaking at roughly 12.5°C in the late afternoon, Scenario S4 (Glazing + Roof) exhibits better performance than previous scenarios, albeit with still higher peak temperatures. With a peak temperature of about 12.5°C, Scenario S5 (Glazing + Wall) exhibits a continuous drop in temperature, beginning at roughly 10°C and staying below 12°C until the afternoon. This suggests a notable improvement in temperature control.

Maintaining higher indoor temperatures is significantly improved in Scenario S6 (Roof + Wall), which starts at about 10°C and peaks at about 12.5°C in the afternoon. This scenario follows a similar trajectory to S5. Compared to the BC and other scenarios, Scenario S7 (All Scenarios) performs the best, with a peak temperature of approximately 13.5°C in the afternoon and a relatively stable temperature throughout the day. This represents the largest increase in temperature. In conclusion, scenarios S5, S6, and S7 show the most significant temperature increases for R1 in Gjirokaster on a normal winter day in February. Thermal comfort is improved in these conditions by a significant amount, especially during the coldest hours and indoor temperatures. All of the suggested modifications are included in Scenario S7, which regularly displays the greatest peak temperature and improved overall performance, demonstrating how successful it is at enhancing thermal performance in the winter.

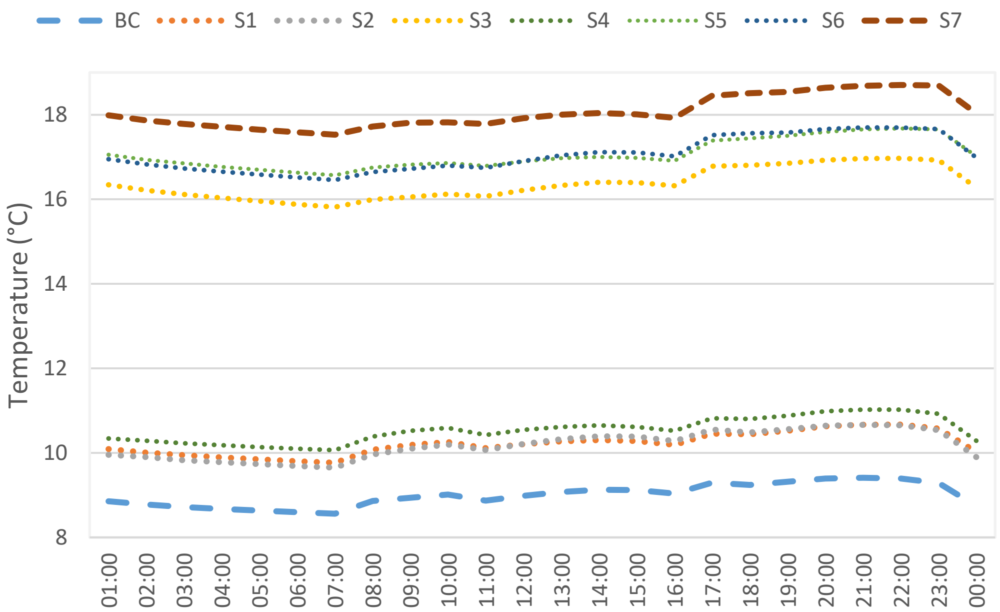


Figure 82. R1-Gjirokaster: Temperature improvement inside in a typical winter day

6.7.2 Thermal performance in R2 (Korce) during a typical day in summer and winter

Figure 83 represents the improvements in interior temperature performance, measured in degrees Celsius (°C), for Residence 2 (R2) in Korçë throughout the course of a normal summer day (24 hours) under different circumstances. The Base Case (BC) assumes that the indoor temperature is roughly 28.5°C at 1:00 AM, rises gradually during the morning, peaks at 3:00 PM and 4:00 PM, and then falls back to about 29°C by midnight. With temperatures beginning at roughly 28°C and peaking at roughly 30.5°C in the afternoon, Scenario S1 (Glass) exhibits a minor improvement over the BC in terms of lowering indoor temperatures.

When compared to S1, Scenario S2 (Roof) performs better, with a more noticeable improvement starting at about 28°C and peaking at about 30.3°C in the afternoon. With a peak temperature of about 30°C, Scenario S3 (Wall) exhibits a similar trend to S2, beginning at roughly 27.5°C and continuing to be lower throughout the day. This suggests that the insulation measures are effective. The lowest temperatures are maintained in the early hours of Scenario S4 (Glazing + Roof), peaking at about 27°C in the afternoon. Compared to previous situations, this one performs better, but it still raises the temperature during peak hours. With a high temperature of about 30.5°C, Scenario S5 (Glazing + Wall) exhibits a continuous drop in temperature, beginning at about 27.5°C and staying below 30°C until the afternoon. This suggests a notable improvement in temperature control. Similar to S5, Scenario S6 (Roof + Wall) starts at about 28°C and peaks at a little bit higher temperature in the afternoon at about 30.2°C. This scenario shows a significant improvement in keeping indoor temperatures lower. In comparison to the BC and other scenarios, Scenario S7 (All Scenarios) performs the best, starting at roughly 27.5°C and keeping very steady temperatures throughout the day, peaking at roughly 30.5°C in the afternoon. This represents the largest reduction in temperature.

In conclusion, scenarios S5, S6, and S7 show the most effective temperature improvements for R2 in Korçë on a normal summer day. These conditions result in much cooler interior temperatures, especially in the afternoon when people are most comfortable. All of the suggested modifications are included in Scenario S7, which consistently displays the lowest peak temperature and superior overall performance, demonstrating how successful it is at enhancing thermal performance in the summer.

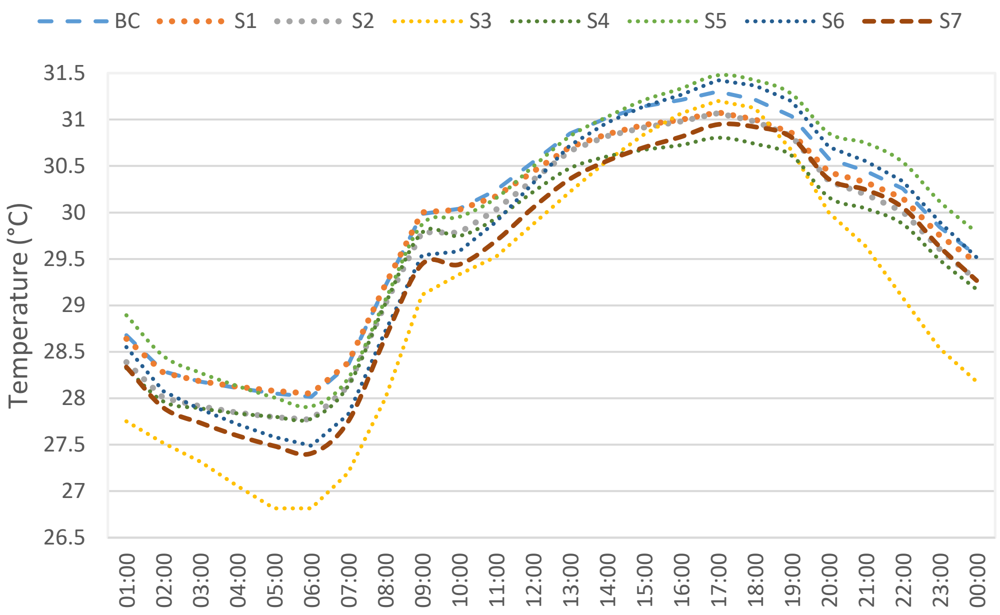


Figure 83. R2-Korce: Temperature improvement inside in a typical summer day

Figure 84 demonstrates the improvements in Residence 2's (R2) indoor temperature performance throughout a typical 24-hour winter day in February under different conditions. Under the Base Case (BC), the temperature inside the building begins at around 5.5°C at 1:00 AM, rises steadily during the morning, peaks at about 8.5°C between 3:00 PM and 4:00 PM, and then falls back to about 7°C by midnight. Temperatures in Scenario S1 (Glass) start at roughly 6°C and peak at roughly 9°C in the afternoon, which is a modest improvement over the BC. When compared to S1, Scenario S2 (Roof) performs better, with a more noticeable improvement starting at roughly 6°C and peaking at roughly 9°C in the afternoon. With a peak temperature of approximately 8°C, Scenario S3 (Wall) exhibits a similar trend to S2, beginning at roughly 5.5°C and continuing to be lower throughout the day. This suggests that the insulation measures are effective. While scenario S4 (G + R) performs better than previous scenarios, it still results in higher temperatures during peak hours. It maintains the lowest temperatures in the early hours, starting at roughly 5°C and peaking at roughly 7.5°C in the afternoon. With a peak temperature of about 8.5°C, Scenario S5 (G + W) exhibits a continuous drop in temperature, beginning at roughly 6°C and staying below 8°C until the afternoon. This suggests a notable improvement in temperature control. Similar to S5, Scenario S6 (R + W) starts at roughly 6°C and peaks at a little bit higher temperature in the afternoon at about 9°C. This case shows a significant improvement in keeping interior temperatures higher. In comparison to the BC and other scenarios, Scenario S7 performs the best, with a high temperature of roughly 9.5°C in the afternoon and a very steady temperature throughout the day. This represents the largest increase in temperature. In conclusion, scenarios S5, S6, and S7 show the most effective temperature improvements for R2 in Korçë on a normal winter day in February. Thermal comfort is improved in these conditions by a significant amount, especially during the coldest hours and indoor temperatures. All of the suggested modifications are included in Scenario S7, which regularly displays the greatest peak temperature and improved overall performance, demonstrating how successful it is at enhancing thermal performance in the winter.

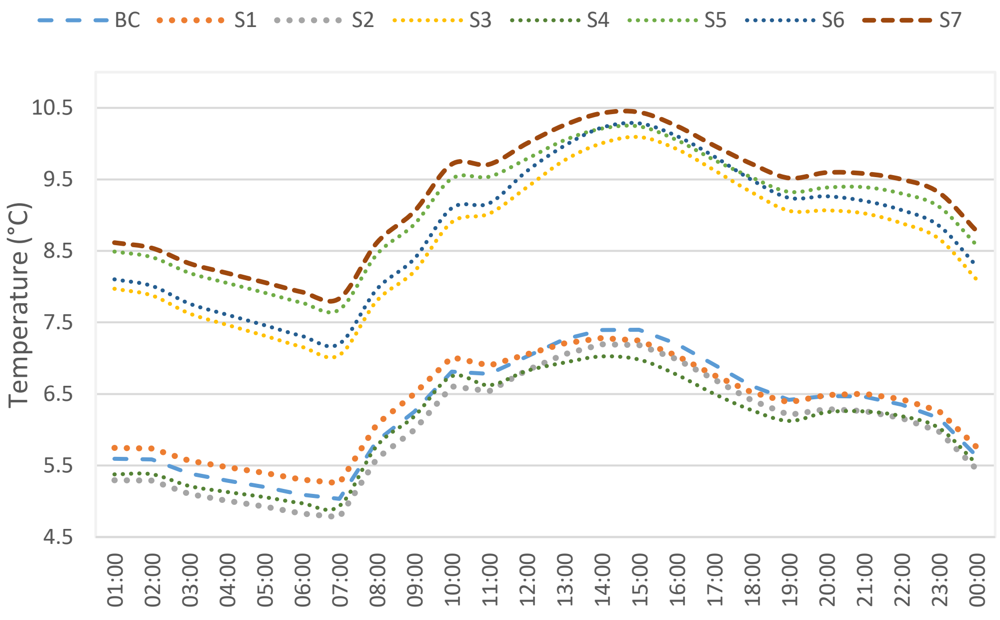


Figure 84. R2-Korce: Temperature improvement inside in a typical winter day

6.7.3 Thermal performance in R3 (Berat) during a typical day in summer and winter

The Residence 3 (R3) in Berat interior temperature performance improvements are shown in *Figure 85* with degrees Celsius (°C) for each scenario throughout the course of a normal summer day (24 hours). By 1:00 AM, the Base Case (BC) predicts that the indoor temperature will be roughly 29°C. It will then rise steadily over the morning, peaking at 31°C between 2:00 PM and 3:00 PM, and then fall down to nearly 29°C by midnight. With temperatures beginning at roughly 28.5°C and peaking at roughly 30.5°C in the afternoon, Scenario S1 (Glass) implies a marginal improvement in lowering indoor temperatures when compared to the BC. In comparison to scenario S1, Scenario S2 (Roof) performs better, peaking at roughly 30.5°C in the afternoon after beginning at about 28°C. S3 (Wall), which starts at about 27.5°C and maintains lower temperatures throughout the day, culminating at about 30°C, shows significant gains in insulation. This trend is comparable to that of S2. With a morning temperature of about 27°C and an afternoon temperature high of about 30°C, S4 (Glazing + Roof) maintains the lowest temperatures. While this scenario performs better than the others, it still raises the temperature during peak hours. The temperature control is significantly improved in Scenario S5 (G+W), as it continuously displays lower temperatures. It starts at about 27.5°C and stays below 30°C until the afternoon, with a high temperature of about 30.5°C. Scenario S6 (R+W) shows a significant improvement in maintaining temperature, beginning at roughly 28°C and rising somewhat higher at about 30.2°C in the afternoon. S6 (R+W) shows a significant improvement in maintaining lower interior temperatures, with a similar trend to S5, beginning at about 28°C and peaking somewhat higher at about 30.2°C in the afternoon. When compared to the BC and other scenarios, Scenario S7 (All Scenarios) performs the best, starting at roughly 27.5°C and keeping comparatively steady temperatures throughout the day, culminating at roughly 29.5°C in the afternoon. This represents the largest reduction in temperature.In conclusion, scenarios S5, S6, and S7 show the greatest temperature gains for R3 in Berat on a normal summer day. These conditions result in much cooler interior temperatures, especially in the afternoon when people are most comfortable. All of the suggested modifications are included in

Scenario S7, which consistently displays the lowest peak temperature and superior overall performance, demonstrating how successful it is at enhancing thermal performance in the summer.

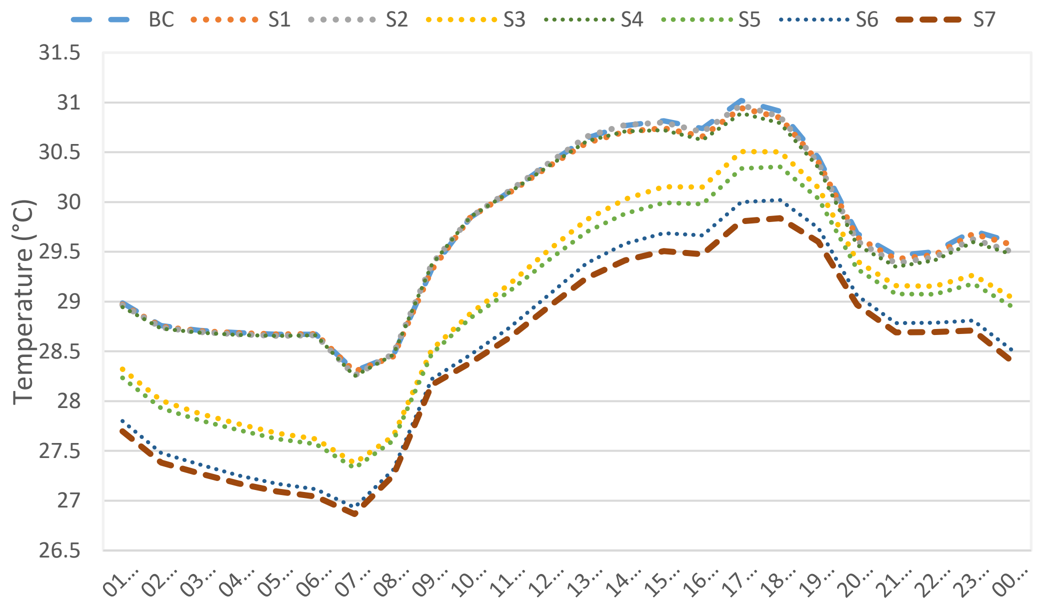


Figure 85. R3-Berat: Temperature improvement inside in a typical summer day

Measured in degrees Celsius (°C), *Figure 86* shows the gains in indoor temperature performance for Residence 3 (R3) in Berat throughout a typical winter day in February (24 hours) under different situations. The interior temperature in the Base Case (BC) begins at roughly 5.5°C at 1:00 AM, rises gradually over the morning, peaks at 7.5°C between 2:00 PM and 3:00 PM, and then falls back to roughly 6.5°C by midnight. Temperatures in Scenario S1 (Glass) begin at roughly 6°C and peak at about 8°C in the afternoon, suggesting a little improvement in maintaining higher indoor temperatures than in BC. Relative to S1, Scenario S2 (Roof) performs better, with a greater improvement starting at roughly 6°C and reaching a high in the afternoon at about 8°C. Following a similar pattern to S2, scenario S3 (Wall) begins at approximately 5°C and maintains lower temperatures throughout the day, reaching a peak at approximately 6.5°C, signifying significant increases in insulation. The lowest temperatures are sustained in the early hours of Scenario S4 (Glazing + Roof), with an afternoon peak of roughly 6.5°C and a morning start of about 5°C. While this scenario performs better than the others, it still raises the temperature during peak hours. With a high temperature of roughly 7°C in the afternoon and a continuous lower temperature starting around 5°C, Scenario S5 (Glazing + Wall) shows a notable improvement in temperature control. S6, shows a significant improvement in maintaining higher indoor temperatures, beginning at about 5.5°C and peaking at about 7.5°C in the afternoon. This scenario's trajectory is comparable to that of S5. When compared to the BC and other situations, Scenario S7 (All situations) performs the best, starting at roughly 6°C and keeping very consistent temperatures throughout the day, culminating at almost 8.5°C in the afternoon, demonstrating the most notable increase. In summary, scenarios S5, S6, and S7 show the most effective temperature improvements for R3 in Berat on a normal winter day in February. Thermal comfort is improved in these conditions by a significant amount, especially during the coldest hours and indoor temperatures. All of the suggested modifications are included in Scenario S7, which regularly displays the greatest peak temperature and improved overall performance, demonstrating how successful it is at enhancing thermal performance in the winter.

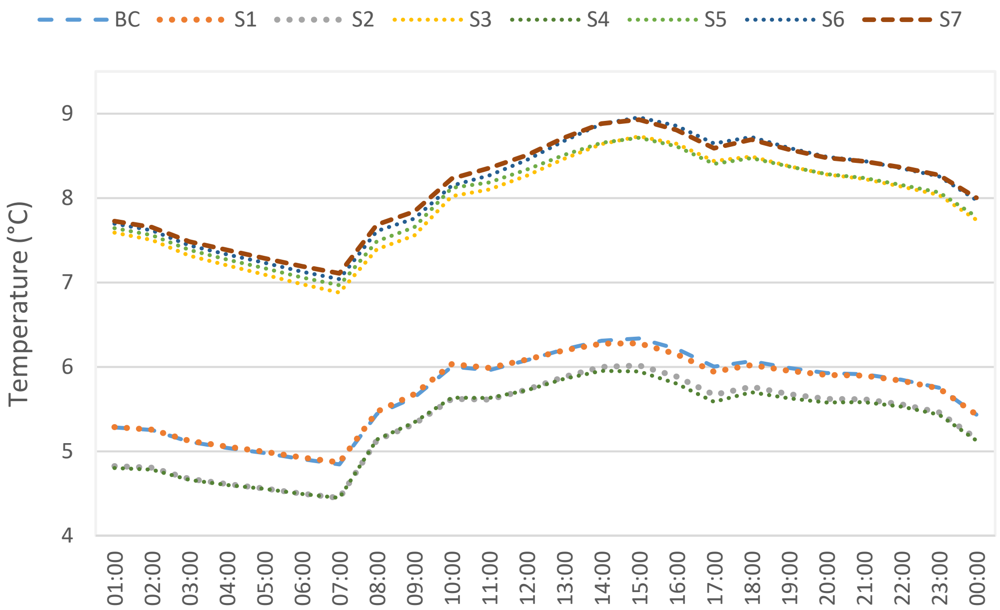


Figure 86. R3-Berat: Temperature improvement inside in a typical winter day

6.7.4 Thermal performance comparison during a typical summer day

On a typical summer day (24 hours), the thermal performance of three houses (R1, R2, and R3) is compared across several situations in Figure 87 where the temperature is expressed in degrees Celsius (°C). At roughly 29.7°C, R2 has the highest baseline temperature in the Base Case (BC), followed by R3 at 29.5°C and R1 at 28.7°C. All residences in S1 (Glass) exhibit marginal improvements, with R1 dropping to 28.5°C, R2 to 29.5°C, and R3 to 29.4°C. With R1 at 28.2°C, R2 at 29.2°C, and R3 exhibiting a significant dip to 28.7°C, Scenario S2 (Roof) results in even more decreases. The results of scenario S3 show notable improvements, particularly for R1, which falls to 27.9°C, and R3, which falls to 28.0°C, while R2 falls to 29.0°C. The temperatures for R1 and R2 in Scenario S4 (Glazing + Roof) rise somewhat to 28.4°C and 29.5°C, respectively, while R3's temperature stays steady at 28.2°C. The greatest reduction is seen in Scenario S5 (Glazing + Wall), when R1 falls to 27.8°C. R2 unexpectedly rises to 29.8°C, and R3 falls even more to 28.3°C. R1 drops even lower to 27.6°C in Scenario S6 (Roof + Wall), R2 rises somewhat to 29.6°C, and R3 rises to 28.4°C.

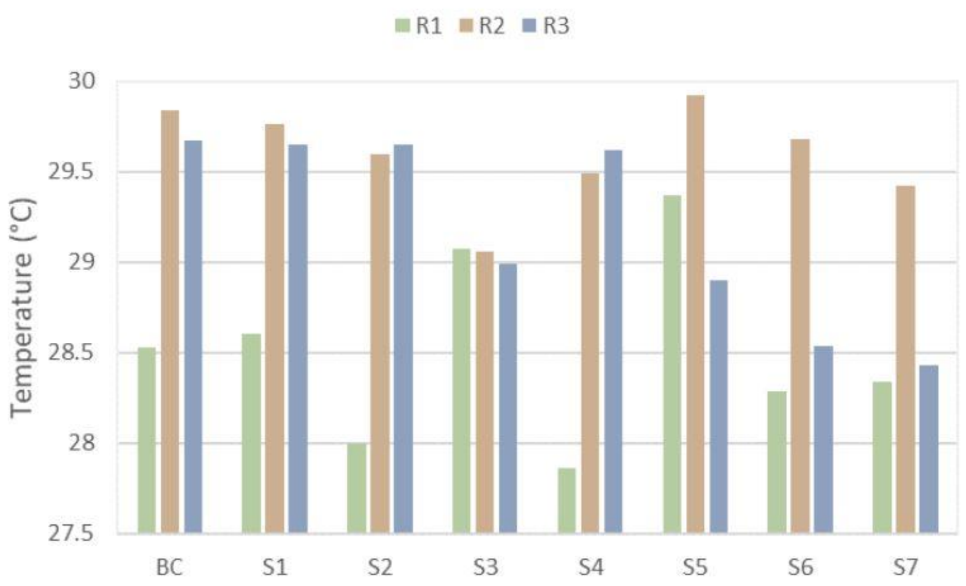


Figure 87. Thermal performance comparison in a typical summer day (24h)

All dwellings exhibit improvements in the final Scenario S7 (All Scenarios), with R1 performing best at 27.5°C, R2 improving to 29.2°C, and R3 reaching 28.2°C. All things considered, R1 shows the most consistent and notable increases in thermal performance across all conditions, especially in S7, suggesting that the enhancement steps are working. R3 exhibits consistent gains, particularly in S3, S5, and S7 scenarios. R2, on the other hand, shows inconsistent improvements and erratic results, indicating that certain interventions might not be as successful for this home.

6.7.5 Thermal performance comparison during a typical winter day

Measured in degrees Celsius (°C), *Figure 88* compares the thermal performance of three houses (R1, R2, and R3) during the course of a typical winter day (24 hours) over multiple scenarios (BC, S1, S2, S3, S4, S5, S6, and S7). Every residence in the Base Case (BC) begins at a baseline temperature of roughly 5.5°C to 6°C. Scenario S1 indicates that R2 and R3 both marginally improve to roughly 8°C, while R1 marginally rises to 6°C. In Scenario S2, R1 reaches 8°C, R2 and R3 reach 10°C, and all households continue to improve. In scenario S3, R1 rises sharply to 16°C, R2 falls to 7°C, and R3 rises somewhat to 6.5°C. In Scenario S4, R2 and R3 both reach 10°C, whereas R1 stays at 16°C. R1 stays at 16°C in Scenario S4, whereas R2 and R3 both rise to 10°C. R1 continues to function well at 16°C in scenarios S5 and S6, but R2 and R3 perform poorly at 8°C and 9°C, respectively. With R1 at 16°C and R2 and R3 at 9°C, Scenario S7 maintains this pattern. All things considered, R1 shows the biggest gains, especially in S3, S5, S6, and S7, showing very successful thermal enhancements; R2 and R3 exhibit consistent but smaller improvements, demonstrating different degrees of thermal performance enhancements throughout the dwellings.

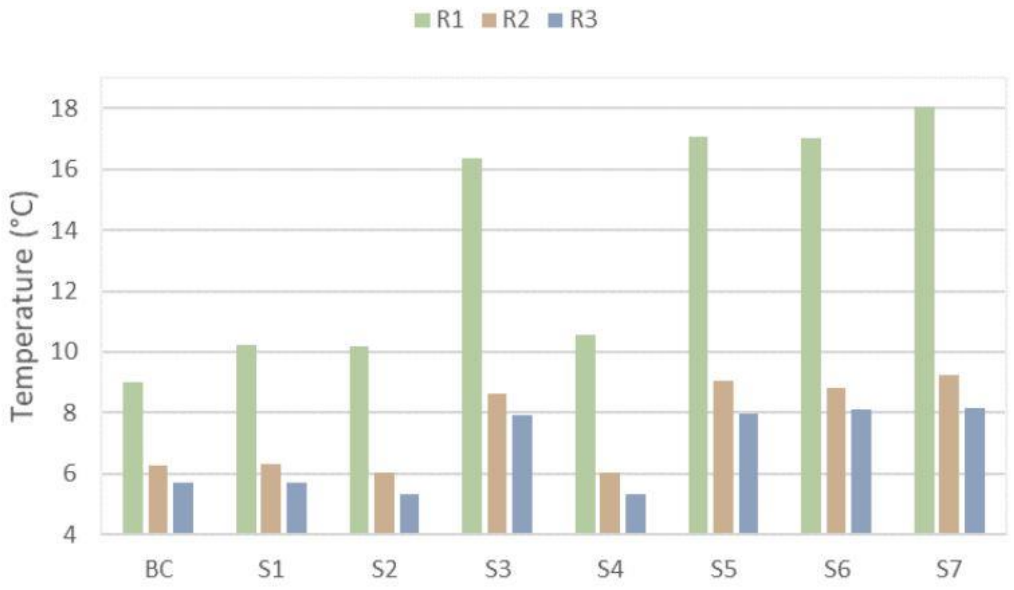


Figure 88. Thermal performance comparison in a typical winter day (24h)

6.7.6 Thermal performance: overheating

The hourly interior operating temperature of three chosen residences is predicted using August 5th as a reference day in order to assess the consequent thermal comfort conditions throughout the dry season. Each scenario was analyzed using the hourly mean over-heating (OHm) for comparison reasons (see Eq. (1)).

$$OHm = \sum_{j=1}^{n} \frac{(\theta ij - \theta r)}{n} \ m$$

The variable θ i is the average interior temperature (◦C) at hour, j is the average temperature across all simulated zones in the house, θ r is the reference indoor temperature for overheating (◦C), and n is the total number of hours that the home is inhabited. For those hours where δ i,j > δ r, the phrase θ i,j − δ r was taken into consideration. The value is 0 if there are no positive temperature differences to be considered.

The overheating tables provide the recorded minimum and maximum temperatures as well as the overheating degree hours (Ohm) for the three residences (R1, R2, and R3) under various circumstances (BC, S1, S2, S3, S4, S5, S6, and S7). They also examine the thermal performance and overheating for the dwellings. With an Ohm of 3.53, the Base Case (BC) for Residence 1 (R1) as illustrated in *Table 12* indicates a minimum temperature of 27.77°C and a maximum temperature of 29.49°C. Scenario S4 has the best performance, with an Ohm of 2.86, suggesting that the most effective way to reduce overheating is to combine changes to the roof with glass. Scenarios S2 (Ohm 3.00) and S6 (Ohm 3.29) exhibit noteworthy enhancements as well.

T [◦C]	***Min***	***Max***	***Ohm***
BC	27.77	29.49	**3.53**
S1	27.86	29.55	**3.61**
S2	27.15	29.00	**3.00**
S3	28.27	30.30	**4.07**
S4	27.09	28.80	**2.86**
S5	28.67	30.48	**4.37**
S6	27.46	29.55	**3.29**
S7	27.60	29.51	**3.34**

Table 12. R1-Thermal overheating performance comparison on 5 August

For Residence 2 (R2) as illustrated in *Table 13* the BC shows a minimum of 28.01°C, a maximum of 31.30°C, and an Ohm of 4.84. Scenario S3 offers the best reduction in overheating with an Ohm of 4.06, suggesting that wall improvements alone significantly impact overheating reduction. Scenarios S7 (Ohm 4.42) and S2 (Ohm 4.60) also provide substantial improvements.

T [◦C]	***Min***	***Max***	***Ohm***
BC	28.01	31.30	**4.84**
S1	28.05	31.08	**4.76**
S2	27.76	31.07	**4.60**
S3	26.81	31.20	**4.06**
S4	27.78	30.80	**4.49**
S5	27.91	31.48	**4.92**

S6	27.48	31.42	**4.68**
S7	27.40	30.95	**4.42**

Table 13. R2-Thermal overheating performance comparison on 5 August

The BC records a minimum temperature of 28.30°C as shown in *Table 14*, a high temperature of 31.02°C, and an Ohm of 4.67 in Residence 3 (R3). With an Ohm of 3.43, Scenario S7—which combines all of the improvements—achieves the best result, demonstrating the value of all-encompassing measures. Furthermore, compared to the base case, scenarios S5 (Ohm 3.90) and S6 (Ohm 3.54) exhibit notable gains.

T [◦C]	***Min***	***Max***	***Oh_m***
BC	28.30	31.02	**4.67**
S1	28.29	30.94	**4.65**
S2	28.25	30.97	**4.65**
S3	27.37	30.51	**3.99**
S4	28.25	30.89	**4.62**
S5	27.32	30.35	**3.90**
S6	26.93	30.02	**3.54**
S7	26.86	29.84	**3.43**

Table 14. R3-Thermal overheating performance comparison on 5 August

To summarize, the optimal way to reduce overheating for all houses is to combine numerous improvement methods (Scenario S7). Out of these, R1, R2, and R3 demonstrate notable gains in lowering the overheating degree hours. Singular actions, such as wall upgrades (Scenario S3), also work well, especially for R2 and R3. This analysis highlights the different degrees of thermal performance improvements that may be achieved for each of the three homes, with complete measures consistently yielding the greatest benefits.

CHAPTER 7

CONCLUSIONS

7.1 Gjirokastra (R1) Heating & Cooling loads Analysis

From January to March, the heating loads in Gjirokastra show a distinct pattern of reduction across the various scenarios compared to the Baseline Case (BC). In January, the BC starts with a heating load of approximately 4.5 kWh/m², which slightly decreases in February before dropping to around 3.5 kWh/m² in March. Across scenarios SC1 to SC7, there is a consistent trend of decreasing heating loads. This reduction becomes particularly significant in scenarios SC4 and beyond, with SC7 exhibiting the lowest heating load values. By March, SC7's heating load is approximately 1.5 kWh/m², indicating substantial energy savings.

From April to May, the heating loads are generally minimal. In April, the BC shows low heating loads that nearly drop to zero by May. The scenarios from SC1 to SC7 follow a similar trend but demonstrate even lower values, approaching zero more rapidly, especially from SC3 onwards. This suggests enhanced efficiency or improved insulation in these scenarios.

In the period from October to December, the heating loads start to increase again. In the BC, the heating load rises to around 2 kWh/m² in October, continuing to climb and reaching approximately 4.5 kWh/m² in December. However, in scenarios SC1 to SC7, there is a notable decrease in heating loads. The reduction is particularly evident in scenarios SC5 through SC7, with SC7 showing a significant reduction to about 2 kWh/m² in December. This indicates that the energy-saving measures or improvements in these scenarios are quite effective in reducing heating demands during the colder months.

The cooling simulation results provide a detailed view of the cooling load requirements throughout the year from the Base Case (BC) to Scenario 7 (SC7). By analyzing the values, we can observe the following trends and changes:

- The cooling loads in Gjirokastra are significantly higher during the summer months, with peaks occurring in July and August.
- In July, the cooling load for BC is approximately 2.0 kwh/m². This value increases across scenarios, reaching around 2.7 kwh/m² in SC4 and SC5. This represents a 35% increase from the Base Case.
- In August, the cooling load follows a similar pattern, with BC at about 2.1 kwh/m², and the peak values in SC4 and SC5 at approximately 2.8 kwh/m², marking an approximate 33% increase.
- The Base Case (BC) consistently shows the lowest cooling loads, highlighting baseline conditions with fewer external influences.
- From BC to SC4 and SC5, there is a noticeable increase in cooling loads, with July's load increasing by 35% and August's by 33%.
- SC6 and SC7 show a slight reduction in cooling loads compared to SC4 and SC5, with July’s cooling load at about 2.5 kwh/m² and August’s at around 2.6 kwh/m², indicating a 7-8% decrease from the peak values in SC4 and SC5.
- The cooling load requirements drop significantly from September onwards, with values dropping from around 1.5 kwh/m² in September to negligible values from November to April.
- The cooling load in May is approximately 0.5 kwh/m² for BC, increasing to about 0.7 kwh/m² in SC4 and SC5, indicating a 40% increase.

7.2 Korca (R2) Heating & Cooling loads Analysis

In Korça, from January to March, the heating loads are substantially higher compared to Gjirokastra. The BC starts at around 16 kWh/m² in January, slightly decreases in February, and drops to approximately 12 kWh/m² in March. Across scenarios SC1 to SC7, there is a consistent reduction in heating loads. The reductions become particularly significant in scenarios SC4 and beyond, with SC7 showing a decrease to around 6 kWh/m² by March. This substantial reduction indicates that the energy-saving measures or insulation improvements are highly effective in Korça, where the initial heating loads are higher.

From April to May, the heating loads in Korça follow a similar trend to those in Gjirokastra, with minimal values that drop to nearly zero by May. The scenarios from SC1 to SC7 show even more rapid reductions, with scenarios SC3 to SC7 approaching zero faster than the BC. This suggests that the energy efficiency measures in these scenarios are effectively minimizing heating requirements during these months.

From October to December, the heating loads begin to rise again in Korça. In the BC, the heating load reaches around 8 kWh/m² in October and increases to about 16 kWh/m² in December. However, across scenarios SC1 to SC7, there is a notable reduction in heating loads. This reduction becomes more pronounced in scenarios SC5 through SC7, with SC7 showing a significant decrease to about 8 kWh/m² in December. This indicates that the energy-saving measures or insulation improvements in these scenarios are effective in significantly reducing heating demands during the peak heating months.

The cooling simulation results present the cooling load data for Korce from BC to SC7, with patterns similar to those in Gjirokastra but with some differences in magnitude:

- The cooling loads in Korce also peak in July and August.
- In July, the BC cooling load is around 2.1 kwh/m², increasing to about 2.8 kwh/m² in SC4 and SC5, showing an approximate 33% increase.
- For August, the cooling load is about 2.0 kwh/m² in BC, rising to around 2.7 kwh/m² in SC4 and SC5, indicating a 35% increase.
- The Base Case (BC) shows the lowest cooling loads, reflecting minimal external stressors.
- From BC to SC4 and SC5, July's cooling load increases by approximately 33%, and August's by 35%.
- SC6 and SC7 show a slight reduction in cooling loads compared to SC4 and SC5, with values for July around 2.6 kwh/m² and for August around 2.5 kwh/m², representing a 7-9% decrease from the peak values.

- Similar to Gjirokastra, cooling load requirements in Korce drop significantly after September, with values reducing from about 1.5 kwh/m² in September to negligible levels from November to April.
- The cooling load in May is approximately 0.5 kwh/m² for BC, rising to about 0.8 kwh/m² in SC4 and SC5, showing a 60% increase.

In conclusion, the analysis of heating loads for both Gjirokastra and Korça reveals a clear trend of decreasing heating demands from BC to SC7 across all months, with more significant reductions observed during the colder months (January to March and November to December). In Gjirokastra, the heating loads are lower compared to Korça, but the trend of reduction across scenarios is consistent. Starting from SC4, there is a noticeable drop in heating loads, with SC7 achieving the most substantial reductions, indicating effective energy-saving measures or improved insulation.

In Korça, the initial heating loads are higher, but the reductions from BC to SC7 are also evident across all months, particularly during the colder periods. The scenarios from SC1 to SC7 demonstrate progressive improvements in reducing heating loads, with SC7 providing the most significant energy savings. This suggests that similar energy-saving measures or insulation improvements are effective in both cities, despite the higher initial heating loads in Korça.

Overall, the scenarios indicate that the measures implemented in SC1 to SC7 are effective in mitigating heating demands, particularly during the peak heating months. SC7, in particular, shows the greatest energy savings, highlighting the potential for substantial improvements in energy efficiency and heating load reductions in both Gjirokastra and Korça. The comparative analysis of cooling loads in Gjirokastra and Korce reveals similar trends in both locations, with peak cooling demands during the summer months and minimal requirements during the winter. Key observations include:

- Base Case (BC): Both Gjirokastra and Korce have the lowest cooling loads in the BC scenario, indicating fewer external influences on energy demands.

- Peak Loads: The highest cooling loads are observed in Scenarios 4 (SC4) and 5 (SC5) in both locations, with increases of approximately 33-35% compared to BC.

- Slight Reductions in SC6 and SC7: Both regions show a slight decrease in cooling loads in SC6 and SC7 compared to SC4 and SC5, indicating possible mitigation or efficiency improvements.

- Seasonal Trends: Cooling loads are significantly higher from June to September, peaking in July and August, and dropping to minimal levels from November to April.

This analysis underscores the critical need for effective energy planning and cooling strategies during the peak summer months. It also highlights the potential benefits of mitigation measures or efficiency improvements in reducing future cooling demands. Effective management of these energy requirements is essential for both Gjirokastra and Korce to ensure sustainable energy use and mitigate the impacts of increasing cooling loads.

7.3 Berat (R3) Heating & Cooling loads Analysis

From January to March, the heating loads in Berat show a distinct pattern of reduction across the various scenarios compared to the Baseline Case (BC). In January, the BC starts with a heating load of approximately 5 kWh/m², which slightly decreases in February before dropping to around 4 kWh/m² in March. Across scenarios S1 to S7, there is a consistent trend of decreasing heating loads. This reduction becomes particularly significant in scenarios S3 and beyond, with S7 exhibiting the lowest heating load values. By March, S7's heating load is approximately 2 kWh/m², indicating substantial energy savings.

From April to May, the heating loads are generally minimal. In April, the BC shows low heating loads that nearly drop to zero by May. The scenarios from S1 to S7 follow a similar trend but demonstrate even lower values, approaching zero more rapidly, especially from S3 onwards. This suggests enhanced efficiency or improved insulation in these scenarios.

In the period from October to December, the heating loads start to increase again. In the BC, the heating load rises to around 2 kWh/m² in October, continuing to climb and reaching approximately 4 kWh/m² in December. However, in scenarios S1 to S7, there is a notable decrease in heating loads. The reduction is particularly evident in scenarios S5 through S7, with S7 showing a significant reduction to about 2 kWh/m² in December. This indicates that the energy-saving measures or improvements in these scenarios are quite effective in reducing heating demands during the colder months.

The cooling simulation results provide a detailed view of the cooling load requirements throughout the year from the Base Case (BC) to Scenario 7 (S7). By analyzing the values, we can observe the following trends and changes:

- The cooling loads in Berat are significantly higher during the summer months, with peaks occurring in July and August.
- In July, the cooling load for BC is approximately 3 kWh/m². This value increases across scenarios, reaching around 4 kWh/m² in S4 and S5. This represents a 33% increase from the Base Case.
- In August, the cooling load follows a similar pattern, with BC at about 3 kWh/m², and the peak values in S4 and S5 at approximately 4.2 kWh/m², marking an approximate 40% increase.
- The Base Case (BC) consistently shows the lowest cooling loads, highlighting baseline conditions with fewer external influences.
- From BC to S4 and S5, there is a noticeable increase in cooling loads, with July's load increasing by 33% and August's by 40%.

- S6 and S7 show a slight reduction in cooling loads compared to S4 and S5, with July's cooling load at about 3.5 kWh/m² and August's at around 3.6 kWh/m², indicating a 10-15% decrease from the peak values in S4 and S5.

- The cooling load requirements drop significantly from September onwards, with values dropping from around 2 kWh/m² in September to negligible values from November to April.

Overall, the best improvements in reducing energy consumption are observed in scenario S7 across all periods, indicating that a comprehensive approach incorporating multiple energy-saving measures is the most effective in enhancing energy efficiency for both heating and cooling demands in Berat.

7.4 Recomandations for future research

Future research should focus on identifying and analyzing the specific factors that contribute to the significant increase in cooling loads observed in Scenarios 4 and 5. Detailed studies on the impacts of climate change, urbanization, and population growth on energy demands will be crucial. Additionally, research should explore advanced cooling technologies and sustainable building practices that can effectively mitigate these increased loads. Comparative studies between different regions, incorporating local climatic conditions and socioeconomic factors, will provide valuable insights. It is also essential to investigate the long-term effects of implementing energy efficiency measures observed in Scenarios 6 and 7, to understand their sustainability and scalability. Future research should integrate a thorough cost-benefit analysis to evaluate the economic feasibility of the thermal performance improvements identified in this study. By assessing the financial implications and long-term benefits, stakeholders can make informed decisions about the most effective and sustainable strategies for enhancing building energy efficiency. This approach ensures that the investments are justified and contribute to both economic and environmental sustainability.

REFERENCES

Stefanizzi, Pietro, Fato, Ida, and Di Turi, Silvia. . (2016). "Energy and Environmental Performance of Trullo Stone Building. An Experimental and Numerical Survey." . *International Journal of Heat and Technology, 34 (Special Issue 2)*.

A. Alsalemi, C. Sardianos, F. Bensaali, I. Varlamis, A. Amira and G. Dimitrakopoulos. . (2019). The Role of Micro-Moments: A Survey of Habitual Behavior Change and Recommender Systems for Energy Saving. . *IEEE Systems Journal*, 3376-3387.

Abdel Hadi, M. (2013). Possibility of developing Eco-Friendly residential buildings in the Palestinian cities—A case study from Jenin and Rammallah cities. .

Abel C. (1980). Architecture as Identity,: The essence of architecture. *Semiotics*.

Akbari, H. K. (2016). "Three decades of urban heat islands and mitigation technologies research." . *Energy and Buildings 133*.

Albania., M. o. (n.d.). "The Cultural Heritage of Korçë".

Aliaj, B. (2003). "The Vernacular Architecture of Southern Albania: A Study of Traditional Building Forms and Materials".

Ascione, F., Beccali, M., Cellura, M., & Mistretta, M. (2011). Energy M. (2011). Energy and environmental benefits in public buildings as a result of retrofit actions. *Renewable and Sustainable Energy Reviews, V 15, .*, 460-470.

British., P. (2013). BP Statistical Review of World Energy. London: British Petroleum.

Bronner, S. (2006). Control and authority in vernacular architecture," in Vernacular Architecture in the Twenty-First Century:Theory, Education and Practice. *Building Tradition:*. New York.

Brunskill, R. W. (1981). Traditional Buildings of Britain. In *Introduction to Vernacular Architecture.* London: Orion Publishing Group.

Buchanan, W. (1985). Labour Intensive and Small Scale Brickmaking. . *UNIDO*.

Climate-Data. (2024). Retrieved from https://en.climate-data.org/

Cromley, E. (2008.). Cultural embeddedness in vernacular architecture. *Building Research & Information*.

Çuka, N., & Gjeta, Z. (2017). *"Traditional House of Korçë and Its Typological Development".*

Curl JS. (2006). *A Dictionary of Architecture and Landscape Architecture, Oxford University.* Oxford: Press, Oxford.

Delia D'Agostino, Danny Parker, Paco Melià. . (2019). Environmental and economic implications of energy efficiency in new residential buildings: A multi-criteria selection approach. . *Energy Strategy Reviews.* .

Development, U. D. (2015). *"Sustainable Construction in Indian Country,"*. Retrieved from https://www.huduser.gov/publications/pdf/na_constr_FAQ.pdf

Elham Delzendeh, Song Wu, Angela Lee, Ying Zhou. . (2017). The impact of occupants' behaviours on building energy analysis: A research review. *Renewable and Sustainable Energy Reviews*.

Energy., U. D. (2020). *EnergyPlus | EnergyPlus. US Department of Energy's.* . Retrieved from https://energyplus.net/

European Parliament, D. 2. (2012). The European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. *Official Journal of the European Union.*

EuropeanCommission. (2008). *Proposal for a recast of the energy performance of buildings. Brussels: EuropeanCommission.*

F.Torresi. (2001). Gjirokastra analisi ed indirizzi per lo sviluppo.

Farmer, B. (1993). "Needs and means, ". *Companion to Contemporary*, pp. 21-28.

Fathy H. (Chicago). *Architecture for the Poor, University of Chicago Press,.* 1976.

Fathy, H. (1976). Architecture for the Poor: An Experiment in Rural Egypt . Chicago: University of Chicago Press, .

Fernandes, J.; Dabaieh, M.; Mateus, R.; Bragança, L. (2014). The influence of the Mediterranean climate on vernacular architecture: a comparative analysis between the vernacular responsive architecture of southern Portugal and north of Egypt. . *In Proceedings of the World Sustainable buildings SB14*.

Galán-Marín, C.; López-Cabeza, V.P.; Rivera-Gómez, C.; Rojas-Fernández, J.M. (2018). On the Influence of Shade in Improving Thermal Comfort in Courtyards. Seville, Spain.

García-Esparza, J. (2015). "Epistemological paradigms in the perception and assessment of vernacular architecture.". *International Journal of Heritage Studies no. 21*, 869-888.

Gjirokastër, Albania. (2020). Retrieved from Encyclopedia Britannica: https://www.britannica.com/place/Gjirokaster

Haddad, H. (2010). A Framework of Sustainable Design for the Region of Palestine; The Pennsylvania State University: State College,.

Heath, K. W. (1988). "Defining the Nature of Vernacular.". In *Material Culture no. 20* (pp. 1-8).

Heritage, U. W. (2005). *"Gjirokaster: A World Heritage City."*.

Hidayatun M. I., Prijotomo J, Rachmawati M. (2015). *Sustainability is important part of the identity in the dimension of regionalism architecture. Applied Mechanics and Materials.*

Hodder, I. (1998). *Çatalhöyük, Anatolian Archaeology.*

Hoxha, A. (2019). "Neoclassical Influences in the Architecture of Korçë".

Hussein, M.H.; Barlet, A.; Semidor, C. . (2010). Socio-Environmental Dimensions of Private Outdoor Spaces in Contemporary Palestinian Housing. *Open House*, 35, 67–76.

Ijla, A.; Broström, T. (2015). The sustainable viability of adaptive reuse of historic buildings: The experiences of two world heritage old cities; Bethlehem in Palestine and Visby in Sweden. 52–66.

Ionescu, C., Baracu, T., Vlad, G. E. Horia, N. & Badea, A. . . (2015). The buildings. historicalevolutionoftheenergyefficient RenewableandSustainableEnergyReviews,. 243-253.

Itma, M. (2014). High-density housing in Palestine: learning from traditional typologies. . *The Sustain. City IX* , 191, 87–95.

Jacques, E. (1995). The Albanians: An Ethnic History from Prehistoric Times to the Present. *McFarland & Company, Inc.*

Jina, P. S. (1996). *the Land and the People*. Srinagar: Indus Publishing.

Lamprakos, M. (2010:). Conservation of Gjirokastra, Albania. *Onsite Review Report*.

Laustsen, L. (2008). EnergyEfficiency Requirements in Building Codes. . *IEA Information Paper*.

Levinson, Ronnen, Akbari, Hashem, Reilly, Joseph C. . (2007). "Cooler tile-roofed buildings with near-infrared-reflective non-white coatings." . *Building and Environment*.

Lika, A., & Sulçe, S. . (2019). "Climatic Conditions and Their Influence on Agriculture in Albania.". *International Journal of Environmental and Agriculture Research*, 12-20.

Ltd., D. S. (2020). *DesignBuilder*. Retrieved from https://designbuilder.co.uk/software/product-overview

Mahabir Bhandari, Som S Shrestha, Joshua Ryan New. (2012). Evaluation of weather datasets for building energy simulation. *Energy and Buildings 49,*, 109-118.

Mahapatra, K., Alm, R., Hallgren,. . (2018). A behavioral change-based approach to energy efficiency in a manufacturing plant. . *Energy Efficiency 11*. .

Mahmoudi, M., & Mofidi, M.,. (2008). "Analysis of typology architecture of Yazd Wind-catcher and finding functional optimal such ". *Fine Arts Journal, 36* .

Marku, S., & Tashko, A. . (2018). "Assessment of Climatic Conditions in the Albanian Alps." . *Journal of Mountain Science*, 567-579.

Matthew Kuperus Heun, Paul E. Brockway. . (2019). Meeting 2030 primary energy and economic growth goals: Mission impossible? . *Applied Energy*. .

McLennan J. F. (2006). *The Philosophy of Sustainable Design*. Kansas City: MO EcoTone.

Meier, I.A.; Roaf, S.C.; Gileard, I.; Runsheng, T.; Stavi, I.; Mackenzie-Bennett, J. (2004). The vernacular and the Environment towards a comprehensive Research methodology. *In Proceedings of the 21th Conference on Passive and Low Energy Architecture, Eindhoven*, 719–724.

Meksi, A., Baçe, A., Riza, E., Karaiskaj, G., & Thomo, P. . (1979). History of Architecture in Albania.

Mercer, E. (1997). The Unfulfilled Wider Implications of Vernacular Architecture Studies. *Vernacular Architecture no. 28* . doi:10.1179/030554797786050437.

Mirela Kamberi, Besim Islami, Eglantina Bruci. (2021). *Albania's First Biennial. Raporti i pare dyvjecar I perditesuar per Shqiperine.* Tirane.

Mongiu, A. (2004). Centro Italiano Femminile. .

Nash, G. (2009). Stewartby Brickworks, Bedfordshire Monitoring Programme for two Hoffman Kiln Buildings . .

Navapalos, C. (1994). Centro Demonstrativo para el Desarrollo Rural Sostenible. .

Noble, A. G. (2007). Traditional Buildings: A Global Survey of Structural Forms and Cultural Functions. London and New York:: I.B. Tauris & Co.

Norberg-Schulz C. (1996). *Semiotics Architecture as Identity, I: The Essence of Architecture.* New York: Rizzoli.

Olgyay, V. (1963). Design with climate. Princenton University Press.

Oliver P. (2003). Dwellings: The vernacular house worldwide.

Oliver, P. (1997). Encyclopaedia of Vernacular Architecture of the World. (pp. 21-28). Cambridge: Cambridge University Press.

Oliver, P. (1998). Encyclopedia of vernacular architecture of the world. *Cultures and habitats. Vol. 2,*. Cambridge: Cambridge University Press.

Oliver, P. (2000). Built to Meet Needs: Cultural Issues in Vernacular Architecture. London.

Orsini, B. & Baduel, C. . (1802). Dell'Architettura. Perugia, Libro VI,. La Casa di Hatra . .

Osama Nasir, Mohammad Arif Kamal. (2021). Vernacular Architecture as a Design Paradigm for Sustainability and Identity: The Case of Ladakh, India. *American Journal of Civil Engineering and Architecture.* , 219-231.

Oxford dictionaries, I. M. (2017). *Retrieved from oxford dictionaries*. Retrieved from https://dictionary.cambridge.org/dictionary/english/identity

Pashako, F. (2012). Knowing in order to preserve and enhance historical architectures: the case study of Berat. *Ist International Conference on Architecture & Urban Design, Proceedings 19-21,* 355-362.

Philokyprou, M. (2011). "Teaching Conservation and Vernacular Architecture.". *Journal of Architectural Conservation no. 17,* 7-24. doi: 10.1080/13556207.2011.10785086.

Rais A., K. W. (2019). “Jammu and Kashmir, State, India”. In *Encyclopædia Britannica.*

Rapoport, A. (1972). *Pour une anthropologie de la maison.* Paris: Dunod.

Riza, E. (1984). Nje shembull i zhvilluar i baneses Gjirokastrite. *Monumentet*.

Riza, E. (2006). Fondacioni kulturor "Saadi Shirazi". 78.

Riza, E. (2009). Gjirokastra: The City of Stone. *Context of Albanian Heritage Foundation's initiatives.*

Riza, E. (2014). *"Albanian Traditional Architecture: A Typological Overview".*

Robert, E. (2017). "The Albanian Tower House: A Forgotten Landmark of Domestic Architecture." . *The Architectural Review*.

Roberts, J. (1996). "Researching the vernacular garden.". In *Landscape Research no. 21* (pp. 175-187).

Rudofsky, B. (1964). A short introduction to non-pedigreed architecture. New York: Doubleday & Co. Inc., .

Sagbaş, A. ve Başbuğ, B., Sürdürülebilir Kalkınma. . (2018). Ekseninde Enerji Verimliliği Uygulamaları: Türkiye Değerlendirmesi,. . *European Journal of Engineering and Applied Sciences.* .

Sahin, C., Arsan, Z., Tuncoku, S., Broström, t., & Akkurt, G. . (2015). transdisciplinary approach on the energy-efficient retrofitting of a historic building in the Aegean Region of Turkey. *Energy and Buildings, 96,* , 128-139.

Salman A. Z., M. (2007). *The sustainability potential of traditional architecture in the Arab World.* Huddersfield.

Spence, R.J.S. & Cook, D.J. . . (1983). Building Materials in Developing Countries.

TimeandDate. (2024). Retrieved from https://www.timeanddate.com/

Tota, P., & Bajraktari, F. . (2020). "Climate Change and Its Impact on Tourism in Albania." . *Albanian Journal of Agricultural Sciences*, 245-254.

Turan, M. (1990). *Vernacular architecture: paradigms of environmental response.* Avebury.

Tzikopoulos, Argiris, Karatza, M. C., and Paravantis, John. . (2005). "Modeling energy efficiency of bioclimatic buildings." . *Energy and Buildings,*.

Upton, D. (1985). Common Places: Readings in American Vernacular Architecture. Hattiesburg.

Uzal, O. (1996). Técnicas constructivas en la arquitectura doméstica de los moriscos granadinos. .

Vissilia, A.-M. (. (2009). "Evaluation of a sustainable Greek vernacular settlement and its landscape: Architectural typology and building physics." . *Building and Environment vol. 44*.

Webb, A. (2017). . Energy retrofits in historic and traditional buildings: A review of problems and methods". . *Renewable and Sustainable Energy Reviews, 77,* , 748- 759.

Weber, W.; Yannas, S. . (2013). Lessons from Vernacular Architecture . *; Routledge: Abingdon-on-Thames, UK,* .

Wells, C. (1986.). Old Claims and New Demands: Vernacular Architecture Studies Today. In *Perspectives in Vernacular Architecture no. 2:1-10.* doi:10.2307/3514311

Winchip S. M. (2011). *Sustainable Design for Interior Environments, Fairchild Books.* New York.

Winston, A. (2018, May 22). *BIG wants to create new styles of vernacular architecture, says Bjarke Ingels*. Retrieved from Dezeen: https://www.dezeen.com/2015/05/26/bjarke-ingels-in-our-time-lecture-metropolitan-museum-new-york-new-vernacular-architecture/

Yılmaz, M., Yıldız, S. ve Gültekin, A.B., Yıkıcı Yeniliklerin. . (2016). Sürdürülebilir İnşaat Sektöründe Tehditler ve Fırsatlar. . *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi.* .

Zeneli, A. &. (2021). "Impacts of Climate Change on Water Resources in Albania.". *Hydrology Research*, 864-877.

Zinzi, M. (2016). "Characterisation and assessment of near infrared reflective paintingsfor building facade applications." . *Energy and Buildings 114* .

APPENDIX

Appendix A- Questionnaire to the inhabitants

1. How long have you been residing in the historical building?

2. How many residents live in the house?

3. Any renovation has been made through the years?

4. Any thermal insulation in different parts of the building?

-roof

-building envelope:

no –floor:

membrane

5. How would you describe your overall comfort level regarding indoor temperature throughout the year?

6. During summer, could you describe the indoor temperature?

-Cold

-Slightly cold

-Neutral

-Slightly warm

-Warm

-Hot

7. During winter, could you describe the indoor temperature?

-Cold

-Slightly cold

-Neutral

-Slightly warm

-Warm

-Hot

8. How often and for how long do you open the windows during the day? (summer/winter)

Summer-

Winter-

9. How do you perceive the humidity

-Very low

-Low

-Neutral

-High

-Very high

10. How often do you utilize heating or cooling systems within your residence?

11. What sources of energy do you currently use for heating/cooling?

-electricity- air conditioner

-wood charcoal

-stardust of chip

-other

12. During what months do you use heating system?

13. On which rooms do you use heating system?

14. Could you estimate the powers costs of the Heating System over a period of one month?

15. During what months do you use cooling system?

16. On which rooms do you use cooling system?

17. Could you estimate the powers costs of the Cooling System over a period of one month?

18. For what purpose do you use electricity

19. What types of lamps do you use for the artificial lighting system?

20. Do you feel that the current energy costs associated with living in the historical building are reasonable?