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MASTER'S THESIS

RENEWABLE ENERGY AND BIOCLIMATIC HABITAT

Topic :

Verifying the reasons of the distance for the setbacks in traditional houses in Beni Isguen GARDAIA

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Abstract

The tertiary residential sector in Algeria is the largest consumer of energy, with 36% of total final energy, considering that the priority is to fight against waste in the residential sector because it does not produce wealth unlike industry and transport, but also an opportunity to protect the environment by reducing the impacts of greenhouse gas emissions.

This thesis is considered as a contribution to the evaluation of the energy performance of a bioclimatic house. The objective is not only to evaluate but also to improve the energy and environmental performance of this bioclimatic house located in Ghardaïa in the M'zab valley in southern of Algeria named Ksar of beni isguen by changing the distance between this house and the neighboring houses to help cool the house with natural ventilation.

The methodology consists in the first place of making simulations on this house using the software Pleiades and méteonorm with scenarios of occupants, dissipated power, cooling schedule and ventilation, then add Mask around this house and varies the distance between them to find the optimal distance.

The results obtained show that in summer conditions, the best distance that separates the house is 1m because it will lower the temperature by 4 degrees.

Keywords: Energy performance, Ksar of beni isguen, Natural ventilation., Setbacks, traditional houses.

Résumé

Le secteur résidentiel tertiaire en Algérie est le plus grand consommateur d'énergie, avec 36% de l'énergie finale totale, considérant que la priorité est de lutter contre le gaspillage dans le secteur résidentiel car il ne produit pas de richesse contrairement à l'industrie et au transport, mais aussi une opportunité de protéger l'environnement en réduisant les impacts des émissions de gaz à effet de serre.

Cette thèse est considérée comme une contribution à l'évaluation de la performance énergétique d'une maison bioclimatique. L'objectif est non seulement d'évaluer mais aussi d'améliorer la performance énergétique et environnementale de cette maison bioclimatique située à Ghardaïa dans la vallée du M'zab au sud de l'Algérie nommée Ksar de beni isguen en changeant la distance entre cette maison et les maisons voisines pour aider à refroidir la maison avec la ventilation naturelle.

La méthodologie consiste en premier lieu à faire des simulations sur cette maison en utilisant les logiciels Pléiades et méteonorm avec des scénarios d'occupants, de puissance dissipée, de programme de refroidissement et de ventilation, puis à ajouter des Masques autour de cette maison et à faire varier la distance entre eux pour trouver la distance optimale.

Les résultats obtenus montrent qu'en conditions estivales, la meilleure distance qui sépare la maison est de 1m car elle permet d'abaisser la température de 4 degrés.

Mots clés : Performance énergétique, Ksar de beni isguen, Ventilation naturelle. Revers, Maisons traditionnelles.

ملخص

يعتبر القطاع السكني الثالث في الجزائر أكبر مستهلك للطاقة، حيث يحتوي على 36٪ من إجمالي الطاقة النهائية، مع الأخذ في الاعتبار أن الأولوية هي محاربة الهدر في القطاع السكني لأنه لا ينتج ثروة على عكس الصناعة والنقل، بل يمثل أيضًا فرصة لتحقيق حماية البيئة عن طريق الحد من آثار انبعاثات غازات الاحتباس الحراري.

تعتبر هذه الأطروحة كمساهمة في تقييم أداء الطاقة لمنزل مناخي بيولوجي. الهدف ليس فقط تقييم ولكن أيضًا تحسين الطاقة والأداء البيئي لهذا المنزل المناخي الحيوي الواقع في غرداية في وادي ميزاب في جنوب الجزائر المسمى قصر بني إيسكين من خلال تغيير المسافة بين هذا المنزل والمنازل المجاورة إلى تساعد في تبريد المنزل بالتهوية الطبيعية.

تتمثل المنهجية في المقام الأول في إجراء عمليات محاكاة على هذا المنزل باستخدام برنامج Meteonorm/Pleiades

مع سيناريوهات المقيمين، والطاقة المشتتة، وجدول التبريد والتهوية، ثم إضافة قناع حول هذا المنزل وتغيير المسافة بينهما للعثور على المسافة المثلى.

أظهرت النتائج أنه في ظروف الصيف أفضل مسافة تفصل بين المنزل هي 1 متر لأنها ستخفض درجة الحرارة بمقدار 4 درجات.

الكلمات الدالة: أداء الطاقة ، قصر بني إسكن ، التهوية الطبيعية ،النكسات، البيوت التقليدي

General introduction

Bibliographic research

Case Study and Simulation

Results and discussion

List of figures

List of Tables

Classification

Te : inlet temperature

Ts : dry-bulb temperature

Th : wet-bulb temperature

WF : water flow injected into the system

Acronym

APRUE: National Agency for the Promotion and Rationalization of Energy Use

BWh : Hot and dry desert climate

Csa: Warm temperate climate with dry summer (Mediterranean)

DTR: Regulatory Technical Document

DV: Double glazing

PNEE: Aggressive national efficiency program

STD: Dynamic thermal simulation

VMC: Controlled mechanical ventilation

1. Introduction

The unique features and construction methods typical of traditional homes are a result of the local material availability, climate, and cultural practices. Ksar de Beni Isguen, a traditional settlement located in the Ghardaia province of Algeria, is an example of how traditional homes can be built to suit the local climate and provide occupants with a comfortable living environment. However, maintaining temperature in traditional homes during hot weather can be challenging, given the limited availability of modern cooling systems.

This thesis focuses on using natural ventilation as a means to cool traditional homes in hot weather conditions.

Chapter 1 of this thesis provides an introduction to the research plan and the necessary recommendations for our case study.

Chapter 2 includes a bibliographic search and state of the art analysis to draw, as well as the case study of Ksar de Beni Isguen.

Chapter 3 includes the modeling of the adapted study case in our site, where we analyze how natural ventilation can be used to improve heat retention in traditional homes.

Chapter 4 of this thesis includes the results and discussions of various simulations, along with proposed solutions aimed at improving the energy efficiency of the case study.

Through this research, we aim to provide an understanding of the role of natural ventilation in cooling traditional homes. In addition, the thesis offers practical guidance to homeowners in Ksar de Beni Isguen and other similar communities on how to integrate traditional knowledge and practices with modern technologies to create a comfortable living environment during hot weather while preserving the local cultural heritage.

2. The problematic

Climate conditions: The climate conditions in Ksar de Beni Isugen may pose challenges in cooling traditional homes through natural ventilation. Investigating the average temperature range, seasonal fluctuations, and humidity levels can help identify how these factors impact natural cooling strategies.

2.1 Architectural design:

Traditional homes in Ksar de Beni Isugen may have unique architectural designs that affect the effectiveness of natural ventilation. Exploring design elements like window shape, building orientation, and natural material usage can help assess how these impact cooling with natural ventilation.

2.2 Energy efficiency:

Ensuring energy efficiency is one potential challenge to cooling traditional homes with natural ventilation. Evaluating energy consumption and greenhouse gas emissions from traditional cooling methods can help determine the potential benefits of natural ventilation as an alternative.

2.3 Health and comfort:

Using natural ventilation to cool traditional homes may impact resident health and comfort levels. Exploring potential health risks due to increased exposure to outdoor pollutants and allergens and how natural ventilation affects overall home comfort levels is key.

2.4 Cost and feasibility:

Investigating the cost and feasibility of implementing natural ventilation systems for cooling traditional homes in Ksar de Beni Isugen is crucial. Evaluating the cost and availability of needed materials and equipment and retrofitting existing homes is necessary, and potential social or cultural barriers must be considered as well.

3. Assumptions

1. That traditional homes in Ksar de Beni Isguen are designed in a way that allows for implementation of natural ventilation strategies for cooling.

2. That natural ventilation can be used as a main cooling method in Ksar de Beni Isguen, providing a cost-effective and sustainable alternative to traditional cooling methods.

3. That residents of traditional homes in Ksar de Beni Isguen are willing to adopt a new cooling strategy and have the necessary knowledge of how to use and maintain it effectively.

4. That implementation of natural ventilation strategies will not negatively impact the indoor air quality or comfort of residents in traditional homes in Ksar de Beni Isguen.

4. Objectives

1) To assess the feasibility of using natural ventilation strategies as a primary cooling method in traditional homes in Ksar de Beni Isguen.

2) To evaluate the effectiveness of natural ventilation strategies in providing adequate cooling in traditional homes in Ksar de Beni Isguen.

3) To investigate the energy efficiency of natural ventilation compared to traditional cooling methods in Ksar de Beni Isguen.

4) To assess the impact of natural ventilation on indoor air quality and overall resident comfort levels in traditional homes in Ksar de Beni Isguen.

5) To explore potential social and cultural barriers to implementing natural ventilation strategies in traditional homes in Ksar de Beni Isguen and develop recommendations for overcoming these barriers.

5. The research methodology

The research methodology section of this thesis is comprised of both theoretical and practical approaches.

The theoretical approach describes the overarching framework or theoretical perspectives that guided this research. The theoretical framework for this study focuses on sustainable design and energy-efficient technologies in traditional architecture, with a focus on evaluating the feasibility, effectiveness, and energy efficiency of using natural ventilation as a primary cooling method.

The practical approach outlines the data collection and analysis methods used in this study. Both qualitative and quantitative methods were employed, including interviews, surveys, and case studies to assess the impact of natural ventilation on indoor air quality, resident comfort levels, and energy consumption. These methods also helped identify social and cultural barriers to implementing natural ventilation, and recommendations were developed to overcome these barriers.

Overall, this research methodology emphasizes the importance of combining a theoretical and practical approach to develop a comprehensive understanding of the research questions and achieve the objectives of the study. This approach ensures that the research is both grounded in real-world data but also guided by a sound theoretical perspective, resulting in rigorous and trustworthy findings.

6. Conclusion

By combining a theoretical and practical approach, this research aims to provide valuable insights and recommendations for enhancing energy efficiency and reducing greenhouse gas emissions in traditional communities.

1. Introduction

Traditional homes are built to adapt to the local climate, using materials and construction methods that are often shaped by local cultural practices. Ksar de Beni Isguen, a traditional settlement in Algeria's Ghardaia province, is a prime example of how traditional architecture can enhance comfort and quality of life for occupants. However, maintaining temperature in traditional homes during hot weather remains a challenge due to the limited availability of modern cooling systems.

This thesis explores the potential of natural ventilation as a means to cool traditional homes in hot weather conditions, with a focus on Ksar de Beni Isguen. Through this research, we aim to provide a comprehensive understanding of the role of natural ventilation in cooling traditional homes, including the benefits, limitations, and possible challenges. Additionally, this thesis offers practical guidance for integrating traditional knowledge and practices with modern technologies to create a comfortable living environment during hot weather while preserving the local cultural heritage.

By combining theoretical and practical approaches, this thesis seeks to contribute to the growing body of knowledge on sustainable housing design while offering practical solutions for residents in traditional communities. Our goal is to provide valuable insights and recommendations that can enhance energy efficiency and reduce greenhouse gas emissions in traditional homes while maintaining the unique cultural identity of Ksar de Beni Isguen and similar communities.

2. Traditional architecture

Traditional architecture is a field that encompasses the historical techniques, processes, and aesthetics of designing and constructing buildings. It is influenced by the local materials and resources available, as well as the cultural beliefs and values of a particular region. Traditional architecture is often characterized by its emphasis on sustainability and durability, with a focus on the use of natural materials. It has evolved over time to reflect changing societal needs and technological advancements, but still remains a unique and important aspect of architecture. Understanding traditional architecture is important for preserving cultural identity and advancing sustainable building practices. Traditional architectural styles and techniques are often associated with specific regions or cultures, such as the adobe construction used in Southwestern United States or the vaulted stone architecture of Iran [1]. These traditional building practices have also inspired modern architecture, as seen in the work of contemporary architects like Glenn Murcutt and Ken Yeang [2].

Traditional architecture is also important for understanding the ways in which people interact with their environment. Traditional building practices are often developed through observation and adaptation to local climate conditions, resulting in buildings that are well-suited to their surroundings [4]. Furthermore, traditional architecture is often representative of local cultural values and reflects people's beliefs and customs [3]. The cultural influence on traditional architecture can be seen in the decorative elements and symbolism woven into the design of buildings [1].

Figure 1 Traditional architecture [5]

Traditional architecture is a valuable form of design that has been developed over centuries of trial and error, and reflects the unique cultural and environmental contexts in which it was developed. It is important to understand traditional architecture in order to preserve cultural identities and to apply sustainable building practices in modern architecture. The study of traditional architecture also helps provide insight into the development of sustainable building practices and their application in contemporary building design.

Figure 2 Traditional architecture building design [42]

3. Bioclimatic architecture

Bioclimatic architecture is an approach to sustainable building design that aims to optimize the building's energy performance, while minimizing its environmental impact and enhancing the occupants' comfort. This design approach focuses on the integration of the building design with the local climatic conditions [7]. The design process accounts for natural resources, such as sunlight, wind, and water, and their fluctuation and availability in different seasons in order to create a microclimate that benefits the occupants [8]. Bioclimatic architecture can result in buildings that are self-reliant in terms of energy use and have a small carbon footprint. This approach to building design can reduce the energy consumption of buildings by up to 50% when compared to conventionally designed buildings [7].

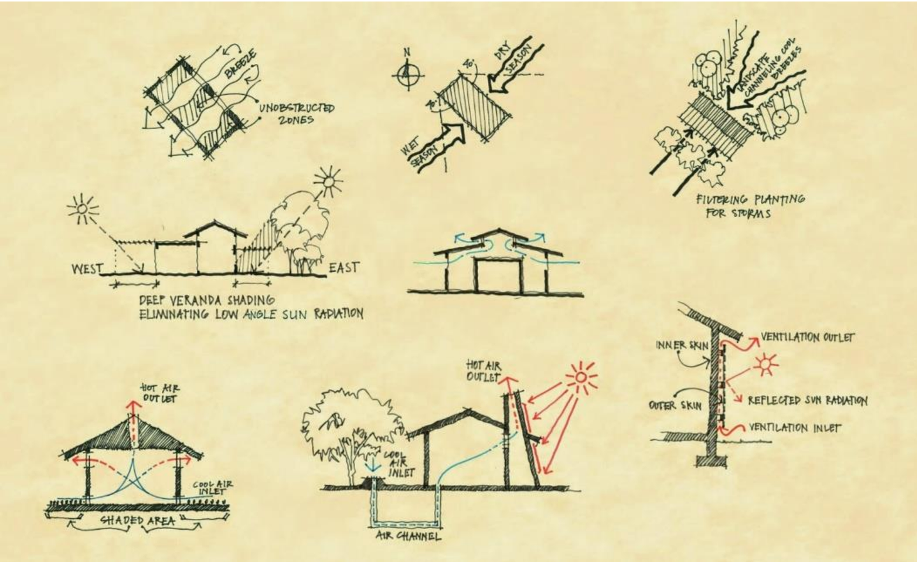

Figure 3 Bioclimatic Architecture Tropical Architecture [10]

One of the key components of bioclimatic architecture is passive solar design. Passive solar design is the use of building elements, such as high-performance windows and well-positioned shading elements, to capture and control solar radiation. This reduces the building's reliance on air conditioning and heating systems and lowers the energy bill [6]. The orientation of the building can also enhance the passive solar design and optimize the building's energy performance. For example, a building in the Northern Hemisphere should have the majority of its windows facing south to capture the maximum amount of sunlight [7].

Bioclimatic architecture offers an innovative approach to sustainable building design by acknowledging local environmental resources, promoting energy conservation, enhancing indoor environmental quality, and improving the occupants' well-being. This approach offers opportunities for architects and building designers to create buildings that are socially, environmentally, and culturally responsive. Further research into bioclimatic architecture could provide insights into how sustainable building design can be applied in the context of different environmental and cultural settings.

Figure 4 The Benefits of Integrating Bioclimatic Design into Your Construction Projects [9]

4. The objective of bioclimatic architecture

Bioclimatic architecture is an architectural approach that aims to create sustainable buildings that work in harmony with the environment. The primary objective of bioclimatic architecture is to reduce the negative impact of human activity on the environment while ensuring optimal comfort levels for occupants [11].

This design approach is based on the principles of passive design, which use natural resources like sunlight and airflow to provide lighting, heating, and cooling of a building. Thus, bioclimatic architecture prioritizes energy efficiency and sustainability by using materials that are locally sourced and renewable.

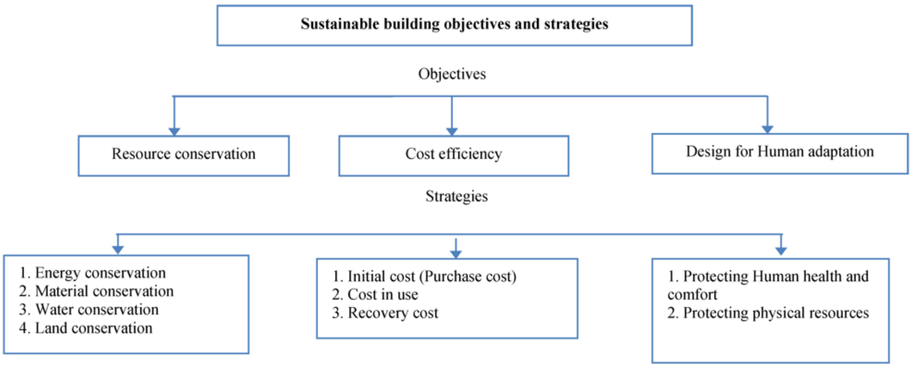

Figure 5 Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector [14]

According to a study conducted by Givoni, architects and building designers must take into account a range of environmental factors when designing bioclimatic buildings, including site location, orientation, and local climate. Furthermore, proper design and construction techniques can result in enormous energy savings while enhancing thermal comfort levels for the occupants [12].

In conclusion, bioclimatic architecture provides a sustainable and environmentally friendly approach to architectural design. It aims to minimize the use of energy and materials while providing optimal comfort levels for building occupants. With proper construction techniques and a focus on passive design principles, bioclimatic architecture has the potential to create a more sustainable built environment.

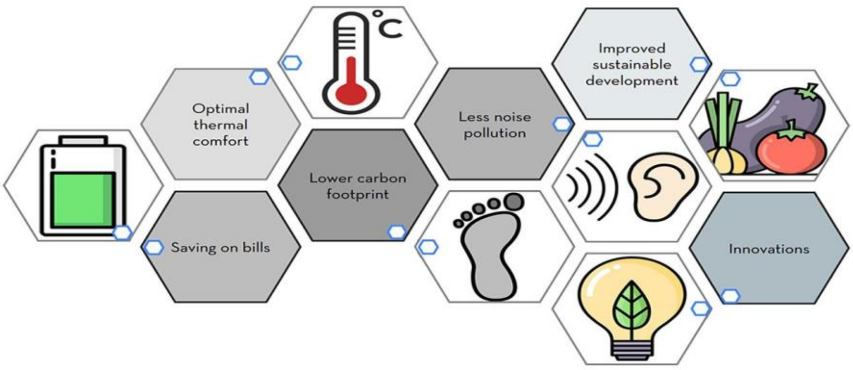

Figure 6 Bioclimatic Architecture: Essential Philosophy Of Sustainable Design [13]

5. Envelope color

Envelope color is an important aspect of architectural design, as it can affect the aesthetics and energy efficiency of a building. The color of the building envelope can impact the amount of heat absorbed by the building, which in turn affects the energy consumption of the building. Color can also be used to create a visual impact, highlight certain architectural features, or blend into the surrounding environment.

Figure 7 Building Envelope Systems [60]

Studies have shown that using light-colored envelopes can significantly reduce the amount of heat absorbed by a building. For example, a study by the Department of Architectural Engineering at the University of Seoul found that using a light-colored envelope reduced the heat gain by up to 78% compared to a dark-colored envelope [58]. This can lead to significant energy savings, especially in hot climates where air conditioning is required.

In addition to energy efficiency, envelope color can also be used to create a visual impact. For example, using a bright or bold color can make a building stand out and become a landmark in a cityscape. On the other hand, using a neutral color can help a building blend into the surrounding environment and create a sense of harmony between the building and its surroundings.

Envelope color can also be used to highlight certain architectural features of a building. For example, using a different color on the facade of the building can draw attention to specific areas [57], such as the main entrance or the upper floors. This can help create a more interesting and dynamic building design.

Figure 8 ROCKWOOL [59]

Envelope color is an important aspect of architectural design, affecting both the energy efficiency and aesthetics of a building. The choice of color can have a significant impact on the building's performance and appearance. Architects should consider the environmental and visual impact of the envelope color when designing new structures.

6. Roofs

Roofs are an essential element of any building. They provide protection from the elements, support solar installations, and contribute to the overall aesthetics of the building. The choice of roofing material and design can have significant impacts on the energy efficiency and sustainability of the building.

Figure 9 Green roof – Wikipedia [56]

One key consideration for roofs is the choice of material. Traditional roofing materials such as clay tiles or slate are durable and long-lasting, but can be expensive. Other materials such as asphalt shingles are more affordable, but have a shorter lifespan and are less environmentally friendly. In recent years, there has been a trend towards using green roofs, which are covered in vegetation and provide many benefits such as insulation, stormwater management, and habitat creation. [53]

Another consideration when it comes to roofs is their design. Modern architecture has embraced a variety of roof designs to create unique and visually striking buildings. Flat roofs, for example, have been used extensively in modern architecture and allow for easy installation of solar panels and other renewable energy technologies. On the other hand [55], sloped roofs are a traditional roofing style that helps with rainwater runoff and can be designed in a variety of shapes and materials to achieve specific architectural goals.

The energy efficiency of the roof is also an important consideration. A white or light-colored roof will reflect the sun’s rays and help keep the building cooler, reducing the need for air conditioning. On the other hand, a dark-colored roof will absorb more heat and result in higher energy consumption. Furthermore, proper insulation is critical for minimizing heat loss and improving energy performance.

Figure 10 Green Roof Technology [55]

The choice of roofing material and design is an important aspect of architectural design. Architects should consider the environmental impact, energy efficiency, and visual impact of the roofing system when designing new structures. [54]

7. The basic principles of bioclimatic architecture

The basic principles of bioclimatic architecture involve several design factors that work together to create sustainable buildings that reduce energy consumption, promote natural cooling and heating, and provide optimal comfort for residents. These design factors include orientation, implantation, compactness, natural ventilation, and thermal comfort. Orientation is a critical design aspect that takes into account the position of the building concerning the sun's path. Proper orientation ensures that the building takes advantage of natural sunlight, reducing heating costs in the winter and lighting costs year-round [15].

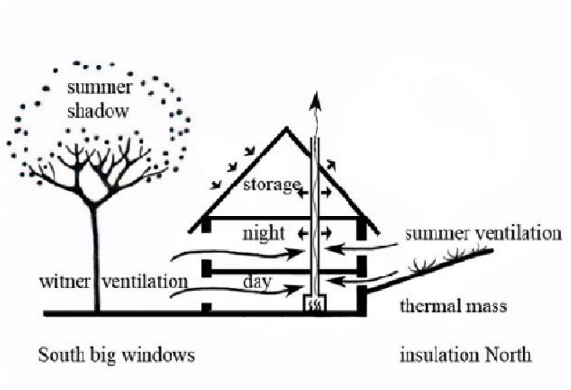

Figure 11 Bioclimatic Architecture [21]

Implantation refers to the building's location on the site. Buildings that are carefully sited make use of natural topography and wind patterns to improve energy efficiency. In addition, the location of the building can reduce the need for artificial lighting by positioning the building correctly [16].

Compactness plays a vital role in bioclimatic architecture by minimizing the surface area exposed to the environment, reducing energy losses due to heat transfer. Compact designs also maximize opportunities for natural cooling and heating through natural ventilation [17].

Natural ventilation is a critical principle of bioclimatic architecture design that promotes healthy indoor air quality and reduces the need for artificial heating and cooling. Architectural design should take into account the local wind patterns and airflow potentials to enhance natural ventilation [18].

Thermal comfort is an essential principle of bioclimatic architecture, and it relates to the occupants' comfort level concerning temperature. The bioclimatic building should regulate indoor temperature levels to ensure occupants' comfort with minimal energy consumption. This includes both winter comfort and summer comfort [19].

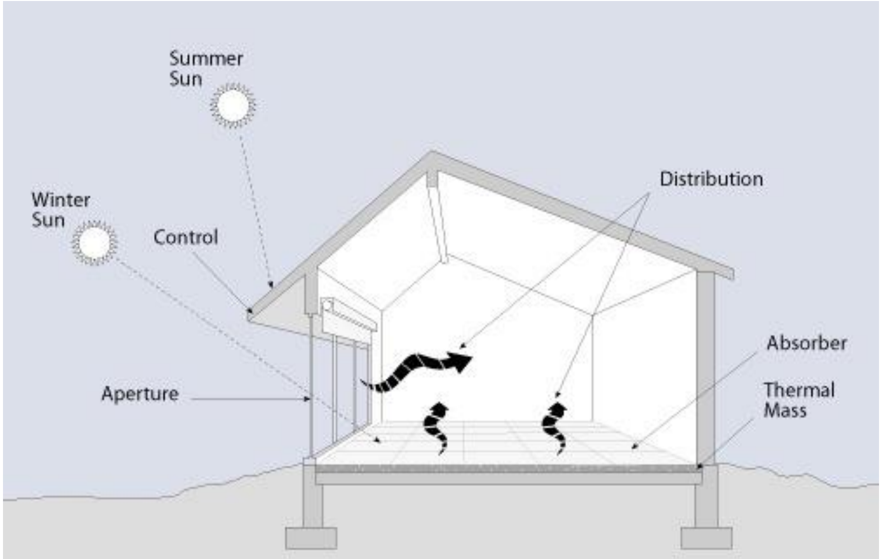

Figure 12 Green Passive Solar Magazine [20]

In conclusion, the basic principles of bioclimatic architecture include several critical design considerations that work together to create sustainable, energy-efficient buildings that promote natural cooling and heating and provide occupant comfort. Proper orientation, implantation, compactness, and natural ventilation are key principles to promote thermal comfort for occupants.

8. Thermal inertia

Thermal inertia is a crucial aspect of bioclimatic architecture, referring to the capacity of building materials to absorb, store, and release heat over an extended period. Materials with high thermal inertia can prevent the rapid oscillation of indoor temperature due to external climate changes, and thereby minimize energy consumption.

The principle of thermal inertia is significant in bioclimatic architecture because it provides a way to regulate indoor temperature levels passively. Materials such as concrete, stone, and adobe possess high thermal inertia and can store excess heat during the day and release it at night, reducing the need for heating and cooling systems [22].

Furthermore, high thermal inertia is beneficial for controlling humidity levels in indoor spaces as the materials used help absorb excess moisture, leading to a comfortable and healthy environment for occupants. High thermal inertia materials also have the benefit of longevity, reducing the need for frequent replacement and saving resources.

Thermal inertia can also be optimized by appropriate design and placement of thermal mass elements, such as floors, walls, roofs, and ceilings. Proper orientation, size, shape, and position of mass elements will enable optimal thermal performance and energy efficiency [22].

Thermal inertia is an essential principle of bioclimatic architecture, allowing the regulation of indoor temperature levels passively and reducing energy consumption. Materials with high thermal inertia can store and release heat over an extended period, leading to energy-efficient buildings and a comfortable indoor environment.

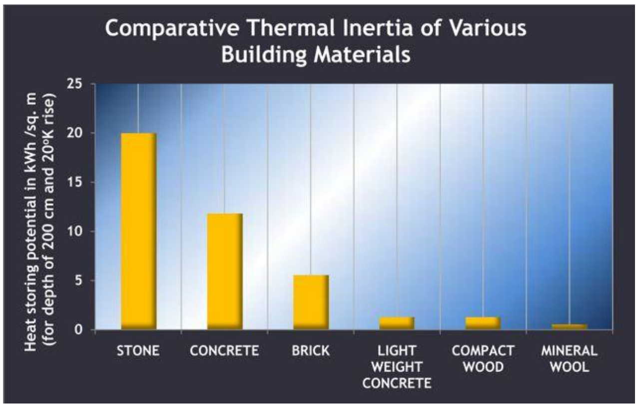

Figure 13 Thermal-Inertia [23]

9. The effect of Alleys between buildings

Alleys play a big role when it comes to natural ventilation and providing a layer of insulation made with air, the width of the alley between two buildings is quite important because if the alley is too wide or too narrow then we lose the benefit of having that alley.

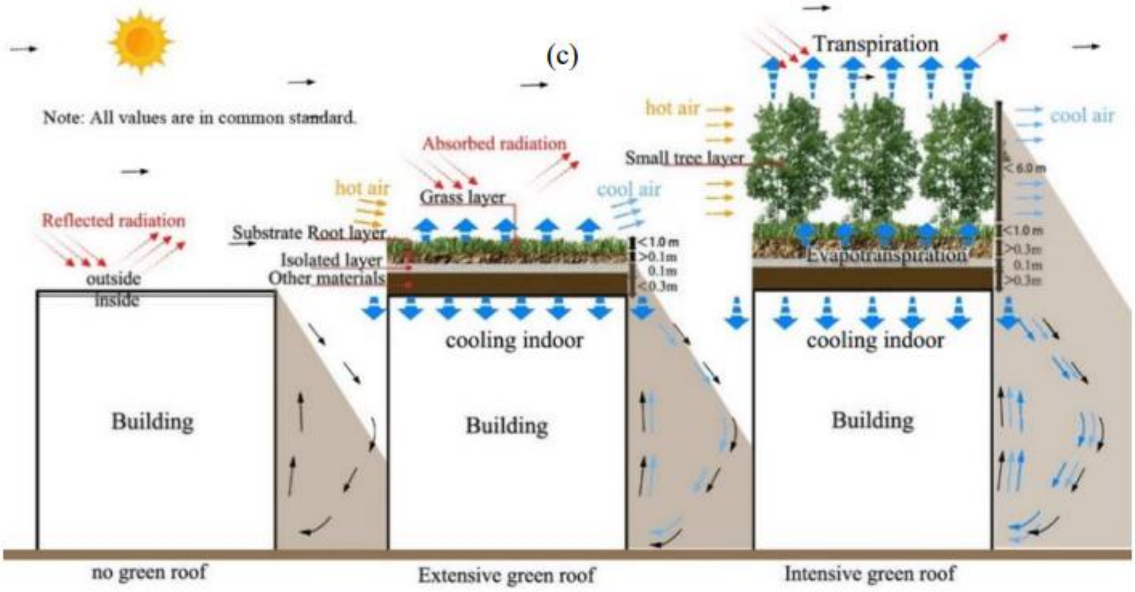

Figure 14 The cooling mechanism during the day (Zhang, He, Zhu, & Dewancker, 2019)

10. Building materials of a ksar

A ksar is a traditional fortified village found primarily in the Sahara region of North Africa. The building materials used to construct a ksar are essential to its significance as a cultural heritage site. The use of locally sourced materials and traditional building techniques are prevalent features in the construction of a ksar. The following are examples of building materials commonly used in a ksar:

10.1. **Mud brick (Adobe):** Mud brick is a traditional building material used in many traditional buildings in the Sahara region of North Africa, including ksars. Adobe is made from a blend of local clay soil, sand, and straw that is mixed together, shaped into bricks, and sun-dried. Mud brick constructions provide good insulation and thermal regulation [24].

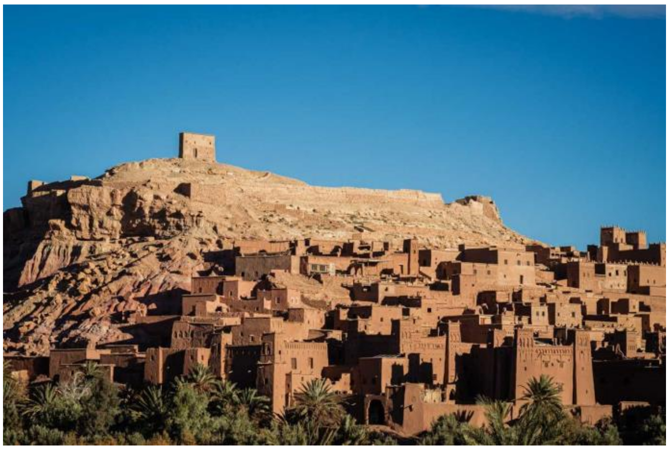

Figure 15 Ksar Ait Ben Haddou [30]

10.2. **Stone:** Many ksars are constructed from locally sourced stone. Dry-stone masonry is a traditional technique dating back thousands of years, and it involves stacking stones without the use of any bonding agents. In some cases, stones are also used as a foundation, providing a stable base for the building [25].

Figure 16 Natural Stone Rectangular Blocks Pattern Stock [29]

10.3. **Palm wood:** Palm wood is a traditional building material used in the construction of a ksar, prominent in the roof structure. The palm wood frames are used in conjunction with other materials as support and provide a distinctive aesthetic that highlights the cultural heritage of the region [26].

Figure 17 Coconut Wood [28]

10.4. **Terracotta:** Terracotta is a type of fired clay that is used extensively in traditional architecture in North Africa. It is commonly used in the construction of mud-brick buildings' roofs, where it can be shaped into a variety of forms to create decorative patterns and provide water resistance [24].

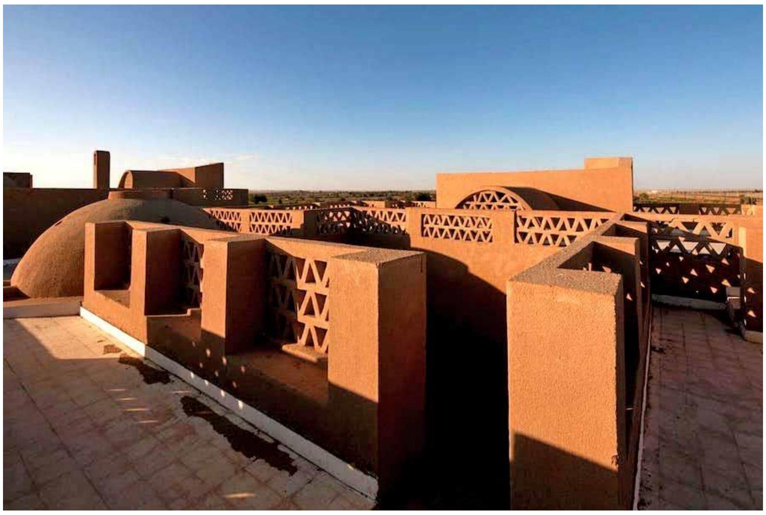

Figure 18 Traditional Building Materials in Modern Times [27]

The building materials used in the construction of a ksar reflect the local environment and cultural heritage of the region. The use of mud brick, stone, palm wood, and terracotta highlight the importance of sustainable and locally sourced materials in traditional building practices.

11. Historical overview of the valley beni M'Zab

The valley of Beni Mzab is a unique cultural site located in the Mzab region of Algeria. The valley is home to a group of five ksars, which are traditional fortified villages dating back to the 11th century. A historical overview of the valley of Beni Mzab is important in understanding the cultural relevance of the site.

Figure 19 The Fortified Towns of M'Zab Valley [34]

The valley of Beni Mzab has a long and complex history, characterized by a blend of Berber, Arab, and Islamic culture. The earliest records of the region date back to the 11th century when the Ibadite settlers established the ksars of the Mzab Valley. The settlers were members of the Ibadite sect of Islam, who fled persecution from the Fatimid Caliphs in North Africa [31].

The Beni Mzab valley thrived under the Ibadite rule, becoming a center for trade, crafts, and agriculture. The ksars' well-preserved architecture reflects the prosperous social, economic, and cultural conditions of the region. The five ksars are Ghardaïa, Beni-Isguen, El-Atteuf, Melika, and Bounoura. Each ksar has a unique architectural style that reflects its history and cultural traditions.

Figure 20 valley in Algeria [33]

The Beni Mzab valley has been recognized as a UNESCO World Heritage Site since 1982 for its cultural and historical significance [32]. However, in recent years, the valley has faced challenges from modernization and urbanization, which threaten the ksars' unique architecture and cultural heritage.

In conclusion, the valley of Beni Mzab has a rich and complex history characterized by a blend of Berber, Arab, and Islamic culture. The ksars of the valley reflect the region's prosperous social, economic, and cultural conditions and have been recognized as a UNESCO World Heritage Site since 1982.

12. The structural elements of ksar beni isguen

Ksar Beni Isguen is a unique example of traditional architecture in southern Algeria, and its structural elements have been studied by architects and researchers around the world. The village is a maze of narrow alleyways, high walls, and fortified buildings, all designed to provide protection from the harsh desert climate and potential invaders.

Figure 21 The city Tafilelt Tajdite à Beni-Isguen [37]

One of the key features of Ksar Beni Isguen is its wall system, which consists of a high perimeter wall surrounding the village and smaller walls surrounding individual buildings. The walls are made of mud bricks and are up to 4 meters high, providing protection from sandstorms and potential invaders. The walls also contain a series of watchtowers and gates, which provide a way in and out of the village [35].

The houses in Ksar Beni Isguen are designed with a central courtyard, which is a common feature of traditional Algerian architecture. The courtyards are surrounded by a series of rooms, with the upper floors accessible by an external staircase. The houses have flat roofs, which are used for outdoor living and are often covered with mats to protect from the sun.

The streets in Ksar Beni Isguen are narrow and winding, creating a labyrinthine effect and providing shade from the sun. The streets are often less than a meter wide and are lined with mud-brick houses, creating a tunnel-like effect.

The village also contains several public buildings, including mosques, markets, and communal spaces. The mosques in Ksar Beni Isguen are some of the most impressive structures in the village, with tall minarets and intricate decorations. The markets are designed to be functional and efficient, with narrow covered alleys lined with stalls selling goods [36].

Overall, the structural elements of Ksar Beni Isguen are a testament to the ingenuity and adaptability of traditional architects in southern Algeria. These elements have been studied by architects and researchers and have become a source of inspiration for modern architects looking to incorporate traditional elements into contemporary design.

13. The local dimension of the situation of ksar beni isguen

The local dimension of Ksar Beni Isguen refers to the social, cultural, and economic context of the village and its inhabitants. Ksar Beni Isguen is located in the Ghardaia province in southern Algeria, which is known for its rich history, cultural heritage, and unique architecture.

The village is home to the Ibadites, a religious minority in Algeria, who have lived in the region for centuries. The Ibadites are known for their conservative values, which are reflected in the social norms and traditions of the village. For example, women in Ksar Beni Isguen traditionally wear a black veil that covers their entire body when they are in public [38].

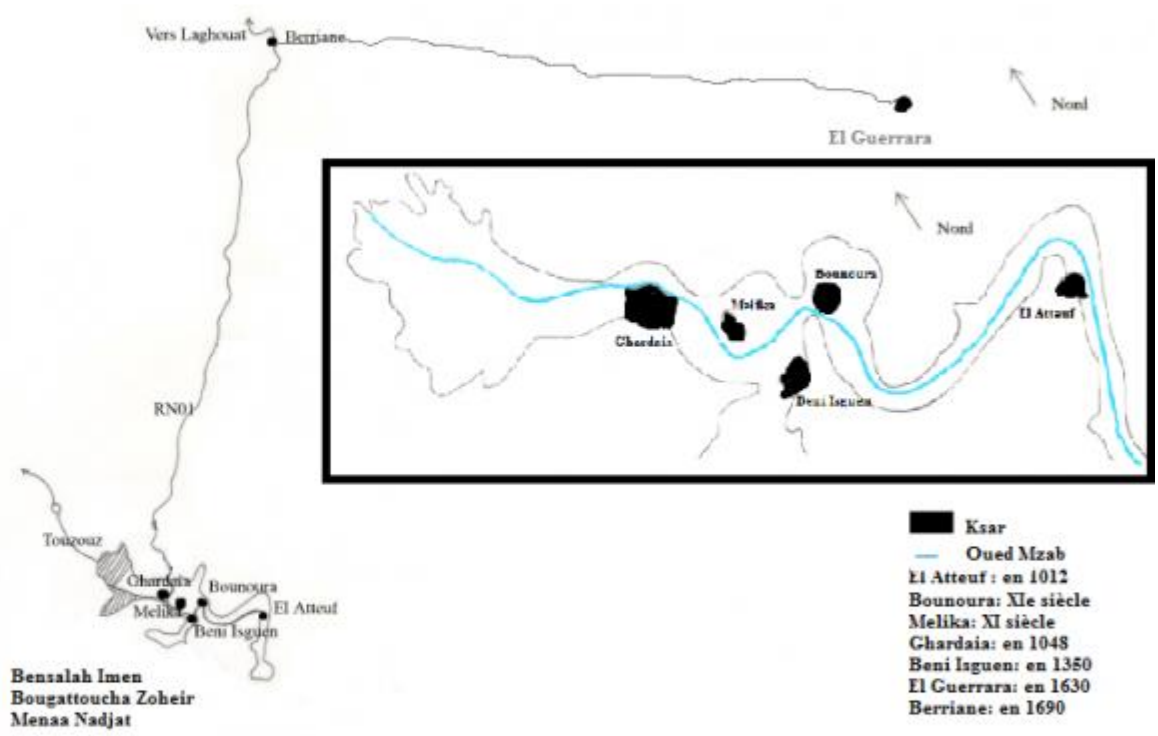

Figure 22 Urbanisation de la vallée du M'zab et mitage de la palmeraie de Ghardaïa (Algérie) : un patrimoine oasien menacé [41]

The economy of Ksar Beni Isguen is primarily based on agriculture and tourism. The village is surrounded by date palms and other crops, which provide a source of income for the inhabitants. The village also attracts tourists who are interested in the unique architecture and cultural heritage of the region. However, the tourism industry has also brought challenges to the village, such as overcrowding and increased pressure on the local infrastructure [39].

The local government plays a critical role in the management and development of Ksar Beni Isguen. The government has implemented several policies and programs to promote sustainable development, improve infrastructure, and enhance the quality of life for the inhabitants of the village [40]. For example, the government has implemented a system for managing water resources, which is critical in a desert environment.

Overall, the local dimension of Ksar Beni Isguen is an essential factor in understanding the situation of the village and its inhabitants. The social, cultural, and economic context of the region has shaped the village's architecture, traditions, and way of life. Understanding these factors is critical for developing sustainable and effective policies that support the development of Ksar Beni Isguen and its inhabitants.

14. Traditional architecture and sustainability

Traditional architecture has evolved over thousands of years and is inherently sustainable. It has always been designed to fit into its environment, to be comfortable, and to reflect the cultural values of the community. This type of architecture relied on local materials, vernacular construction techniques, and was adapted to weather extremes and regional climate fluctuations. With the critical challenges of depletion of resources and environmental degradation, the revival of traditional architecture has gained a lot of attention towards sustainability.

Figure 23 What is Vernacular Architecture? [51]

The use of sustainable materials is one of the most significant aspects of traditional architecture. Traditional buildings were constructed with materials that were readily available locally, such as stones, wood, bamboo, and mud. Such natural materials not only have a low carbon [47] footprint, but also have built-in insulation properties; helping to reduce energy consumption.

Apart from using sustainable materials, traditional architecture also optimizes the use of natural resources. For instance, the use of courtyards is one of the unique features of traditional architecture. Courtyards create a micro-environment that allows air to move throughout the building, keeping indoor temperatures comfortable even in extreme climates, thus reducing the need for mechanical heating or cooling. [48]

In addition to that, the principle of passive design was widely used in traditional architecture to harness the local environment. The design of roofs and windows has been optimized to rely on natural light, ventilation, and solar heat gain, which decrease energy consumption and the greenhouse gas footprint.

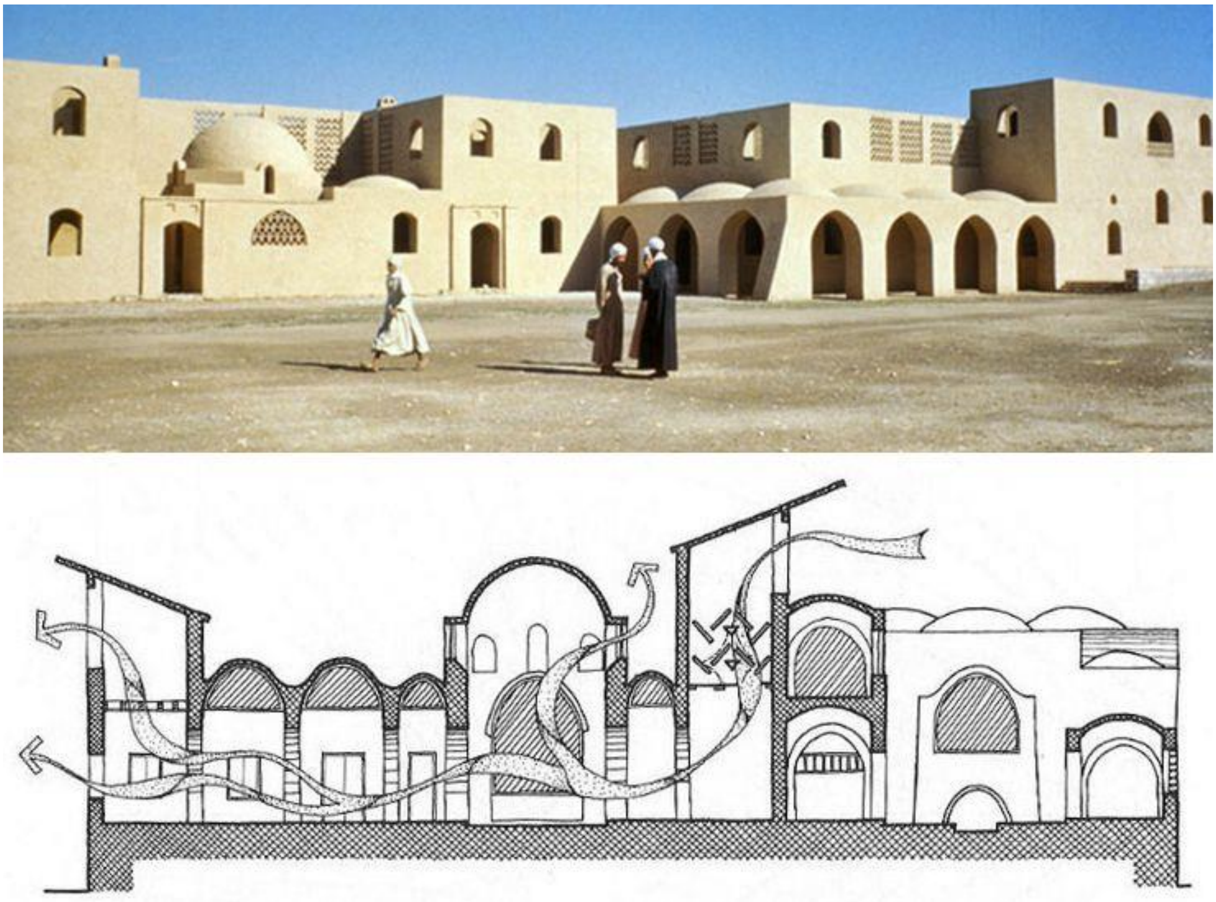

Figure 24 Traditional architecture and sustainability [50]

Adopting traditional architecture also has healthy benefits. Numerous research studies have shown that the use of natural materials in buildings can improve indoor air quality and promote well-being. For example, plaster was traditionally used extensively in construction which provides a natural resistance to moulds and fungi. [49]

Overall, the revival of traditional architecture in modern building practices offers a sustainable design approach, considering environmental and social concerns. It demonstrates the wisdom of the traditional communities in utilizing locally available materials, climatic adaptation, and passive design, contributing to biodiversity conservation and reducing the impact of climate change on the built environment.

15. Traditional architecture, between yesterday and today: the valorization of practices traditional adaptation to bioclimatic architecture

Traditional architecture has been an important part of the world's cultural heritage for centuries. It is deeply rooted in the local context and climate, using materials and techniques that are carefully selected and adapted to the specific needs and conditions of the area in which they originate.

The valorization of traditional architecture has become increasingly important in recent years as a means of preserving cultural heritage [43], maintaining sustainable practices, and promoting local identity. As the world becomes more globalized, traditional architecture offers a unique way to connect people with their heritage and preserve cultural diversity.

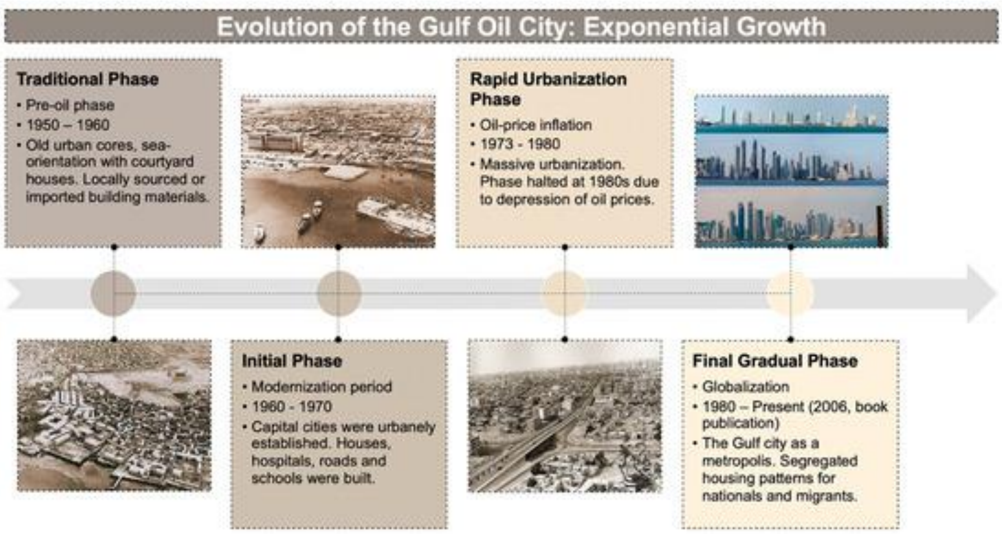

Figure 25 A Cultural Heritage Framework for Preserving Qatari Vernacular Domestic Architecture [46]

Bioclimatic architecture, which is the application of ecological and sustainable principles to building design, has emerged as one of the key ways to promote traditional architecture and adapt it to modern needs. By using materials that are sustainable and locally sourced, bioclimatic architecture seeks to reduce the environmental impact of construction and promote sustainable living practices.

Many examples of traditional architecture that have been adapted to bioclimatic principles can be found around the world. One such example is the use of earth and clay construction in the Middle East and North Africa. In these regions, mud brick and rammed earth construction have been used for centuries, providing excellent insulation and natural cooling during hot summer months. [44]

Another example is the use of timber construction in Northern Europe, where timber-framed buildings have been popular for centuries due to their flexibility and resilience in harsh climates. These buildings are often constructed using traditional methods and materials, such as locally sourced timber and clay or lime-based mortar. [45]

Overall, the valorization of traditional architecture and its adaptation to bioclimatic principles can provide valuable insights into sustainable building practices, cultural heritage preservation, and promoting a sense of local identity.

16. State of the art

16.1. The theses consulted:

16.1.1.1. Thesis 1: «OPTIMIZING THE THERMAL PERFORMANCE OF ROOFS HOUSING IN HOT AND ARID CLIMATES. Case study Ksar of Beni Isguen»

Presented by: Kadri Meryem

In traditional cities in hot and arid climates, roofs are the surfaces most exposed to intense solar radiation. Therefore, due to its position and importance in the building, the roof can play an important role in improving the thermal and energy performance of the building if it is designed in rational and bioclimatic ways. A thermal assessment study of the impact of the roof on the energy performance of buildings has been developed in this work, acting on thermo physical (albedo, thermal inertia, insulation) and geometric (shape, design) parameters. The study aims to improve the thermal and energy performance of the roof by saving energy and avoiding overheating situations. The Ksar of Béni Isguen located in the M'zab valley in southern Algeria is chosen as a case study. This study is conducted mainly by means of in situ measurements. The study of the optimization of the thermal performance of a double skin roof coupled with a thermo-reflective paint is also carried out by the parametric simulation tool "the TRNSYS expert system". The parameters measured are ambient air temperatures, average radiant temperatures, relative humidity and wind speeds. The results obtained show that in summer conditions, the level of thermal overheating felt is well observed especially in the upper floor. Also, the temperatures of the roof surfaces are the highest and cause the problem of overheating in the houses. In addition, in summer conditions, the design of a double skin roof coupled with a heat reflective paint on the exterior contributes to optimise the thermal performance of the roof and improves the thermal conditions inside the dwellings. This has resulted in a reduction of the internal operating temperature by 5°C and energy consumption by 572kW/h.

16.1.1.2. Thesis 2: « IMPROVING ENERGY PERFORMANCEOF A RESIDENTIAL BUILDING ADAPTED IN SEVERAL ALGERIAN SITES»

Presented by: BOUMEDDINE Fatima Takoua El-Koloub

Our work is part of a comparative study to improve the thermal comfort of a building model in different regions, each representing a different climate zone, thus covering the entire national territory, by insulating the building's envelope using local ecological materials, and studying their effect on heating and air conditioning demands. The simulations performed before and after improvement through Pleiades software, and the thermal balance achieved allowed us to find the most effective methods to improve thermal comfort and identify the needs in heating (winter period) and air conditioning (summer period), in order to minimize energy consumption. In the end, we conclude this research with suggesting the PDEC (Passive Downdraught Evaporative Cooling) system to reach the hygrothermal comfort in the southern regions of the country.

16.2. The articles consulted:

16.2.1.1. Article 1: «Energy performance of assets architectural mozabite»

Presented by: Nora Gueliane

This proposal addresses the bioclimatic aspect of habitat through a study of traditional Mozabite architecture. The question is how can mozabite architecture be useful in the renewable energy sector? We are able to evolve its principles in contemporary solutions? It is therefore a question of studying the Mozabite habitat. To achieve our objectives, we will adopt a qualitative approach. Thus, the tools mobilized for the collection and data analysis are, essentially, literature search. The purpose of this document search is, among other things, to theoretical framework of the subject. We will be particularly concerned about cross different types of approaches and perspectives without

move away from the field and forget to mobilize our architectural skills. We then mobilized other tools such as observation.

16.2.1.2. Article 2: «Comparative bioclimatic approach for comfort and passive heating and cooling strategies in Algeria»

Presented by: S. Semahi, N. Zemmouri, M. Singh and S. Attia

The energy consumption and comfort of buildings are strongly affected by weather conditions. For this reason, the purpose of this article is to analyze the potential climatic zones of Algeria. This analysis was carried out on eight regions representative (Algiers, Guelma, Chlef, Sétif, Biskra, Bechar, Adrar, Tamanrasset –In Guezzam) and based on the ASHRAE 55-2017 model. The assessment of the bioclimatic potential was using the EnergyPlus simulation software. The results of heating and air conditioning have been calculated and compared for each climate zone in order to passive solutions such as passive solar heating, natural ventilation and direct evaporation cooling.

1. Introduction

This chapter is intended for our case study which will be presented thoroughly and the dynamic simulation of the chosen housing for this case , the simulation is done using the software Pleiades + Comfie version 5.23.5.0.

2. Pléiades + Comfie

The software was developed at the end of the 80's at the Energy Center of Paris to address the lack of easy-to-use software that takes into account the dynamics of the building's thermal behaviour. Comfie is developed by the Energy Center of the Ecole des Mines de Paris and the Pléiades interface by IZUBA Energies. Pléiades+Comfie is a combination of two programs. [15]

PLEIADE provides the various calculation modules with an efficient, ergonomic and secure interface, greatly accelerating the entry of a project and the study of its variants. PLEIADE allows the input of the characteristics of the building elements, the detailed description of the building, the launch of the calculations and the analysis of the results. Depending on the calculation module used, PLEIADE can be used, among other things, for bioclimatic design and thermal comfort analysis (COMFIE dynamic thermal simulation engine) with calculation of energy needs and consumption and comfort indicators. [15].

3. METEONORM

The Meteonorm Stations package includes more than 220 additional weather stations (France Belgium, Switzerland, Luxembourg and Maghreb countries) for thermal simulation dynamic. The Pleiades+Comfie software integrates the "Meteocalc" module that allows you to create own weather data for dynamic thermal simulation (STD). Pleiades+Comfie uses meteorological files in TRY format. This software will allow to import (from software such as Meteonorm) or generate weather files.

4. Presentation of the ksar of Beni Isguen

The Ksar of Beni Isguen in the M'Zab valley, 25 km long, is located in a desert site 600 km south of Algiers characterized by a warm and dry climate, it is a limestone plateau cut into valleys and ravines that intersect in the shape of a net.

This valley, forming a homogeneous urban and landscape ensemble consisting of a network of five ksour (traditional cities) and palm groves, covering an area of approximately

6,000 hectares between 32° and 33°20 latitude North and 2°30 longitude East with an altitude of 450 km, and housing a total population of 170,000 inhabitants.

The M'Zab valley, structured around a «Oued», was urbanized according to a territorial structure articulating a model of organization of a singular agro-system, based on the triptych water/ habitat/ palm grove.

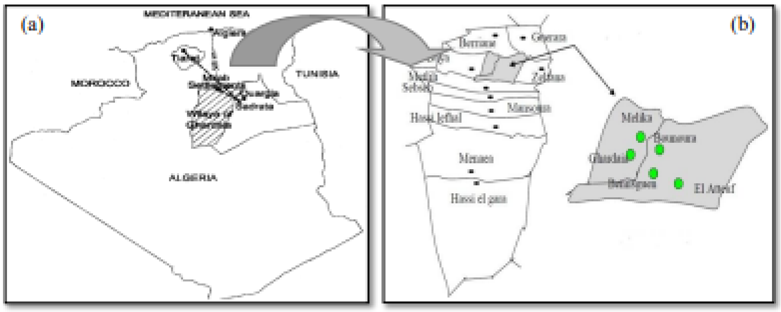

Figure 26 The M'Zab valley

5. The territorial resources of the Ksar

The territory of the Ksar of Beni Isguen has three main resources: the cultural resources, the environmental landscape and a specific local economy. The cultural resources are the most important because they have important potential material and intangible. The material heritage consists mainly of:

- The urbanization system of the territory, structured in city-oasis with management of specific water.
- The architectural heritage Ksourien with its monuments such as mausoleums, defensive systems, cemeteries, etc.
- Intangible heritage mainly includes: crafts, gastronomy and festivals popular (Balalou, 2008).

6. Urbanization mode of Ksar (Association man-culture-climate) :

The founding group chose a site based on the possibilities of military defence and the availability of water resources, a condition that ensures the creation of palm groves essential for human implantation. The size of the ksar and the importance of its built space depend on the soil’s nourishing capacity. When it exceeds the capacity of the mosque, it agrees to build another on top of a piton and to found a new city around (M Chabi & Dahli, 2011). The built space, contained in ramparts, is structured by three artificial and symbolic elements, the well guaranteeing life, the tower guaranteeing the peace and the prayer area for doctrine. Figure IV.6 shows an overview of the Ksar of Beni Isguen.

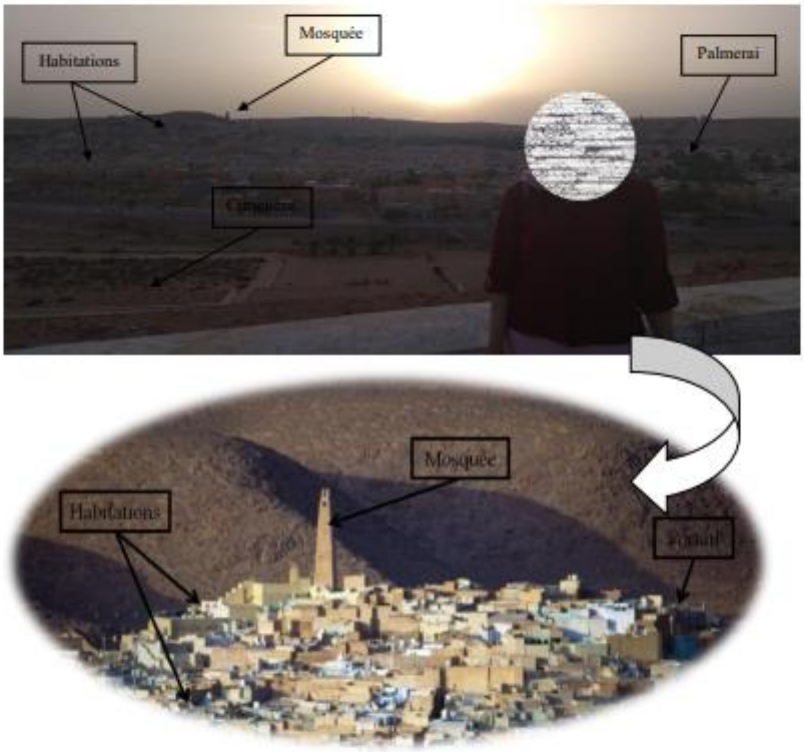

Figure 27 Urbanization mode of Ksar

7. Principle of urban organization of the Ksar

The principle of urbanization of the Ksar of Beni Isguen is linked to the method of implantation built on a piton around a mosque (Mohammed Chabi, 2009). Around the mosque are organized the houses grouped harmoniously arranged in terraces. The logic of the urban implementation of the ksar of Beni Isguen rests on an urban fabric compact with narrow streets (Bouchair et al., 2013).

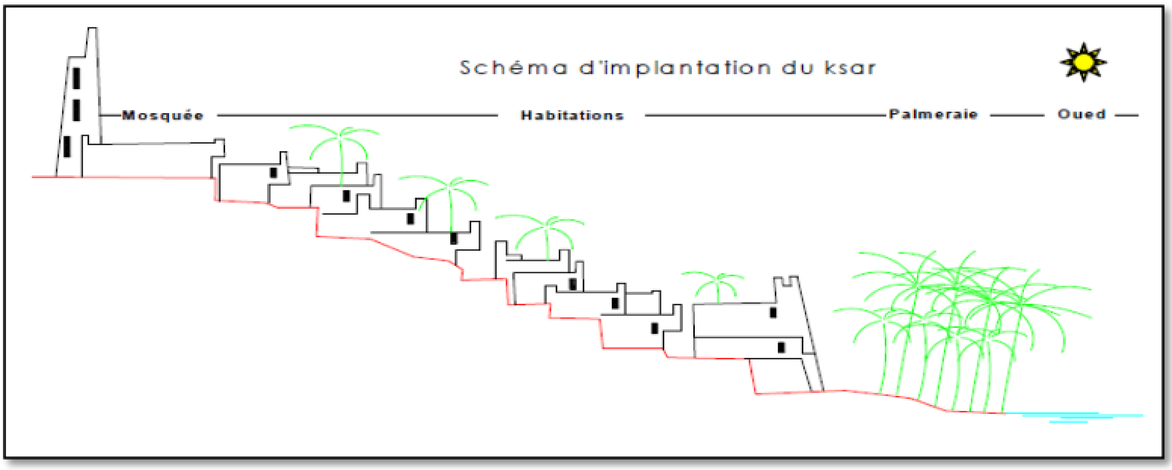

Figure 28 Principle of urban organization of the Ksar

8. The elements of the Ksar

The streets and alleys of the Ksar are traced according to the topography of the land from which the nature and semi-spherical form divide the street structure into two types. The streets ascending towards the mosque have the shape of slopes, embankments and stairs and shaped streets oval and flat that are parallel to the mosque and connect between the east and west sides of the Ksar.

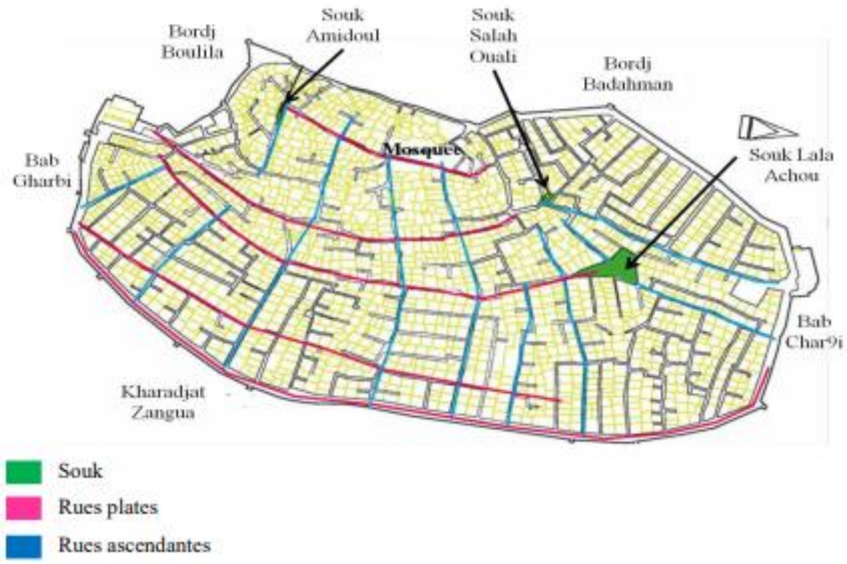

Figure 29 The elements of the Ksar

9. The streets

The streets are simple and narrow; there are two types of streets:

- Shopping streets: are close to the souk, forbidden to women (the woman

Ask a child to do their shopping for privacy reasons).

- Intimate street (hurm): Are next to the houses, around the mosque, the foreigners of the

city never enter.

Figure 30 The streets of Bene Isguen

10. The Alleys

Within cities, traffic is carried out through alleyways, sometimes partially covered, accessible to pedestrians and donkeys. Streets are animated only by the shape and colour of the walls (Didillon & Donnadieu, 1977).

Figure 31 Alleys in Ghardaïa

11. The elements of the house mozabite

Mozabite is characterized by its simplicity and functionality without any superficial decoration. It must not contain any external sign of wealth by principle of equality and social solidarity. The M'Zab house corresponds to the type of house There are two types of houses in the Ksar of Beni Isguen: the one that is integrated into the urban fabric of the Ksar inside the rampart and that of their palm grove or summer house.

Table 1 The elements of the house mozabite

Type of house	Plan	overview
urban house		
House of the palm (house summer)		

12. Chebek in house of the palm

The patio house is a very responsive construction method in the hot and dry climate of the Ksar of Beni Isguen, since the patio has several climatic roles, from which he lets the house ventilate during the night. Indeed, after sunset temperatures drop considerably and create convection currents that replace hot air with fresh air (Bouchair, 2013). The patio is generally covered by the Chebek in the terrace.

Figure 32 Chebek in house of the palm

13. Chebek:

It is a large opening overlooking the outside. It is a hole in the ceiling that plays the role of a lighting and ventilation element and sunshine. It can be opened or covered with canvas as required. It has a rectangular shape and is generally above the central position.

Figure 33 Chebek

14. Construction Materials

Traditional building materials are distinguished, such as load-bearing walls in local stone or earth masonry, traditional floors in palm trunks and branches, or roofs and their sealing traditional sand, traditional lime mortar, two-layer lime milk, coated outside with sand, traditional lime, Timchemt (traditional coating) or openings and façade elements such as loopholes (CasanovasBoixereu, 2012; Didillon & Donnadieu, 1977).

The houses are built with thick walls of high thermal capacity, from locally available materials such as stones, mud and lime.

Figure 34 Traditional building materials

15. Sunshine/orientation and lighting of the Ksourian house

The different spaces of the house are articulated around the patio, based on the principles and customs that reflect the way of life of the Mozambican peoples. For example, the offers the privacy of the interior of the home vis-à-vis the outdoor space. The houses are well suited to enjoy the sun in winter while protecting from aggressive sun rays during the summer.

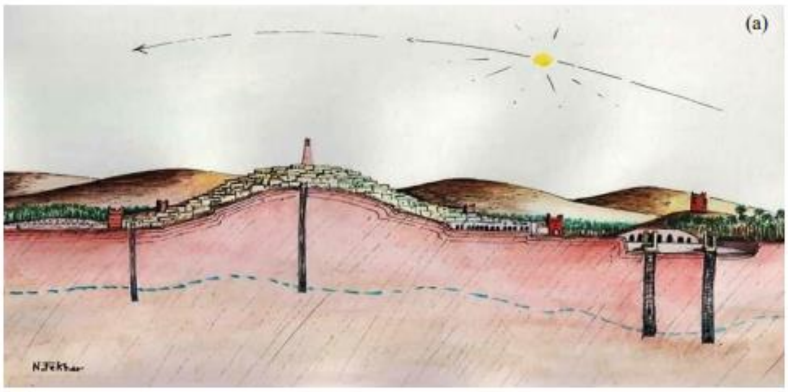

Figure 35 Lighting of the Ksourian house

Natural lighting is done during the day through the patio which is considered the main source of lighting and sunshine of the house. During the days very hot summer period, the Chebek is covered to reduce high solar irradiation and minimize interior glare. The Figure shows orientation and sunshine from the traditional Mozabite house in the Ksar of Beni Isguen.

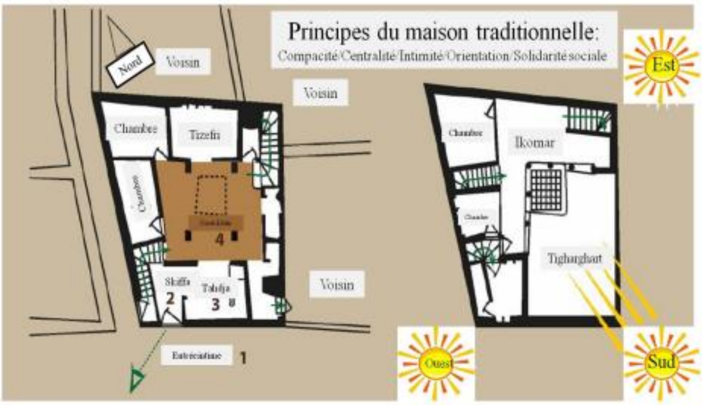

Figure 36 Sunshine from the traditional Mozabite house in the Ksar of Beni Isguen

16. Climate data from the Ksar of Beni Isguen

The Ksar of Beni Isguen in the M'Zab valley is located in the south-east of Algeria. It is one of the Saharan regions characterized by a warm and dry climate. The valley of M'Zab is located 190 km west of the city of Ouargla, 505 km southwest of the city ofBiskra and 550 km south of Algiers. It covers approximately 8,000 square kilometres, between 32° and 33°20 latitude North and 0°4 and 2°30 longitude East with an altitude of 450 km (https://en.wikipedia.org/wiki/Mzab).

Latitude: 32.4 | Longitude: 3.81 | Altitude: 450

Figure 37 Case study schematics

17. Materials Creation

The PLEIADE-COMFIE software has a large database of materials, and even other elements can be integrated through the identification of their thermophysical characteristics.

17.1. Composition of constructive elements

Table 2 Composition of constructive elements

Description	Materials	Conductivity	Thermal Capacity	Density	Thickness
Exterior wall	Hard Stone Lime Mortar Sand	2.4 0.87 0.6	936 1080 823	2350/2580 1800 1300	38 4 2
Interior wall	Hard Stone Lime Mortar Sand	2.4 0.87 0.6	936 1080 823	2350/2580 1800 1300	20 2 2
Ground floor	Palm Tree truck Stone Mortar of Timchemt Clay Lime Mortar	0.122 1.4 0.75 1.15 0.87	3 936 1080 936 1080	850 1840/2340 100/1300 1700/2000 1800	15/20 13 / 10 5
Roof	Palm Tree truck Stone Mortar of Timchemt Clay Lime Mortar	0.122 1.4 0.75 1.15 0.87	3 936 1080 936 1080	850 1840/2340 100/1300 1700/2000 1800	15/20 13 / 10 5

18. Definition of scenarios in Pléiades

Before running the simulations, we model the scenarios that show the internal gains (heat sources related to the indoor environment from occupants, lighting, electrical appliances or water evaporation). Hourly scenarios can be defined over a whole year for temperature instructions, occupations, power dissipated by equipment, glazing occultations, ventilations, etc. [16]

18.1. Occupancy scenarios

The occupancy scenario: allows to determine the number of users of the dwelling as well as the rate of occupancy of the space per hour, the purpose of this scenario is to determine the internal inputs produced by the occupants of the studied dwelling.

For our simulation, we decided to perform different occupation scenarios for each zone according to the occupation of the space per hour:

Number of occupants: 05 people.

Values

S	Name	Value	Unit
	Value	5	Occupants
	Value 1	0	Occupants

Days

S	Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Day	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	5	0	0
	weekend	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	5	5	5	0	0

Weeks

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Semaine	Day	Day	Day	Day	weekend	weekend	Day

Figure 38 Occupancy scenarios 1

Values

S	Name	Value	Unit
○	Value	2	Occupants
○	Value 1	1	Occupants
○	Value 2	0	Occupants

Days ☐ Display name

S	Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
○	Day	2	2	2	2	2	2	2	2	0	0	0	0	0	1	1	1	0	1	1	0	2	2	2	2
○	weekend	2	2	2	2	2	2	2	2	1	1	0	0	0	1	2	2	0	1	1	0	0	1	1	2

Weeks

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Semaine	Day	Day	Day	Day	weekend	weekend	Day

Figure 39 Occupancy scenarios 2

Values

S	Name	Value	Unit
○	Value	2	Occupants
○	Value 1	0	Occupants

Days ☐ Display name

S	Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
○	Day	2	2	2	2	2	2	2	2	0	0	0	0	0	2	0	0	0	0	2	2	0	0	2	2
○	weekend	2	2	2	2	2	2	2	2	2	2	0	0	0	2	2	2	0	0	2	2	0	0	2	2

Weeks

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Semaine	Day	Day	Day	Day	weekend	weekend	Day

Figure 40 Occupancy scenarios 3

Values

S	Name	Value	Unit
	Value	1	Occupants
	Value 1	0	Occupants

Days Display name

S	Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Day	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1
	weekend	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	1

Weeks

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Semaine	Day	Day	Day	Day	weekend	weekend	Day

Figure 41 Occupancy scenarios 4

18.2. Dissipated power scenario

This scenario makes it possible to determine the heat emitted by electrical appliances for dynamic thermal simulation and always with the aim of identifying internal inputs.

Values

S	Name	Value	Unit
	Réduit	1.14	W/m²
	Normal	5.70	W/m²

Days Display name

S	Name	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Ouvré	.14	.14	.14	.14	.14	.14	.70	.70	.70	.70	.14	.14	.14	.14	.14	.14	.14	.14	.70	.70	.70	.70	.14	1.14
	Mercredi	.14	.14	.14	.14	.14	.14	.70	.70	.70	.70	.14	.14	.14	.14	.70	.70	.70	.70	.70	.70	.70	.70	.14	1.14
	Week-end	.14	.14	.14	.14	.14	.14	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70	.14	1.14

Weeks

Name	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Semaine	Ouvré	Ouvré	Mercredi	Ouvré	Week-end	Week-end	Ouvré

Figure 42 Dissipated power scenario

18.3. Proposed ventilation Scenario

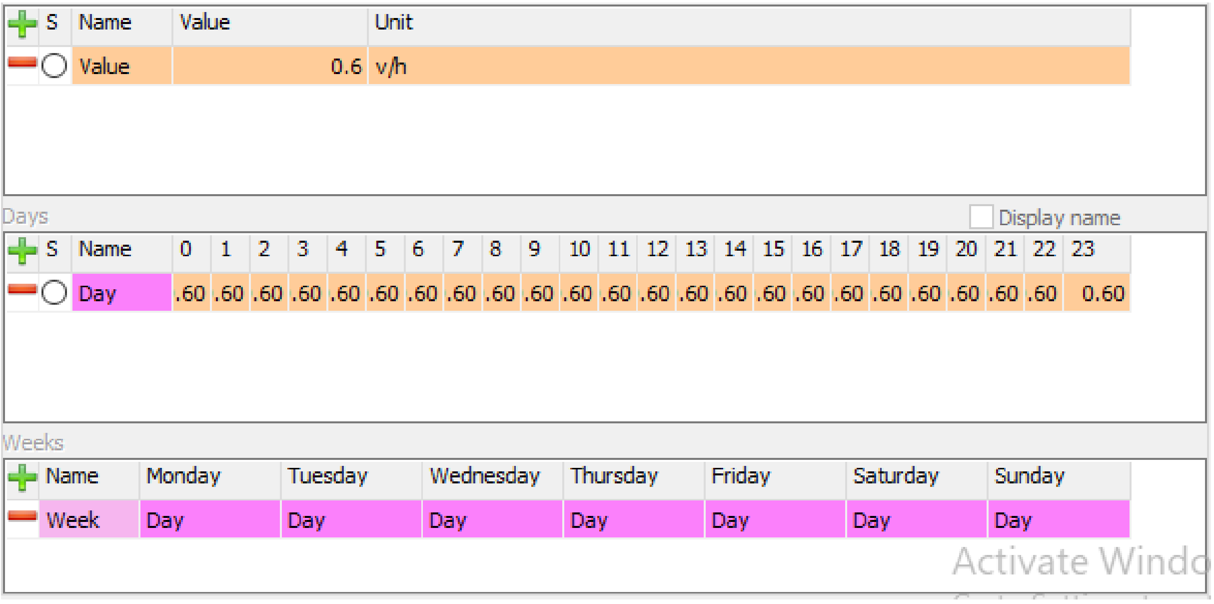

Figure 43 ventilation Scenario

19. Creating a weather file

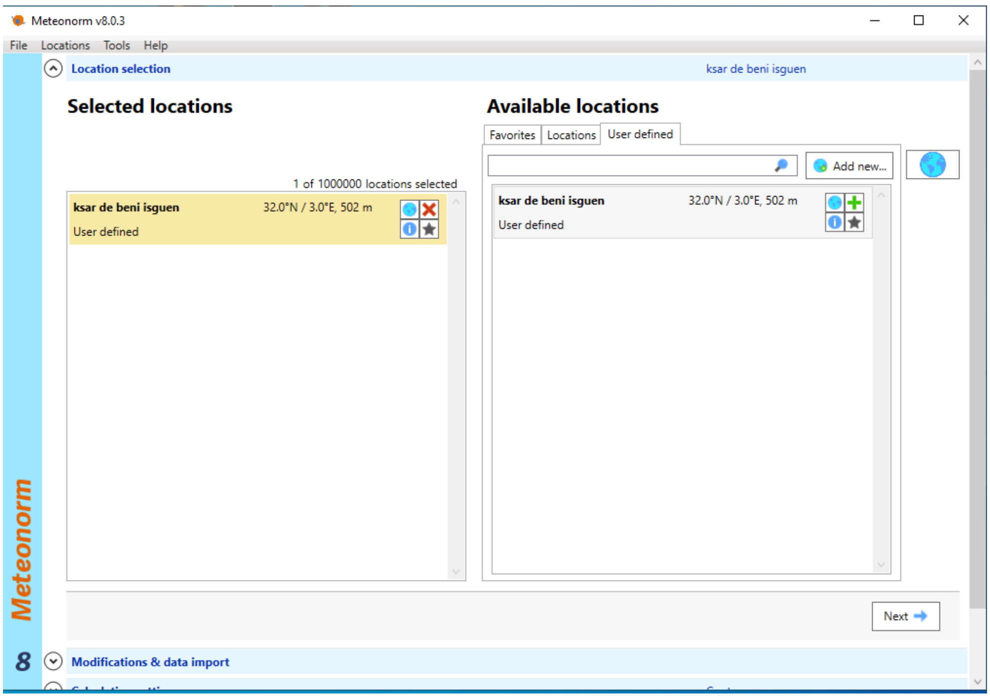

Figure 44 METEONORM Interface

	Gh kWh/m²	Dh kWh/m²	Bn kWh/m²	Ta °C	Td °C	FF m/s
January	110	28	186	11.2	0.6	3.4
February	122	37	163	13	-0.5	3.9
March	170	56	185	17.4	1.1	4.1
April	197	68	191	21.7	2.9	4.5
May	214	88	175	26.4	4.8	4.4
June	226	87	184	31.5	7.1	3.9
July	234	86	196	35.3	8.6	3.5
August	214	84	176	34	9.9	3.3
September	168	66	155	29.1	10.4	3.2
October	147	50	170	23.5	8.4	2.9
November	119	25	193	16.2	4.4	3.1
December	100	26	173	12.1	2.4	3.3
Year	2021	700	2145	22.6	5	3.6

Figure 45 METEONORM Temperature Data

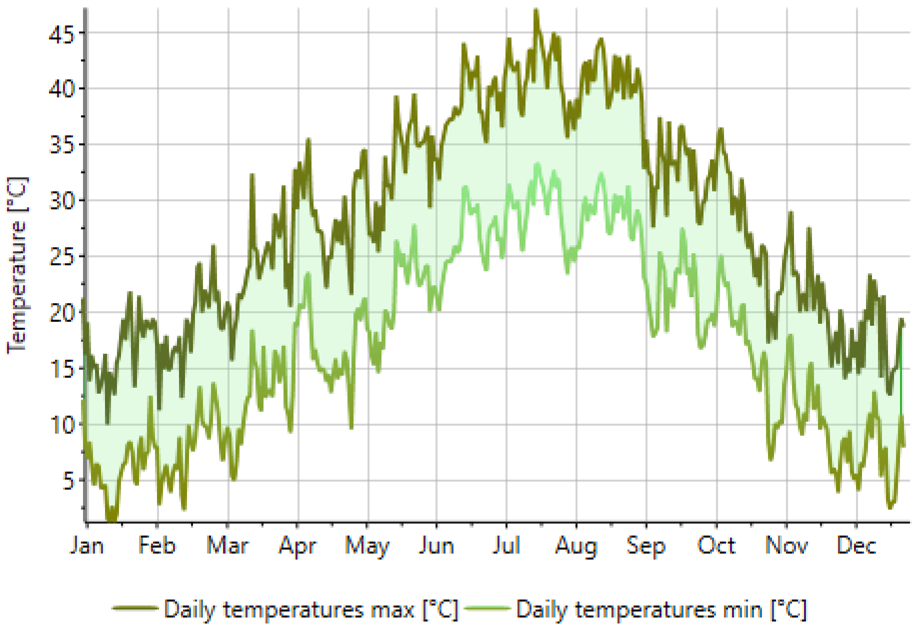

Figure 46 Temperature chart METEONORM

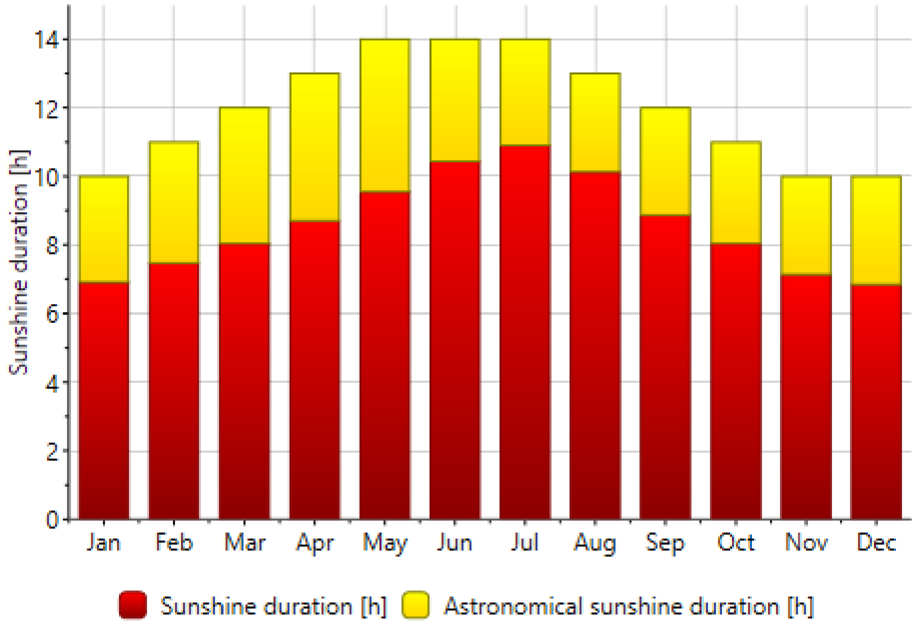

Figure 47 Sunshine duration

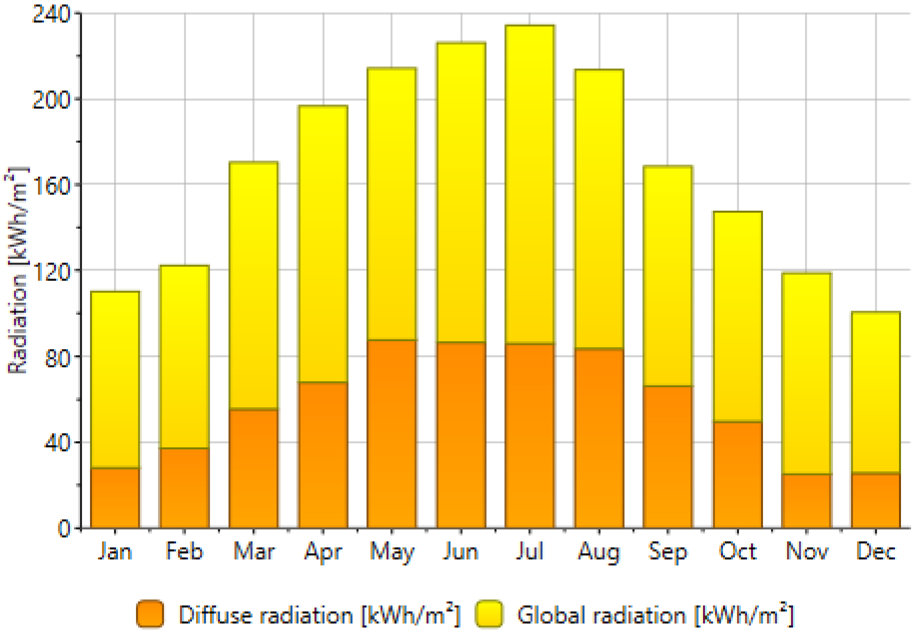

Figure 48 Radiation Chart

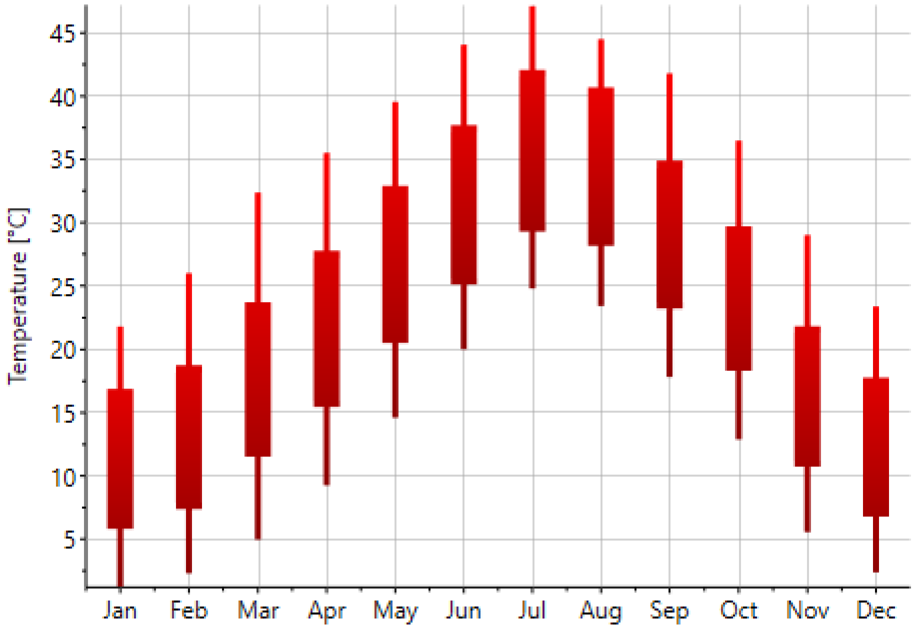

Figure 49 Temperature candle chart

20. Launch of the simulation

Finally, the simulation can be started, the results will be displayed in the next chapter.

21. Conclusion

In this chapter we have defined the dynamic thermal simulation, presented the process of operation of the software, also describes all the scenarios performed.

In the next chapter we will present the results and discussions obtained after launching the simulations established by the Pléiades software.

1. Introduction

Due to the cost and experimental times, simulation is an effective way to develop and study the thermal behavior of buildings in variable conditions. But is necessary to know what you are looking for in order to use the tool optimally.

2. Simulation goal

The goal of our simulation is to determine the effect of alleys in providing protection from direct exposer to the sun and providing cooling using the air that runs through those alleys.

The distance between houses plays a big role in cooling and proving shade from the sun, hence we will be running our first simulation without any neighbors, then with neighbors and with different alleys width and see which width provide the best results in reducing the house's temperature and compare it to the real-life width.

3. Simulations of house in the various study cases

3.1. Simulation 1 (Direct exposer to the sun)

Figure 50 Simulation Plan 3D

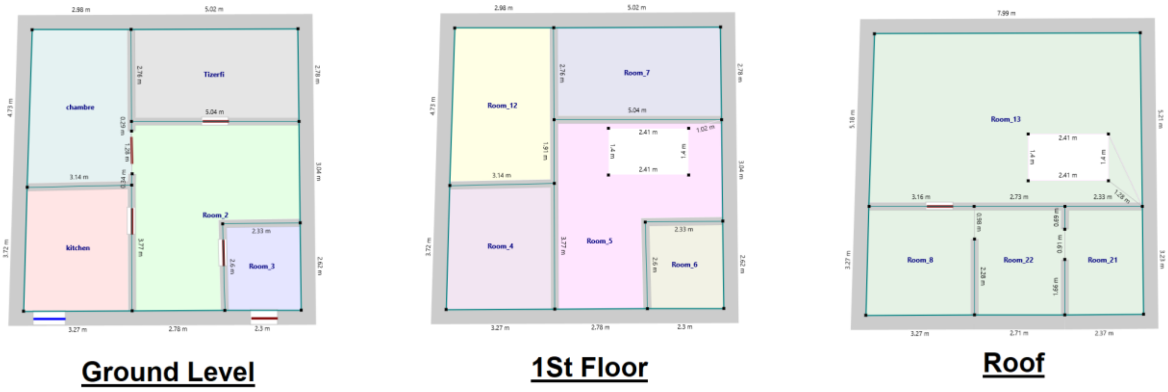

Figure 51 Simulation Plan 2D

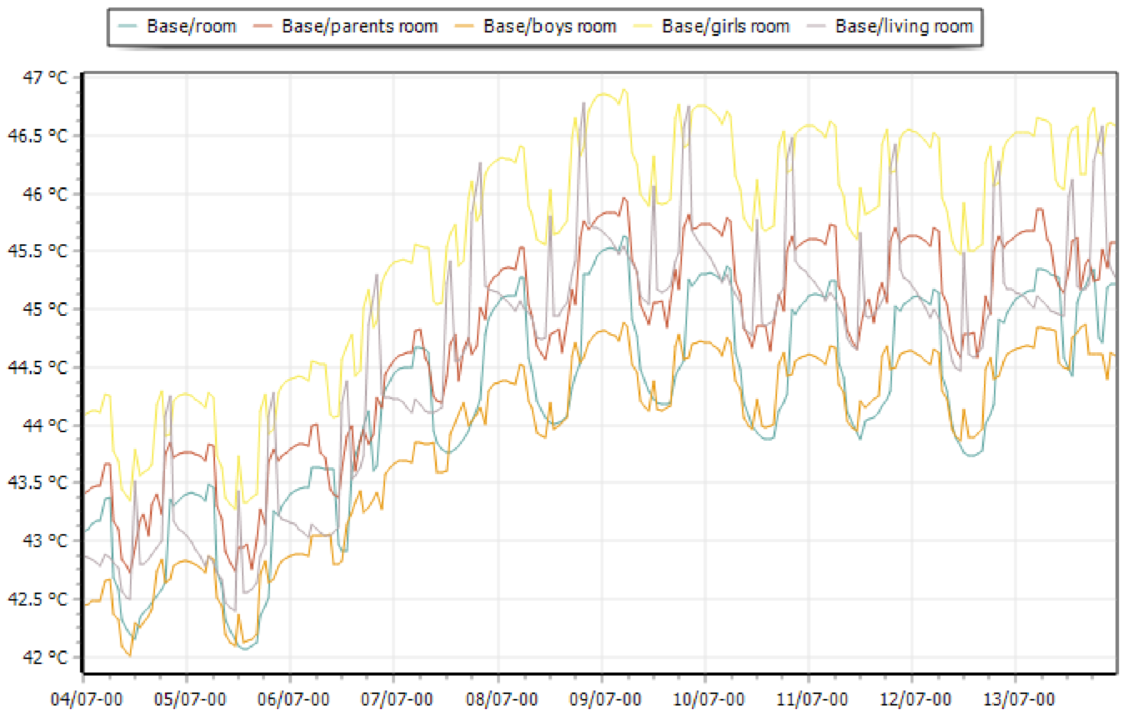

Figure 52 Temperature Direct exposer to the sun No cooling

Zones names	Heating Load	Heating Load	Cooling Load	Cooling Load	Heat. Power	Cool. Power	T° Min	T° Average	T° Max
	kWh	kWh/m²	kWh	kWh/m²	W	W	°C	°C	°C
Total	0	0	12 029	174	0	18 738	14.5	28.1	43.8
Zone 1	**0**	**0**	0	0	**0**	0	**14.5**	**29.2**	**43.8**
kitchen	0	0	0	0	0	0	15.6	28.3	40.4
hall	0	0	0	0	0	0	15.6	28.2	41.2
lobby	0	0	0	0	0	0	14.8	28.8	41.5
room	0	0	2 641	180	0	**4 396**	15.4	26.6	42.3
parents room	0	0	2 024	140	0	3 620	16.4	27.1	42.6
boys room	0	0	1 936	161	0	3 013	16.3	26.8	41.6
girls room	0	0	2 485	177	0	3 505	16.1	27.0	43.6
closet	0	0	0	0	0	0	15.3	28.8	41.8
lobby 01	0	0	0	0	0	0	16.1	28.1	41.8
living room	0	0	**2 944**	**210**	0	4 206	15.4	26.5	43.6

Figure 53 Simulation Results 1 With cooling

3.1.1.1. Discussion

The first simulation results indicates that the temperature reaches 47 degrees Celsius inside some of the areas inside the house without cooling, even with cooling we notice that the average temperature fluctuates around 27 degrees with a total of 12.029kWh of cooling load.

3.2. Simulation 2 (With neighbors 0m apart)

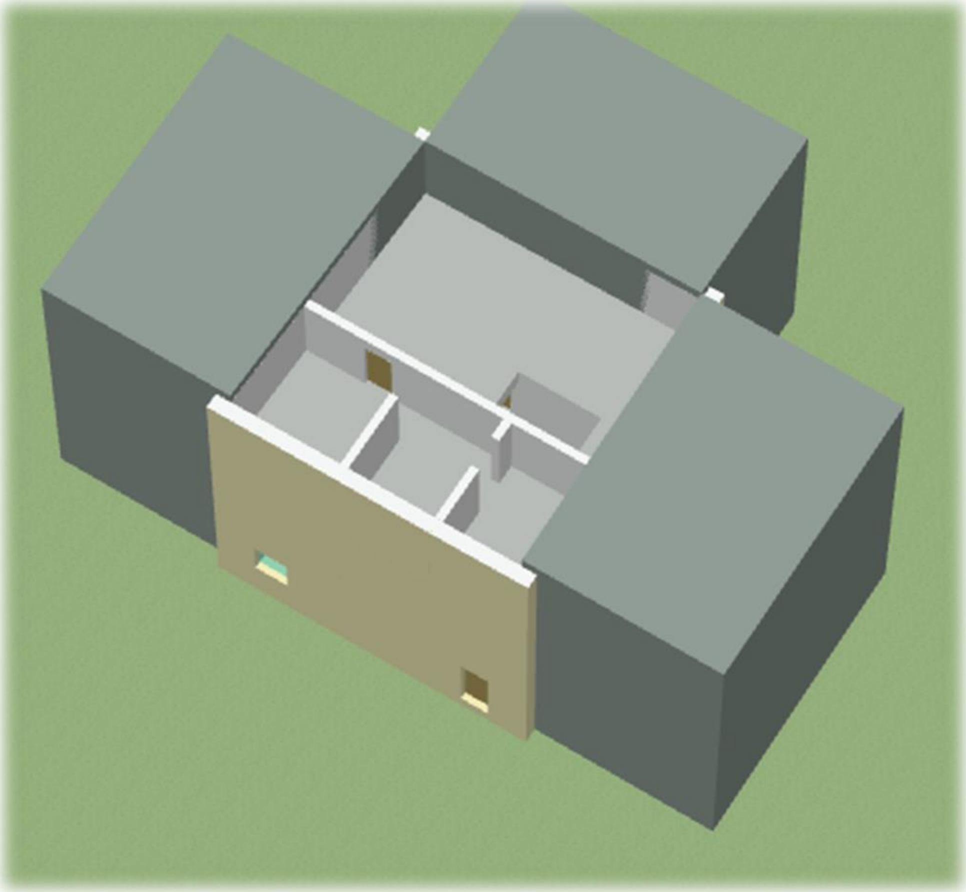

Figure 54 Simulation Plan 3D with neighbors 0m

Zones names	Heating Load	Heating Load	Cooling Load	Cooling Load	Heat. Power	Cool. Power	T° Min	T° Average	T° Max
	kWh	kWh/m²	kWh	kWh/m²	W	W	°C	°C	°C
Total	0	0	11 185	162	0	18 636	14.0	27.0	42.6
Zone 1	**0**	**0**	0	0	**0**	0	14.2	**28.6**	**42.6**
kitchen	0	0	0	0	0	0	14.6	27.1	38.2
hall	0	0	0	0	0	0	14.7	26.8	37.9
lobby	0	0	0	0	0	0	**14.0**	27.4	39.3
room	0	0	2 443	167	0	**4 293**	14.1	25.2	39.1
parents room	0	0	1 950	135	0	3 620	15.4	25.9	40.0
boys room	0	0	1 956	162	0	3 013	15.5	25.9	39.7
girls room	0	0	2 289	163	0	3 505	15.1	25.8	40.1
closet	0	0	0	0	0	0	14.5	27.4	38.9
lobby 01	0	0	0	0	0	0	15.2	26.8	38.9
living room	0	0	**2 547**	**182**	0	4 206	14.3	25.1	39.3

Figure 55 Simulation Plan 3D with neighbors 0m results

3.3. Simulation 3 (With neighbors 1m apart)

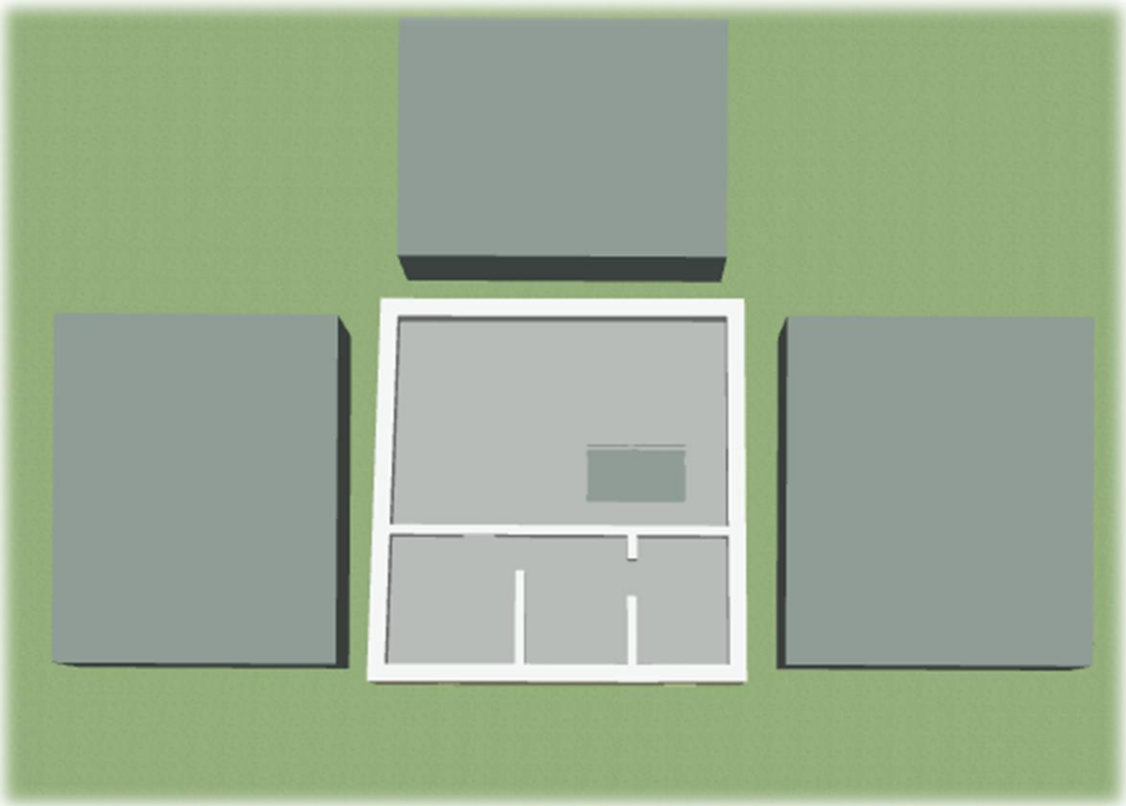

Figure 56 Simulation Plan 3D with neighbors 1m

Zones names	Heating Load	Heating Load	Cooling Load	Cooling Load	Heat. Power	Cool. Power	T° Min	T° Average	T° Max
	kWh	kWh/m²	kWh	kWh/m²	W	W	°C	°C	°C
Total	0	0	10 702	155	0	18 525	13.4	26.5	41.0
Zone 1	**0**	**0**	0	0	**0**	0	**13.4**	**27.5**	**41.0**
kitchen	0	0	0	0	0	0	14.3	26.9	38.0
hall	0	0	0	0	0	0	14.6	26.6	37.5
lobby	0	0	0	0	0	0	14.0	27.2	38.9
room	0	0	2 402	164	0	**4 251**	13.8	25.0	38.9
parents room	0	0	1 862	129	0	3 620	14.8	25.5	39.2
boys room	0	0	1 887	157	0	3 013	15.0	25.6	39.1
girls room	0	0	2 100	150	0	3 505	14.7	25.4	38.9
closet	0	0	0	0	0	0	14.4	27.0	38.0
lobby 01	0	0	0	0	0	0	14.9	26.4	38.0
living room	0	0	**2 451**	**175**	0	4 137	14.2	24.9	39.0

Figure 57 Simulation Plan 3D with neighbors 1m results

3.4. Simulation 4 (With neighbors 2m apart)

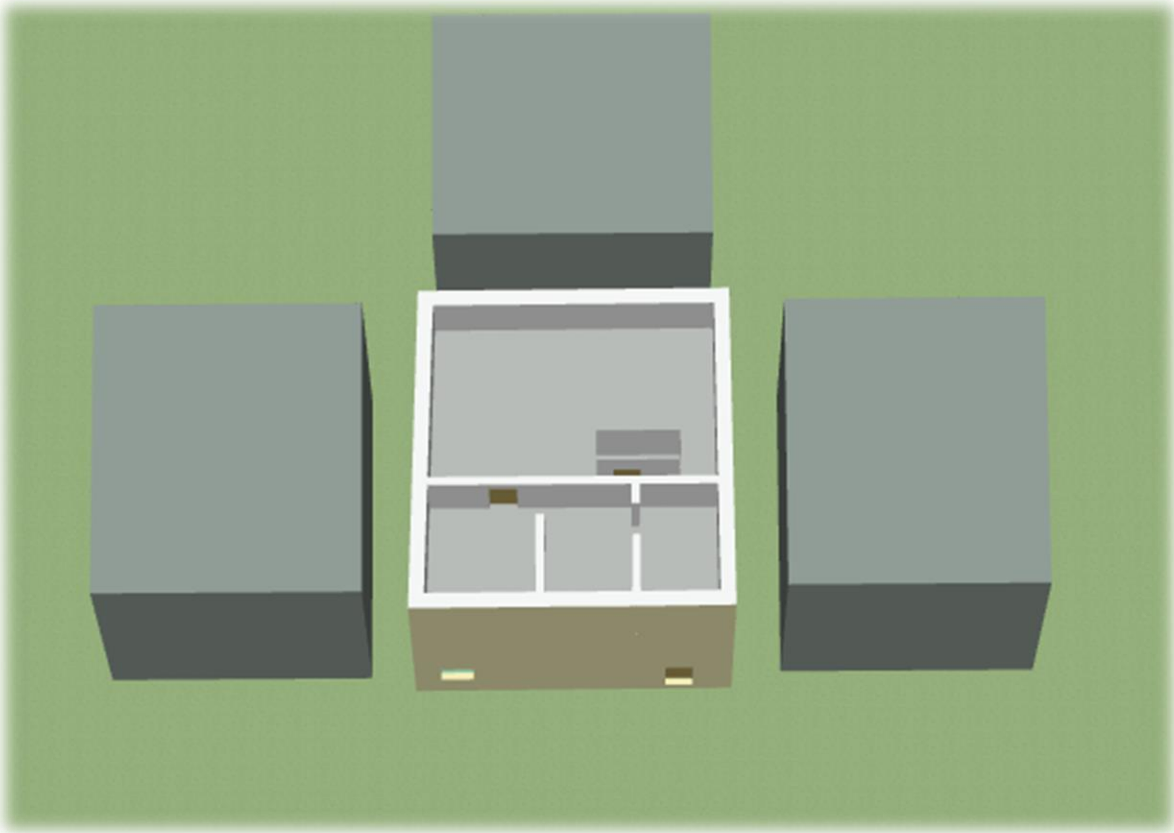

Figure 58 Simulation Plan 3D with neighbors 2m

Zones names	Heating Load	Heating Load	Cooling Load	Cooling Load	Heat. Power	Cool. Power	T° Min	T° Average	T° Max
	kWh	kWh/m²	kWh	kWh/m²	W	W	°C	°C	°C
Total	0	0	10 987	159	0	18 657	13.9	26.8	41.9
Zone 1	**0**	**0**	0	0	**0**	0	**13.9**	**28.1**	**41.9**
kitchen	0	0	0	0	0	0	14.5	27.1	38.2
hall	0	0	0	0	0	0	14.8	26.8	37.7
lobby	0	0	0	0	0	0	14.2	27.4	38.9
room	0	0	2 483	170	0	**4 330**	14.0	25.2	39.2
parents room	0	0	1 944	134	0	3 620	15.0	25.8	39.6
boys room	0	0	1 913	159	0	3 013	15.1	25.7	39.4
girls room	0	0	2 154	154	0	3 505	14.9	25.6	39.2
closet	0	0	0	0	0	0	14.5	27.3	38.3
lobby 01	0	0	0	0	0	0	15.1	26.6	38.3
living room	0	0	**2 493**	**178**	0	4 190	14.3	25.1	39.2

Figure 59 Simulation Plan 3D with neighbors 2m results

3.5. Simulation 5 (With neighbors 3m apart)

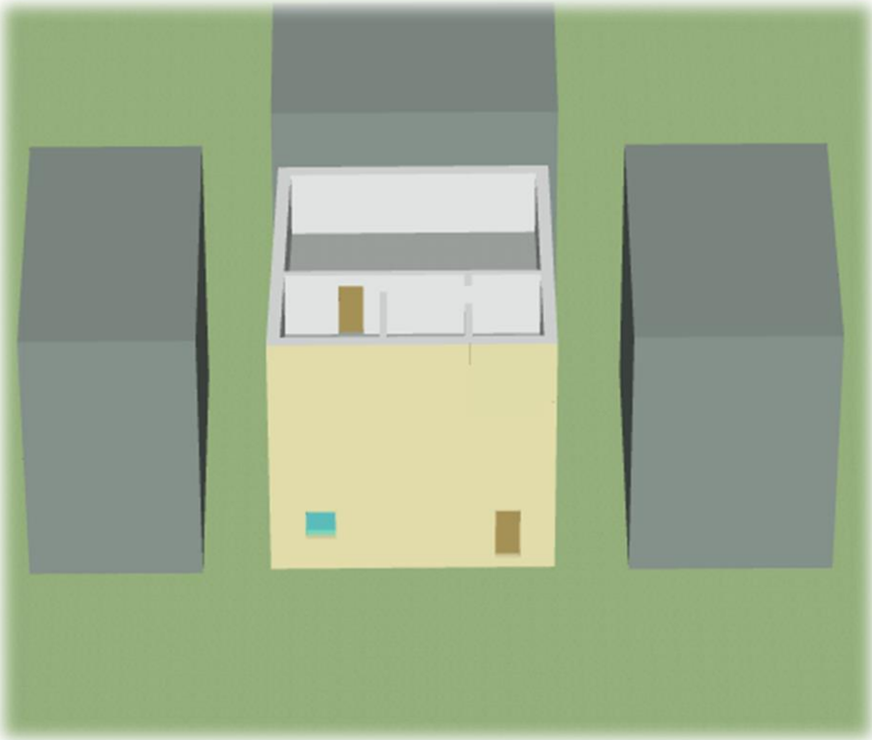

Figure 60 Simulation Plan 3D with neighbors 3m

Zones names	Heating Load	Heating Load	Cooling Load	Cooling Load	Heat. Power	Cool. Power	T° Min	T° Average	T° Max
	kWh	kWh/m²	kWh	kWh/m²	W	W	°C	°C	°C
Total	0	0	11 137	161	0	18 684	14.0	27.0	42.4
Zone 1	**0**	**0**	0	0	**0**	0	14.1	**28.4**	**42.4**
kitchen	0	0	0	0	0	0	14.5	27.1	38.3
hall	0	0	0	0	0	0	14.8	26.9	37.8
lobby	0	0	0	0	0	0	14.2	27.5	39.0
room	0	0	2 505	171	0	**4 346**	**14.0**	25.3	39.3
parents room	0	0	1 977	137	0	3 620	15.2	25.9	39.9
boys room	0	0	1 937	161	0	3 013	15.3	25.8	39.5
girls room	0	0	2 205	157	0	3 505	15.1	25.7	39.5
closet	0	0	0	0	0	0	14.6	27.5	38.5
lobby 01	0	0	0	0	0	0	15.2	26.7	38.5
living room	0	0	**2 513**	**179**	0	4 201	14.4	25.1	39.3

Figure 61 Simulation Plan 3D with neighbors 3m results

3.5.1.1. Discussion

Simulation with neighbors located 0 meters apart: The indoor temperature fluctuated around 27 degrees Celsius, indicating some level of insulation provided by the neighboring buildings. However, the cooling load remained high at 11,185 kWh, suggesting the continuous need for cooling.

Simulation with neighbors located 1 meter apart: With a 1-meter gap, the temperature fluctuations inside the house consistently remained below 27 degrees Celsius. This gap acted as a sunshade and allowed for the circulation of cold air, reducing the cooling load to 10,702 kWh.

Simulations with neighbors located 2 meters and 3 meters apart: As the distance increased, the insulation effect diminished, leading to higher temperature fluctuations above 27 degrees Celsius. The cooling loads for these simulations were relatively similar at 10,987 kWh and 11,137 kWh.

4. Conclusion

1-meter gap between the house and neighbors showed improved thermal comfort by acting as a sunshade and facilitating air circulation. Increasing the distance beyond 1 meter resulted in reduced insulation effect. Further optimization can be explored to find the best balance between thermal insulation, energy efficiency, and occupant comfort.

General Conclusion

Based on the simulations conducted for a house in Beni Isguen, Ghardai, Algeria, using the Pleiades software, several important conclusions can be drawn regarding the impact of neighboring buildings and their distance on the thermal comfort and cooling load of the house.

Firstly, in the simulation without any neighbors, the extreme heat of the region resulted in the indoor temperature reaching around 47 degrees Celsius, posing a significant challenge for maintaining a comfortable environment without a cooling system in place. This demonstrates the urgent need for effective cooling methods in such climates.

Secondly, when simulating the house with neighbors located 0 meters apart, it was observed that the temperature inside the house fluctuated around 27 degrees Celsius. This suggests that the presence of neighboring buildings provided some level of insulation, shielding the house from direct sunlight and reducing the temperature fluctuations. However, it is important to note that the cooling load remained quite high at 11,185 kWh, indicating that continuous cooling is required to maintain a comfortable indoor temperature.

However, when the distance between the house and neighbors increased to 1 meter, the simulations revealed a significant improvement in thermal comfort. The temperature fluctuations inside the house were consistently kept below 27 degrees Celsius. This can be attributed to the 1-meter gap acting as a sunshade, preventing direct exposure to the intense sunlight. Furthermore, this gap provided an effective means for cold air circulation around the house, contributing to the cooling effect. As a result, the cooling load was reduced to 10,702 kWh, which indicates improved energy efficiency compared to scenarios where the neighbors were closer.

In contrast, simulations with neighbors located 2 meters and 3 meters apart observed temperature fluctuations that exceeded 27 degrees Celsius. This suggests that as the distance from the neighboring buildings increases, the insulation effect diminishes, leading to a decrease in thermal comfort. The cooling loads for these scenarios remained relatively similar at 10,987 kWh and 11,137 kWh, indicating a slight increase compared to the 1-meter gap simulation.

In conclusion, the simulations highlight the significance of considering the proximity of neighboring buildings and their distance as crucial factors affecting the thermal comfort and cooling load of a house in Beni Isguen, Ghardai, Algeria. The 1-meter gap between the house and neighbors played a vital role as a sunshade, effectively shielding the house from direct sunlight. Additionally, this gap facilitated the circulation of cold air around the house, enhancing the cooling effect. Further research and exploration of improved insulation techniques and cooling systems are important to reduce cooling loads and enhance energy efficiency in such climates.

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