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The integration of geothermal energy for an ecotourism village

case study (Hammam Ouled Ali, Guelma)

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option: architecture, environment and technology

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بسم الله الرحمان

الرحيم

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Dedication

I dedicate this humble and modest work with great love, sincerity and pride:

To my dearest mother

Whatever I do or say, I will never be able to thank you properly. Your affection covers me, your kindness guides me, and your presence at my side has always been my source of strength to face various obstacles.

To the memory of my beloved father
Though you are no longer with us, your support and comfort continue to echo in my heart. May this work be a tribute to the love and guidance you gave me To my dearest sister Wissal and my brother Mouhaned

To all the members of My family.

To all my friends, all my teachers

And to all who consult this modest work.

ملخص

يهدف هذا العمل إلى تقديم نظام بيئي جديد لم يتم تطبيقه مسبقًا في الجزائر، وخاصة في ولاية قالمة، حيث تعُد منطقة حمام أولاد علي من المناطق المعروفة بوفرة الينابيع الحارة وبإمكاناتها الجوفية الحرارية المتميزة، والتي تتسم بارتفاع التدرج الحراري الأرضي، مما يجعلها مناسبة للاستخدامات العلاجية الحرارية. وتتميز المنطقة بمناخ شبه جاف، يكون معتدلًا وماطرًا في الشتاء وحارًا في الصيف، مما يجعلها موقعًا مثاليًا لأنظمة الطاقة المستدامة التي توفر التدفئة والتبريد معًا.

وفي هذا السياق، يقترح المشروع تطبيق نظام Geogrid، وهو نظام توزيع طاقوي يعتمد على الطاقة الجوفية ويستخدم حرارة الأرض لتدفئة وتبريد المنازل. وقد تم تصميم هذا النظام لخدمة قرية سياحية بيئية صغيرة مكونة من عدة منازل سياحية صديقة للبيئة، حيث يتم ربط جميع الوحدات السكنية في شبكة واحدة، مما يوفر مرونة وكفاءة أكبر مقارنة بالأنظمة الجوفية المنعزلة والفردية.

ولتأكيد فعالية هذا النظام في تحسين درجة حرارة الهواء الداخلي، تم استخدام برنامج DesignBuilderحيث تم اختيار مواد بناء خاصة) مثل الزجاج الحراري لزيادة فوائده. أظهرت النتائج أن درجة حرارة الهواء داخل منازل سياحية تبقى ضمن المعدل المثالي بين 20و24 درجة مئوية طوال العام، وهو ما يضمن راحة حرارية للمقيمين.

ومن خلال هذه النتائج، يمكننا القول إن السكان لن يحتاجوا لاستخدام أي مصادر طاقة أخرى للتدفئة أو التبريد، مما يؤدي إلى تقليص كبير في استهلاك الطاقة، ويؤكد ملاءمة الطاقة الجوفية لتطبيقات السياحة البيئية في المناخات شبه الجافة مثل مناخ حمام أولاد علي. ويسلط هذا المشروع الضوء على الإمكانيات الحرارية الجوفية غير المستغلة في الجزائر ويدعم التنمية المستدامة للسياحة الريفية من خلال دمج تقنيات الطاقة النظيفة والمتجددة.

Abstract

This work aims to introduce a new ecological system that has not been previously applied in Algeria especially in the Guelma and one of its regions that renowned for its abundance of natural hot springs is hammam Ouled Ali and its remarkable geothermal potential which is characterized by its high geothermal gradient for thermal therapeutic uses. The region is characterized by a semi-arid climate; this climate is mild and rainy in winter and hot in summer. Making it an ideal location for sustainable energy systems that provide both heating and cooling.

In this context, the project proposes the implementation of Geogrid, a geothermal district system that uses the earth below our feet to heat and cool the home. this system is designed to serve a small-scale eco-touristic village comprising a number of environmentally friendly bungalows where it Interconnects all bungalows in the village, provides greater resiliency and cost-effectiveness than individual and isolated geothermal systems.

to confirm the suitability of geothermal energy performance in optimizing indoor temperature we used design builder software where specific building materials were selected to maximize its benefits (thermochromic glazing), the results showed that after the installation of this system the temperature of the air is in the ideal average between 20 and 24 all the year, well within the comfort zone for occupants.

from this resalts we can say that the occupants will not use any other energy resources for both heating and cooling that means a significant reduction in energy consumption, confirming the suitability of geothermal energy for eco-tourism applications in semi-arid climates like that of Hammam Ouled Ali. This project not only highlights geothermal potential in Algeria but also supports the sustainable development of rural tourism through the integration of clean, renewable energy technologies.

Résume

Ce travail vise à introduire un nouveau système écologique qui n'a pas encore été appliqué en Algérie, en particulier dans la wilaya de Guelma, notamment dans la région de Hammam Oulad Ali, réputée pour son abondance de sources chaudes naturelles et son potentiel géothermique remarquable, caractérisé par un gradient géothermique élevé, utilisé à des fins thérapeutiques. La région se caractérise par un climat semi-aride, doux et pluvieux en hiver, chaud en été, ce qui en fait un lieu idéal pour les systèmes énergétiques durables assurant à la fois le chauffage et le refroidissement.

Dans ce contexte, le projet propose l'implémentation du système Geogrid, un réseau géothermique collectif utilisant la chaleur du sous-sol pour chauffer et rafraîchir les habitations. Ce système est conçu pour desservir un petit village écotouristique composé de plusieurs bungalows respectueux de l'environnement. Il connecte tous les logements entre eux, offrant ainsi une meilleure résilience et une rentabilité supérieure par rapport aux systèmes géothermiques individuels et isolés.

Afin de confirmer la performance du système géothermique dans l'optimisation de la température intérieure, une simulation a été réalisée à l'aide du logiciel Design Builder. Des matériaux spécifiques ont été sélectionnés, notamment le verre thermochromique, pour maximiser les bénéfices. Les résultats ont montré qu'après l'installation du système, la température intérieure de l'air se maintient entre 20 et 24°C tout au long de l'année, ce qui reste bien dans la zone de confort pour les occupants.

Ces résultats permettent d'affirmer que les habitants n'auront plus besoin d'utiliser d'autres sources d'énergie pour le chauffage ou le refroidissement, ce qui représente une réduction significative de la consommation énergétique. Cela confirme la pertinence de l'énergie géothermique pour les applications écotouristiques dans des climats semi-arides comme celui de Hammam Oulad Ali. Ce projet met en lumière le potentiel géothermique inexploité en Algérie et soutient le développement durable du tourisme rural à travers l'intégration de technologies propres et renouvelables.

Key words: Eco tourism, Ecovillage, geo thermal, Canadian wells, guelma, Findhorn ecovillage

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Abbreviation list

PEX – *Cross-Linked Polyethylene*

EPDM – *Ethylene Propylene Diene Monomer*

HDPE – *High-Density Polyethylene*

PE-R – *Raised Temperature Polyethylene (PE-RT)*

GHP – *Geothermal Heat Pump*

LPG – *Liquefied Petroleum Gas*

PV – *Photovoltaic*

AES – *Appreciated Energy System*

General Introduction

Nowadays, environmental and climate protection, as well as sustainable development become more widely discussed issues, in which both developed and developing countries pay attention on how to integrate underground geothermal infrastructure in their systems1. Generally, it can be stated that renewable energy source plants or heating plants emit far less carbon dioxide during their life cycle than the ones that operate on a fossil basis 2. The conventionally exploitable fossil fuel reserves are rapidly diminishing, so sustainability is threatened. The widespread exploitation of renewable energy sources can serve as a partial solution to both concerns. However, technology must be cost-effective and reliable for such investments. This depends on geographical location, environmental capabilities, and needs as well.

Interest in the urban challenges raised by the growing debates on sustainable development, the demographic growth continues to surge leaded to increase the needs of energy and global environmental change has increased very rapidly in recent years. Sustainable urban development, particularly through the implementation of sustainable houses, has emerged as a key solution to these challenges

Since gaining independence, the Algerian government has focused on providing housing for its growing population, prioritizing rapid construction over environmental and landscape considerations and over the tourism because Tourism in Algeria is underdeveloped despite its rich cultural heritage and landscapes. Security concerns, poor infrastructure, and limited government investment have hindered growth, as the country prioritizes fossil fuels for reliable income over tourism. The extensive reliance on fossil fuel industries to power these developments and meet the country's energy demands has further exacerbated environmental issues.

The first solution we can think about to solve these problems is the renewable energy where there are different solutions available, such as solar and wind, but geothermal energy stands out as the best choice for Guelma due to its rich natural hot springs. Tapping into this geothermal potential can provide clean, sustainable energy; Guelma’s hot springs as hammam OULAD ALI offer an opportunity to develop eco-friendly tourism by the construction of an ecotourism village, attracting visitors while supporting both energy production and local economic growth.

This dual benefit makes geothermal energy an ideal solution for addressing the region’s energy and tourism challenges.

Problem statement

The integration of geothermal energy in a tourist eco-village presents a significant opportunity to address the dual challenges of rising energy demands and environmental sustainability. As the global population increases and tourism expands, traditional energy sources contribute to deplete natural resources. In regions like Guelma, Algeria, the lack of sustainable energy solutions not only threatens local ecosystems but also hinders the development of a vibrant tourism sector. This project aims to explore the feasibility and benefits of harnessing geothermal energy to power the eco-village, providing a renewable energy source that minimizes environmental impact while enhancing the attractiveness of Guelma as a sustainable tourist destination.

Research questions :

How can eco-thermal systems be effectively integrated into eco-villages to mitigate the environmental impacts of traditional building practices while enhancing their appeal as sustainable tourist destinations and serving as a model for sustainable development?

1. Sustainable Housing Design

What architectural designs and materials are most effective in reducing energy consumption in residential buildings?

Hypotheses

- The integration of eco-thermal systems in eco-villages will significantly reduce energy consumption and greenhouse gas emissions associated with traditional building practices, while simultaneously enhancing the eco-village's attractiveness as a sustainable tourist destination. This approach will create a model
- The architectural design and materials are most effective in reducing energy consumption in residential buildings is Passive Solar Design, Green Roofs, energy-efficient materials

Research objectives

- The integration of the geothermal energy in the region of guelma, Hammam Ouled ali and use it for heating and cooling application
- design sustainable model of bungalows that incorporates energy-efficient building materials and geothermal infrastructure.
- To evaluate the environmental benefits of using geothermal system (GeoGrid™) in comparison to conventional fossil fuel-based systems.
- explore the role of urban planning, including land use and mixed-use developments, in supporting geothermal integration within a sustainable village model.

Methodology

Before any dissertation project, developing a working method is essential. This allows the student to better understand their subject from various angles, and, more importantly, allows those who will be evaluating and drawing inspiration from this work to

better understand the entire process and the structure of the work.

The thesis is structured into two (4) chapters:

two chapters are dedicated to the theoretical foundations. It consists of a bibliographic and documentary research with the objective of understanding all the key concepts and theoretical elements related to the research topic. To gain knowledge about, ecotourism, ecovillages and the geothermal energy

the other two chapters contributing directly to the practical dimension of the project:

Analytical Study of Similar Examples

This section presents a detailed analysis of case studies that integrate geothermal energy within eco-tourism or sustainable architectural contexts. These examples serve as a basis for comparison and inspiration, helping to extract best practices and design strategies relevant to the development of the proposed eco-village.

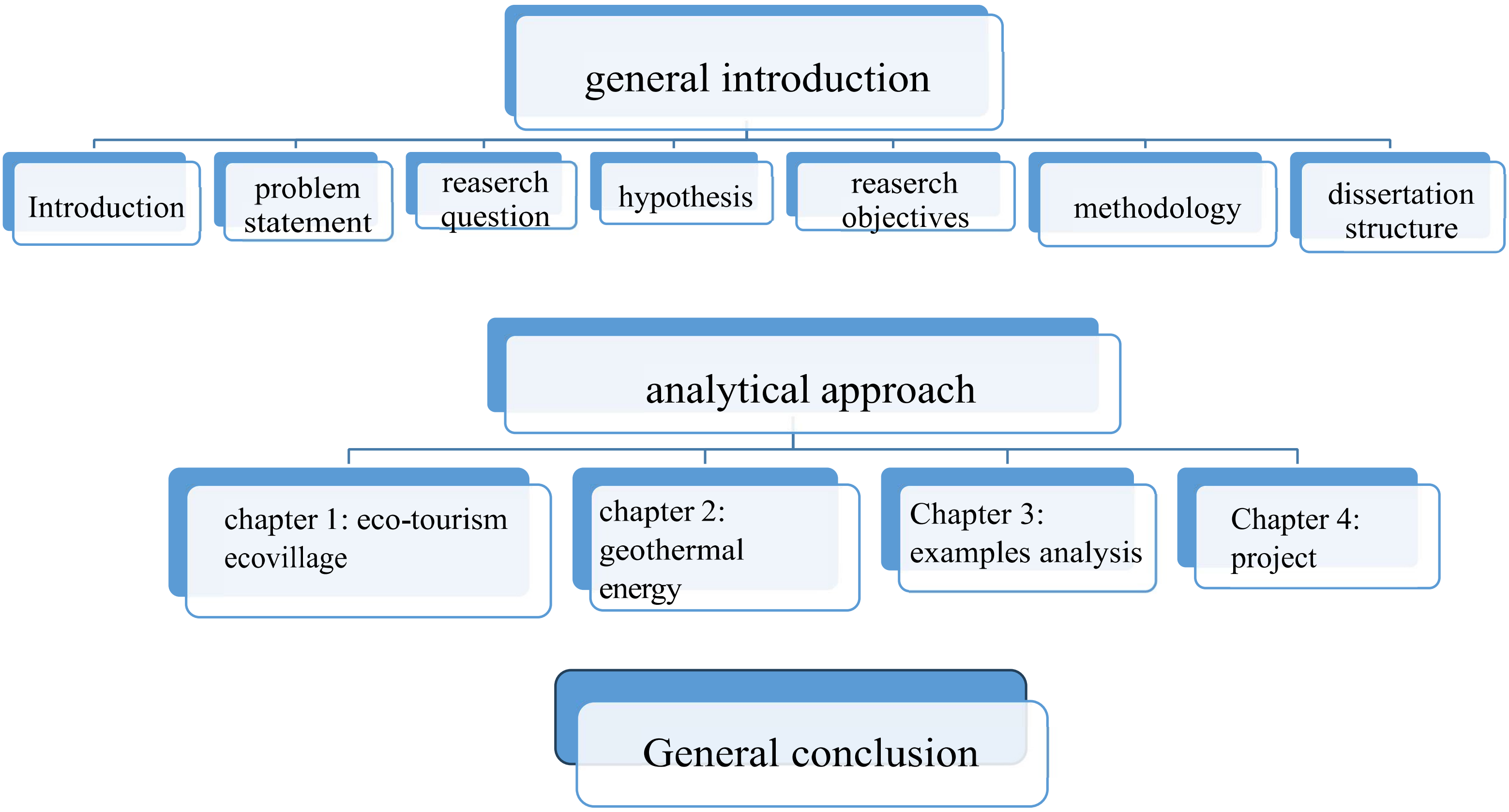
Site Analysis

The second section focuses on the terrain analysis of the project site in Hammam Oulad Ali, Guelma. It includes a study of the geographical, geological and climatic characteristics of the site. Special attention is given to the geothermal potential of the area, considering the presence of hot springs and the land's suitability for sustainable tourism development.

Thermal simulation

The third and final section consists of a thermal simulation, carried out using Design Builder software. This simulation evaluates the energy performance of the proposed bungalows when using a geothermal heating and cooling system.

Dissertation structure



I. Chapter 1: Eco touristic ecovillage

I: Ecotourism

I.1: introduction

The International Ecotourism Society (TIES) characterizes Ecotourism as "responsible travel to natural areas that conserves the environment and sustains the well-being of local people and involves interpretation and education[3]

According to Fennell, "Ecotourism is a sustainable form of natural resource-based tourism that focuses primarily on experiencing and learning about nature, and which is ethically managed to be low-impact, non-consumptive, and locally-oriented (control, benefits, and scale). It typically occurs in natural areas, and should contribute to the conservation or preservation of such areas[4]

Ecotourism encompasses nature-based activities that increase visitor appreciation and understanding of natural and cultural values. They are experiences that are managed to ensure they are ecologically, economically and socially sustainable, contributing to the wellbeing and conservation of the natural areas and local communities where they operate. [5]

Simply put, ecotourism is where sustainable travel and conservation meet. If you look at ecotourism activities, you will notice they all have something common. These "things" are called ecotourism principles, and they include:

- Ensuring direct financial benefit for conservation, local communities, and the private sector;
- Minimizing physical, psychological, social, and behavioral impacts;
- Ensuring that both tourists and hosts have memorable experiences;
- Increasing cultural and environmental awareness;
- Designing and operating sustainable facilities;
- Creating empowerment through unities between indigenous people and travelers[6]

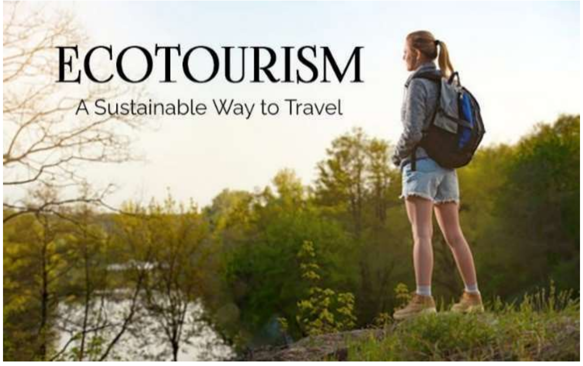


Figure -I-1:ecotourism

I.2: The history of ecotourism

The history of ecotourism dates back to 1901 when a group of active workers took part in a trip for the preservation of the forests, but at that time, it had no specific name or any identification or autonomy from standard tourism, The term 'Ecotourism' was born in 1965, and by the 1970 The environmental movement gains momentum, leading to increased public awareness about ecological issues. This period sees a growing dissatisfaction with mass tourism and a demand for more nature-based experiences and [7] that leaded to make the ecotourism became more popular in the 1980s partly because of an increase in resources to make sure the tourists are safely returned to their homes after the visit "In the 1980s the idea of sustainable development was new," Epler Wood recalls. In 1987 Ceballos-Lascurain's definition is widely recognized, marking the formal establishment of ecotourism as a concept that combines ecological awareness with tourism practices aimed at conservation[8]

By the 1990s Ecotourism expands globally, with many developing countries recognizing its potential for economic growth and environmental protection. The concept becomes integrated into national tourism policies. 2000s and Beyond: Ecotourism continues to evolve, with increasing emphasis on sustainable practices, community involvement, and educational experiences. It becomes a significant sector within the broader tourism industry, responding to travelers' desires for responsible and meaningful travel experiences[9]

I.3: Ecotourism Goals

- Ecotourism seeks to protect and enhance biodiversity and natural ecosystems. It promotes responsible travel to natural areas, ensuring that tourism activities do not harm the environment but rather contribute to its preservation
- A core goal is to provide economic benefits to local communities. This includes creating jobs, supporting local businesses, and ensuring that a portion of the revenue generated from tourism is reinvested into the community[10]
- Ecotourism emphasizes the importance of respecting local cultures and traditions. It encourages interactions that foster understanding and appreciation of local customs, thereby helping preserve cultural heritage[11]
- Education is a fundamental aspect of ecotourism, aimed at both tourists and local communities. It involves raising awareness about environmental issues, conservation efforts, and the significance of preserving natural and cultural resources[12]

- Promoting low-impact travel practices is essential to minimize the ecological footprint of tourism activities. This includes using sustainable transportation, reducing waste, and employing eco-friendly accommodations[13]

I.4: ecotourism Impacts

Ecotourism is a form of sustainable travel that focuses on experiencing natural environments while promoting conservation and benefiting local communities. As travelers seek more meaningful and responsible experiences, ecotourism has gained popularity for its potential to protect ecosystems and support local economies[14]

However, the impacts of ecotourism are complex. it can lead to positive outcomes such as increased funding for conservation efforts and improved livelihoods for residents

Understanding these impacts is essential for ensuring that ecotourism remains a viable and beneficial option for both nature and communities

I.4.1: Social Impacts:

- Empowers local communities through economic opportunities
- Improves infrastructure and social services in tourism areas
- Promotes cross-cultural understanding and interactions
- Enhances community pride and social cohesion

I.4.2: Environmental Impacts:

- Supports conservation efforts and biodiversity protection
- Reduces environmental degradation by creating economic alternatives
- Raises global awareness about environmental challenges
- Funds habitat restoration and wildlife protection programs
- Encourages sustainable resource management

I.4.3: Cultural Impacts:

- Preserves traditional knowledge and indigenous practices

- Helps maintain cultural heritage and traditional lifestyles
- Creates platforms for cultural exchange

Figure -I-2::Ecotourism, Cultural Impacts

- Promotes respect for local customs and traditions
- Provides economic value to cultural practices
- Prevents cultural erosion by making traditional ways economically viable

I.4.4: Ecotourism Management Practices

Ecotourism management involves a comprehensive approach to developing sustainable tourism practices that prioritize environmental conservation, community involvement, and educational experiences. Here are key practices that define effective ecotourism management:

- Establishing strong, trust-based relationships with local communities is essential. This collaboration ensures that the interests and needs of the community are considered, enhancing the quality of the travel experience and promoting local culture and heritage
- Engaging with community members helps in understanding their expectations and integrating their insights into ecotourism practices.
- Ecotourism businesses must embed conservation efforts into their operations. This includes developing policies that minimize environmental impact and actively promoting sustainability initiatives through marketing channels like social media and official websites

- Companies should transparently share their conservation efforts and encourage travelers to participate in these initiatives.
- Planning is crucial for successful ecotourism management. This involves setting clear objectives, identifying conservation targets, and ensuring that all stakeholders are involved in the planning process

The planning should address:

- Site Selection: Choosing locations that minimize ecological disruption.
- Resource Management: Implementing energy, water, and waste systems that conserve resources.
- Visitor Education: Providing interpretive experiences that enhance awareness of ecological issues
- Continuous monitoring of ecotourism activities is vital to ensure they align with sustainability goals. This includes tracking environmental impacts, visitor satisfaction, and community benefits. Adaptive management allows for adjustments based on feedback and changing conditions
- Following established guidelines for ecotourism development is critical. For instance, the Best Practice Ecotourism Development Guidelines provide a framework for ensuring that ecotourism operations are ecologically sustainable and culturally respectful
- Compliance with local regulations helps maintain the integrity of natural areas while supporting economic development.
- Educating both tourists and local communities about the importance of conservation is a fundamental aspect of ecotourism management. Programs should focus on sustainable practices, local ecosystems, and cultural heritage to foster a deeper connection between visitors and the environment
- Successful ecotourism requires collaboration among various stakeholders, including government bodies, NGOs, local communities, and tourists themselves. Engaging stakeholders through dialogue ensures that diverse perspectives are considered in decision-making processes

I.4.5: Challenges and Barriers to Effective Ecotourism

Ecotourism, while promising as a sustainable travel option, faces numerous challenges and barriers that hinder its effective implementation. These obstacles stem from a variety of factors, including environmental, social, economic, and political issues. Here are the key challenges identified:

- The increasing number of tourists can lead to significant environmental degradation. This includes pollution, loss of biodiversity, and strain on natural resources. As more visitors flock to ecotourism destinations, the delicate ecosystems may suffer from overuse and exploitation, undermining the very principles of ecotourism aimed at conservation and sustainability
- A significant barrier is the lack of awareness among tourists regarding the principles of ecotourism and its importance for environmental conservation. This ignorance can result in irresponsible behaviors that negatively impact local ecosystems. Additionally, local communities often lack education about the benefits of ecotourism, which can diminish their involvement and support for sustainable practices
- Many ecotourism initiatives struggle with inadequate funding, which is essential for developing necessary infrastructure such as transportation, accommodations, and waste management systems. Without sufficient financial resources, it becomes challenging to implement effective ecotourism practices or improve existing facilities to meet sustainability standards
- Effective ecotourism requires collaboration among various stakeholders, including government agencies, local communities, tourism operators, and conservation organizations. A lack of coordination can lead to fragmented efforts that dilute the impact of sustainability initiatives. This disjointed approach often results in ineffective implementation of ecotourism practices
- Political instability and socioeconomic challenges can significantly impede the development of ecotourism. Issues such as corruption, lack of clear policies, and bureaucratic hurdles can create an environment where sustainable tourism initiatives struggle to thrive. Moreover, economic priorities may overshadow environmental concerns, leading to unsustainable tourism practices
- Local communities often face barriers related to skills and capacity. Many community members may not possess the necessary skills or training to engage effectively in

ecotourism activities or management roles. This skills gap can limit job opportunities for locals while favoring foreign professionals for higher-skilled positions

- A lack of long-term planning and vision for sustainable tourism development can hinder progress in ecotourism initiatives. Without clear goals and strategies that integrate ecological sustainability into tourism planning, efforts may become short-sighted or reactive rather than proactive

II : Eco village

II.1: Introduction

An ecovillage is more than a place; it's a consciously and collectively designed community, where individuals come together to create a home with a shared vision that aims to become more socially, culturally, economically and/or environmentally sustainable, this word created from the combination of ecological and village with the aim of introduce the ecological practices in the smallest parts of urban fabric where this concept serves as microcosms of innovative solutions to global issues such as climate change, resource depletion that were created because of mal connection between human and nature .

Figure -I-3:ecovillages

The principal applications of an ecovillage include the use of renewable energy, the local

food production, water conservation, waste reduction, using local materials and the adaptation with the environment by friendly technologies. To ensure the success of any ecovillage the social cohesion is a key aspect that involves practices like sharing governance, cooperative decision-making and collaborative problem-solving where all these practices come true by creating common spaces to encourage opportunities for casual meetings between neighbors

The urban and architecture design of any ecovillage reflects shows its commitment to sustainability practices, involving principles of green building, permaculture, and regenerative agriculture. The buildings and infrastructures are typically designed to minimize the energy consumption where some ecovillages can reach to zero energy consumption and also reserving the extra energy produced, and for the landscapes are cultivated to support biodiversity and regenerative ecological systems. Now days many ecovillages integrate educational programs, workshops, and cultural activities to spread awareness and inspire broader societal change.

II.2: Historical background

The ecovillage traced its roots from the beginning of the humanity with the desire to live harmoniously with the environment (nature) but the concept of ecovillages emerged in the 19th century by thinkers like Henry David Thoreau and Ebenezer Howard in the with the growing of the environmental concerns because the of the nature's overexploitation with the desire to solve these problems and promoted harmony with nature and planned communities.[15] The term "ecovillage" was first coined in 1991 by Diane and Robert Gilman in their report for Gaia Trust, outlining principles for sustainable living, marking a shift towards the communities that focuses on sustainability like Findhorn Foundation Ecovillage in Scotland, showcasing ecological living in practice where the first conference about ecovillages was held [16]in it leading to the establishment of the Global Ecovillage Network (GEN) in 1995 that facilitates collaboration among ecovillages over the world. By the entrance of the 20th century, ecovillages expanded over the world using renewable energy uses like solar and wind energies, local food production and social resilience. Now days ecovillages continue as a solution of the nature challenges such as climate change, resource depletion, and social equity, demonstrating …etc.

II.3: Principals of ecovillages:

II.3.1: Sustainable living:

Sustainable Lifestyles are considered as ways of living, social behaviors and choices, that minimize environmental degradation (renewable energy use, permaculture, organic farming, waste reduction, and water conservation) and prioritize environmental stewardship,

II.3.2: Social Sustainability:

one of the most important principals in ecovillages is the social sustainability that could come in true by the building of strong communities by offering common spaces and sustainable education to create collaborative relationships, fostering inclusive and promoting social equity.

II.3.3: Economic Sustainability:

one of the important goals of any ecovillage is to create local economies that should be sufficient, diverse and flexible, while this includes local food production, local resource utilization …etc.

Figure -I-4:Principals of ecovillages, Social Sustainability

II.3.4: Cultural Sustainability:

Culture is defined as a set of beliefs, morals, methods, institutions and a collection of human knowledge that is dependent on the transmission of these characteristics to younger generations. Communities in ecovillages tray to celebrate all the cultural events to make opportunities for all the habitants to encouraging creativity, learning, and shared values. They aim to preserve and enhance cultural traditions while adapting to modern needs.

II.4: Components of the ecological design

II.4.1: Green Buildings and Ecological Architecture:

inexpensive to build, use and convert to different uses. Features like passive lighting and natural cooling techniques applied to minimize energy use. These buildings apply simple and sustainable principles like: reduced energy use by passive lighting, natural ventilations etc.; minimizing external pollution and environmental damage (better waste managements, appropriate density to eradicate cases of extensions) and reduced embodied energy.

The use of sustainable building designs is one of the latest trends in Eco-villages. This design known as the sustainable urban matrix model is socially, economically and ecologically responsive.

II.4.2: Infrastructure and layout Design:

these are designed and organized in an environmentally friendly way through a participatory planning process by the locals and interested stakeholders.

II.4.2.A: Recycling waste

(waste water, solid waste and sewage) the designs advocates for the waste is resource principle thus emphasizes the reuse and or recycling of waste where applicable. This thus yields organic energy and manure or consumed in appropriate means.

II.4.2.B: Permaculture design:

this is an urban agricultural design that blends production with nature. Clearing of land to produce food is avoided hence forests and crops can o-exist. This can be practiced in the open spaces instead of paying them, between the developed and undeveloped areas and a possible replacement of gardens and flowers.

Resource and energy consumption strategies: this advocates for the use of green energy and reduced fossil energy usage. This reduces the gas emissions combating climate change.

II.4.2.C: Alternative modes of transportation:

Eco villages apply ecologically transportation principle discourages the reliance on cars that are socially unequal for not all the age groups can drive, need space for parking and pollute both the air and sound, besides, they could cause accidents. Thus, Eco-villages are designed to encourage walking and cycling by providing for their facilities (pathways and bike ways). Cars are restricted by using narrow streets, car-calming and limited parking spaces and carpooling.

II.5: Urban design principles

Effective urban design is critical to creating vibrant, sustainable, and inclusive cities. More than half of the world’s population lives in cities, and that number is projected to grow in the coming years, driving the need for thoughtful planning and design. As urbanization continues to accelerate, the principles guiding these designs become increasingly crucial. By embracing the core tenets of urban design, planners, architects, civic leaders, landscape architects, and land development service teams can develop new communities that not only meet the demands of modern life but also foster connection, sustainability, and well-being.

II.5.1: Compact and Clustered Development

The urban design of any ecovillage should be compact and cluster to minimize the environment impacts and energy consumption and enhance the connection and the relation between the habitants

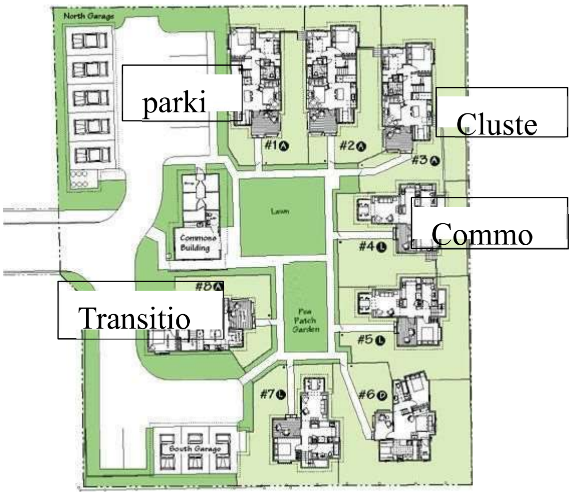


Figure -I-5:Compact and Clustered Development

II.5.2: Centralized Core:

means all the common spaces like meeting halls, restaurants, schools should be in the center of the village to encourage the interactions between neighbors and reducing travel distance, and also the shared spaces considered as a center or hub for cultural or social events

II.5.3: Clustered Housing:

Houses should be grouped into small clusters Houses are grouped into small clusters promoting a relations and interactions between neighbors, while this clusters could share common spaces lake gardens and play areas for children

Figure I-6:Clustered Housing

II.5.4: Transition Zones:

- Clarifying the infrastructures (roads) between the buildings, equipment and common spaces to ensure that the human activity does not encroach on sensitive ecosystems.
- Trying to minimize the using of vehicles in the center of the ecovillage by offering; Pedestrian Pathways:
- A network of walkable paths connects homes, community spaces, and natural areas One of the most basic and ancient forms of transportation is walking, while creating a network of walkable paths connects homes, community spaces, and natural areas is

vital for ensuring walkability. And also adding bikeways for bicycles or small electric vehicles can help to easy the access to the center

- Cars are restricted by using narrow streets, and limited parking spaces where the parking should place outside the village to discourage car use within the core community, encouraging the use of common transport like buses that help in minimizing the carbon emissions

II.6: Integration with Natural Features

II.6.1: Topography

In any urban design of ecovillage that respect ecological practices the buildings must follow the contour line and emphasis a seamless connection with natural environments where this kind of designs helps with Natural drainage systems, such as bioswales, manage stormwater sustainably and minimizing grading and preserving ecosystems.

II.6.2: Green Corridors:

The Green Corridor and associated projects will offer benefits for communities and the environment throughout the length of the railway, protect, maintain and enhance biodiversity and allow species to move through the landscape, making them less vulnerable.

II.7: Sustainable Infrastructure Integration

Urban design in ecovillages incorporates infrastructure that supports ecological and social goals.

II.7.1: Renewable Energy:

Renewable energy comes from unlimited, naturally replenished resources, such as the sun, tides, earth and wind should installed out of the living spaces to avoid their noise and with creating one energy center that distribute the energy to the whole village will reduce the energy consumption

II.7.2: Water Management:

The natural rainfall collected by Rainwater harvesting systems are linked to central collection points or individual homes will be used to sustain the healthy lifestyle of our community, grow our gardens, produce our food, grow timber, sustain our riparian habitats, and maintain the natural pattern of the stream flows that leave our site.

II.7.3: Waste Management:

efficient Full waste removal and recycling services and systems should be centralized to be easy to reach, it can be used as a type of renewable energy that generate electricity

II.7.4: Water Conservation

House designs in ecovillages integrate systems to minimize water use and reuse resources.

II.7.4.A: Rainwater Harvesting:

Rainwater harvesting is a technology used to collect, convey and store rain for later use from relatively clean surfaces such as a roof that equipped with gutter systems channel rainwater to storage tanks, land surface or rock catchment. The water is generally stored in a rainwater tank or directed to recharge groundwater, collected water can be used for irrigation or non-potable purposes

II.7.4.B: Greywater recycling:

Greywater can be defined as any domestic wastewater produced, excluding sewage It mainly originates from low-load sources (bath tubs, showers, hand washbasins) and high-load sources (laundry and kitchen), this water can be reused by installing systems in houses to filter and reuse the waste for gardening or flushing toilets

II.8: Architectural design principles

Design principles are the foundation you build on when creating shapes and spaces. They ensure that any structure is both aesthetically pleasing and practical for human use it contains

II.8.1: passive design

Passive building is a set of design principles for attaining a rigorous level of energy efficiency while also creating comfortable indoor living spaces

II.8.2: Passive heating

Passive solar heating lets in winter sun and ensures that the building envelope keeps heat inside.

It must be matched by careful design and management of summer heat in many climates.

II.8.3: Passive Cooling

Using components including air movement, evaporative cooling, and thermal mass, passive cooling strategies cool the house and its occupants. Orientation The way you position your house on the site to benefit from the sun and the local winds is known as orientation.

Proper alignment can lower your heating and cooling requirements and greatly increase comfort

II.8.4: Thermal mass

Thermal mass is the ability of a material to absorb and store heat energy. Appropriate use of thermal mass in your home can save significantly on heating and cooling costs.

II.8.5: Insulation

Insulation acts as a barrier to heat flow and is essential for keeping your home warm in winter and cool in summer. Some types of insulation can also help with weatherproofing and soundproofing.

II.8.6: shading

Appropriate shading — which can include eaves, awnings, shutters, and plantings — can maximize thermal comfort by allowing in winter sun but blocking summer rays. The most appropriate strategy will differ with climate and orientation.

II.8.7: Skylights and roof windows

Skylights are a good source of natural light, and careful choice and placement can minimize any contribution to glare or heat gain.

II.8.8: Ventilation and airtightness

Ventilation with fresh air is essential for a healthy home, but it should be controlled rather than through unwanted air leaks. Sealing your home is one of the simplest upgrades you can make to increase your comfort and reduce energy costs.

II.8.9: Sustainable Materials

II.8.9.A: Local materials

It is important to use local and unprocessed building materials that minimize transport and manufacturing energy and air pollution. This also creates local employment. The more localized the project, the more money stays within the community.

II.8.9.B: Recycled and Reclaimed Materials

The next section explores building options that use local and recyclable materials which are thermally efficient and cost effective. Recycling is an essential ingredient of green building that reduces non-renewable inputs, especially mining activities, energy use and transportation costs. This includes the use of waste products and used building materials. It is especially important to reuse environmentally unfriendly materials that leach toxic materials into the soil and ground water, or release methane into the atmosphere when dumped in landfills

II.8.10: Integration with nature

Biophilic design principles ensure a connection between residents and the environment:

II.8.10.A: Green Roofs and Walls

a green roof is a roof surface, flat or pitched, that has a growing medium over a waterproof membrane planted partially or completely with vegetation. Green walls are external or internal vertical building elements that support a cover of vegetation, rooted either in stacked pots or growing mats. These Green Roofs and Walls used to improve insulation and aesthetics.

II.8.10.B: natural landscaping:

also called native gardening, is the use of native plants including trees, shrubs, groundcover, and grasses which are local to the geographic area of the garden that surround the houses

II.9: Models of Sustainable Living

The ecological footprint of any community can be reduced substantially with ecological building techniques and thermal insulation, the replacement of energy intensive forms of transport and prioritize renewable energy sources like solar, wind, and biomass as well as. They often demonstrate off-grid energy systems that reduce dependence on fossil fuels, reduce the carbon emissions and minimize the energy consumption

II.9.1: Green Building:

the construction of buildings with local and ecofriendly materials (recycled materials), and using renewable energy (geothermal energy, solar, or wind) can improve the quality of life of the environment and minimize their impacts

II.9.2: Resource Conservation:

Practices like rainwater harvesting, greywater recycling, reduces the reliance on traditional water supplies, minimizes the impact on local water resources, and can help mitigate the effects of droughts and water scarcity.

II.9.3: Food Security:

Many ecovillages implement Organic agricultural practices, permaculture and regenerative agriculture, not only secure the own needs but also to sell in local markets and reducing reliance on industrial food systems while enhancing biodiversity and soil health and enhancing their livelihoods and strengthening the community resilience.

II.9.4: Social Support:

by encouraging dialogues and participations in communities that resolve disputes through discussion ecovillages build strong, resilient communities that can adapt to challenges such as climate change or economic instability.

synthesis

In conclusion, eco-tourism and ecovillages together represent powerful pathways toward sustainable development, offering innovative solutions that protect natural and cultural biodiversity while fostering social, economic, and environmental resilience. As travelers become increasingly aware of their environmental and social impact, many are choosing destinations that not only provide unique and authentic experiences but also embody sustainable practices, much like those found in ecovillages. These communities operate as living examples of eco-tourism's core principles, integrating ecological design, renewable energy, local food production, and waste reduction to minimize their ecological footprint while immersing visitors in sustainable ways of living. Architectural features such as compact layouts, clustering of buildings, and the use of local and recycled materials promote energy efficiency and strengthen the connection to surrounding natural landscapes, creating spaces that are both environmentally sustainable and culturally meaningful. Furthermore, ecovillages often incorporate innovative technologies like rainwater harvesting, greywater reuse, and biophilic design, which not only conserve resources but also deepen people's bond with nature. Beyond environmental benefits, these communities serve as vital hubs for cultural preservation, creativity, and learning, encouraging the exchange of knowledge and skills among residents and visitors across generations. By fostering inclusive participation, collective governance, and joint decision-making, ecovillages enhance social cohesion and adaptability, embodying the spirit of eco-tourism by demonstrating that tourism can be a catalyst for positive change rather than a burden on local ecosystems and communities. Together, eco-tourism and ecovillages pave the way toward a future where travel not only delights and educates but also actively contributes to sustaining the planet and nurturing human well-being on multiple levels.

II. Chapter 02: Geothermal energy

I : introduction

it is the thermal energy that extract from the deep Earth's internal heat. the term "geothermal" comes from the Greek word geo (meaning "earth") and thermal (meaning "heat")[17]

this energy is considered as renewable energy because it is nonstop produced and long-lasting energy supply energy from the deep of earth where the temperature of the earth being hotter when we go deeper and the temperature of the earth can change from place to other place because of the deference of earth layers, the tectonic plate and the volcanic activities

Geothermal energy uses for two important purposes, the first one is for generating electricity by harnessing the steam or hot water coming from deep ground to moving to power turbines that generate electricity. The second one is Ground heat pumps (GHPs) that harness the underground temperatures for heating and cooling purposes.

This new renewable energy helps to reduce the depending on fossil fuels to generate energy and play a crucial role to fight against the climate change

II. Geothermal electricity generation

II.1: Definition:

is the transformation of the thermal energy from the Earth's interior into electrical energy by the natural heat in term of hot water or steam that is stored in the Earth's layers that can turn the turbine

Figure II-1:Geothermal electricity

II.2: Types of Geothermal Power Plants

II.2.1: Dry Steam Plants:

Use directly the steam coming from geothermal reservoirs to drive turbines.

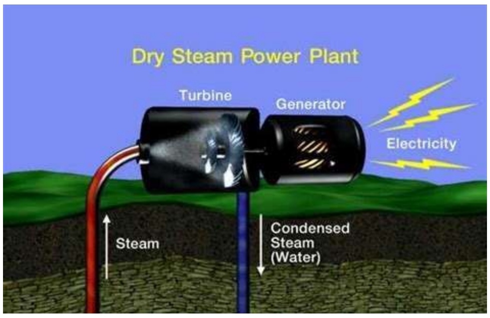


Figure II-2: Dry Steam Plants

II.2.2: Flash Steam Plants:

the hot water extract (pumped) from deep underground travel under high pressures to a low-pressure change in pressure causes some of the fluid to rapidly transform, or “flash,” into vapor. The vapor then drives a turbine

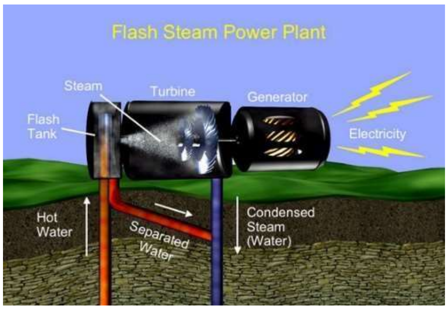


Figure II-3:Flash Steam Plants

2.3: Binary Cycle Plants:

is different from the last two types where the hot water doesn’t have any contact with turbine units, the geothermal fluids with temperature (below 182°C/360°F)[18] pass through a heat exchanger with a secondary, or "binary," fluid that has lower boiling point than water to heat it creating a vapor or steam, which then drives the turbines, spins the generators, and creates electricity.

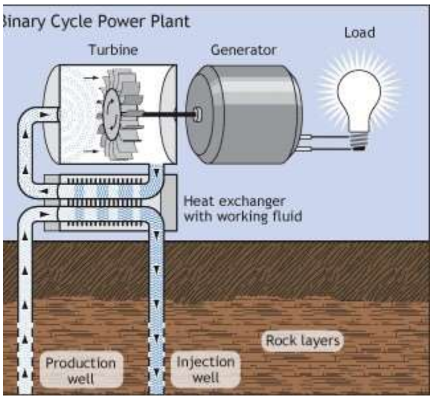


Figure II-4:Binary Cycle Plants

II. Geothermal heat pumps

II.1: Definition:

is an energy-efficient system for heating and cooling that uses the heat from the deep earth to warm homes in the winter and keep them cool in the summer. Geothermal heat pumps operate on simple thermodynamic principles, transferring heat between earth and buildings through a network of underground summers and winter pipes where it composes from three essential parts:

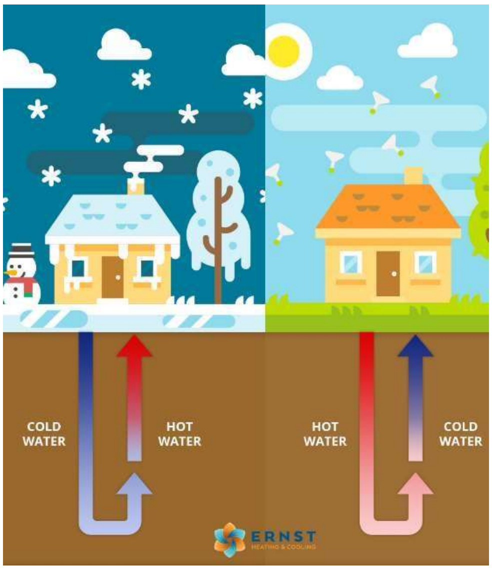


Figure II-5:Geothermal heat pumps

a/ the underground loop system which represents the pipes that dipped into the earth to absorb the heat in the close loop system or hot water in the open loop system

b/ the heat pump unit that present the central part in the system its job is to pump the geothermal water or the mixture water from the loops to and exchange the heat c/the distribution system and its job is to distribute the heat to the whole building

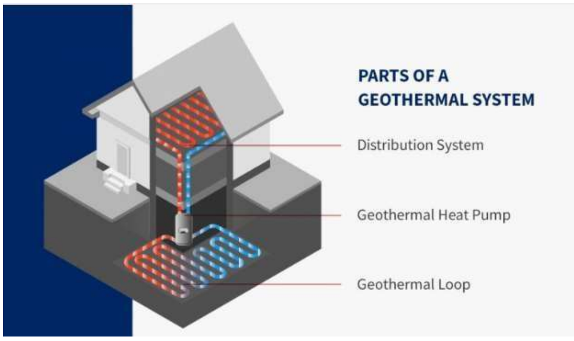


Figure II-6:: the Components of Geothermal Heat

II.2: the Components of Geothermal Heat Pump

the geothermal heat pump system includes of three elements:

II.2.1: geothermal heat pump

II.2.1.A: Definition:

Its unit that installed inside a building, it operates on electricity. It serves as the main center for the apparatus in the geothermal system that aids in the heating and cooling procedures. It comprises vital elements such as the compressor and the heat exchanger. Its function is to carry the water or water mixture via the geothermal loop to circulate heat throughout the system.

II.2.1.B: Components of the geothermal heat pump

a: Compressor Operation:

Within the indoor unit, after the refrigerator absorb heat from the ground, the compressor raises the temperature of the it to transfer its temperature to the secondary water Expansion

b: Valve:

This component reduces the pressure of the refrigerant after it has released its heat, allowing it to cool down.

c: the Heat Exchange:

heat exchanger is crucial elements within the indoor unit that transfers heat between the refrigerant and the water or water mixture used for heating and cooling

d: Control System:

The indoor unit is equipped with controls that allow homeowners to set desired temperatures and manage heating schedules.

II.2.2: Ground Loop System

II.2.2.A: Definition:

Ground loop systems are essential parts of geothermal heat pump systems. These systems are made up of a number of subterranean polyethylene pipes in form of closed or open system that facilitate energy exchange with the earth by circulating a heat transfer fluid

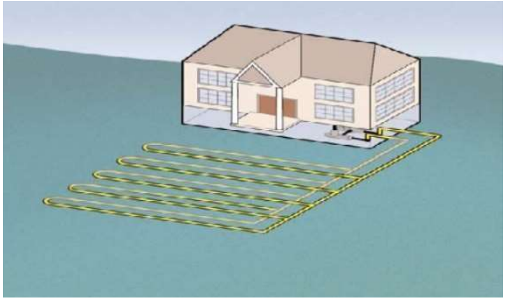


Figure II-7:Ground Loop System

II.2.2.A.a: Types of ground loop system

There are four basic types of GHP ground loop systems. Three of these—horizontal, vertical, and pond/lake and the fourth one are closed-loop systems. Several factors such as climate, soil conditions, available land, and local installation costs determine which is best for the site.

1: closed-loop systems

1.1: definition

this system is placed underground or immersed in water. These systems absorb heat from the earth to heat fluid, usually a mixture of water and antifreeze which moves within these pipes to heat the secondary water

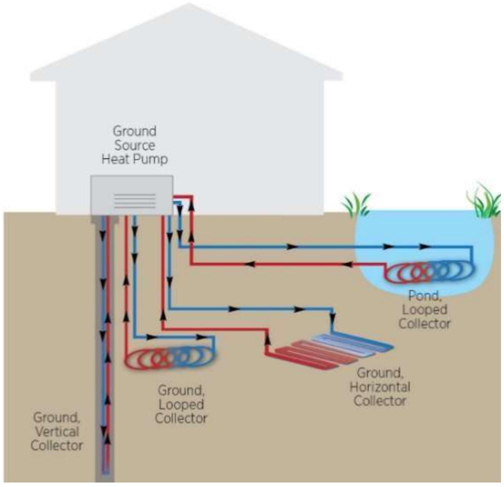


Figure II-8:Horizontal Closed loop

1.2: Horizontal Closed loop Systems

Horizontal closed-loop systems are a widely used type of geothermal heat pump installation, especially ideal for residential purposes when there is plenty of land available. These systems use a network of pipes installed in trenches and laid out in parallel or in a "slinky" configuration to transfer heat to and from the ground.

Horizontal loops are typically installed 4 to 6 feet deep, although trenches can be dug deeper (up to 10 feet) for optimal performance[19].

1.3: Vertical Closed loop Systems

this system uses for the big projects because of its high efficiency heating and cooling. Vertical loops are installed in deep boreholes drilled directly into the ground with (depths ranging from 100 to 400 feet)20 based on the building's heating and cooling needs.

Figure II-9:Vertical Closed loop Systems

With a high quality of plastic material like the high-density polyethylene (HDPE), is inserted into each borehole with a U-bend at the bottom. This design allows the fluid to circulate effectively within the loop.

1.4: Pond/Lake Closed loop Systems

this system uses coils of pipe submerged in hot lake, which circulate a fluid mixture (often water and antifreeze) to transfer heat between the pond and the building.

Figure II-10:Pond/Lake Closed loop Systems loop

The pond or lake must be large enough and deep enough (typically at least 8 feet) to accommodate 21

2: Open loop Geothermal Energy System

2.1: Definition:

An open loop geothermal energy system uses hot water extracted from the deep earth or surface water. This water pumped by the heat pumps utilized to transfer heat for either heating or cooling purposes, and subsequently released back into the surroundings. These systems are recognized for their effectiveness and reduced installation expenses.

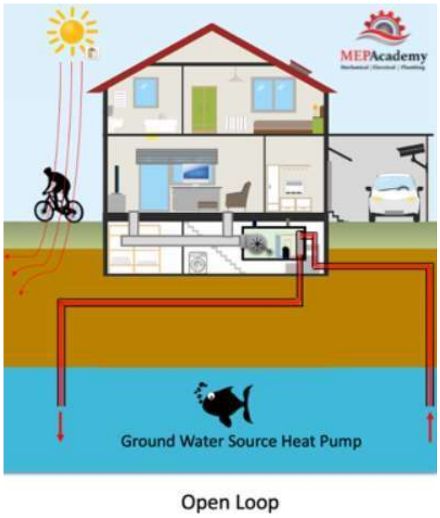


Figure II-11:Open loop Geothermal Energy

2.2: How Open Systems Work

Water Extraction: this system extract water from a well or surface source (such as a pond)

Heat Exchange: The extracted water goes to the geothermal heat pump, which exchange the heat from the ground water to the secondary water

Water Discharge: Once it has gone through the heat pump, the water that is either cooled or heated is:

-Went back to the primary source (e.g., the well) through an injection well.

-Released into a nearby body of surface water, like a pond or drainage ditch

3: Materials

Materials	HDPE	PEX	PE-R	Copper
				
System	Closed loop system	Closed loop system (horizontal & vertical)	Closed loop system (horizontal, vertical)	Advanced systems

Table II-1:loop system materials

II.2.3: distribution system

II.2.3.A: Definition

distribution system is an important element that assure the transformation of the heat extracted from ground to the whole building.

II.2.3.B: Types of Distribution Systems

There are primarily two types of distribution systems used in geothermal installations: ducted systems and radiant systems.

1: ducted system

1.1: Definition:

Ducted systems distribute hot or cold air from the geothermal heat pump to different rooms in the building, it can be equipped with zone control mechanisms allowing for controlling temperature settings in different areas this enhances comfort and energy efficiency by directing airflow where it is needed most within the building

1.2: Material

Metal Ducts (Galvanized Steel/Aluminum) 	Fiber glass Ductwork 	Clay or Cement Ducts 

Table II-2:ducted system materials

2: Hydronic Radiant Heating

2.1: Definition

Hydronic radiant heating is a network of tubes installed in floor, walls or ceilings of a home these tubes assure the circulation of hot water to warm the rooms

2.2: Types of Hydronic Radiant Heating Systems

Floor Heating: This is the most common type of hydronic system, where the tubes installed beneath the floor

Wall Heating: In this type of radiant the tubes installed in the walls

Ceiling Heating: This system incorporates pipes within ceiling panels to provide warmth from above.

III.Canadian wells

III.1: Definition

The Canadian well is an ecological ventilation device which consists in ventilating a dwelling independently. Based on geothermal energy, its purpose is to collect the outside air via a tube, to make it circulate via a duct buried deep enough in the ground using the subsoil temperature to reduce the excess of heat or cold in homes.in order to benefit from the thermal inertia by heating or cooling the interior of the house by heat exchange between the air and the ground. (Incoming air may be up to 10 degrees colder or warmer than outside air)22 They can be adapted to every kind of subsoil, do not require deep excavations and represent a low cost, ecological, efficient and sustainable solution. The principle of the Canadian air well

III.2: The components of the Canadian well

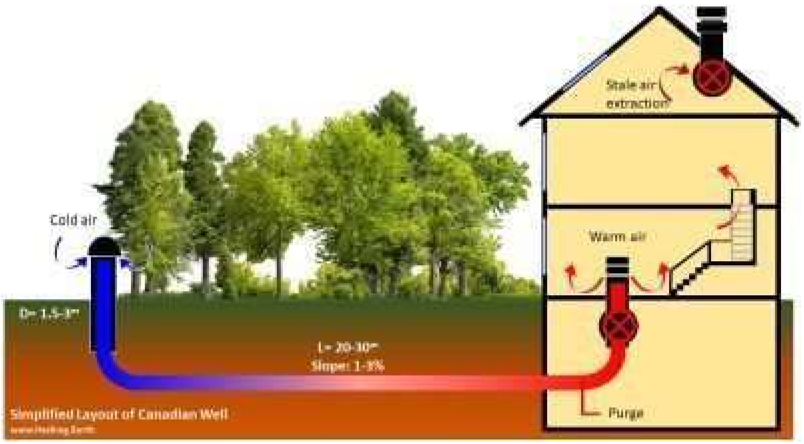


Figure II-12:Canadian wells

III.2.1: A network of pipes:

connected to the house, placed in the subsoil at a depth between 1.5 m and 5 meters and covering a certain number of meters underground. This network of pipes works under the principle of thermal inertia to adapt the air temperature that during the summer is higher than the temperature underground. Therefore, when the air passes through the pipes it releases heat to the ground and cools down, reaching the home with several degrees less and creating a comfortable environment. A longer tube length generates more air-soil thermal transfer. Depending on the specific characteristics of place and soil, the most used values range between 10 and 100 meters in length while the diameter of the pipe ranges between 20 and 40 cm.

III.2.2: An external collection point of the air:

The chimney is located by choosing an area where the air keeps moving and must have a grid that prevents access to the system by insects or animals that can contaminate the air.

2.3: The filters: necessary to purify the air and prevent the entry of dust and dirt into the ducts.

III.2.4: The drain point.

The condensed water in the pipes, due to the inclination is directed to the drain point where it is removed from the system. • A system for air circulation. The system needs an element that drives the air and circulates it through buried pipes. Depending on the design of the work, it is possible to opt for active (mechanical) or passive elements (solar chimney)

III.3: How does it work?

The operating principle of Canadian wells is based on geothermal energy and the inertia of the earth. A terminal installed outside the house draws in the surrounding air. It is then transported in underground pipes. The basement is where the important step of this ventilation system, heat exchange, takes place. The transported air then becomes warmer or colder. Finally, it is powered by a fan located in the house inside an interior duct before exiting through the air vents arranged in different places.

During the winter season, the outside air is colder than the ground. The Candian well therefore consists in naturally preheating the air which will then be dissipated in the building. On the other hand, during the summer season, the ground is colder than the outside air. As a result, the device distributes cold air, which is naturally cooled by the floor, into the house.

Synthesis

Geothermal energy is a type of renewable energy extracted from the interion deep part of the earth called the core used for two purposes electrical generation and for geothermal heating where both of them are sustainable applications contribute minimize the carbon emissions available year-long (24/7) unlike solar and wind energies that present higher variability and intermittence and can found around the world , it does not have any emissions can harm the environment and reduce global warming effects and public health risks resulting from the use of conventional energy sources and also reduce the depending on the fossil fuels Despite these benefits, the development of this type of energy can be costly, as it requires significant infrastructure and drilling to access the heat from the Earth's core. However, as technology improves and more research is done, it has the potential to become a more widely used and affordable energy source in the future. Although geothermal energy is not currently a dominant renewable source worldwide, its dependability, minimal environmental impact, and growth potential position it as a crucial element in future sustainable energy plans. Ongoing investments and technological progress could improve its contribution to the shift towards a cleaner energy environment

III. Chapter 03 : Examples analysis

I : Example 1: Findhorn ecovillage (Moray Scotland)

I.1: situation

Findhorn is an ecological community situated in Moray Scotland in the northeast part of the coast line. It is situated between Findhorn Bay in the south and Burghead Bay in the north. The village features a scenic coastal landscape, with a slender inlet that leads into a bigger bay, forming a charming atmosphere

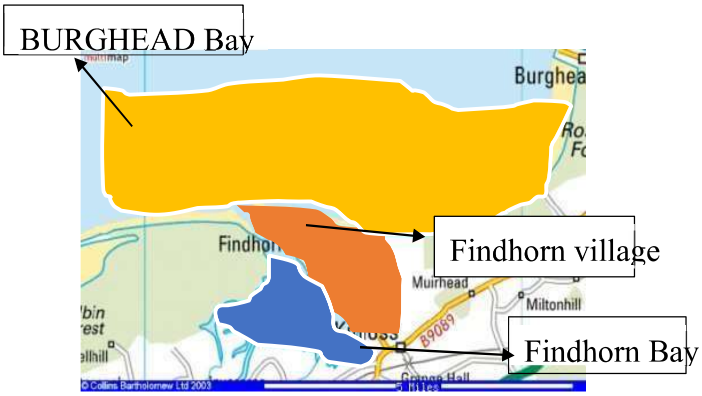


Figure III-1:findhorn situation

I.2: Physical Features

Elevation: The village itself is at sea level, while the surrounding landscape includes the Monadhliath Mountains to the west, which rise to elevations of about 500 meters (1,640 feet) above sea level

Immediate environment: Findhorn is close to the Culbin Forest and is bordered by sandy beaches that extend for miles along the coast. The area is also known for its mud flats at low tide, which attract various bird species[23]

I.3: Findhorn ecologic history

I.3.1: The Original Site: Findhorn Bay (1962–Present)

The initial settlement was situated at the southern boundary of Findhorn Bay, close to an exmilitary site (RAF Findhorn). The bay is an essential natural characteristic of the region. The creators (Eileen Caddy, Peter Caddy, and Dorothy Maclean) Initially established in trailers near the bay, they embarked on their journey to build a flourishing community grounded in spiritual values and sustainable practices

I.3.2: Formalization of the Community and the Beginning of Urban Organization:1970s

by the early 1970s, the Findhorn community had grown, and there was a need to formalize both its spatial organization and architectural development. The Findhorn Foundation was established in 1972, and this led to more intentional planning and development [24]

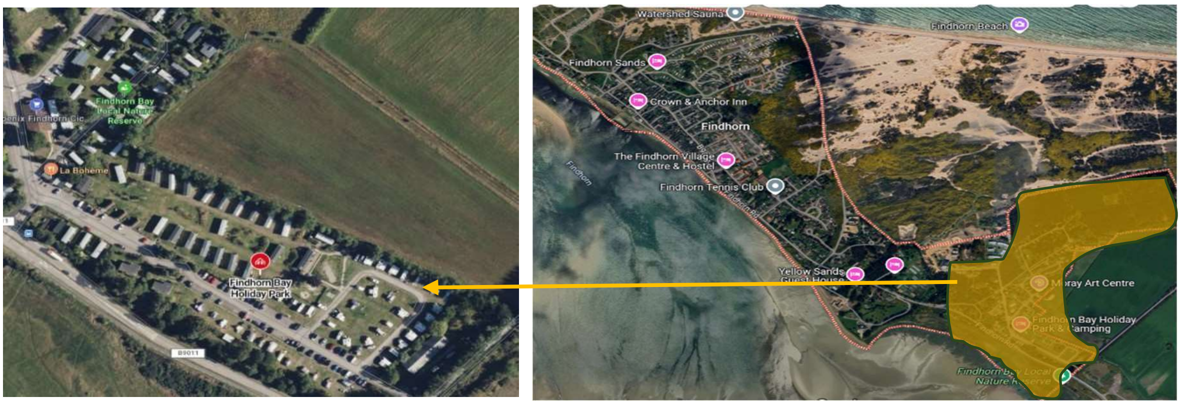


Figure III-2:The Original Site: Findhorn Bay

I.3.3: Incorporating Sustainable Systems and Innovations: 1980s–1990s:

Findhorn had emerged as a globally acknowledged hub for sustainable living practices. The community's methodology regarding land and architecture grew more advanced, leading them to incorporate sustainable systems into their designs.

I.3.3.A: total Structures:

As of now, Findhorn has constructed over 100 ecological buildings, with ongoing plans for further development

1: Houses types

Design features	structure	External walls finish
Circular chamber built for meditations and singing, built of recycled materials.	Cavity wall dressed with stone on the outside	Stone 

Ecological/natural materials, passive solar heat gain, glazing on South	Timber 	Untreated larch cladding
 Slate: Slate is a highly regarded construction material known for its durability, aesthetic appeal, and versatility	Warm cell: Sustainable  recycled cellulose fiber	Solar panels, wood stove with gas boiler
Copper and mineralized bitumen 	Rock wool 	Water powered under floor heating run by LPG boiler, wood stove 

Table III-1:Findhorn Houses types

2: Energy Efficiency:

Findhorn prioritizes energy-efficient buildings, using renewable energy sources like solar, wind and biomass heating systems

2.1: Solar Panels

Findhorn Ecovillage dedicate to sustainable living applicating different forms of renewable energy. One of them is solar energy that significantly contributes to the community's energy system, enhancing other renewable sources such as wind and biomass.

2.1.A: Types of Solar Energy Systems

a: Photovoltaic (PV) Panels:

Installation: The community has set up many solar photovoltaic panels on both older and newer residences. These panels transform sunlight directly into electricity, supplying energy for home and communal use.

b: Solar Thermal Panels:

These panels mainly serve to heat water, greatly decreasing the dependence on fossil fuels for household hot water requirements. The regional firm, Appropriate Energy Systems (AES), produces and sets up these systems.

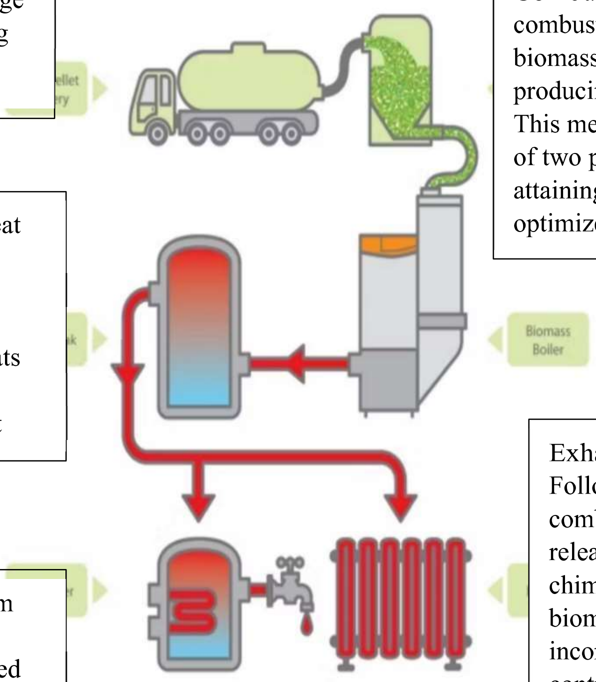
2.2: Biomass Boiler District Heating System:

Findhorn utilizes a (250-kW biomass boiler that serves as a central heating source for the community.)25

This system uses for heating demands, supplying warm water to the community buildings, thereby enhancing energy efficiency and reducing reliance on fossil

Fuel Feeding: Biomass fuel is automatically fed into the combustion chamber from the storage unit automatically using an auger or conveyor system as needed

Combustion: Within the combustion chamber, the biomass is set on fire, producing energy as heat. This method usually consists of two phases of combustion, attaining temperatures to optimize energy production.



Heat Transfer: The heat generated in the combustion chamber is transferred to a heat exchanger, where it heats water or a heat transfer fluid flowing through it

Exhaustive Management: Following heat transfer, combustion gases are released through a flu or chimney. Contemporary biomass boilers frequently incorporate emission control technologies to reduce environmental effects.

Distribution: The warm water is circulated to different buildings linked by a district heating system, enabling several facilities to utilize one boiler arrangement.

2.3: Water Management in Findhorn Ecovillage

Findhorn Ecovillage utilizes creative and sustainable methods for water management. The most important one is the Living Machine that works to clean waste and gray water using natural processes by biological sewage treatment system that contains mix of microorganisms, algae, fish, and plants. This system replicates natural ecological functions, enhancing oxygenation and nutrient circulation

Figure III-3:Living Machine water management in findhorn

I.3.4: Urbanization and Growth: 2000s present

Since the 2000s, Findhorn has prioritized the construction of ecological buildings and has expanded its renewable energy initiatives significantly where Findhorn now operates multiple turbines and solar heating systems, making it a net exporter of electricity as of 2006 [26] This shift has positioned Findhorn as a model for energy self-sufficiency

I.3.4.A: architecture side

strengthen the central area to provide a welcome entrance point reinforce the ecovillage character

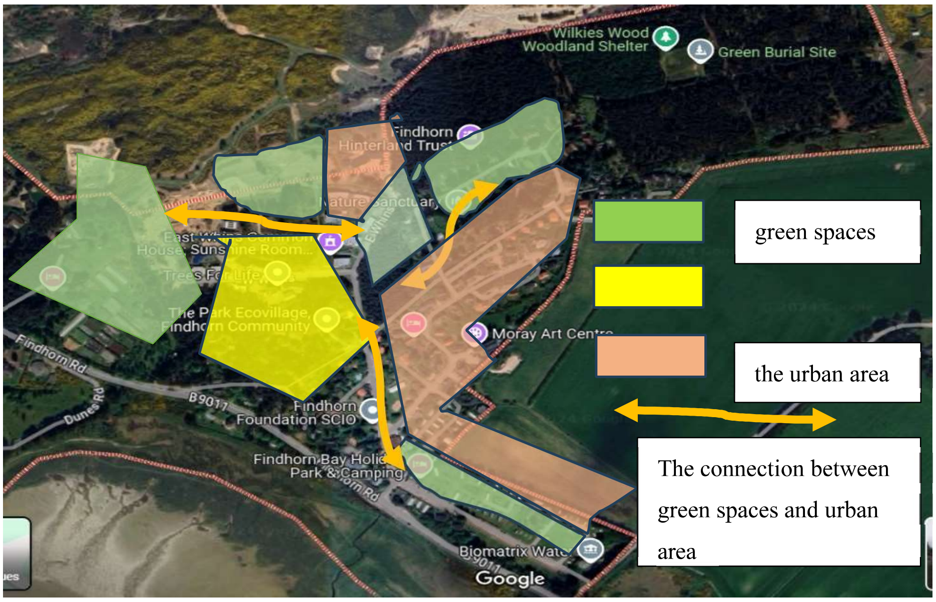


Figure III-4:findhorn urban program

The Findhorn Ecovillage represents a pioneering model of sustainable urbanism, searching ecological, social, and economic solutions. The urbanism plan for Findhorn emphasizes a holistic approach to living sustainably

1: Harbour House

the Harbour House in Findhorn is a quaint, detached stone home that provides a special fusion of contemporary conveniences and heritage. Is a detached house of 163 sq m27, contains 3 bedrooms

Figure III-5:Harbour House

1.1:Interior spaces

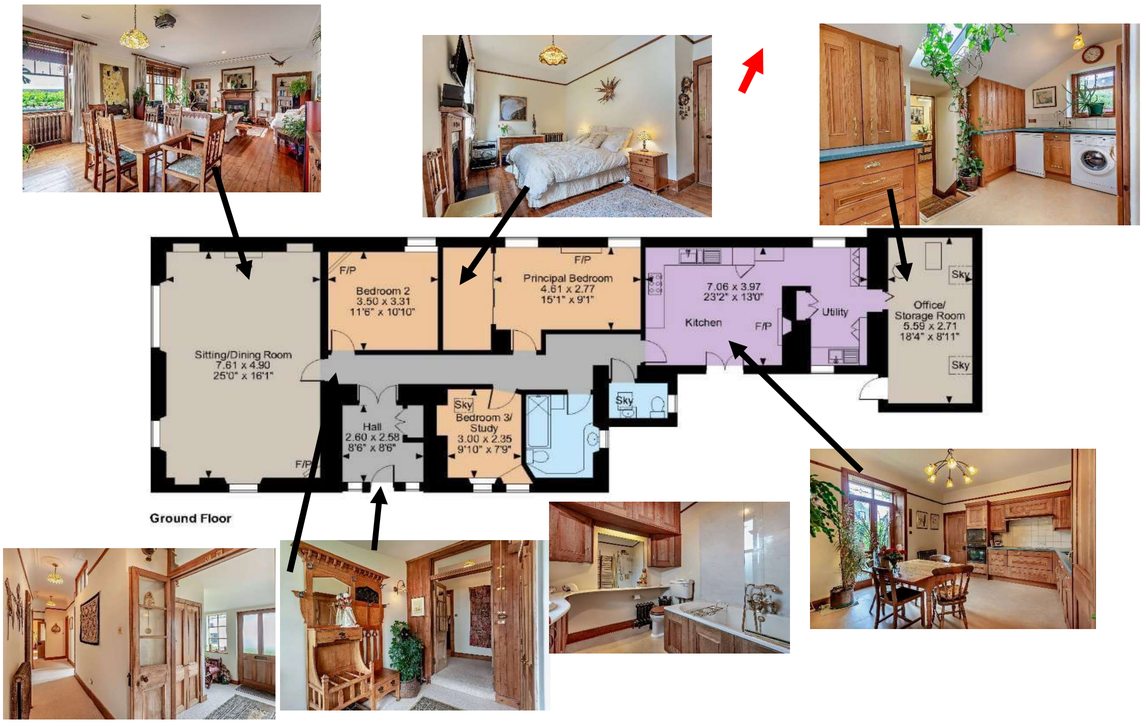


Figure III-6:Harbour House plan

1.2: Surface program

Example 1: HARBOUR house	number	surfaces
Dining / sitting room	1	7.61*4.9
Bed room	3	(4.61*2.77) (3.50*3.31) (3.00*2.65)
hall	1	2.60*2.58

Bathrooms	1	
Kitchen	1	7.06*3.97
Storage room	1	5.59*2.71
Utility room	1	

Table III-2:Harbour House surface program

1.3: façade

Stone-Constructed Building: The residence is mainly made from nearby stone, offering strength while seamlessly blending with the coastal scenery.

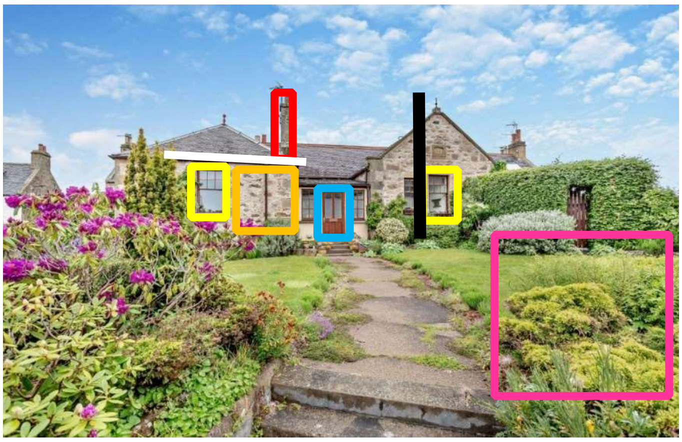


Figure III-7:Harbour House façade

Windows: The exterior showcases spacious multifaceted windows that permit plenty of natural light to fill the interior areas.

Double Entry Doors: The primary entry is highlighted by stylish double doors that open into a spacious entrance hall.

Eaves and Guttering: Clearly defined eaves offer rain protection and enhance the roofline’s visual appeal.

Fireplaces: Original feature fireplaces, both indoors and outdoors, are emphasized as important aspects of the home, reflecting the craftsmanship from the time of the house's construction.

Garden Enclosure: The estate is encircled by beautifully designed landscaping. The garden features tidy lawns and vibrant plants, boosting the visual appeal of the facade.

2: Exemple 2: Wadingburn House

The Wadingburn House is specifically Findhorn model.it is detached villa with luxurious five-bedrooms, designed to harmonize with the countryside surroundings

Figure III-8:Wadingburn House

2.1: plan and surface program

Ground floor

First floor

Figure III-9:Wadingburn House plans

Spaces									
Spaces	Sitting Room	Dining	Kitchen	Family Room	Study/Bedroom 5	Master Bedroom	Bedroom 2	Bedroom 3	Bedroom 4
surfaces	18.45	7.6	9.8	9.5	8.2	14	12.5	10	7

Table III-3:Wadingburn House surface program28

2.2: Structure and Material

Wading burn House is built using a timber frame, which is typical in the eco-village due to its sustainable and insulating qualities. This approach enables effective energy utilization and a decreased carbon footprint.

3.3: design features

3.3.1: Large Windows:

The house includes large windows, strategically placed to maximize natural light and provide views of the beautiful surroundings. These windows used double glazed to enhance thermal performance, keeping the home warm in winter and cool in summer and this
is essential for passive solar heating and reducing reliance on artificial lighting.

Figure III-10:Wadingburn House large windows

3.3.2: Natural Slate Roofing:

The roof is likely covered with natural slate tiles, which are durable and provide excellent weather resistance.

I.4: Synthesis

I.4.1: Ecological synthesis

Findhorn Ecovillage employs ecofriendly construction methods, incorporating recycled resources such as whisky barrels, stone facades, and untreated larch timber. It includes environmental elements such as passive solar architecture, and natural insulating materials such as rock wool and Warmcell.whereas the roof incorporates native vegetation, zinc, slate …. etc. for resilience, promoting an energy-efficient and eco-friendly design wind turbines: Findhorn Ecovillage integrates wind turbines into its sustainable energy strategy, generating renewable electricity and promoting autonomy while lowering carbon emissions. However, challenges like inconsistent wind, visual/noise pollution, and maintenance costs exist. The community also employs energy-saving methods like efficient insulation and passive solar heating Solar energy:

Solar panels, such as photovoltaic (PV) for electricity production and thermal for water heating, are frequently used in the community.

panels must be positioned at an angle that corresponds to the location's latitude to optimize energy collection.

The biomass installation:

Findhorn Ecovillage employs a biomass boiler for district heating, providing heated w ater to multiple structures. Biomass is combusted automatically to produce heat, which is then transferred to water and distributed. Emission control technologies minimize environmental e ffects, improving energy efficiency and decreasing reliance on fossil fuels, in alignment with s ustainability goals.

Living machine: Findhorn Ecovillage uses innovative, sustainable water management methods, centering around the Living Machine. This biological wastewater treatment method cleans sewage and gray water through the use of microorganisms, algae, fish, and plants, imitating natural ecological processes. The recycled water is subsequently utilized for irrigation, minimizing the ecological impact of the community.

I.4.2: Architectural synthesis

maximizes natural light through strategic orientation. The main living areas, such as the spacious sitting/dining room and kitchen, are positioned to receive sunlight throughout the day, particularly from the south-facing except the bedrooms that oriented to the north-facing

- The distribution of the bedrooms in the inertance of the house minimize the intimacy
- The bathrooms could be oriented to the north because bathrooms need ventilation more that sunshine

Façade

The facades reflect a commitment to ecological principles through its use of natural materials, energy-efficient design, and integration with the surrounding landscape. These elements not only enhance its visual appeal but also ensure that it operates sustainably within the Findhorn Ecovillage context

II: Example 2: Whisper Valley, Texas, USA

Figure III-11:Whisper Valley, Texas, USA Skyview

II.1: Location

Whisper valley residential is located east of the SH-130 Tollway (near Manor, TX, approximately 25 minutes from downtown Austin with a surface of 2,063 acres) 29 approximately 8.5 million square meters. Its location makes it a speed evolving region because of its closeness to Austin and major developments.

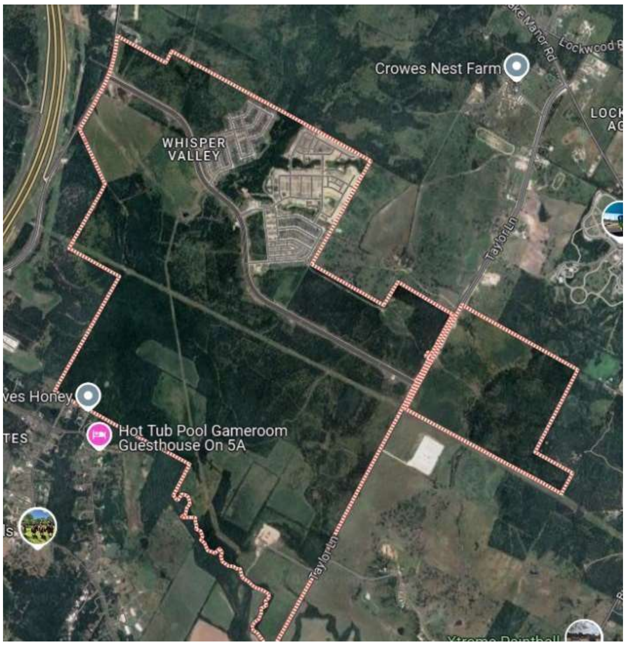


Figure III-12:Whisper Valley location

II.2: Immediate environment

Downtown Austin: Whisper Valley is approximately from downtown Austin, allowing residents to enjoy the city's vibrant culture, dining, and entertainment options while living in a quieter suburban environment

Austin-Bergstrom International Airport: The airport is approximately from the valley offering convenient travel options for residents

Major Employers: The community is strategically located near significant employers such as (Tesla's Gigafactory, Dell, Samsung, and Google),30 making it an attractive option for professionals working in these companies

II.3: Whisper Valley ecology applications

Whisper Valley started with development strategies to establish an eco-friendly community aimed to fight against the climate change. where the first phase of construction was zero energy consumption and to achieve that they integrated geothermal heating and cooling systems, and installed solar panels on every home. Now days the community expanded its amenities with the introduction of organic gardens

II.3.1: Eco-Friendly Home Features in Whisper Valley

Zero Energy Capable Homes: net- Figure 30: whisper valley sky view zero energy consumption is the technology using in the whisper valley houses where they were designed to produce as much energy as it consumes. This reduces reliance on traditional energy sources.

Geothermal Heating and Cooling: The community uses the Geogrid system that uses the deep ground stable temperatures for heating and cooling, where its system works as a thermal center that distribute heating to the whole village

Solar Energy Integration: Homes are also equipped with solar panels that generate electrical renewable energy that contribute the community's goal of achieving net-zero energy consumption

Battery Storage Options: Future phases will offer battery storage options for homes, allowing residents to store excess solar energy for use during low production periods.

Organic Gardens: Whisper Valley boasts community-managed organic gardens that allow residents to engage in gardening tasks, fostering sustainable living and yielding fresh produce.

II.3.1.A: Geothermal Heating and Cooling [Geogrid system]:

a: Functionality:

The Geogrid is a geothermal loop system that spans the entire community, linking every home to an underground piping network. This system utilizes thermal energy sourced from the earth (significantly reducing energy consumption for heating and cooling by up to 75-80% compared to traditional systems)31

Figure III-13:Geothermal Heating and Cooling [Geogrid system]

b: Components:

Geothermal Heat Pumps: Each house in Whisper Valley equipped with heat pump that extract heat from the energy center which is connects to it with hybrid loop system.

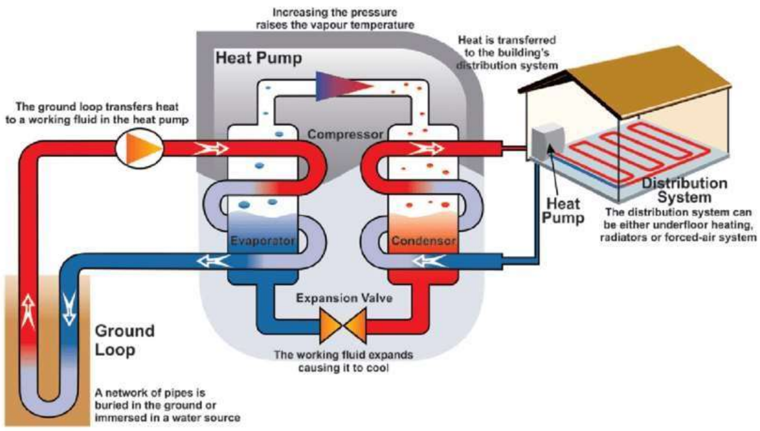


Figure III-14:Geothermal Heat Pumps contents

The Energy Center: is considered as the heart of the Geogrid system, that extract or pump heat from the earth by using heat pumps than distribute this energy to Whisper Valley's houses. This ensures that all homes connected to the system receive optimal heating and cooling

Hybrid loop system: the energy center uses a vertical loop system for higher efficiencies because of its deep boreholes and extract more energy these loops connect with horizontal system that connects between whisper valley's houses and the energy system

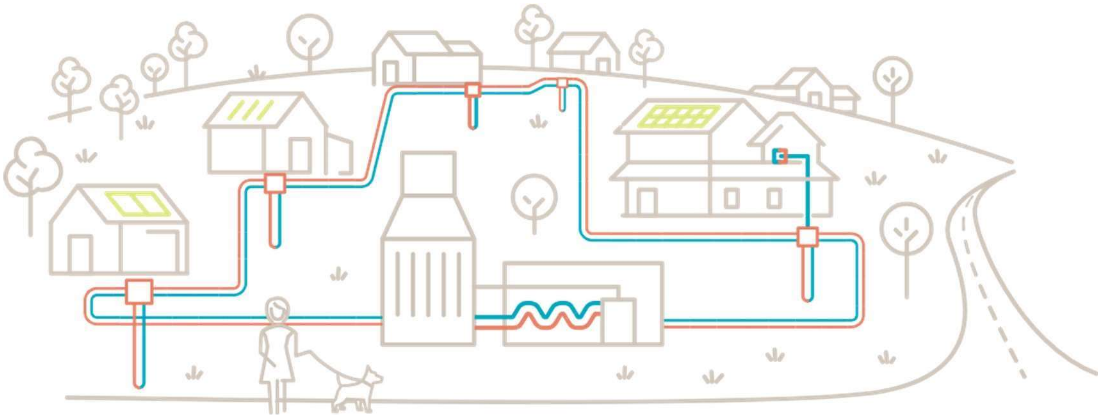


Figure III-15:geogrid distribution example

c: Installation steps of Geogrid in Whisper Valley

c.1. Site Assessment and Planning

the first step is doing a geological analyze to the site to evaluate soil conditions, groundwater levels, and thermal properties of the earth. This step is essential for determining the feasibility the installation geothermal energy system

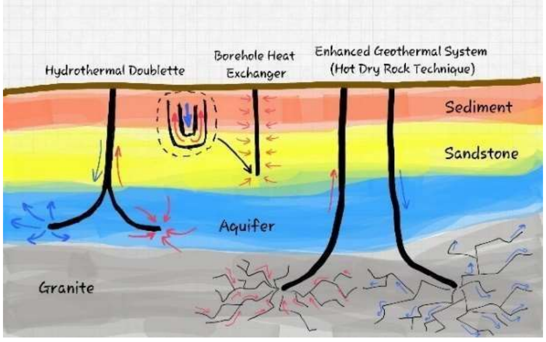


Figure III-16:first step of geothermal installation Site Assessment and Planning

Analyze topography and land use to identify optimal locations for boreholes and horizontal piping systems, which are crucial for the Geogrid's performance.

Figure III-17: second step, Infrastructure Integration

c.2.Borehole Drilling in Whisper Valley

Depth and Design Specifications

The energy center in Whisper Valley (required drilling a 360-foot-deep)32 (about 110 meters). This depth allows for efficient heat exchange with the earth, utilizing the stable ground temperatures for heating and cooling purposes

Use of Advanced Pipe Technology

The boreholes are equipped with (REHAU RAUGEO™ PEXa double U-bend pipe loops), which enhance the efficiency of heat exchange. These double U-bends can increase the output of each borehole (by up to 30%) 33 compared to traditional single U-bends, the double U-bend design facilitates efficient heat exchange between the ground and the fluid circulating through the pipes. This setup allows for effective thermal transfer.

Figure III-18:REHAU RAUGEO™ PEXa double U-bend pipe loops),

The ambient temperature of the loop water typically ranges from about 60°F in winter to around 90°F in summer, optimizing performance throughout the year

Integration with Horizontal Piping

After drilling, horizontal trenches are excavated to interconnect each vertical ground loop into a district-wide geothermal network known as the Geogrid. This system links all homes to a centralized geothermal resource, allowing for shared thermal energy and improving overall efficiency

Geothermal Piping

Polyethylene piping is installed for both vertical and horizontal geothermal exchanges.

c.3: Central Pumping Stations

components the energy centers in the geogrid system often uses electrical submersible pumps or centrifugal submersible pumps these two types of pumps are important to support the high-temperature geothermal fluids

Figure III-19:Central Pumping Stations

c.4: Heat Pump Integration

Each home is equipped with a high-efficiency geothermal heat pump that works in conjunction with the Geogrid system. These pumps significantly reduce energy consumption for heating and cooling by utilizing the stable underground temperatures

II.3.1.B: Solar panels

Installing the soler panels according to the roof orientation, shading from nearby construction, and available space are evaluated to maximize sunlight exposure. The goal is to position the solar array where it will receive the most direct sunlight throughout the day

II.3.1.C: Smart Appliances and Systems

Homes in Whisper Valley use smart home technologies like Nest thermostats and Google Fiber high-speed internet to minimize, monitored and controlled remotely energy use while maintaining performance

II.3.1.D: Sustainable-Sourcing

The community aims to create homes that not only meet modern living standards but also support environmental sustainability by using materials like the reclaimed wood that reduces waste and minimizes the demand for new lumber, thus conserving forests impact

II.3.1.E: Energy-Efficient-Insulation

Homes are insulated with high-density spray foam, which provides excellent thermal resistance. This contributes to better energy efficiency and a more comfortable living environment,

Figure III-20:high-density spray foam, thermal insulation

II.4: Architectural designs

Example 1: The Leon House

The Leon House plan in Whisper Valley is designed as a spacious and modern family home, emphasizing open spaces and high-quality finishes.

Figure III-21:The Leon House

1: plan and surface program

Spaces	Covered porch	Master bedroom	Master bath	Kitchen/dinning/ great room to be	Bedroom 2	Bedroom 3	entry	Garage	Total surface
surfaces	22.4	20		72	11.2	11.2	4	41	152

Table III-4:The Leon House surface program

Figure III-22:The Leon House plan

2: Orientation of Living Spaces:

2.1: The primary living space

faces south with a big window permitting plenty of sunlight for the whole open space during the day. This orientation improves natural light while also aiding in passive solar heating.

2.2: Bedrooms:

Typically situated towards the quieter sections of the house, bedrooms are oriented to receive morning sunlight, enhancing the waking experience as the master bedroom but for the first additional Bedroom that open to the west benefits from bright afternoons, so it misses out on morning sunlight. The second bedroom open to the south with a small window benefit from the sunlight the whole day

2.3: Bathrooms:

Bathrooms are strategically placed near bedrooms for convenience while maintaining privacy from common areas and oriented to the north because bathrooms need ventilation more than sunlight

3: Synthesis

The layout of the Leon House in Whisper Valley illustrates contemporary design concepts centered around sustainability and communal living. Focusing on open areas, natural illumination, and practical designs, it creates a welcoming atmosphere that encourages social engagement as well as individual privacy.

Example 2: Ferguson house

1:the surface program

Figure III-24:Ferguson house plan

Figure III-23:Ferguson house

spaces	Covered porch	Master bedroom	Master bath	kitchen	living room	Dining room
surfaces	35.15	25		24	30	12.22

spaces	Bedroom 2	Bedroom 3	study	entry	Garage
surfaces	15.5	12.5	12.5	4	43

Table III-5:Ferguson house srface program

Utility A dedicated space for laundry and storage, often located near the garage entrance for convenience.

2: Orientation

- The location of the master bedroom and the second room to the north, along with the living areas, exposure to light is limited, resulting in dark interiors and a greater reliance on artificial lighting, which affects comfort and functionality. Additionally, they may be colder in winter.

- The 3rd Bedroom is ideally located on the east side of the house that helps it to benefit from the morning sunlight.
- This allows natural light and warmth in the morning while preventing the room from becoming too hot in the □ afternoon.
- the 4th Bedroom that opens to the west benefits from bright afternoons, so it misses out on morning sunlight.

3: General synthesis

3.1: Ecological

3.1.1: Geothermal

- The GeoGrid™ Energy Center functions as a hybrid loop system and serves as the backbone of this network, overseeing the distribution and circulation of geothermal energy across the community to guarantee optimal efficiency for all linked residences.
- The installation process starts with evaluating the site and planning, which involves geological assessments to verify suitable ground conditions for effective geothermal energy exchange.
- The process of borehole drilling includes creating deep vertical holes (around 360 feet) and employing advanced REHAU RAUGEO™ PEXa double U-bend pipes for maximum heat exchange efficiency.
- Heat exchangers incorporated into CPS (central pumping stations) enhance energy efficiency by transferring heat between geothermal fluids and other water systems without direct contact.

3.1.2: Solar energy

Durable materials such as aluminum and galvanized steel are used for solar panels fixing them on the roofs structure with the inverters, ensuring stability and durability.

3.2: Architectural

- Open-Concept Design: Spacious layout with interconnected living room, dining, and kitchen areas.

- Natural Light & Energy Efficiency: South-facing living areas maximize sunlight exposure, aiding in passive solar heating and reducing energy use.
- The best orientation for the bedrooms is the east to benefits from morning sunlight.
- Large windows and well-positioned openings allow for effective airflow, reducing the need for artificial cooling during warmer months.
- The porches offer a shaded outdoor space for relaxation and socializing

III : Example 03 : OIA, Santorin, Greek

III.1: situation

OIA is the most popular place in the Iceland of Santorin located on the northwestern tip of Santorini where it is situated in the south of the Greek, the village built on (volcanic cliffs with an elevation of 130 m)34 surrounded by the sea of Aegean, it covers an area of (73 square kilometers with a total population of around 15,550 residents)35

Figure III-25:OIA, Santorin, Greek situation

III.2: Urban plan:

According to the urban plan of Oia we can see that all the houses (habitant places) placed in the upper level of the village in the opposite of the touristic and public spaces putted in the lower level of the village with the aim of respecting the natural beauty, open a view for all the building to the sea and protect the privacy of the habitants

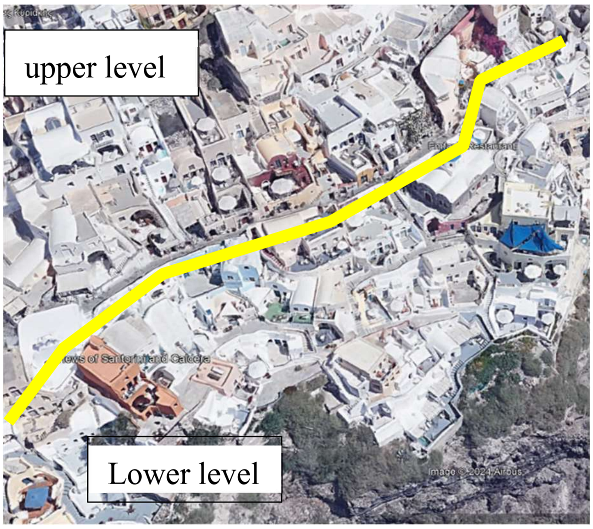


Figure III-26:OIA, Santorin, Greek geographical division

III.2.1: Geographical factors:

Oia is built on cliff side with a dramatic view over the sea, The lower levels of the village that contain public and touristic places such as restaurants and shops are closer to the sea can take full advantage of the views of the sea and sunset where the houses occupied the upper level allow the visitors or even the village habitant to enjoy the panoramic view with the breathtaking sunsets from the comfort of their homes, and also this organization may create kind of intimacy separating the public and residential spaces

III.2.2: accessibility:

placing public spaces, restaurants, and entertainment facilities closer to the sea allows easy access for visitors and helps managing the flow of people, especially those arriving by boat or ships and also offer more intimate and residential parts of Oia. And accpording to oia topography the main circulation in it is for pedestrians where just in the upper level we can find parkings in each house

III.2.3: Natural Light and Ventilation:

this organization ensure that all the buildings profit from the natural lighting and ventilation especially the top buildings profit from the natural flow of
the wind helping to cool and refresh the houses

III.3: The urban program

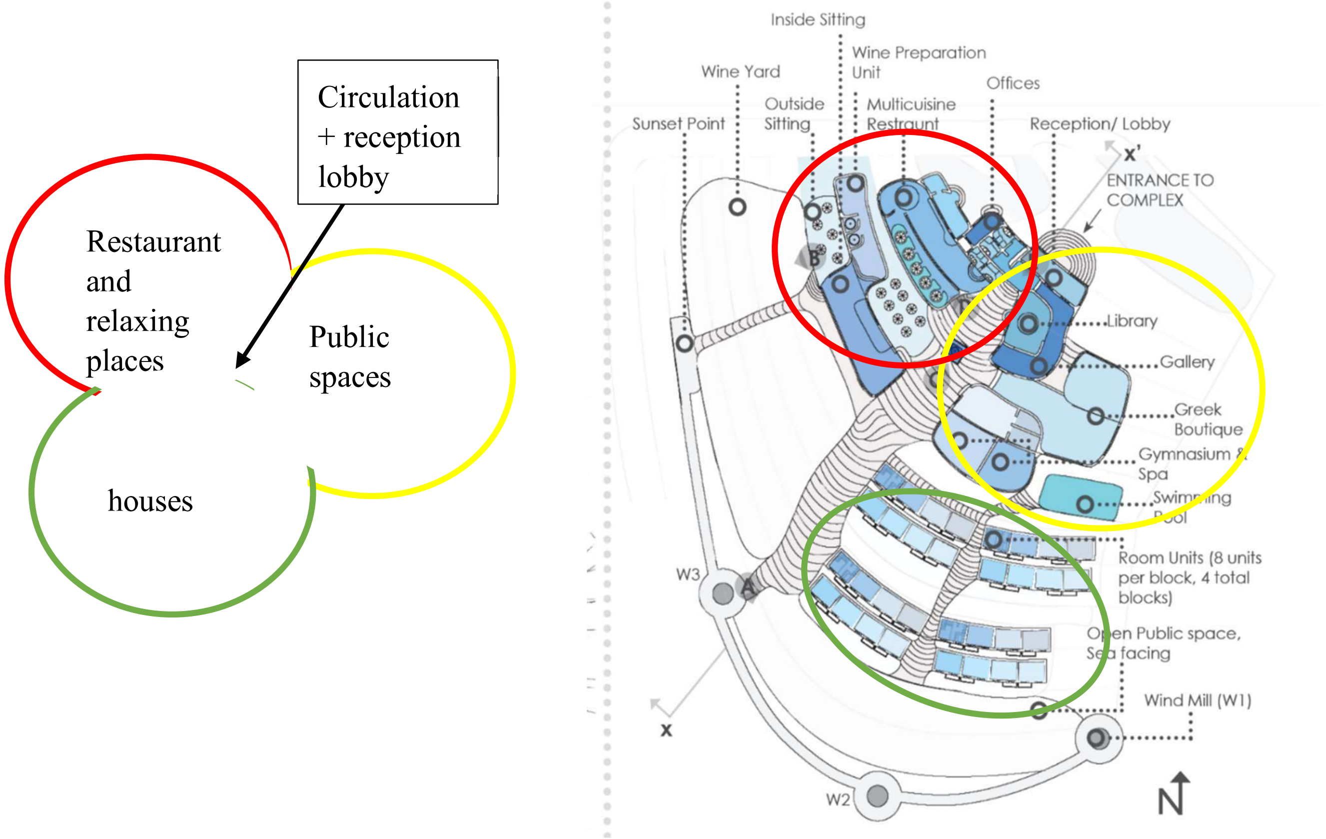


Figure III-27:OIA , urban distribution

Individual Houses	Swimming pools	Swimming pools	spa	gallery	boutiques	library
Reception lobby	restaurants	Offices				

Table III-6:OIA urban program

III.4: Urban facade

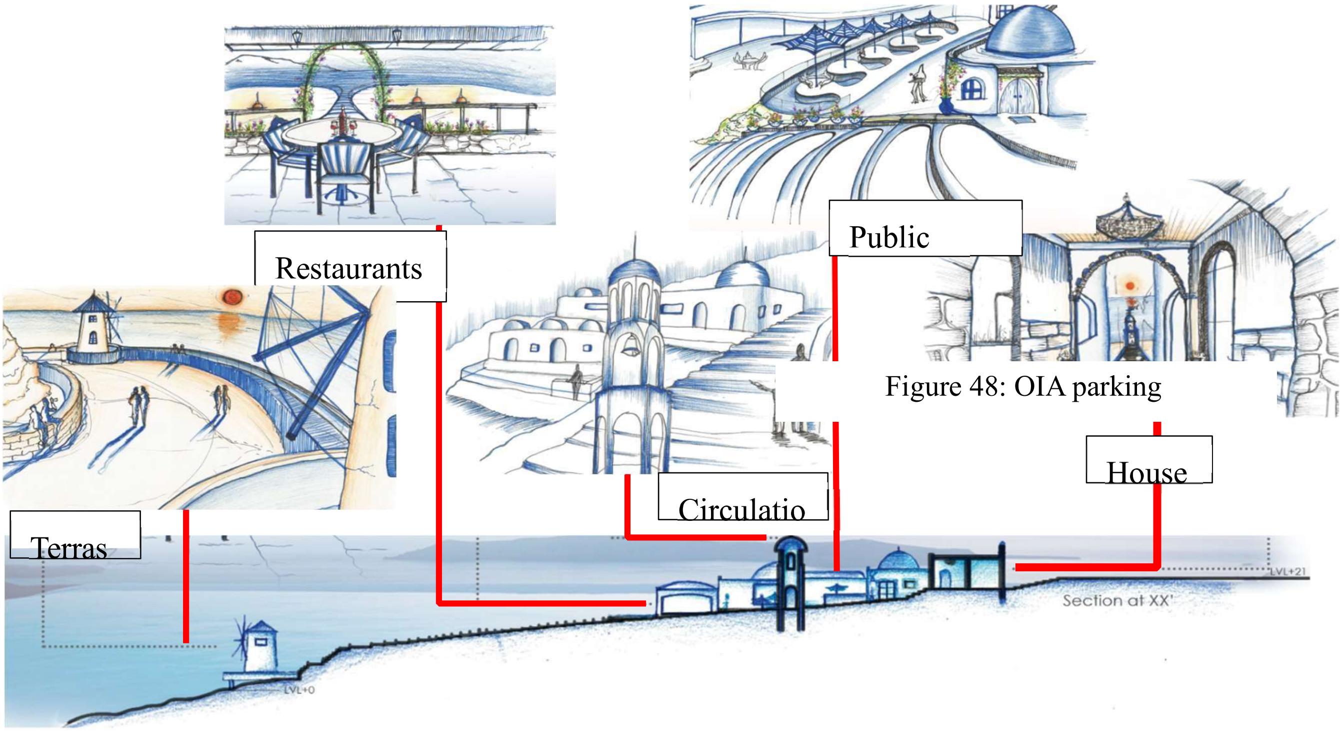


Figure III-28:OIA urban façade

III.5: Parking:

according to OIA topography the main circulation in it is for pedestrians where just in the upper level we can find parking's in each house for long sitting visitors and for instant visitors there are free opening packings like Kyklos Square Parking and There are also private options like (Sunset Parking and Oia Parking, which provides charging services for electric vehicle.) 36

Figure III-29:OIA public parking

III.6: Architecture side

The architecture of Oia showing the best adaptation with the environment and the nature of the nature of the terrain, including steep slopes and limited building materials create a type of houses that could find just in oia where they were constructed with natural volcanic stone and were built into the volcano cliffs as Yposkafa Spitia (cave houses), and many are designed to blend seamlessly with the landscape with curving smooth lines and rounded blue domes.

Figure III-31:smooth lines and rounded blue domes

Figure III-30:OIA environment adaptation

III.6.1: House example

Example 1: Architect’s house

its beautiful shape looks like handmade form and its white color harmonizing with pool color showing a good adaptation with the nature of oia and to contract and give some uniqueness to the house they use the yellow color for the windows and doors

Figure III-32:Architect’s house

1: The house plan

Living Area: 145 sqm

Outdoor Area: 400 sqm

Figure III-33:The architect's house plan

1.1: living area:

the main living space and the center of the house is an open plan includes sitting and dining area that has entrance to the kitchen which is open on the on the front yard that includes the swimming pool, and also the center area separates between the master rooms and small room

Figure III-34:Architect's house living area

1.2: Bedrooms

The house includes 3 bedrooms, two of themes with big size sharing one master bathroom and have there one entrance that led to both of them, the rooms are open on the outdoor area

1.3: Outdoors

Figure III-35:Architect's house outdoors

a big spaces Private heated swimming pool (45 sqm. Outdoor heated jacuzzi Outdoor dining area, Wood-fired BBQ, Outdoor WC, Terrace with sun loungers, Private parking area for 2 cars

III.7: synthesis

- the conception of the buildings is done according to the natural topography of oia where they blended seamlessly with it
- the distribution of the buildings (residential spaces in upper levels, while public and tourist in lower levels) is done to ensures privacy for habitants while facilitating access to tourist attractions.
- Buildings are arranged to ensure maximum exposure to natural light and airflow
- The architecture in Oia is designed primarily for pedestrians, promoting sustainable tourism by reducing vehicular traffic

- Using natural materials (volcanic stones) for the buildings not only enhances the aesthetic appeal but also ensures the durability and sustainability
- The houses built into the cliffs to adapt the terrain

IV: Example 04: El Moumnin touristic complex

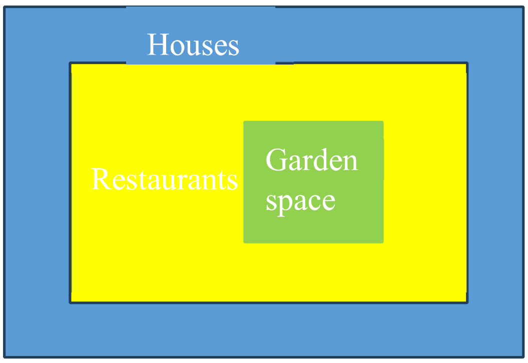
IV.1: Situation

The complex is located in Bouaedjar between Ain Temouchent and Oran facilitate the accessibility for visitors traveling from major urban centers, it is far from Bouzedjar center about 3.2 km, The site is surrounded by coastal and mountainous landscapes, offering breathtaking views and diverse natural experiences. And because of its terrain topography that overlooks the sea and its houses conception that was inspired from the aunt’s house makes it one of the most attractive touristic complexes in Algeria

Figure III-36:: El Moumnin touristic complex

IV.2: Urban plan

the urban plan of bouzedjar village organized around a garden space where the center of the village is a small garden surrounded by the restaurants surrounded by the houses to facilitate the entrance to the center and create a common space to maximizer the interaction between the habitants that help for recreation and also should mention the t perfect adaptation with the terrain where the buildings is constructed in respect with of the terrain topography (line ….) , each building has an overlooking view to the sea 3.1: Adaptation with the contour line



The buildings are placed in a way that respects the slope of the land, following the natural contours rather than imposing rigid geometric grids.

This prevents excessive excavation or land alteration, reducing environmental disruption.

IV.3: Pedestrian Flow:

The circulation within the complex is primarily pedestrian-oriented, with vehicles restricted to specific zones.

Pathways follow the natural slope, making navigation easier while integrating seamlessly with the environment.

IV.4: Natural Ventilation & Lighting:

Buildings are strategically placed to maximize exposure to natural light and sea breezes, reducing energy consumption.

The curved, dome-like structures also enhance airflow, keeping interiors cool in the Mediterranean climate.

IV.5: accessibility

the village has a bad accessibility where the street that led to it is unpaved and there is no lead marks to the village make it difficult to reach to it but in the village itself the streets are organized and paved for the car's circulation but between the houses (the walkable roads) are made by local stones

IV.6: Architectural Features

IV.6.1: Design Inspiration & Concept

- Designed by architect Ibrahim Meki, known for blending traditional and modern architectural elements.
- Inspired by the traditional architecture of Ghardaïa and Oued Souf, regions famous for their adobe buildings and organic urban planning.
- The structures resemble ant nests, earning the complex the nickname "Ant's Nest Village."
- The design integrates Islamic and Western influences, creating a harmonious balance between aesthetics and functionality.

IV.6.2: Construction & Materials

- Built using locally sourced materials, promoting sustainability and regional authenticity.

- White exteriors reflect sunlight, reducing heat absorption and helping to maintain cooler indoor temperatures.
- The minimalist design allows the complex to blend seamlessly into the coastal landscape.
- Materials were carefully chosen to ensure durability against coastal weather conditions, such as high humidity and strong winds.

IV.6.3: Structural Features

- Dome-shaped roofs and curved walls provide:

Natural ventilation, reducing the need for artificial cooling.

Soft, diffused lighting, creating a comfortable indoor ambiance.

- Circular chalet layouts improve airflow, comfort, and space utilization.
- Chalets are clustered in close proximity, mimicking the natural organization of ant colonies.
- The design ensures privacy while maintaining a sense of community.

IV.7: Synthesis

Terrain Integration: Design buildings to blend with the land's natural topography, minimizing environmental impact.

Pedestrian Circulation: Prioritize walkable pathways and reduce vehicle access in some areas.

Natural Ventilation & Lighting: Maximize natural airflow and light through strategic placement and design features like curved walls.

Sustainable Materials: Use locally sourced, sustainable materials that reflect the region's climate and culture.

Blend Traditional & Modern Design: Combine local architectural influences with modern design for a unique identity.

Community-Centered Spaces: Organize buildings around shared communal areas to encourage interaction.

Climate-Responsive Features: Incorporate strategies like reflective roofs and shaded spaces to adapt to the local climate.

IV. Chapter 4: project

I: terrain analyses

I.1: Guelma presentation

I.1.1: situation

The Wilaya of Guelma is located in the northeast of Algeria, between the parallels of 39° and 40° north latitude, and the meridians of 5° and 6° east longitude. It is situated in the center of the northeast region, 537 km from the capital, covering an area of 3,686.84 km². The capital, Guelma, is 60 km from the Mediterranean coastline. It is positioned at an altitude of 300 meters in a basin at the foot of the Maouna Mountains, which gives it the name of "the dish city.

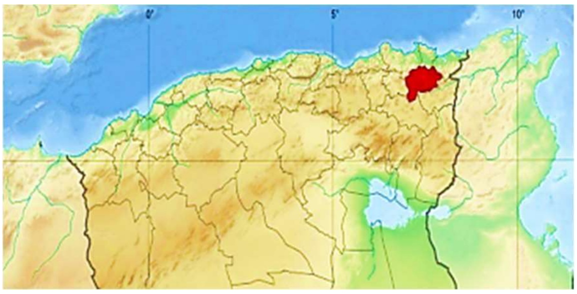


Figure IV-1:guelma situation

I.1.2: limits

The Wilaya of Guelma is bordered by: NORTH: Wilaya of Annaba (65 km), NORTH-WEST: Wilaya of Skikda (95 km), WEST: Wilaya of Constantine (116 km). SOUTH: Wilaya of Oum El-Bouaghi (168 km), EAST: Wilaya of Souk Ahras (78 km), NORTH-EAST: Wilaya of El Taref (126 km) 37

I.2: Hammam oulad ali:

I.2.1: presentation

Hammam Ouled Ali is a small yet strategically located village in the Guelma Province of northeastern Algeria. Due to its important strategic location on the slope of a picturesque mountain range and the abundance of its fresh and thermal waters, it attracts a large number of tourists from different states of the country, seeking rest and leisure. It is considered a thermal tourism hub of the state, especially in winter and spring, the prime seasons for thermal tourism[38]

I.2.2: Geographical situation:

The village of Hammam Ouled Ali is located west of the municipality of Héliopolis, 17 km northwest of the city of Guelma, along National Road No. 8, which connects the states of Guelma and Skikda. Several municipalities surround Hammam Ouled Ali: Heliopolis from the east, Guelma from the Southeast, Bouhamdan from the Northeast and Nechmaya from the North

I.2.3: Accessibility

Hammam Ouled Ali boasts excellent accessibility, situate directly along National Road No. 8 (RN8), which connects the wilayas of Guelma and Skikda. Located just 17 km northwest of Guelma city, it can be reached in about 20 minutes by car, making it convenient for both locals and tourists

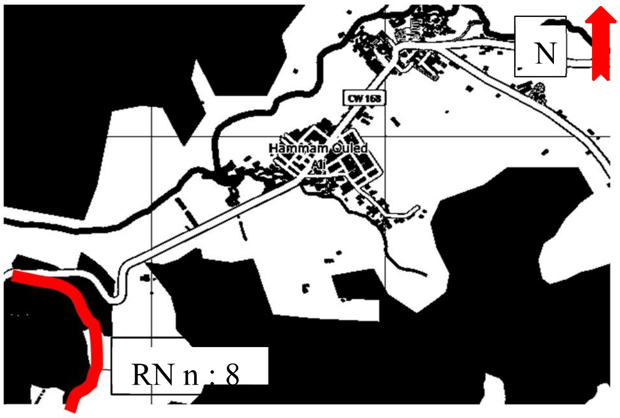


Figure 55: Hammam Ouled Ali accessibility

I.2.4: Climate:

Temperature and Seasonal Variations: Summer (June to August): The region sees high temperatures, often exceeding 35°C (95°F), with maximums reaching around 43.83°C (110.89°F) in August. Average temperatures 37.71°C and can decrease to a minimum of about 22.42°C at night

Winter (December to February): The temperatures are significantly lower, ranging from about 5°C to 15°C Rainfall is more frequent during this season, contributing to the overall wet conditions4.

I.2.5: Seismic Activity

The commune of Heliopolis is part of the wilaya of Guelma, which is classified as a medium seismicity zone (Zone 2).

I.2.6: energy use

Parameter	Observations
Number of Thermal Springs	4[39]
Temperature of Springs	Approximately 57 °C
Primary Energy Sources	Natural gas, crude oil
Residential Energy Consumption	Ranges from 37.30 to 83.90 kWh/m²/year
Main Uses of Energy	Heating, cooling, electricity, tourism facilities like hotels and thermal complexes

Table IV-1:Hammam Ouled Ali energy use

I.2.7: thermal source of Hammam Ouled Ali:

The thermal source of hammam oulad ali is situated 12 km the north of Guelma and approximately 2 km to the right of the Guelma-Skikda national road

- Spring captured and used; Water is captured through pipes from the griffons to the reservoirs and then pumped to supply the baths; The springs are used for spa treatments; The flow rate is constant and permanent; Captured flow rate: between 4 and 17 l/s, Leakage flow rate is around 1 l/s.40

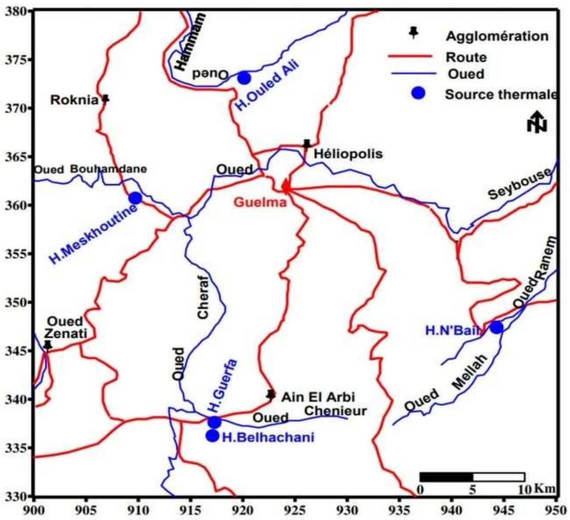


Figure IV-2:Inventory map of the thermal springs of Guelma (according to DIB.H, 2004).

I.2.8: Land choice motivation:

-Hammam Oulad Ali is renowned for its thermal springs, which have therapeutic properties. This natural resource is a significant draw for wellness tourism, providing a unique selling point for your eco-village.

-The area is surrounded by scenic hills and forests, enhancing its appeal as a tourist destination focused on nature and relaxation

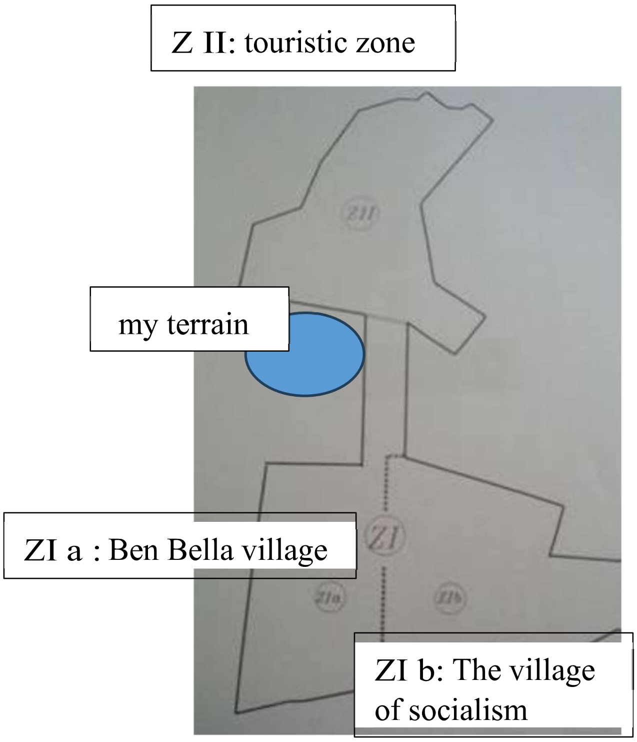


Figure IV-3:terrain situation

I.2.9: terrain analyzation:

I.2.9.1: terrain situation

The chosen land occupies a central position within the POS of HAMMAM OULAD ALI, as planned within the programmed framework of the POS, intended to accommodate touristic extension with a surface of 20000m² and pentagon shape

I.2.9.2: terrains constraints

I.2.9.2.A: North side hammam al baraka

Hammam Al Baraka already attracts visitors for its hot springs, and my ecovillage can benefit from this by offering complementary experiences such as eco-lodging, wellness retreats, or outdoor dining.

I.2.9.2.B: West Side (River Border)

Natural water source, scenic views, and potential for eco-recreational activities.

- Develop riverside lodges, walkways, or Open-area restaurants by the river will create a unique dining experience with natural views and a relaxing atmosphere

I.2.9.2.C: East Side (Main Road) accessibility

- Key accessibility points for visitors and supplies.

- Visibility for tourists passing by, increasing visitor flow.

I.2.9.2.D: South Side (Restaurants & Individual Houses)

- Social and commercial interaction zone.
- Collaborations with local restaurants for organic food supply and tourism synergy.
- Create a community-driven atmosphere
- Shared infrastructure potential (waste management, energy, water recycling).

I.2.9.2.E: Servitude (Floodable Water course):

A floodable watercourse serves as a natural drainage channel and plays an important environmental role, but it limits construction due to flood risk and regulations. Managed creatively, it can be turned into a valuable eco-friendly feature, enhancing the ecovillage through

Avoid heavy construction in the flood zone and ensure compliance with flood management regulations

I.2.9.2.F: Electric Line:

the existence of an electric line in the middle of terrain may divide the land and complicate project layout or circulation paths or it may create a buildable mesh for the project

I.2.9.2.G: Topography (contour line)

The terrain is approximately rectangle with 212 m for the lang side and 121 m for the short side where:

Long side (212 m)

higher point: 239 m above sea level

lowest point: 229 m above sea level

Figure IV-4:terrain Topography (contour line) the slope: 239-229=10/212=0.0472*100=4.72% short side (121 m)

higher point: 239 m above sea level lowest point: 236 m above sea level

theslope:239236=3/212=0.0248*100=2.48%

Figure IV-5:terrain Topography (contour line)

I.2.9.3: immediate environment

The land is bounded to the northwest and west by extensive agricultural fields, characterized by dense vegetation and tree cover. This natural barrier presents a significant obstacle to the prevailing cool winds from these directions, potentially

The land is bordered to the north and northeast by urban tourist developments, establishing an eco-village within this urban context promotes sustainable tourism, encouraging environmentally responsible practices that significantly reduce the carbon footprint of tourism

The land is bordered to the south and southwest by a residential area, which provides essential amenities such as a hospital and a mosque. This proximity ensures convenient access to vital services for both residents and visitors, enhancing the overall appeal and functionality of the touristic

The land is bordered to the south and southeast by expansive agricultural fields, creating an open terrain that exposes the area to prevailing hot winds from these directions, which may affect the local thermal

I.2.10: synthesis

This slope has medium inclination in the two directions approximately 4.72% and 2.48% which makes it manageable for most practical uses, whether you're considering agriculture, building, or landscaping. The topography of the terrain shows a higher point that could be suitable for the geogrid center, which could help with the hot water distribution without using more energy make us minimize the energy consumption

Terrain split

Electric Line Constraint i have placed the houses and commercial areas in a way that avoids interference with the electric line. This ensures safety and compliance with building regulations.

2. Sanitation Line Parallel to the Main Road the sanitation line parallel to the main road suggests an efficient water and waste management system. It also ensures easier maintenance and access.
3. Functional Zoning

- Residential Zone Centrally positioned, providing easy access to the road and commercial areas.
- Commercial and Restaurant Area: Positioning the restaurants near the river enhances its aesthetic and commercial value, this placement can attract more visitors and improve the overall experience. it aligns with sustainable urban planning by utilizing natural landscapes for economic benefits
- Geothermal Center: Placed the geothermal center at a higher elevation minimize energy loss and improving efficiency. The natural flow due to gravity can assist in the distribution of heat, making the system more efficient and potentially reducing the need for additional pumps, further lowering energy consumption

4. Main Road Accessibility

- Ensuring that key zones (residential, commercial, geothermal center) are accessible via the main road enhances mobility for both visitors and residents.
- Easy access also improves the logistics for supplies and services.

- Adding pedestrian safety, incorporate sidewalks or green pedestrian paths leading from the main road to key areas. Consider creating designated bus stops or bike paths to encourage eco-friendly transportation options.

II: Project concept

II.1: The retained Urban and architectural program

retained Urbain Program
Luxury villas
Public squares and gathering areas
Fitness centers and wellness hubs
Geothermal energy system infrastructure
Parking areas
pedestrian-friendly trails
Bike trails
Restaurants and pubs, cafeteria
Recreation Spas and wellness centers

Bungalow retained program	surfaces
Souna	6
Thermal pool	16
Hammam	14
Dining room	12
Sitting room	20
Master bed room	16
Bed room	12
Bathrooms	10
Kitchen	12
entry	4

Table IV-2:The retained Urban and architectural program

II.2: project mesh

First mesh: the main road:

The terrain is open on hammam Ouled Ali main road that connect between Guelma and Heliopolis, with this road we can create a horizontal mech all along the terrain

Figure IV-7:terrain limitation

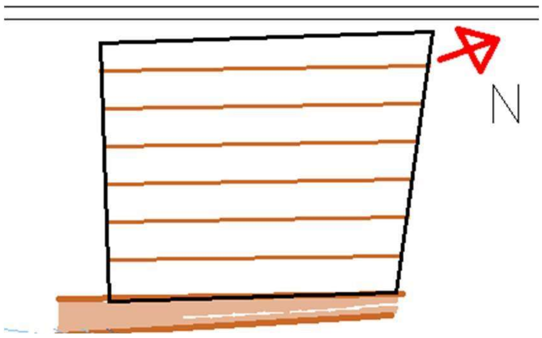


Figure IV-6:the main road mesh

Second mesh: the servitude

Because of the presence of a servitude under a part of the terrain so we can't build any construction on that part so it will be automatically a garden or relaxing space for the project and because of its organic shape it helped to create a mesh and give the first idea of the project concept

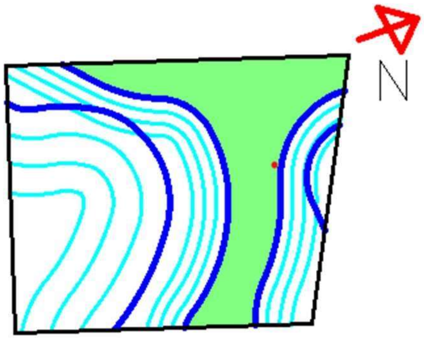


Figure IV-8:the servitude mesh

The third mesh: the electric line

And from one mesh we can create other meshes that could help in the project main idea for example we can do a mirror copy of the main mesh and after collecting all the meshes one above the other it would give the project idea

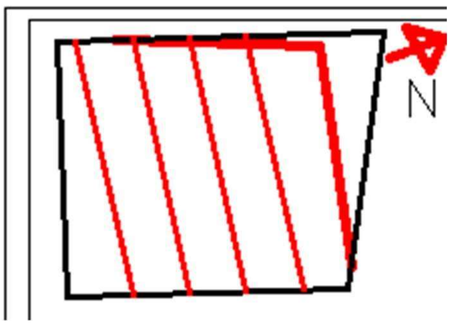


Figure IV-9:the electric line

The final mesh result

and we can do some modifications to give us the last result, which is represented in giving a centrality to the project

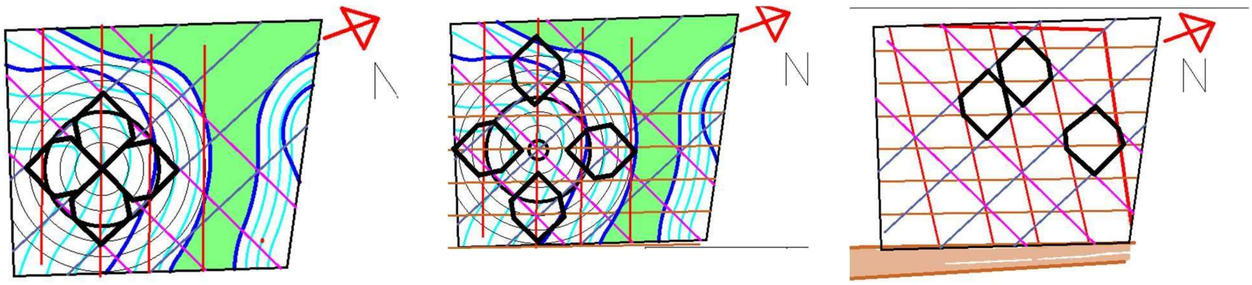


Figure IV-10:the result mesh

II.3: The ground plan

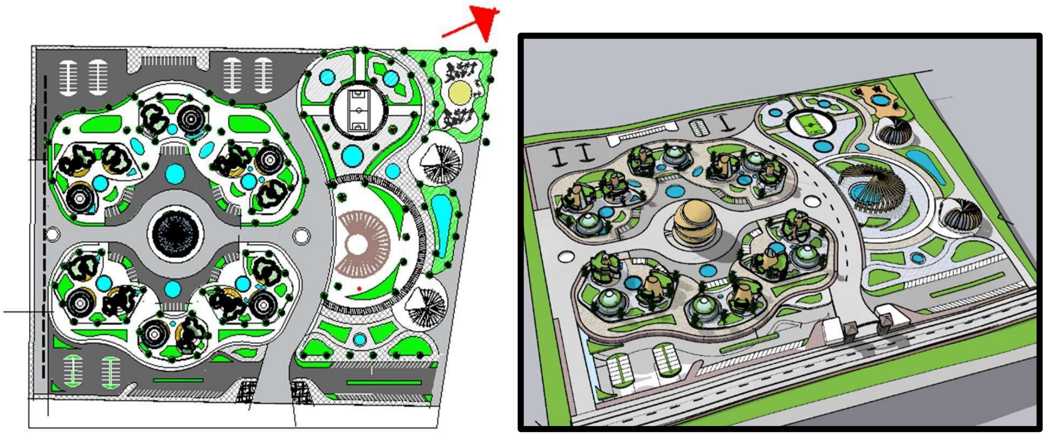


Figure IV-11:the ground plan 2d and 3d view

II.4: The bungalows plans and facades

For the buildings design I went with metaphor as a concept, and for this I choose the pine cone because Guelma is famous by this tree, I inspired its organic form to demonstrate a biomimetic approach, using the pine cone's spiral geometry as the basis for both the 3D form and spatial organization

II.4.1: type one

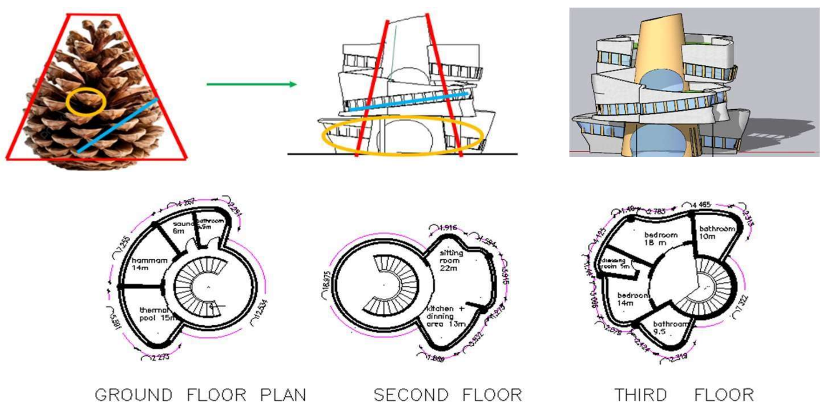


Figure IV-12:the first type of bungalows(3d view ,plans, and façade)

II.4.2: Type two

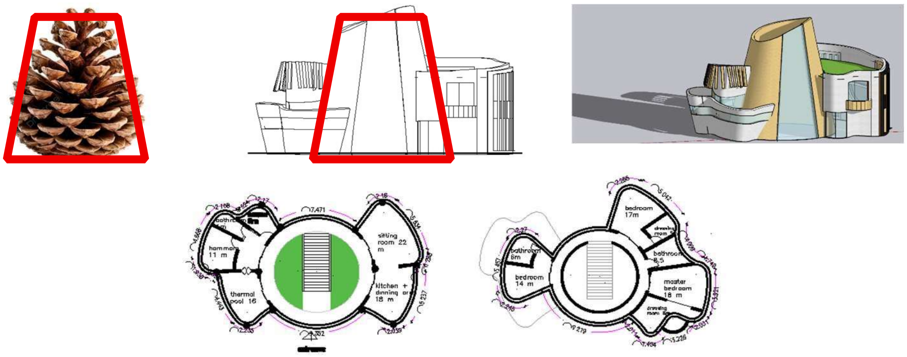


Figure IV-13:the second type of bungalows (3d view, plans, and façade)

II.4.3: Type 3

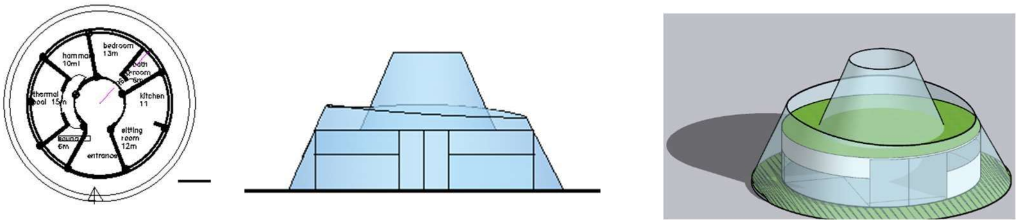


Figure IV-14:the third type of bungalows (3d view, plans, and façade

II.4.4: Restaurant

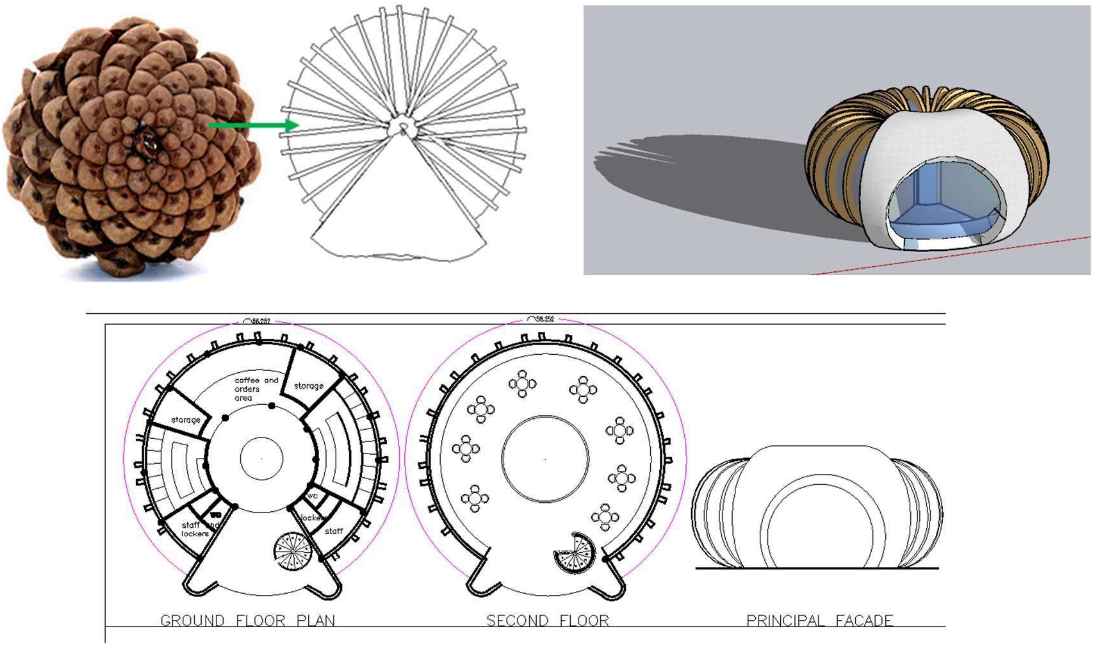


Figure IV-15:restaurant(3d view, plans, and façade)

III: The simulation

The software I used for the simulation is design builder

III.1: the building materials

III.1.1: exterior wall

the materials I used for the exterior wall (from exterior to interior) is

- base coat of resin 1 cm
- terracotta brick

15cm

- air gap 5cm
- terracotta brick 10cm
- base coat of resin 1 cm

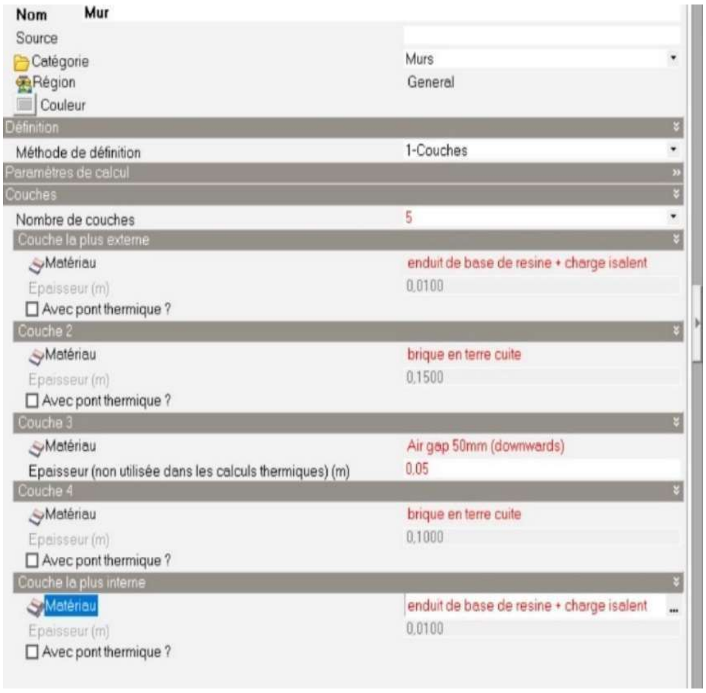


Figure IV-16:exterior wall building materials layers

III.1.2: Floor material

the materials I used for the floor (from interior to exterior) is

- Reinforced concrete 16cm with thermal bridge 5%
- Thermal isolation polyester 4cm
- Vapor barrier 2cm
- PEX pipes diameter 1.6cm
- Cement 5 cm

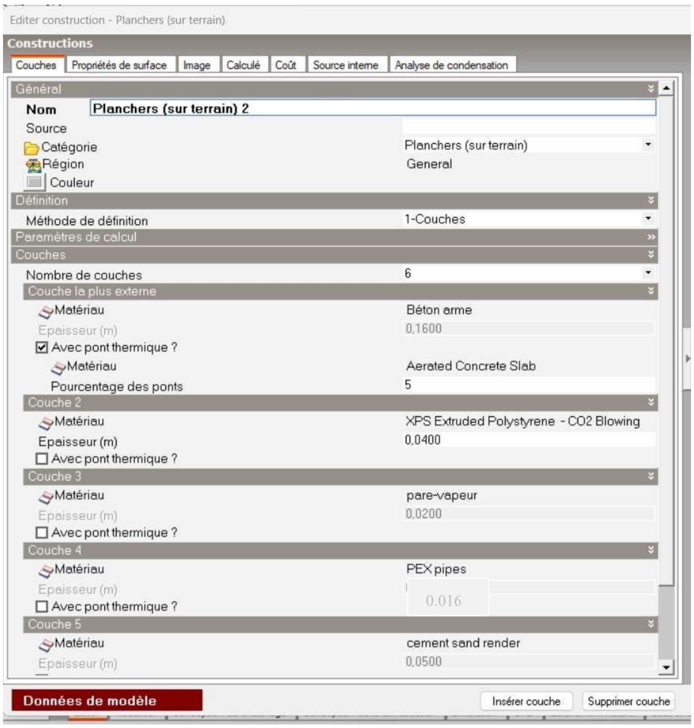


Figure IV-17:floor building materials layers

- Floor covering 1cm

III.1.3: Roof materials

the materials I used for the roof (from interior to exterior) is

- Reinforced concrete 16cm with thermal bridge 5%
- Vapor barrier 2cm
- Thermal isolation PUR 1cm
- EPDM (waterproof material)

1.6cm

- Cement 5 cm
- Vegetation 5cm

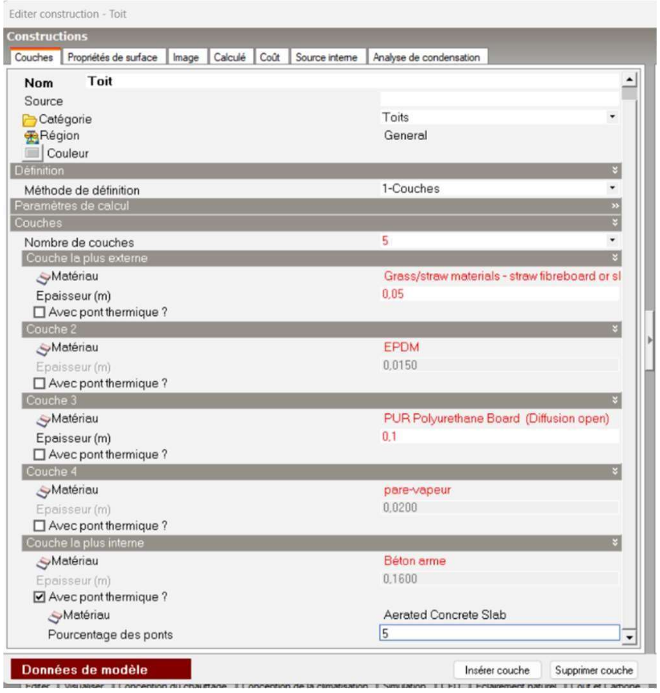


Figure IV-18:roof building materials layers

III.2: Pipes installation

The green line presented the underground pipes that extract the water from earth then it reaches to the red part that represents the hot water circulation that connected with the distribution system,

the hot water used returned to earth as a cold water which represented by blue lines

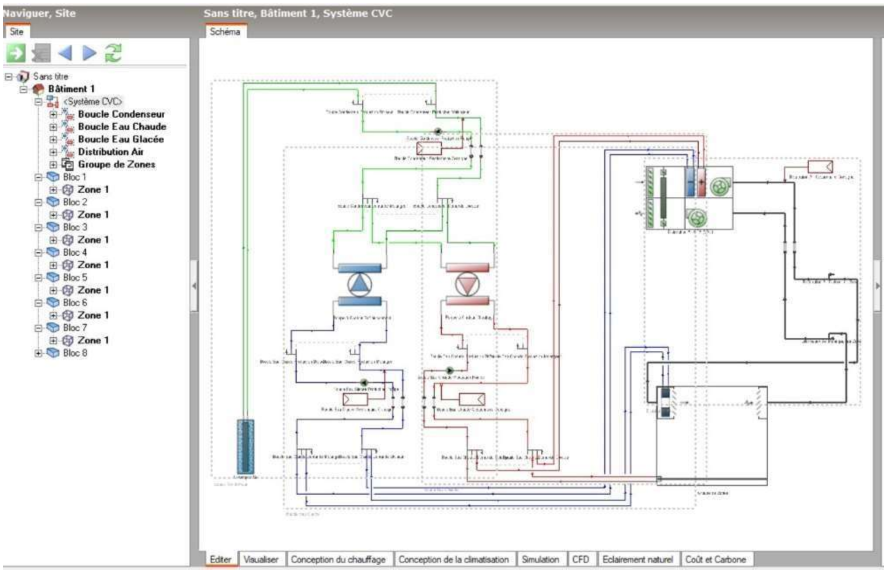


Figure IV-19:geothermal system installation (pipes)

III.3: Interior Temperature simulation

results

III.3.1: bedroom temperature

the temperature inside the house (bedroom) is 23 which is the ideal temperature for the occupants

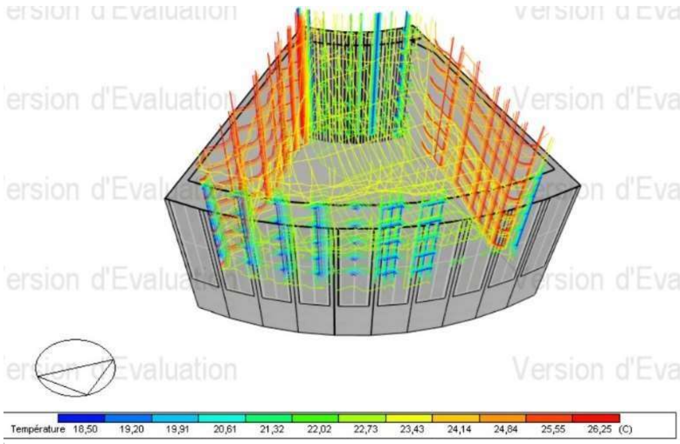


Figure IV-20:bedroom's temperature simulation

III.3.2: Bedroom wind speed

The wind speed inside the bedroom is between 0.2 and 0.4 which represent the thermal cooling ideal wind speed

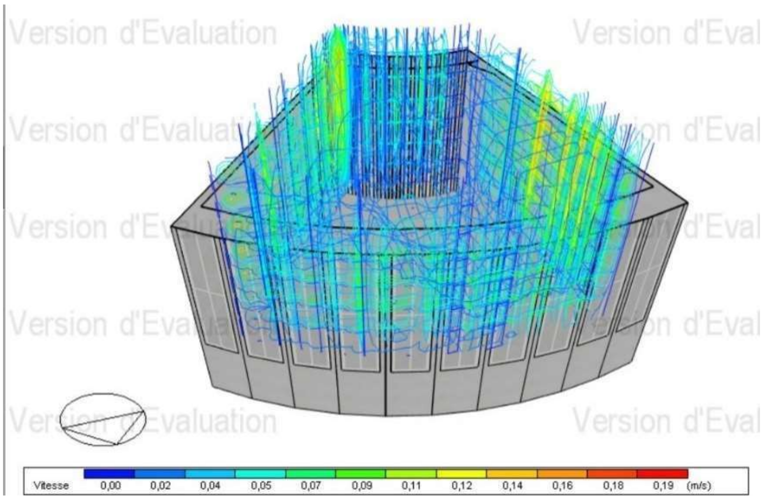


Figure IV-21:bedroom's wind speed simulation

III.3.3: Temperature results 15 Jun

The results show that despite the changes of the exterior temperature, the interior temperature will stay at the ideal range of temperature

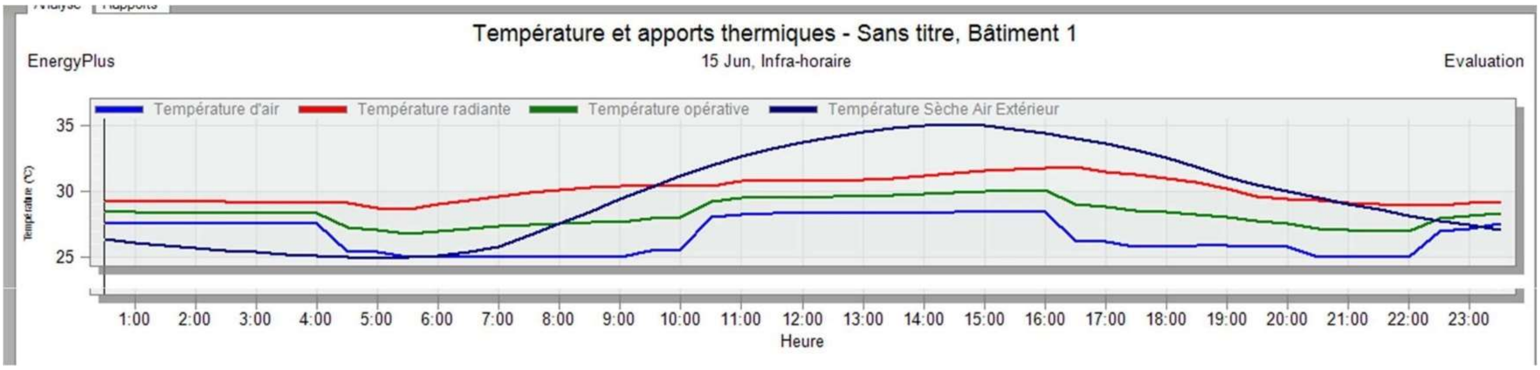


Figure IV-22:temperature results in Jun

III.3.4: The exterior walls temperature:

The blue color represents the roof and it shous that the temperature is 17 its low because of the vegetation

The red and orange it's the parts of the building that face the south this why the temperature is high

And for the part that face the north where the sun rays don't reach its cooler (green color)

And the last part is the floor and it looks a little warmer because of the geothermal pipes

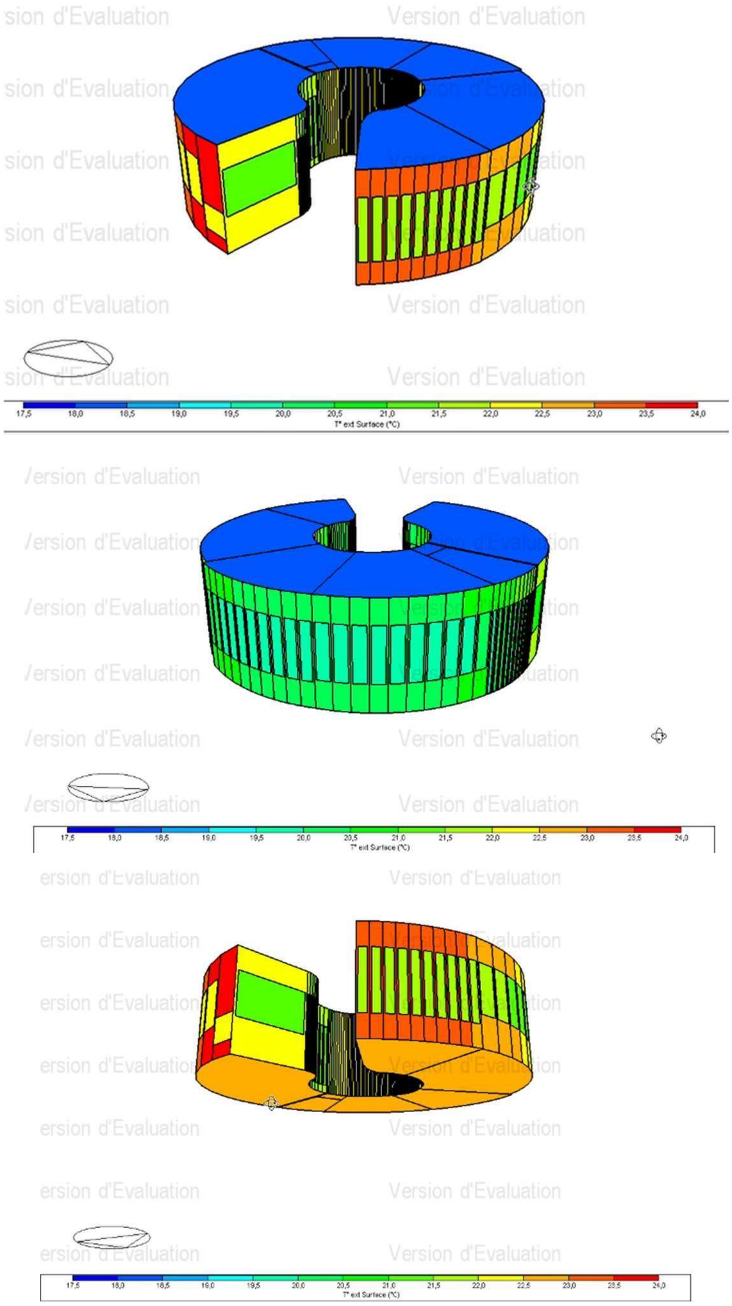


Figure IV-23:the exterior walls temperature

III.3.5: Comparison with normal building

the temperature results of the same building without the geothermal energy system and the specific materials shows that the temperature inside the building changes according to the exterior temperature

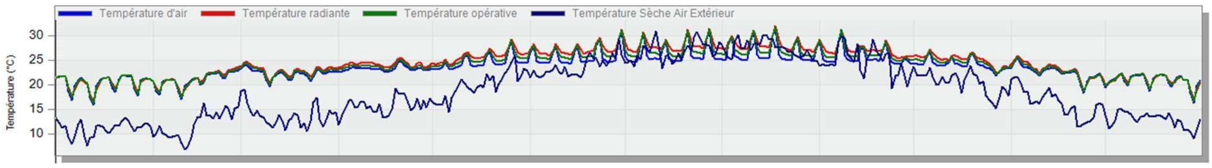


Figure IV-24:normal building temperature results

General conclusion

Geothermal energy is a natural and renewable resource derived from the heat stored within the Earth's core. This vast reservoir of thermal energy can be effectively captured and harnessed for a variety of purposes including cooking, bathing, space heating, and the generation of electrical power. Notably, the total amount of geothermal energy present beneath the Earth's surface far exceeds the current global energy demand, making it a promising and sustainable alternative to fossil fuels.

In the context of our final study project, we explored the specific application of geothermal energy for heating purposes, focusing on an eco-touristic village located in Hammam Ouled Ali, Guelma, Algeria. This region is particularly well-suited for such an endeavor due to its naturally occurring thermal springs and geothermal potential. The proposed system employs a heat exchanger immersed in thermal waters, supported by a network of underground pipes. These pipes, connected to heat pumps, circulate the geothermal water, transferring the accumulated heat to individual bungalows, thereby ensuring the efficient heating of living spaces.

To assess the effectiveness and viability of this system, we utilized **Design Builder**, a simulation software tool used for evaluating building energy performance. Specific sustainable building materials, such as **thermochromic glazing**, were integrated into the simulation to enhance thermal regulation and overall energy efficiency. The results demonstrated that after implementing the geothermal heating system, indoor air temperatures remained consistently within the optimal comfort range of 20°C to 24°C throughout the entire year. This not only confirms the system's potential in maintaining thermal comfort but also highlights its capability in reducing reliance on conventional heating systems, thus lowering energy consumption and environmental impact.

Based on these promising results, it can be concluded that geothermal energy presents a highly viable and profitable solution for residential and touristic heating needs—particularly when certain conditions are met. Key factors such as the geographical location, the thermal characteristics of the land, and the presence of geothermal resources must be carefully evaluated prior to implementation. In our case study, the natural hot springs and geothermal activity in Hammam Ouled Ali offered an ideal setting for this sustainable intervention.

Moreover, when geothermal energy is integrated with eco-conscious architectural strategies and environmentally responsible urban planning, it opens the door to the development of self-sufficient, low-carbon communities. These communities can serve both residential populations and attract eco-tourists, thereby supporting local economies while simultaneously protecting natural resources.

Geothermal energy, therefore, stands out not only as a clean and sustainable energy source but also as a transformative element in the global movement toward sustainable development. In regions like Guelma, where geothermal conditions are favorable, its application offers a unique opportunity to address pressing environmental challenges, foster innovation in renewable energy, and enhance the quality of life for current and future generations. By tapping into this underground source of power, societies can move closer to achieving energy independence, reducing greenhouse gas emissions, and building resilient infrastructures capable of withstanding climate variability.

In conclusion, geothermal energy is more than a heating solution—it is a pathway toward a greener future, where communities live in harmony with the environment while benefiting from modern, energy-efficient technologies.

Reference

1. Bibliography (Books, Journal Articles)

1. Armin Razmjoo et al., 2020, Bujok et al., 2023
2. Conolly, *Renewable and Sustainable Energy Reviews* (2016), pp. 1634–1653
3. Thoreau, H.D. *Walden* (1854)
4. Howard, E. *Garden Cities of To-morrow* (1898)
5. Gilman, Robert & Diane. *Ecovillages and Sustainable Communities*, 1991

2. Websites (Blogs, Articles, Informational Sites)

4. https://www.gstcouncil.org/ecotourism/
5. https://parks.desi.qld.gov.au/management/ecotourism/about#why_is_ecotourism_important
6. https://mize.tech/blog/ecotourism-101-ecotourism-examples-definition-best-practices/
7. https://tashi.travel/blog/2019/the-history-of-ecotourism-and-its-weight-in-sustainabledevelopment
8. https://www.ioi.ngo/blog/2016/10/29/history-of-ecotourism
9. https://ecoelements.co.uk/ets/pages/ecotourism.html
10. https://greenglobaltravel.com/what-is-ecotourism-history-principles-of-responsible-travel/
11. https://www.turtlefiji.com/what-is-ecotourism/
12. https://en.wikipedia.org/wiki/Ecotourism
13. https://en.wikipedia.org/wiki/Geothermal_energy
14. https://www.energy.gov/eere/geotherma/electricity-generation
15. https://envirotechgeo.com/horizontal-and-vertical-geothermal-ground-loops/
16. https://www.geothermalerthe.com/post/unveiling-the-differences-vertical-vs-horizontalgeothermal-systems
17. https://geojerry.com/pondloops.html
18. https://lestresorsderable.com/en/what-is-a-canadian-well-.htm?srsltid=AfmBOooGWBXuwWJxtqPSDaEeQAwVUIrfWt7MVM-u4W9bmzBnxmGUThR
19. Findhorn Feature Page on Undiscovered Scotland
20. Findhorn Foundation - Wikipedia
21. Findhorn Ecovillage: A nearly zero carbon pioneering settlement in Moray Scotland. - Ecoarc
22. https://www.findhorn.org/blog/after-60-years-whats-new.

Reference

23. https://www.struttandparker.com/properties/findhorn-1
24. https://eskgrove.co.uk/developments/wadingburn/house-types/findhorn-plot-8/
25. https://www.hrgreen.com/projects/whisper-valley/
26. https://www.whispervalleyaustin.com/big-tech-companies-near-whisper-valley/
27. https://www.lgihomes.com/resources/announcements/whisper-valley-master-plan
28. https://www.whispervalleyaustin.com/how-our-innovative-geothermal-infrastructurepowers-zero-energy-capable-homes
29. https://www.apoplous.blog/santorini-oia-travel-guide/
30. https://santorinivacationphotography.com/2024/09/07/essential-guide-to-parking-insantorini-tips-for-stress-free-parking-in-fira-oia-and-beyond/

3. Government / Institutional Documents

37. https://www.dcwguelma.dz/fr/index.php/10-menu-principal/44-situation-geographique
38. https://guelma.mta.gov.dz/fr/zone-de-hammam-ouled-ali-2/

4. PDF Reports / Dissertations / Technical Documents

3. DIRK GAUL, FAO Volunteer – *Environmental Impacts of Ecotourism: A review of literature*, March 2003, p.2
4. Dr. Iftikhar Hussain – *An Overview of Ecotourism*, p. 472
5. BEKKOUCHE Mohamed Faouzi – *Caractéristiques hydrochimiques des sources thermales de l'extrême Nord-Est Algérien*, p.12
6. https://conduitcalc.plasticpipe.org/pdf/bcd-whisper-valley-winning-for-theenvironment.pdf