ARCHITECTURAL DESIGN VISION FOR SUSTAINABLE AND ENERGY EFFICIENT TOURISM DEVELOPMENTS IN THE MEDITERRANEAN CLIMATE

Zeynep Naz Yelken - 5724716
Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft

ABSTRACT

The research recognizes the environmental and cultural implications of architectural tourism projects in naturally appealing locations like the Mediterranean, where the impact on local residents and resources are frequently overlooked. The study, which focuses on the energy and resource consumption of tourism projects, examines the possibility of passive design strategies as a sustainable approach for reducing energy usage in hotels. Recognizing the absence of standards and guidelines facilitating passive design, the study develops a design manual adapted specifically to hotel developments in the Mediterranean climate. The methodology involves understanding suitable passive design solutions, establishing analysis criteria for common hotel morphologies and typologies, modeling energy demand, and evaluating architectural design freedom. The study's findings show the effectiveness of passive design solutions with an emphasis on solar passive design and natural ventilation. The produced design manual provides guidelines for integrating passive design principles in hotel projects and achieving architectural design opportunities, with recommendations for optimum morphologies and typologies. The findings indicate that terraced morphology and single-loaded slab typology are extremely successful solutions in terms of both energy efficiency and architectural design flexibility. The study also recommends alternative morphologies and typologies for hotel design, as well as hybrid applications. The findings are generalizable across the Mediterranean climates, giving a foundation for future research into passive design methods in other common areas of hotels, as well as other characteristics for a more complete examination.

KEYWORDS: *Tourism, passive design, energy efficiency, hotel, mediterranean, climate design*

I. INTRODUCTION

Countries that are rich in their natural beauty, culture, and climate conditions have always become targets of architectural tourism developments. Especially in the 20th century, with the unstoppable growth of globalization, mass tourism became the main solution for accommodating large amounts of touristic movement profitably in hotels. Extensive constructions that offered a sense of globalized luxury, while holding significant amounts of tourists in isolated bubbles of tourism activities showed potential for short-term profits (Dredge, 2022, p. 277). This view not only encourages a blindsided view for tourists to disregard the impact on assets of visited locations, but also creates a consumerist design vision and user behaviour for tourism developments.

Additionally, within the development of these projects, the importance of local stakeholders is kept as a secondary importance which affects the sustainability and resilience of local communities (Jojic, 2019, p. 158). Considering the clear shift towards experience and culture-oriented tourism in Europe, it is necessary to follow an all-around vision (Jesse Maida, 2023). However, an all-around application of sustainable tourism focusing on energy efficient projects that benefit both local and commercial interests still lack development. This also reflects heavily on the [building] energy and resource consumption by heating, cooling, and lighting (Mejjad et al., 2022, p. 4).

A major issue of tourism projects relate to high amount of energy and resource consumption throughout the lifespan of the buildings. This is especially important since buildings (or hotels) accommodate tourists for long periods of time regardless of the resources they consume. Considering over 50% of building energy consumption is related to buildings heating, cooling, and lighting, it is important to investigate a solution relevant for the tourism industry (UCLA, 2015). Moreover, “growing desire for better indoor environment, energy demand for heating and cooling is expected to increase steadily” especially when it comes to the Mediterranean context (Imessad et al., 2014). This can bring an even higher energy trend for locations like the Mediterranean region.

Figure 1 Positive and negative impacts of tourism in the mediterranean region (Aston University - EU, 2012; Casals Miralles et al., 2023; Mejjad et al., 2022; WWF, n.d.).

As one of the effective methods of achieving energy efficiency in buildings, passive design strategies show potential to be integrated in the tourism industry. The potential of passive design strategies is significant since it aims to mitigate climate change through detailed evaluation, research, and architectural design. This makes passive design strategies highly appealing as it focuses on ‘low tech’ and cheaper solutions unlike high-tech services that might consume more energy and investments to perform well. It is also shown that implementation of passive design strategies “has proven to be highly effective, which translate into significant energy savings and mitigation of GHG (greenhouse gases - carbon dioxide, methane and nitrous oxide) emissions” (Elaouzy & El Fadar, 2022a, p. 15; Ritchie et al., n.d.). It is also relevant to develop a strategic vision for building efficiency for a high consumption-oriented sector like tourism.

One of the reasons for the lack of passive design strategy adaptation is based on a “clear lack of regulations, policies and funding programs to encourage building owners [or designers] to apply passive design strategies” (Elaouzy & El Fadar, 2022a, p. 15). Recognizing this research gap, as well as the lack of sustainable advancements in the tourism sector (the high profit and low-cost vision), the deployment of a low cost and design-oriented solution shows potential. Related to the lack of guidelines and regulations for passive design strategies, an important factor is to “consider the coordination of various passive strategies with the characteristics of the building in question, and the local climate” (Elaouzy & El Fadar, 2022b). Therefore, it is relevant to determine which strategies are appropriate for selected building “characteristics.” A critical point in this situation is that indoor temperature control is heavily dependent on thermal comfort of the users. This energy demand is, therefore, significantly controlled by the user experience or behavior and may vary from person to person. This issue comes together with the consumerist tourism mentality that the sector promotes for the users. However, in order to promote sustainable tourism industry, it is essential to create a vision for climate conscious buildings and people. Therefore, the research aims to implement passive design strategies to create an ideal indoor environment to promote less need for climate control and lighting. Moreover, creating a foundation for passive architecture in tourism developments can lead to adaptation of these strategies to be easier and more appealing for designers.

Therefore, the thematic research objective aims to develop a passive design manual for tourism developments in the Mediterranean climate. First, this research will dive into understanding which passive strategies are relevant for the Mediterranean climate. Later, these strategies will be evaluated according to their applicability in selected building characteristics relevant for tourism the tourism product (hotel). This manual will later be used for the development of the overall design project to integrate appropriate strategies in the selected site. The selected site is in Malta in the town of Marsaskala. The town of Marsaskala is expected to grow more than 40% over the years for both the local and touristic population and becomes an appealing spot for its closeness to the capital and the airport. The climate issues on the island are faced with higher consequences (such as scarcity of resources, drought, lack of water sources, high seasonality, and high consumption-oriented tourism) and therefore requires a more thorough implementation when it comes to design decisions. Malta is also the 5th biggest contributor to EU for travel and tourism-based GDP and expected to grow this industry by 80% between 2024-2028 (Chapman & Speake, 2011; Vella & Malta Tourism Authority, n.d.). So, the site is chosen as an “extreme” climate context regarding the Mediterranean climate and tourism development in the Mediterranean region (See Appendix A for project overview).

This brings the main research question:

How architectural tourism developments like hotels can minimize their energy consumption with effective and efficient implementation of passive design strategies in the Mediterranean climate and promote application of these strategies?

Sub-questions:

- What are the most common hotel morphologies and typologies used in the Mediterranean region?
- What kind of design parameters drive decision-making in hotel design?
- How much energy can be saved with the implementation of natural ventilation passive design strategies?
- What kind of design constraints do natural ventilation passive design strategies bring for different types of hotel morphologies and typologies?

II. METHODOLOGY

In order to make the researched information accessible and adaptable, it is important to create a design manual/guide for tourism developments in the Mediterranean regio/climate. This can ensure the accessibility and availability of information which can be utilized seamlessly during the project development phase. This is done after the initial literature research based on passive design, tourism management and hotel design study cases (See Appendix A for methodology overview).

Understanding applicable passive design strategies

To be able to assess the potential of passive design strategies effectively, these strategies are filtered according to their applicability for the Mediterranean climate. This is achieved through a review of literature and research papers focusing on passive design strategies applied in the Mediterranean climate on different projects and research. As a focus location, Malta, is chosen to perform a climate analysis and further deepen the knowledge on the Mediterranean climate.

Define analysis criteria and context

The methodology for constructing a passive design manual for tourism developments focuses on; performing architectural and technical evaluations for passive design strategies on hotel designs. These hotel designs are defined as the most common morphological and typological options used in projects currently. Therefore, the context of the research is defined as 4 morphologies: High-rise tower, y-shaped, terraced and village complex and 3 typologies: single-loaded slab, double-loaded slab, and atrium. Assessing architectural and technical evaluation on these design contexts can help provide an overview of the most appealing options for tourism developments.

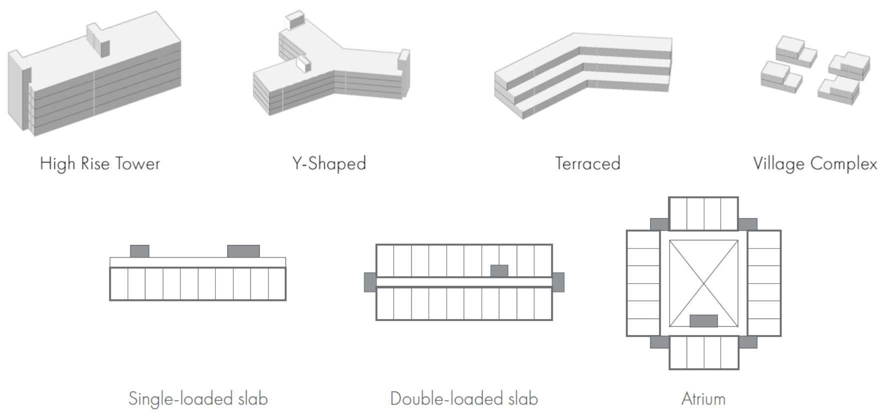


Figure 2 Selected 4 morphologies and 3 typologies that are commonly used in hotel designs.

The architectural evaluation is based on considering conditions that are highly valuable for both hotel designs and passive design strategies. By understanding these themes, it is possible to create criteria of evaluation for both design restriction (for hotel design) and design applicability (for passive design.) These criteria are gathered through case studies of existing hotels in the Mediterranean region and research papers on tourism theory and passive design in the Mediterranean. These assessment criteria are orientation, number of accommodation units, facade openings & privacy and landscape & outdoor activities.

Simulate energy demand

The selected simulation method is through a Rhino, Grasshopper plug-ins Solemma- ClimateStudio with the assistance of Energy Plus and Ladybug plug-in for solar analysis. The simulation creates spatial composition for 4 morphologies and 3 typologies and aims to understand the energy load and passive design potential. A part of this analysis tests the effectiveness of natural ventilation passive design on hotel en suite guestrooms and hotel hallways on Solemma-ClimateStudio. The solar passive design potential is done by understanding the overall solar exposure and the facade area that requires shading according to solar exposure over 6 hours during the day.

Assess architectural design freedom.

To bring an architectural perspective to the success and application of passive design strategies, two architectural assessments are made. The first part focuses on design adaptability by understanding which design criteria are affected to achieve different types of passive design strategies and suggests most appropriate morphologies and typologies. The last part aims to point out the architectural design potential that these morphologies and typologies can offer along side their previously found energy performance. These suggestions and conclusions are made through case studies and architectural evaluations.

Evaluate and synthesize

This is finalized with the data gathered from energy simulations and solar analysis as well as architectural assessments. The combination of all evaluation types is gathered to see which morphologies show most potential (either by being the most energy efficient, most architecturally flexible, or adaptable) and listed. All the design requirements, opportunities, constraints, and conclusions are synthesized in a design manual to provide an overview of passive design implementation in tourism developments.

Additionally, the passive design manual will be used starting from the early design phase to investigate integration of passive design strategies on the existing building in Marsaskala. The strategies will be integrated by trying to satisfy the architectural design opportunities (mentioned in the design manual) and optimal energy efficiency. Therefore, it is expected to create a feedback loop between the design manual and the project.

III. RESULTS

The outcome of the architectural and technical evaluation helped developing a design manual that gives an overview of passive design strategies available for the mediterranean climate. This overview suggests design requirements, restrictions, and effectiveness on the context of 4 morphologies and 3 typologies. Within the design manual, orientation, solar passive design and natural ventilation passive design are discussed. The research also performed architectural and technical evaluations on solar and natural ventilation passive design.

The overall results for solar passive design vary significantly for each design type and it is important to point out the relation between solar exposure and the need for solar protection. Cases where solar exposure is higher than the 'need for solar protection' will be ideal as they can provide more daylighting and consequently decrease lighting energy loads. This is also important to decrease material needed for facade shading. Therefore, y-shaped morphology is the least appealing option due to its high need for solar protection relative to solar exposure. When it comes to multi-story morphologies, High-rise towers and terraced are the most ideal for daylighting and the amount of solar protection needed (See Appendix B for the solar passive design overview.)

For Morphology	For Typology
1. Village Complex	1. Single-loaded slab
2. High-rise tower	2. Atrium
3. Terraced	3. Double-loaded slab

Figure 3 Most effective morphologies and typologies for solar passive design. Considering the need for shading and overall solar exposure.

Natural ventilation passive design and solar shading show variety in their adaptability for hotel design, so it is ideal to suggest ranked options (See Appendix B for the passive design adaptability overview).

In this evaluation, direct passive design methods have more weight due to their higher energy impact. In terms of passive design applicability, the village complex morphology has the most freedom in integrating passive design strategies due to the character of the design having separate units of accommodation. When it comes to the other morphologies, terraced morphology shows the next best potential with major drawbacks for cross ventilation potential. This success is also dependent on the orientation of the terraced morphology as it can be single-directional. High-rise towers and y-shaped morphologies show similarities in their concepts. However, for high-rise towers as the connection with the ground level is lesser, evaporative cooling may become challenging. This becomes a similar drawback for y-shaped in the case of multiple levels (for example over 5 levels.)

For typologies, the distinction is highly visible with single-loaded slab showing the most potential for overall passive design applications. This is followed by the atrium and double-loaded slab respectively. The biggest constraint is faced with double loaded-slab due to creating closed and compact spaces. Compactness can be useful in passive design as well; however, in terms of natural ventilation passive design, it is less appreciated.

Passive Strategies		Most prefered to least preferred by developers->				Most prefered to least preferred by developers->		
		Morphology				Typology		
		High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Only Solar Protection	Before (kWh/m2/yr)	55	55,2	51,5	71,7	57,4	55,9	62,9
	After (kWh/m2/yr)	50,7	51,3	49,3	61,9	50,6	51,9	59
	Impact (% kg CO2/m2/yr)	**8%**	**7%**	**4%**	**14%**	**12%**	**7%**	**6%**
Passive Ventilation Cooling (With solar shading)	Before (kWh/m2/yr)	50,7	51,3	49,3	61,9	50,6	51,9	59
	After (kWh/m2/yr)	37	37,4	36,8	37,9	35,3	37,7	41,5
	Impact (% kg CO2/m2/yr)	**27%**	**27%**	**25%**	**39%**	**30%**	**27%**	**30%**
	Total Decrease in Energy Load	35%	34%	30%	52%	42%	35%	36%

Figure 4 Results of energy demand simulations on selected morphologies and typologies. The figure shows the energy demand decrease after solar passive design and natural ventilation passive design.

The energy performance before and after passive design strategies also suggest nuance. According to the results, the distinction between total percentage decrease in energy load (%) and the final energy consumption per area annually (kWh/m2/yr) is important. Although the village complex becomes a superior option with 52% decrease in the energy load, it has the highest energy consumption per area with 37,9 kWh/m2/yr. Therefore, it is important to prioritize energy consumption over percentage decrease for drawing conclusions. As a result, the terraced morphology becomes the lowest energy-consuming morphology per area annually with 36,8 kWh/m2/yr. A very important difference for village complex and terraced morphologies is also their direct contact with the ground (compared to other morphologies where the ground level is public functions.) This causes significant energy save for hotel designs and makes terraced morphology especially ideal for locations with complex topography.

For typologies, by far the most effective and efficient option is single-loaded slab with both lowest energy consumption of 35.5 kWh/m2/yr and energy decrease of 42%. Although the total decrease in the energy load for the atrium is 36% (compared to 35% for the double-loaded,) double-loaded slab becomes a more ideal option with energy load 37.7 kWh/m2/yr (compared to 41.5 kWh/m2/yr for atrium.) This makes atrium typology a less preferable option compared to double-loaded slab for hotel design. However, atrium can still be integrated as solar chimneys to promote a stack effect rather than a complete building typology.

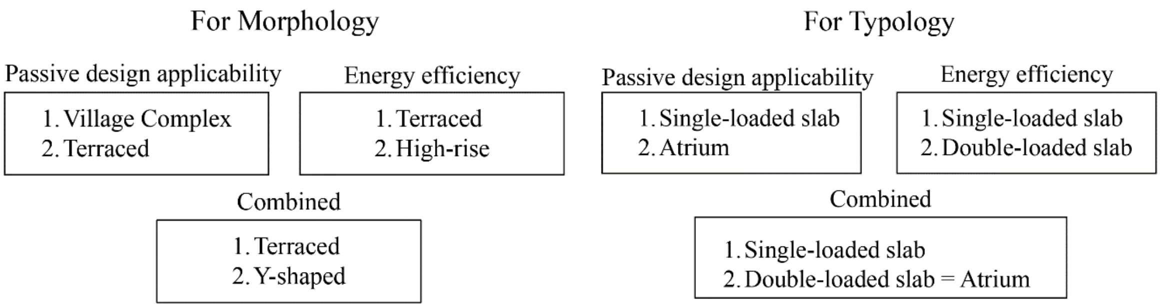


Figure 5 Most effective morphologies and typologies after solar passive design and natural ventilation passive design. According to the overall energy load per area annually.

Architectural design opportunities is a highly important criteria and can help achieve sustainability goals related to hotel design from a social and contextual perspective. These opportunities can help promote healthier relationships with the stakeholders to create healthier communities and overall, a more sustainable design vision. The simulations show that Y-shaped morphology has the highest potential by allowing opportunities for all design criteria. This is due to its radial spread over the context which allows opportunities for all-around views, zoning, landscaping, and creating different levels of public-private interactions. It is also a high-density accommodation morphology which makes it a profitable design choice for developers. The second-best option is the terraced morphology which achieves a multi-story quality without being intrusive to the context with stacked terraces and only facing limitations for orientation. From a design point of view, terrace morphology offers potential for social interactions and a seamless connection between ground level and upper levels. The last morphologies are equally the effective high-rise tower and village complex. The high-rise tower morphology shows potential for achieving high-density accommodation zones and allowing attractive views without privacy issues. This design morphology is especially weak with relating to its context due to the multi-story aspects. The village complex, however, shows strengths in weaker criteria of the high-rise tower: orientation and landscaping & outdoor activities. These are due to the scale of the accommodation zones being significantly smaller allowing flexibility for relating to the context. Village complex also offers opportunity for a more diverse masterplan with zoning and clustering.

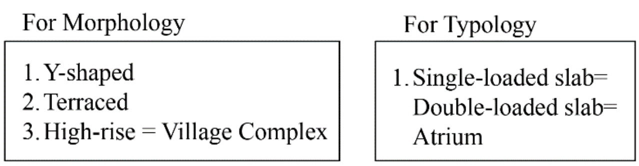


Figure 6 Most effective morphologies and typologies for architectural design potential. According to 4 hotel/passive design criteria that was developed.

Synthesizing all evaluation sections of the research gives an overview of strengths and weaknesses of selected morphologies and typologies. The synthesis suggests that terraced morphology shows an overall competency in all categories in a uniform manner. This is followed by the village complex, y-shaped and high-rise tower. An important detail is related to architectural design opportunities. If several design criteria are less important for the designer, then the lack of this design opportunity will not be critical for the success of the morphology or typology. Therefore, it is important to understand which criteria are available in morphologies and typologies (See Appendix B for hotel design criteria).

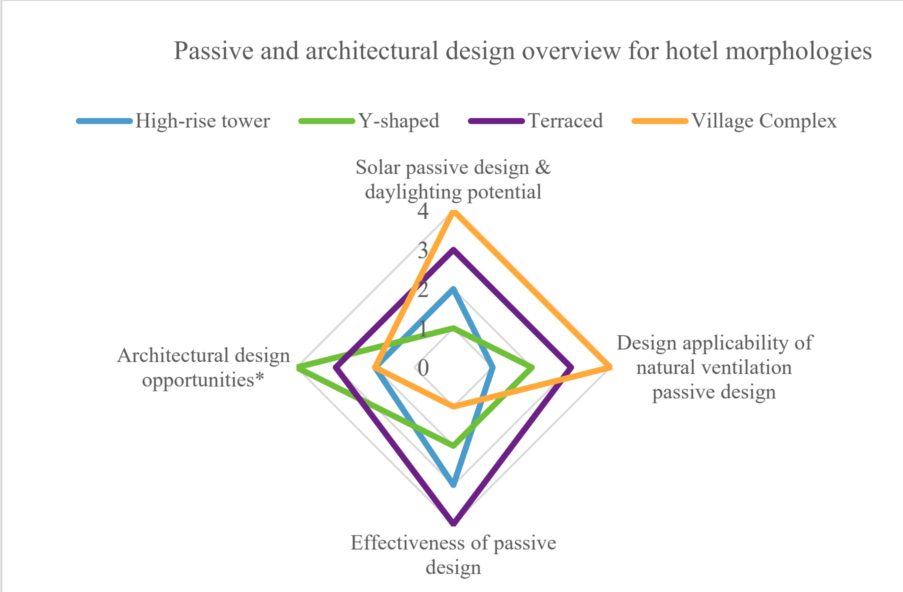


*Figure 7 Passive design and architectural freedom assessment overview for hotel morphologies. (*the design opportunities should be checked by the designer depending on the vision/project. See appendix B)*

For typologies the results suggest success for single-loaded slab typology both for architectural design freedom and energy efficiency. This is followed by atrium typology which shows significant success in passive design applicability and passive solar protection. Finally, double-loaded slab as the most profitable and commonly used typology for hotel design, shows better energy performance compared to atrium.

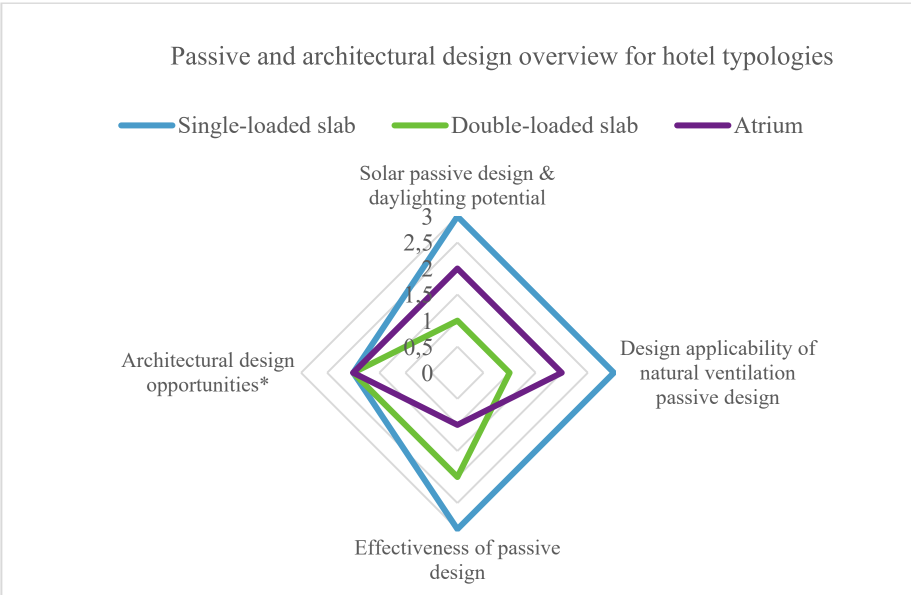


*Figure 8 Passive design and architectural freedom assessment overview for hotel morphologies. (*the design opportunities should be checked by the designer depending on the vision/project. See appendix B)*

IV. CONCLUSIONS

Tourism's international expansion and how it may support a more sustainable construction industry still require major research and development. These projects are usually led by developers which might result in an unhealthy dynamic between profit and sustainability. This study seeks to comprehend how an architect within this ecosystem may intervene during the design process so that sustainability becomes a basis rather than an add-on. Therefore, looking into passive design becomes significant since it requires early design phase action to be implemented. By making this information organized, accessible and available for architects, it is aimed to influence the design development phase of tourism projects. Therefore, the passive design strategies can be applied effectively and efficiently on hotel developments by understanding their individual performance from energy and design perspective.

The results show that terraced morphology becomes a highly effective and efficient design option for hotel developments in the Mediterranean climate. However, it is important to remember that this morphology also comes with design conditions, such as accommodation zones contacting the ground level which might bring significant limitations. Y-shaped morphology on the other hand allows significant opportunities for architectural design freedom, but also requires a significant plot size. For contexts with limited plot size and freedom, high-rise morphologies are more ideal and offer variety of concepts for ground-level functions. Although high-rise morphology has limited passive design applicability, the energy demand is still significantly improved. It is also possible to combine multiple morphologies to take advantage of their strengths. For example, high-rise towers can improve their relationship with the context by adding terraced elements on the plinth level. Another option can be combining y-shaped morphology with terraced morphology to take advantage of architectural design opportunities and to implement more effective daylighting strategies.

Typologies also have combination potential for mainly single-loaded and atrium which allow atrium design to be more effective. This can be done with unheated corridor spaces, or open atrium (courtyards) which are quite common in vernacular Mediterranean architecture. These combinations can be made while considering the vision and goals of the project. Therefore, it is possible to combine appropriate morphologies and typologies together to achieve the most effective, efficient, and aesthetic hotel development. For instance, in the case of large plots with less concern for the amount of accommodation zones, village complex & double-loaded slab can be an effective combination. Projects that are located close to urban zones have a better advantage to combine high-rise morphology with atrium and double loaded slab typologies. So, the combinations can be made relative to the needs and context with the help of the design manual.

These conclusions are also highly generalizable within the Mediterranean region or other locations with Mediterranean climate. Although the energy simulations are done on one location, the climate research shows no extremes that might divert the results for other locations with Mediterranean climates. This suggests that the conclusions, concepts, and ideas that can be drawn from this research can be applicable to any location with Mediterranean climate.

It is, however, clear that all of the morphologies and typologies show energy load decrease between 20% to just over 50%, and showcase the potential for passive design strategies. These rates are only a minimum for the effectiveness of the passive design strategies as this research doesn't go deeper into daylighting potential reflected on the energy load. It is important to mention that the effectiveness of the passive design strategies is also dependent on user behavior which might affect the results. However, the research aims to showcase two conclusions: an overall comfortable indoor environment to minimize the need for climate control is possible through passive design, and already having an integrated vision for passive design strategies in the Mediterranean climate is essential for tourism developments.

Further research

The design manual focuses on deriving data related to the accommodation zones. Although from a design perspective, other programs like lobby, outdoor activities and privacy are mentioned, the research lacks detailed information on these zones. Therefore, the energy efficiency and design applicability of passive design strategies are not explored for other common areas like the lobby, restaurants, SPA, event halls and lounge areas. As a result, further research can perform this analysis for a hotel as a whole for selected morphologies and typologies. This can give a more accurate overview of effectiveness and efficiency. It is also necessary to perform simulations that can include variety of parameters like different envelope properties, different type of façade shadings, impact of existing bodies of water (for evaporative cooling) and daylighting relative to solar exposure. This information can make the research more detailed and help create a clearer overview of passive design strategies on hotel designs.

V. REFERENCES

1. Aston University - EU. (2012). *Sustainable tourism in the Mediterranean*. https://doi.org/10.2863/69472
2. Casals Miralles, C., Barioni, D., Mancini, M. S., Colón Jordà, J., Boy Roura, M., Ponsá Salas, S., Llenas Argelaguet, L., & Galli, A. (2023). The Footprint of tourism: a review of Water, Carbon, and Ecological Footprint applications to the tourism sector. In *Journal of Cleaner Production* (Vol. 422). Elsevier Ltd. https://doi.org/10.1016/j.jclepro.2023.138568
3. Chapman, A., & Speake, J. (2011). Regeneration in a mass-tourism resort: The changing fortunes of Bugibba, Malta. *Tourism Management*, *32*(3), 482–491. https://doi.org/10.1016/j.tourman.2010.03.016
4. Dredge, D. (2022). Regenerative tourism: transforming mindsets, systems and practices. *Journal of Tourism Futures*, *8*(3), 269–281. https://doi.org/10.1108/JTF-01-2022-0015
5. Elaouzy, Y., & El Fadar, A. (2022a). A multi-level evaluation of bioclimatic design in Mediterranean climates. *Sustainable Energy Technologies and Assessments*, *52*. https://doi.org/10.1016/j.seta.2022.102124
6. Elaouzy, Y., & El Fadar, A. (2022b). Energy, economic and environmental benefits of integrating passive design strategies into buildings: A review. In *Renewable and Sustainable Energy Reviews* (Vol. 167). Elsevier Ltd. https://doi.org/10.1016/j.rser.2022.112828
7. Imessad, K., Derradji, L., Messaoudene, N. A., Mokhtari, F., Chenak, A., & Kharchi, R. (2014). Impact of passive cooling techniques on energy demand for residential buildings in a Mediterranean climate. *Renewable Energy*, *71*, 589–597. https://doi.org/10.1016/j.renene.2014.06.005
8. Jesse Maida. (2023). *Global Sustainable Tourism Market 2019-2023 | Shift in Preference Towards Local and Authentic Experiences to Boost Growth*.
9. Jojic, S. (2019). City Branding and the Tourist Gaze: City Branding for Tourism Development. *European Journal of Social Science Education and Research*, *5*(3), 150–160. https://doi.org/10.2478/ejser-2018-0066
10. Mejjad, N., Rossi, A., & Pavel, A. B. (2022). The coastal tourism industry in the Mediterranean: A critical review of the socio-economic and environmental pressures & impacts. In *Tourism Management Perspectives* (Vol. 44). Elsevier B.V. https://doi.org/10.1016/j.tmp.2022.101007
11. Ritchie, H., Rosado, P., & Roser, M. (n.d.). *Greenhouse gas emissions Which countries emit the most greenhouse gases each year? How do they compare per person?*
12. Vella, L., & Malta Tourism Authority. (n.d.). *Sustainable Tourism Challenges and Strategies in Malta*.
13. WWF. (n.d.). *Background information Tourism threats in the Mediterranean Background on tourism in the Mediterranean*.

VI. Appendix

Appendix A – Research

Research scope

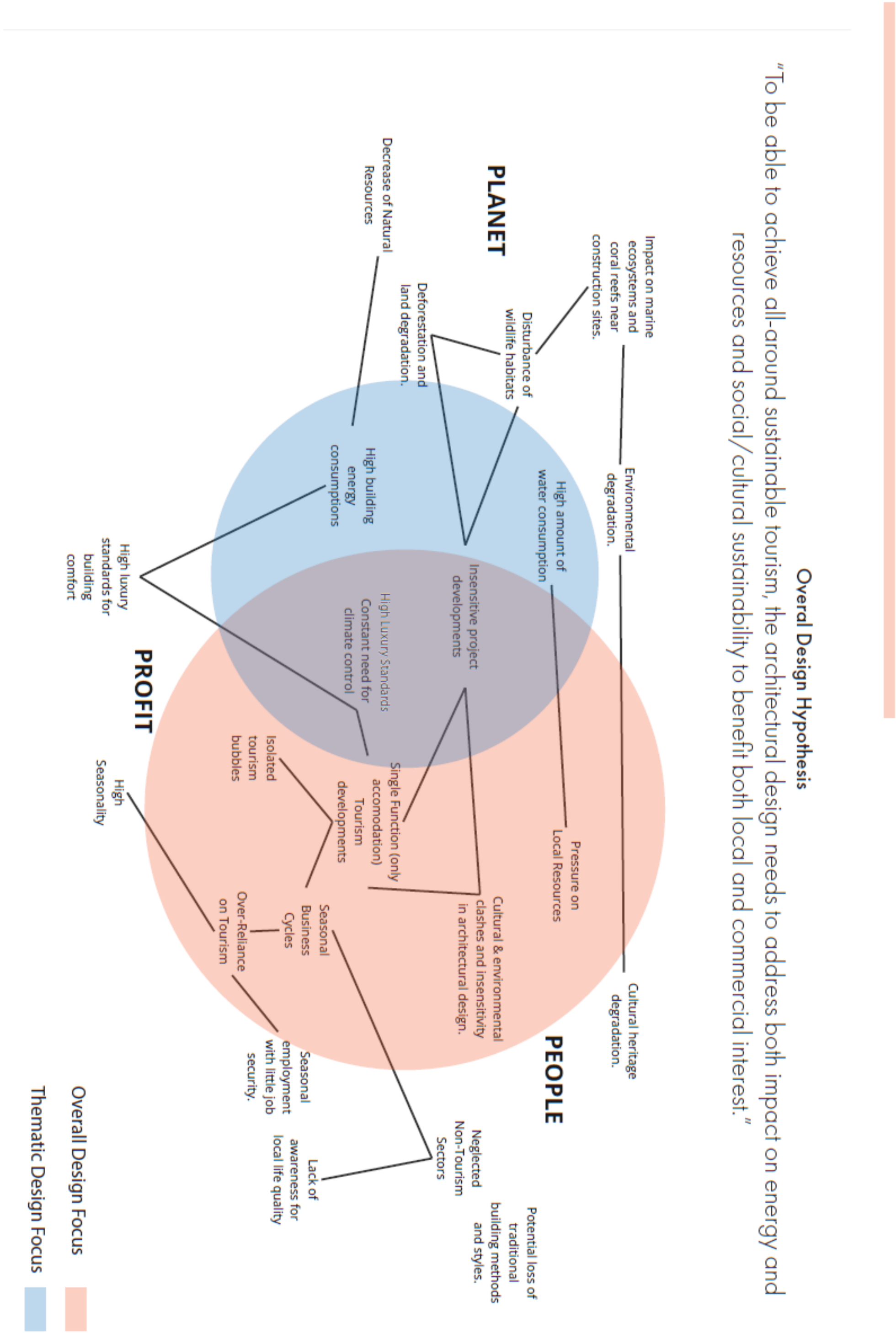


Figure 9 The9 Research Scope

Project Flow

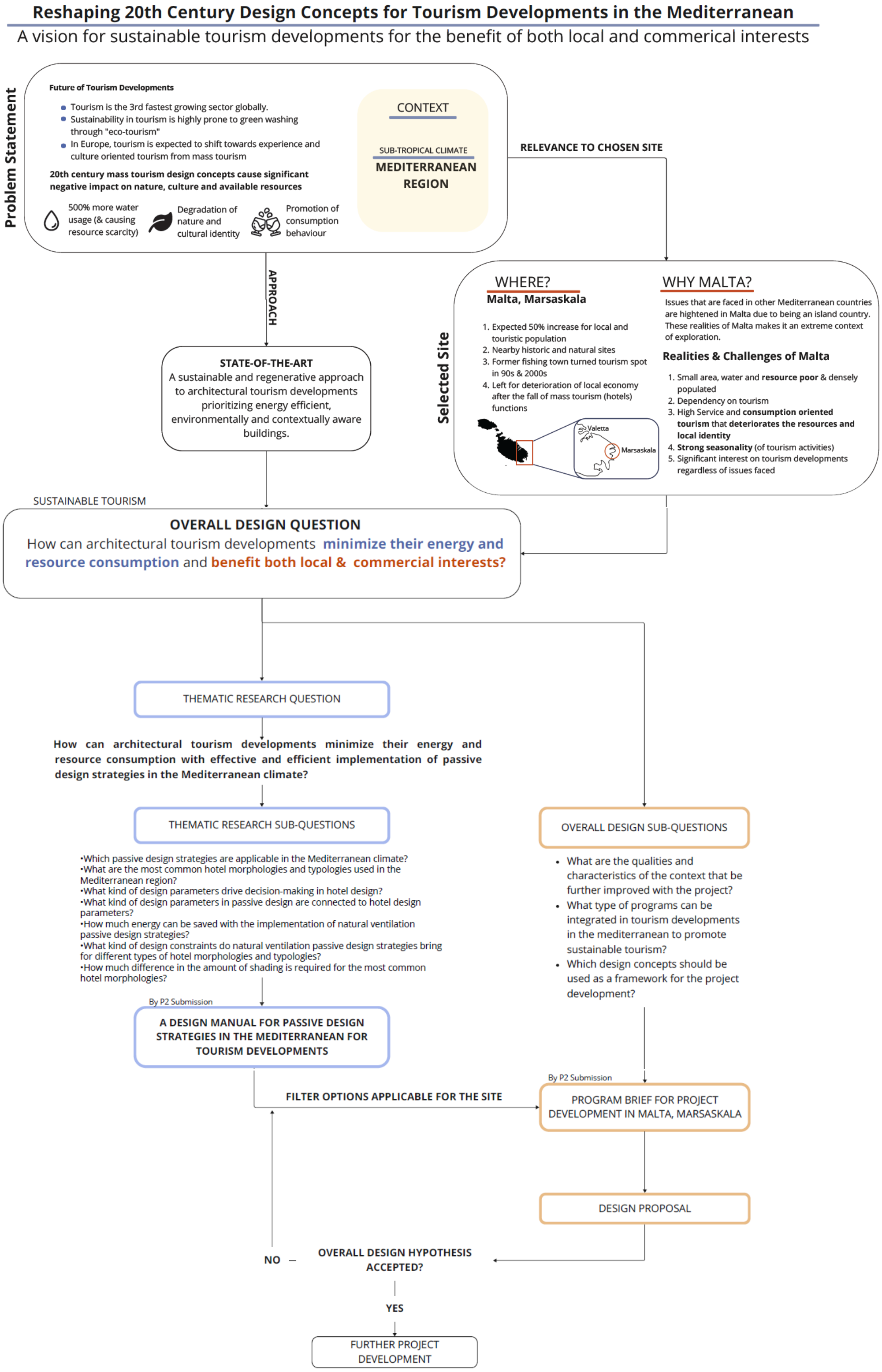


Figure 10 Project Flow and Overview

Methodology

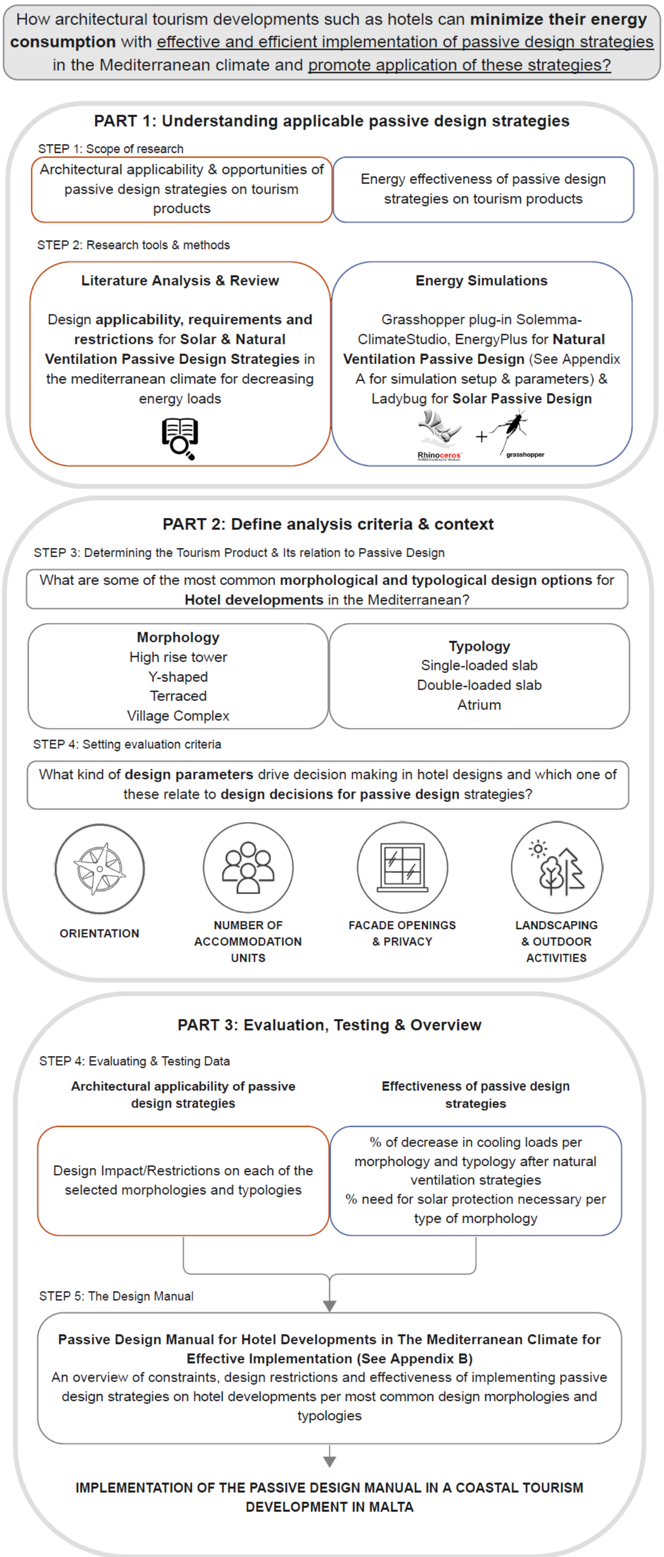


Figure 11 Project Methodology overview of creating the design manual

Appendix B – Results

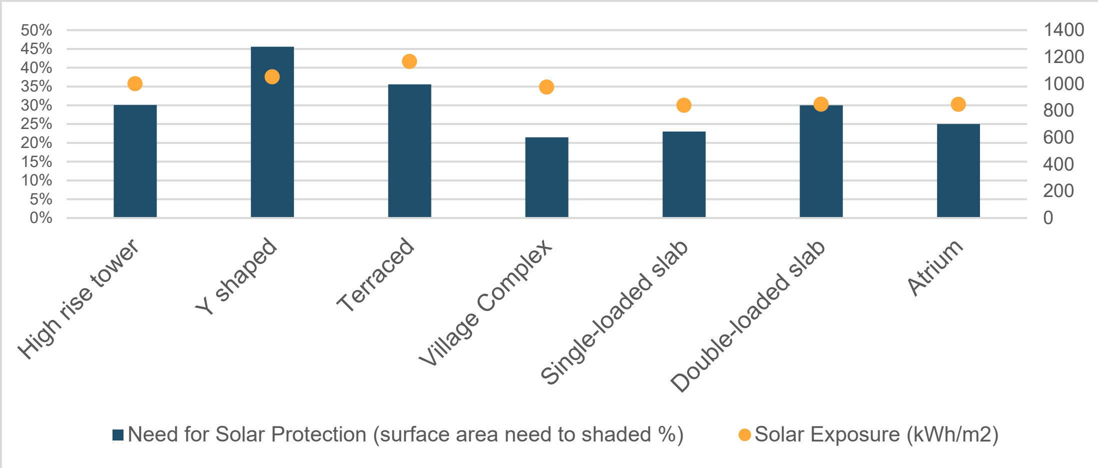


Figure 12 Solar passive design overview: Bigger distance between solar exposure and the need for solar protection shows a higher potential for daylighting.

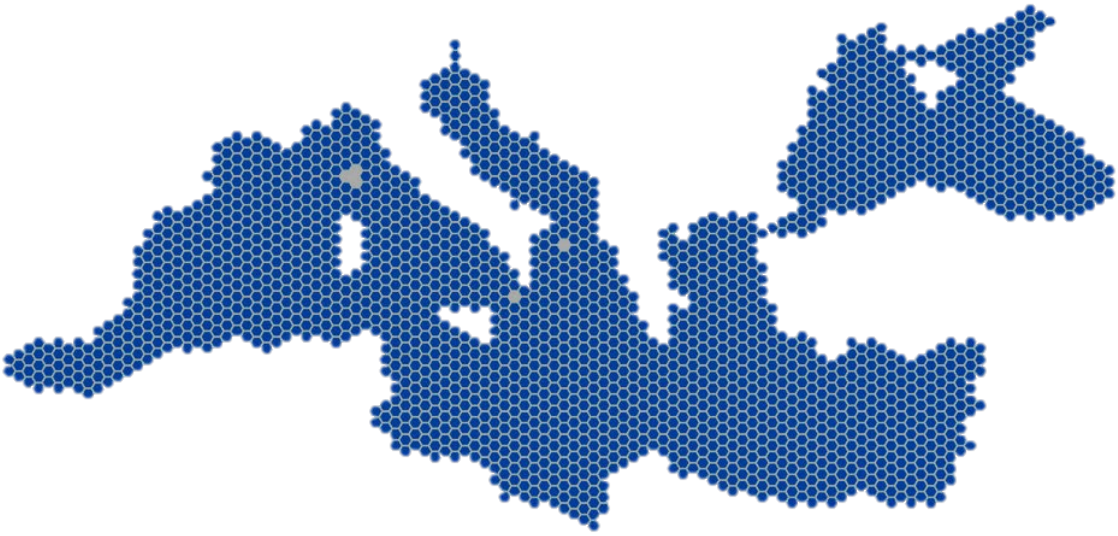
PASSIVE DESIGN APPLICABILITY ON MORPHOLOGY & TYPOLOGY								
Natural Ventilation Passive Design		Most prefered to least preferred by developers->				Most prefered to least preferred by developers->		
		Morphology				Typology		
		High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Direct Methods	Cross Ventilation	Moderate	Moderate	High	High	High	Low	Moderate
	Stack Ventilation	High	High	Low	High	Moderate	High	High
	Underground Constructior	High	High	High	Low	Moderate	Indifferent	High
	Evaporative Cooling	Low	Moderate	High	High	High	Moderate	High
Indirect Methods	Night Ventilation Cooling	High	High	Indifferent	High	High	Indifferent	High
	Radiant Cooling	Moderate	High	Moderate	Moderate	High	High	Low

Figure 103 Passive design applicability on different hotel morphologies and typologies

MORPHOLOGY & TYPOLOGY ARCHITECTURAL DESIGN POTENTIAL							
Architectural design criteria for hotel design	Most prefered to least preferred ->				Most prefered to least preferred ->		
	Morphology				Typology		
	High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Orientation							
Number of Accomodation Units							
Façade openings & privacy							
Landscaping & outdoor activities							

Figure 14 Architectural design opportunities of different hotel morphologies and typologies

APPENDIX C – THE DESIGN MANUAL



PASSIVE DESIGN MANUAL FOR ENERGY-EFFICIENT TOURISM DEVELOPMENTS IN THE MEDITERRANEAN CLIMATE

ARCHITECTURAL DESIGN VISION FOR SUSTAINABLE AND ENERGY-EFFICIENT TOURISM DEVELOPMENTS

Zeynep Naz Yelken | Architectural Engineering Graduation Studio | 26/01/2024

Design Supervisor: Thomas Offermans

Research Supervisor: Christien Janssen (Substitute: Regina Bokel)

Table of Contents

Introduction

Countries that are rich in their natural beauty, culture, and climate conditions have always become targets of architectural tourism developments. Especially in the 20th century, with the unstoppable growth of globalization, mass tourism became the main solution for accommodating large amounts of touristic movement profitably. Extensive constructions that offered a sense of globalized luxury, while holding significant amounts of tourists in isolated bubbles of tourism activities showed potential for short-term profits (Dredge, 2022, p. 277). This vision not only encourages a blindsided view for tourists to disregard the impact on environmental and cultural assets of visited locations, but also creates a consumerist design vision and user behaviour for tourism developments in general.

Additionally, within the development of these projects, the importance of local stakeholders is kept as a secondary importance, which affects the sustainability and resilience of local communities (Jojic, 2019, p. 158). Considering the clear shift towards experience and culture-oriented tourism in Europe, it is necessary to follow an all-around vision (Jesse Maida, 2023). However, an all-around application of sustainable tourism focusing on energy efficient projects that benefit both local and commercial interests still lacks development. This also reflects heavily on the [building] energy and resource consumption by heating, cooling, and lighting (Mejjad et al., 2022, p. 4.)

A major issue of tourism projects is the high amount of energy and resource consumption throughout the lifespan of buildings. This is especially important since buildings accommodate tourists for long periods of time regardless of the resources they consume. Considering over 50% of building energy consumption is related to buildings heating, cooling, and lighting, it is important to investigate a solution relevant for the tourism industry (UCLA, 2015). Moreover, "growing desire for better indoor environment, energy demand for heating and cooling is expected to increase steadily" especially when it comes to the Mediterranean context (Imessad *et al.*, 2014). This can bring an even higher energy demand trend for locations like the Mediterranean region.

Figure 1 Positive and negative impacts of tourism in the mediterranean region (Aston University - EU, 2012; Casals Miralles *et al.*, 2023; Mejjad *et al.*, 2022; WWF, n.d.).

As one of the effective methods of achieving energy efficiency in buildings, passive design strategies show potential to be integrated in the tourism industry. The potential of passive design strategies is significant since it aims to mitigate climate change through detailed evaluation, research, and architectural design. This makes passive design strategies highly appealing as it focuses on 'low tech' and cheaper solutions unlike high-tech services that might consume more energy and investments to perform well. It is also shown that implementation of passive design strategies "has proven to be highly effective, which translate into significant energy savings and mitigation of GHG (greenhouse gases which include carbon dioxide, methane and nitrous oxide) emissions"(Elaouzy and El Fadar, 2022a, p. 15; Ritchie *et al.*, n.d.). It is also relevant to develop a strategic vision for building efficiency for a high consumption-oriented sector like tourism.

One of the reasons for the lack of passive design strategy adaptation is based on a "clear lack of regulations, policies and funding programs to encourage building owners [or designers] to apply passive design strategies" (Elaouzy and El Fadar, 2022a, p. 15). Recognizing this research gap, as well as the lack of sustainable advancements in the tourism business (which promotes the high profit and low-cost vision), the deployment of a lost cost and design-oriented solution shows opportunity. Related to the lack of guidelines and regulations for passive design strategies, an important factor is to "consider the coordination of various passive strategies with the characteristics of the building in question and the local climate" (Elaouzy and El Fadar, 2022b). Therefore, it is relevant to determine which strategies are appropriate for selected building "characteristics." A critical point in this situation is that indoor temperature control is heavily dependent on thermal comfort of the users. This energy demand is, therefore, significantly controlled by the user experience or behaviour and may vary from person to person. This issue comes together with the consumerist tourism mentality that the sector promotes for the users. However, to promote sustainable tourism industry, it is essential to create a vision for climate conscious buildings and people. Therefore, the research aims to implement passive design strategies which can create an ideal indoor environment to promote less need for climate control and lighting usage for its users. Moreover, creating a foundation for passive architecture in tourism developments can lead to adaptation of these strategies to be easier and more appealing.

First, this research will dive into understanding which passive strategies are relevant for the mediterranean climate. Later, these strategies will be evaluated according to their applicability in selected building characteristics relevant for tourism functions. The selected site is in Malta in the town of Marsaskala located in the Mediterranean Sea. The climate issues on the island are faced with higher consequences (such as scarcity of resources, drought, lack of water sources, high seasonality, and high consumption-oriented tourism) and therefore requires a more thorough implementation when it comes to design decisions. Malta is also the 5th biggest contributor to EU for travel and tourism-based GDP and expected to grow this industry by 80% between 2024-2028 (Chapman and Speake, 2011; Vella and Malta Tourism Authority, n.d.). So, the site is chosen as an "extreme" climate context regarding the mediterranean climate and tourism development in the mediterranean.

Methodology

In order to make the researched information accessible and adaptable, it is important to create a design manual/guide for tourism developments in the Mediterranean. This can ensure the accessibility and availability of information which can be utilized seamlessly during the project development phase. This is done after the initial literature research based on passive design, tourism management and hotel design.

Understanding applicable passive design strategies

To be able to assess the potential of passive design strategies effectively, these strategies are filtered according to their applicability for the mediterranean climate. This is achieved through a review of literature and research papers focusing on passive design strategies applied in the mediterranean climate on different projects and research. As a focus location, Malta, is chosen to support the theory with climate analysis and further deepen the knowledge on the mediterranean climate.

Define analysis criteria and context

The methodology for constructing a passive design manual for tourism developments focuses on performing architectural and technical evaluations for passive design strategies on hotel designs. These hotel designs are defined as the most common morphological and typological solutions used in projects currently. Therefore, the context of the research is defined as 4 morphologies: High-rise tower, y-shaped, terraced and village complex and 3 typologies: single-loaded slab, double-loaded slab, and atrium. Assessing architectural and technical evaluation on these design contexts can help provide an overview of the most appealing options for tourism developments.

The architectural evaluation is based on considering conditions that are highly valuable for both hotel designs and passive design strategies. By understanding these themes, it is possible to create criteria of evaluation for both design restriction (for hotel design) and design applicability (for passive design.) These criteria are gathered through case studies of existing hotels in the mediterranean region and research papers on tourism theory and passive design in the Mediterranean. These assessment criteria are orientation, number of accommodation units, facade openings & privacy and landscape and outdoor activities.

Simulate energy demand

The selected simulation method is through a Rhino, Grasshopper plug-ins Solemma- ClimateStudio with the assistance of Energy Plus and Ladybug plug-in for solar analysis. The simulation creates spatial composition for 4 morphologies and 3 typologies and aims to understand the energy load and passive design potential. A part of this analysis tests the effectiveness of natural ventilation passive design on hotel en-suite guestrooms and hotel hallways on Solemma-ClimateStudio. The solar passive design potential is done by understanding the overall solar exposure and the facade area that requires shading according to solar exposure over 6 hours during the day.

Assess architectural design freedom.

To bring an architectural perspective to the success and application of passive design strategies, two architectural assessments are made. The first part focuses on design adaptability by understanding which design criteria are affected to achieve different types of passive design strategies and suggests most appropriate morphologies and typologies. The last part aims to point out the architectural design potential that these morphologies and typologies can offer along side their previously found energy performance. These suggestions and conclusions are made through case studies and architectural evaluations.

Evaluate and synthesize

This is finalized with the data gathered from energy simulations and solar analysis as well as architectural assessments. The combination of all evaluation types is combined to see which morphologies show most potential (either by being the most energy efficient, most architecturally flexible, or adaptable) and listed. All the design requirements, opportunities, constraints, and conclusions are synthesized in a design manual to provide an overview of passive design implementation in tourism developments.

Additionally, the passive design manual will be used from the early design phase to investigate integration of passive design strategies on the existing structure. The strategies will be integrated by trying to satisfy the architectural design opportunities (mentioned in the design manual) and energy efficiency. Therefore, it is expected to create a feedback loop between the design manual and the project.

How to use this manual?

The manual gives an overview of the kinds of consequences passive strategies can have on different architectural design decisions. Natural ventilation passive design strategies are highly sensitive when it comes to design requirements. Therefore, the applicability and effectiveness of natural ventilation strategies are evaluated according to the design themes below (see Fig. 1.)

Figure 2 Four main design decision makers that are important for both hotel design and passive design. (left to right: Orientation, Amount of accommodation units, Facade openings and privacy & Landscape and outdoor activities) & example on a design manual.

The majority of these strategies will have icons in their title which indicate the type of restriction that a passive design strategy can have on hotel design (see Fig. 1). These evaluations are later explained in detail within the section.

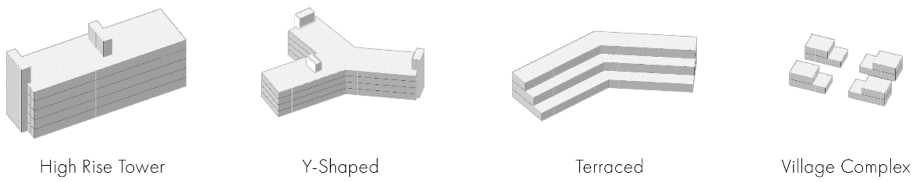


Figure 3 Most common hotel design morphologies: High-rise, Y-shaped, Terraced and Village Complex

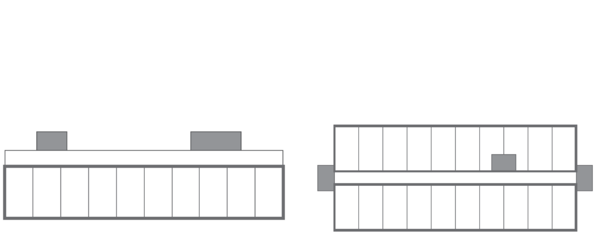


Figure 4 Most common hotel design typologies: Single-loaded slab, Double-loaded slab and Atrium

The conclusion of each evaluation suggests the most effective and applicable type of morphology and typology for the analyzed passive design strategy. Therefore, this manual aims to give an overview to the architect to select and synthesize information most relevant to their project by considering design, energy efficiency, concept development and sustainability. For this reason, in chapter 4, where energy efficiency is discussed, the morphologies and typologies are also evaluated with their architectural design potential. These are also summarized with the small icons next to the sections.

Figure 5 Example of how the architectural design potentials are shown in Chapter 4

1.0 Climate Context

1.1 Climate Classification

The Mediterranean region has a recognizable attractive climate which makes it an ideal holiday destination. These climate zones have extensive parameters that help identify their type such as vegetation type, solar radiation, water availability, suitability for certain crops, biodiversity, habitat distribution and/or climate change. These parameters help define certain zones and their climatic characteristics on Earth. A commonly used climate classification is called the Koppen-Gerber climate classification which bases its parameters on temperature and precipitation patterns (Falquina *et al.*, 2022).

Although appealing climate characteristics are associated with the Mediterranean region, this climate is also seen in locations 30º and 45º north and south of the equator(Gilson, 2021). Therefore, regions like California, Central Chile, South Africa, South-west Australia, and South Australia also experience similar climates as the Mediterranean region.

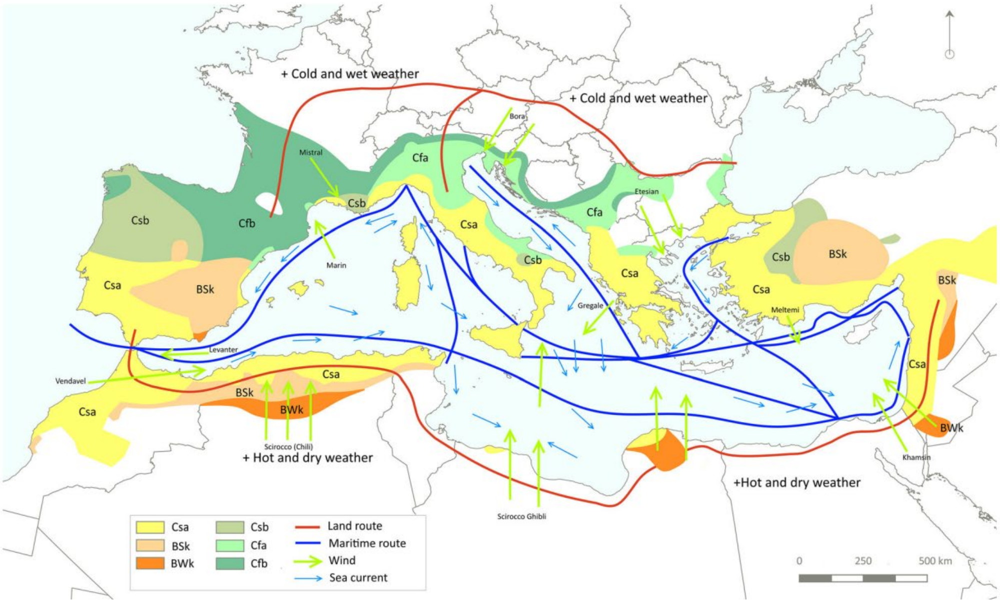


Figure 6 Mediterranean Climate Zones & Wind Flows (Martínez-Moreno *et al.*, 2020)

Although in the Mediterranean it is possible to see different types of climate classifications, in the Koppen-Geiger climate classification most of the areas are classified as Csa, Csb, Cfa, and Cfb (see fig.4). The climate type Csa (Temperate with hot dry summer, hot summer Mediterranean) covers most of the Mediterranean region such as the Iberian Peninsula, southern France, west of Italy, and parts of Turkey and Greece. The classification Csb (Temperate with warm dry summer, warm summer Mediterranean) is also experienced in other areas in the Mediterranean which covers major areas of Italy, Turkey, Greece, and the northern part of the Iberian Peninsula(Falquina *et al.*, 2022). Csa/b climate is one of the most widely seen type in the Mediterranean and other non-European Mediterranean climate regions. The Cfa/b (temperate oceanic climate) classification is also seen significantly in the region referring to a temperate *humid* hot/warm climate(Martínez-Moreno *et al.*, 2020).

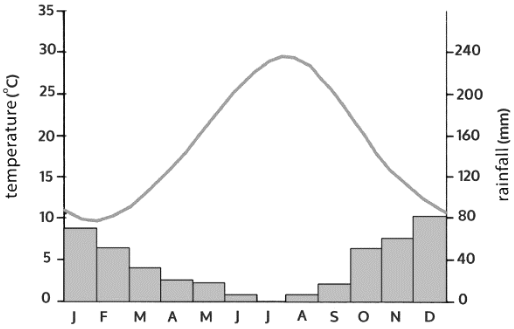


Figure 7 Average Mediterranean Climate. Temperature and precipitation

Therefore, most of the Mediterranean region can be classified as a temperate climate type with dry summers and wet winters. Especially during summer, the prevailing winds from the east can increase the temperature although these effects are less on the 46 km long coastal line of the Mediterranean region (Lionello *et al.*, n.d.; WWF, n.d.). Due to this reason, these regions can also suffer from various environmental consequences such as floods, drought, and strong gale winds (Gilson, 2021.) Considering attractive climate increases the demand for resources, environmental issues like floods and drought can be heightened even more.

On average, the temperature of this region swings between 30 degrees to 10 degrees with average precipitation reaching 80mm during the winter months (see Fig. 5) (Gilson,2021). Considering the long hours of sunlight, and hot winds from the south, these temperatures can get even higher.

1.2 Climate in Malta - Marsaskala

1.2.1 Relevance

The climate classification for Malta is Csa (temperate hot summer, wet winter) which is one of the classifications seen the most in the Mediterranean region. It gives an overall foundation for the development of a design manual for the Mediterranean regions due to having the most dominant climate classification, facing the same environmental issues as drought, energy consumption and floods. These issues are even more heightened due to the interest in tourism developments all around the country because of a consumption-oriented tourism sector.

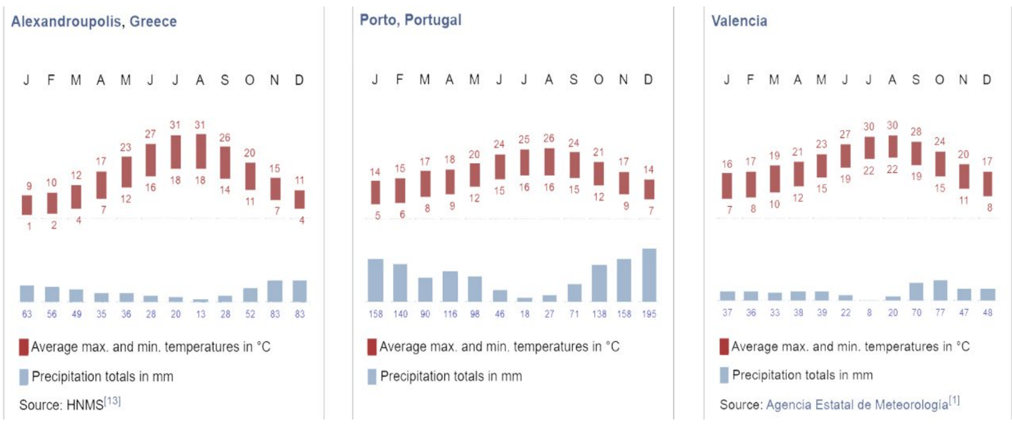


Figure 8 Comparison of Climate on different parts of the Mediterranean

Compared to one of the eastern Mediterranean countries like Greece against one of the most western-like Spain, the average weather statistics don’t show extreme outliers (See fig. 6.) Therefore, focusing on Malta does make the results applicable to the rest of the Mediterranean region for the development of passive design vision for tourism developments (See fig.7.)

Considering the 25% dependency GDP dependency on tourism with a total expenditure of 900 million euros in one year, Malta has become an important location for tourism developments in the Mediterranean(Chapman and Speake, 2011). The motivation behind the site is also related to the sustainability issues faced on the island. Most of the issues that are relevant for Mediterranean countries have higher consequences within an island country. The lack of natural resources, impact on local integrity and energy consumption of tourism products especially become important in island countries. Moreover, service-oriented tourism is highly dominant in Malta which can promote further deterioration of available natural resources. Several of these issues are already heavily discussed such as resource scarcity and loss of local identity due to tourism developments by the European Union, Interreg EuroMed and Malta (Interreg EuroMed, n.d.; Vella and Malta Tourism Authority, n.d.). As a result, Malta becomes an “extreme context” both for tourism developments and for mitigating the climate impacts of such developments.

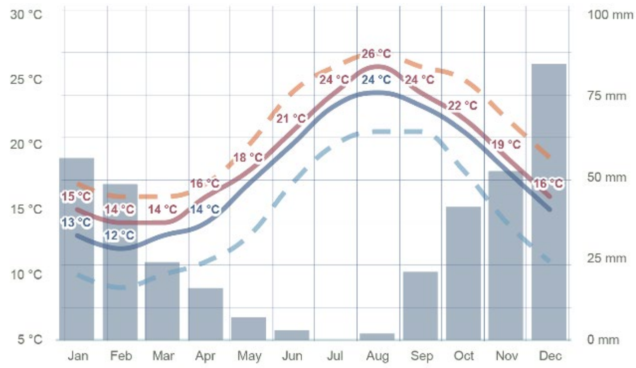


Figure 9 Average ground temperature & average water temperature in Malta, Marsaskala (WeatherSpark, 2016)

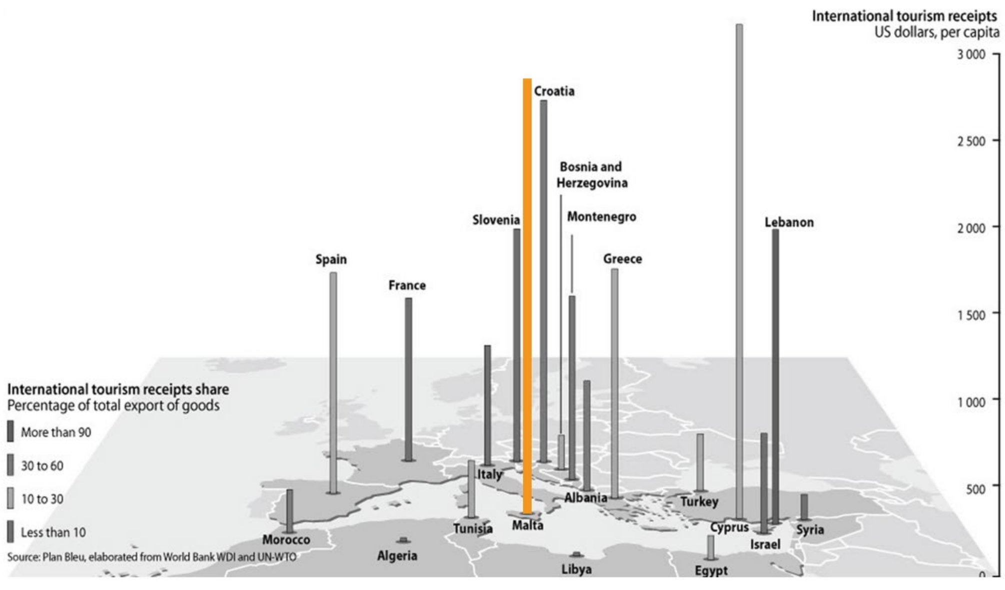


Figure 10 Tourism product density in the Mediterranean region (Grid Arendal, 2013).

1.2.2. Climate Analysis

GEOGRAPHY

The geography of Malta is highly rich in limestone which is also reflected in the building materials and cladding. The geography towards the north-western coast is higher compared to the southern areas of the island. Therefore, it is one of the most dominant and locally found building materials in the Maltese islands (see Fig. 8.) This limestone is also the material that creates the unique Maltese architectural building/cladding stones (called Franka) with yellow to pale grey colours (ERA (Environment & Resource Authority), n.d.).

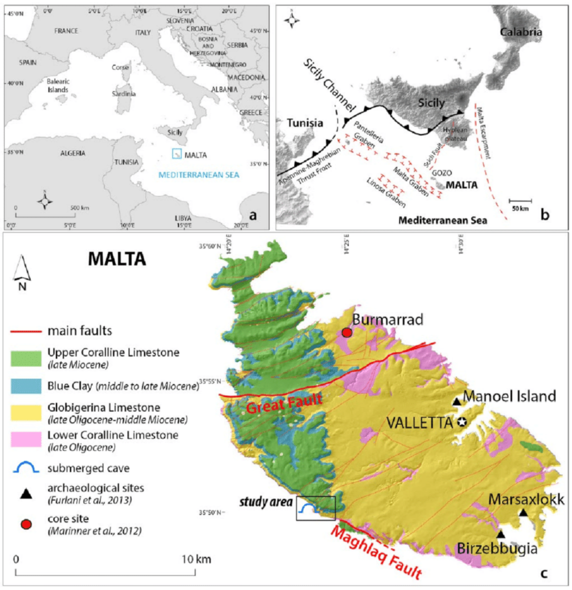


Figure 11 Geology of Malta, types of natural materials (ERA (Environment & Resource Authority), n.d.)

SEASONS

The seasons in Malta can be divided into three types: Rain, dry and tourism. These seasons drive the country in various ways and therefore it is important to understand their dynamic. The tourism season overlaps with the dry season – also the holiday season – and extends towards the rainy season from April to September (See Fig. 9.) Therefore, the dry and tourism seasons make up half of the calendar years. The main rainy seasons are spread from October to April.

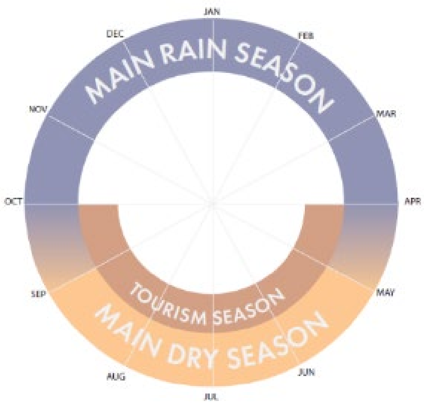


Figure 12 Climate and Touristic seasons in Malta over the year (Met Office Gov UK, n.d.)

TEMPERATURE

The average temperature seen on Marsaskala is extremely comparable to the rest of the island due to the size of the country. During summer the temperature can vary from 28 to 32 C on average (See Fig. 10.) These values can vary depending on the hot wind – sirocco – that comes from Africa or the cool breeze from the sea (Met Office Gov UK, n.d.). These temperatures are usually present from July to September. During winter the temperature

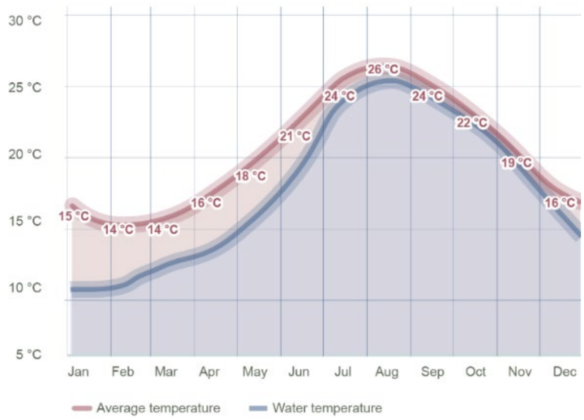


Figure 13 Average ground temperature & average water temperature in Malta, Marsaskala (WeatherSpark, 2016)

can vary from 12 to 17 degrees on average. This time is also the wettest time of the year from October to April although it can stretch to September as well.

SOLAR RADIATION

One of the most valuable renewable energy sources for Malta is solar energy. Starting from 2024, all building is expected to have solar panels installed (Arena, n.d.) The sunshine hours in Marsaskala can go as high as 80% sunshine hours per year which can correspond to 8.1 kWh of Solar energy per month (See Fig. 11.) The high amount of solar energy also requires careful application of solar shading to minimize the need to keep the buildings cool. This will be highly relevant for the summer season, which corresponds to the months from April to October.

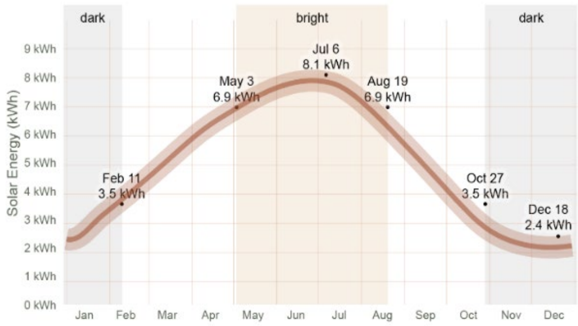


Figure 15 Annual Shortwave Solar Energy in Malta, Marsaskala (WeatherSpark, 2016)

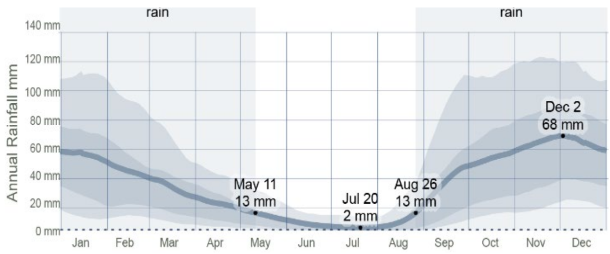


Figure 14 Annual Precipitation rates in Malta, Marsaskala (WeatherSpark, 2016)

Figure 16 Annual Relative Humidity rates in Malta, Marsaskala (WeatherSpark, 2016)

HUMIDITY & PRECIPITATION

As one of the temperate climate categories, Marsaskala precipitation months are usually between October and April. There are also cases where the rainy season can start in September or end in May. The amount of precipitation on average is 68mm per month (See Fig. 12.) However, during the peak of the season from October to December precipitation levels can go as high as 120mm.

On average relative humidity levels are usually steady at 80% all year round (See Fig. 13.) This can especially cause muggy conditions during the summer months from June to October. In a temperate climate, these conditions are mostly impactful in August.

WIND DIRECTION

Overall, the Mediterranean region experiences warm winds from the south that come from North Africa (See Fig.) This is also the main wind pattern for Malta, Marsaskala. Additionally, Malta also experiences winds from the Northwestern direction (also called Maijistral) which blows 1/3rd of the year and strong north easterly winds (also called Grigal) which make up the most common winds experienced. (England and Heathcote, 2002)

For Marsaskala, which is located in the southeastern part of the country, the majority of the wind comes from the Northwestern direction. These winds, which can go as high as 50-

60km/h can also bring heatwaves and an increase in temperature during summer temperatures (See fig. 14.) On average, the wind speed varies between 25.4 km/h during December and 13.1 km/h in August.

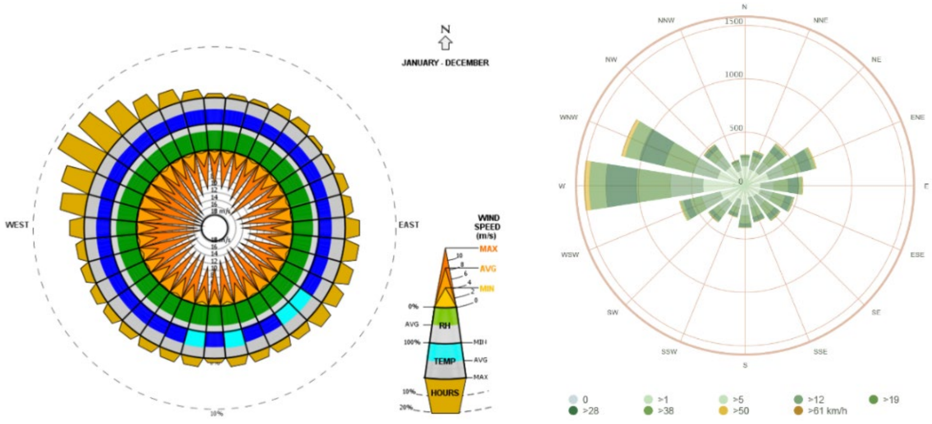


Figure 17 Climate Consultant overview (data input from Malta, Gudja) & Wind Rose for Malta, Marsaskala (WeatherSpark, 2016)

1.3 Thermal Comfort

Beyond the context of passive design, architectural design and planning should ensure the comfort of its users within a space. As a result, many comfort models have been developed over the years which include various parameters such as activity level, resistance of clothing, air temperature, relative humidity, air speed and mean radiant temperature(Lindeman and Keuvelaar, 2004). Especially for passive design ASHRAE Standard 55 Adaptive Comfort Model is the most useful for understanding the temperature range that users feel comfortable with. The thermal comfort requirements for naturally ventilated rooms and buildings are explicitly described in this model (See Fig. 15.) Users with an activity level of 1.0 to 1.3 are eligible for the standard (relaxed sitting, sedentary activity, light activity)(Lindeman and Keuvelaar, 2004). Therefore, the psychometric chart from Climate Consultant is used to set a comfortable temperature range for the energy simulations used later in Chapter 4.

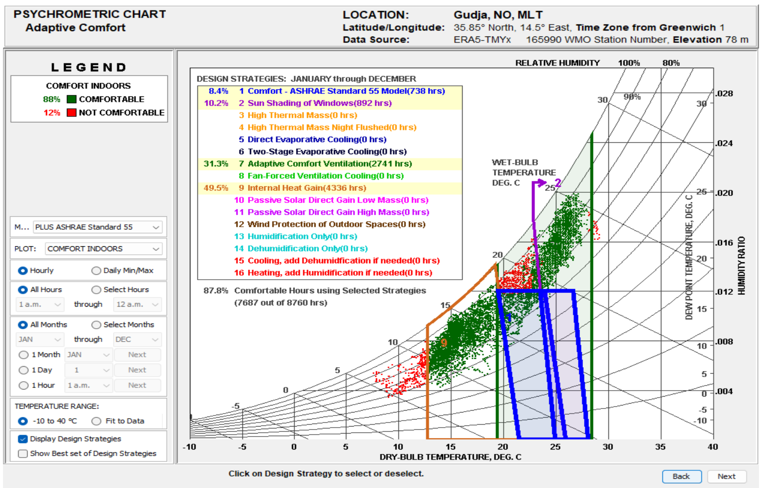


Figure 18 Thermal Comfort Chart for Malta, Gudja (Climate Consultant)

2.0 Hotel Design - Morphology & Typology

2.1 Spatial organization and program

The development of a hotel requires various considerations ranging from spatial organization, materialization, location and creating a sense of belonging for the consumer. Therefore, hotel design and development are a heavily profit-based system to ensure the most efficient way of hosting residents and allowing a group of public programs to benefit internal business. For this reason, various program organization is done to ensure that this internal business thrives throughout the day(De Roos, n.d.). Whether it would be an urban hotel or a coastal resort, there are common patterns in spatial organization that are important to understand to implement the best passive design strategies.

One way of categorizing the spatial organization is the types of programs present. These programs are mainly accommodation units, back-of-house, Food, and beverages (also known as F&B for restaurants, cafes, and bars), Lobby and outdoor facilities. Although these are some of the most common programs, depending on the size and type of the hotel such as SPA, event space, sports facilities, and shops.

In most cases, the public functions are organized on the ground level, occasionally on first levels creating an open flow of public functions. This is to “make sure that the residents are entertained, have a ‘sense of being’ and are occupied during the day” (S&claw *et al.*, n.d.). Therefore, in terms of public and private relations, the building can be divided into three parts: Private (accommodation units), Public (day/nighttime activity zones, F&B and other facilities) and semi-private (Back-of-house: service, maintenance, employee zones, service accessibility etc.)

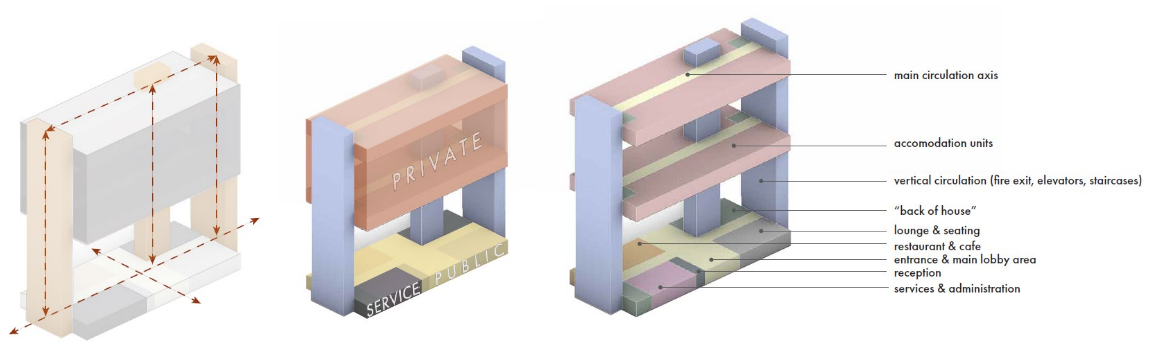


Figure 19 Hotel design analysis - circulation, public and private and program layout

To be able to ensure the profitability of the hotel the ratios of these functions are also important. Several study cases from the Mediterranean region suggest an overall idea for these ratios (see Appendix A). Usually, the expected ratio for hotel accommodation units varies from 60% to 70% to have a profitable business(De Roos, n.d.). This proceeds with back-of-house that varies from 10-20%, F&B with 10-15%, event space 2-3% and occasionally retail with 3% to compensate for a lower accommodation ratio.

The design decisions that might have an impact on the passive design of a hotel can be summarized into 3 considerations:

1. Maximizing the amount of accommodation units and repetition of these units
2. Orientation and views
3. Accessibility and openness of the public zones to maximize internal business to thrive.

2.2. Hotel Morphologies

High-rise tower

High-rise towers are one of the most common morphological applications for tourism buildings. Especially when it comes to a hotel, it is one of the most densely organized morphologies. This design also reacts with its context the least and offers a compact design. Therefore, the orientation of the building is important during the project development phase.

Y shaped

An evolved version of the high-rise tower can be seen in the y-shaped building layout. The distribution of the plan over 3 wings of the building also suggests semi-public zoning around the building. This type interacts with the contexts more and perhaps offers dynamic outdoor zoning options. This layout also offers a wide range of views for the guests.

Terraced

A design that interacts and achieves topographic qualities is the terraced design. Through different levels, this design shows potential for adapting to different height levels but also creating various outdoor spaces in the building. In terms of accommodation units, this is one of the lesser dense options however, since terraced typologies also spread over the site this could be compensated.

Village complex

A village complex can be one of the least preferred options when it comes to high accommodation units per square meter. This design serves as individual villas or houses and offers a summer-house quality for the questions. It can also be highly flexible in terms of orientation towards views however privacy concerns are relatively higher.

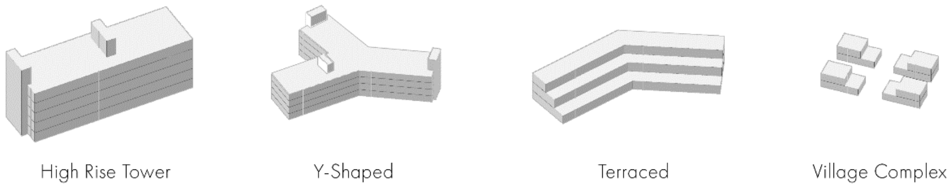


Figure 20 Most common hotel design morphologies: High-rise, Y-shaped, Terraced and Village Complex

2.3 Hotel Typologies

2.3.1 Single Loaded Slab

This typology is one of the common types used in hotel design. A convenient reason for this is the opportunity to include unheated/cooled corridors on one side of the building. This allows the focus of climate regulations on accommodation units only and prevents excessive need for regulating corridors. It is the second most profitable option allowing a 65% accommodation units ratio (See Fig. 19.) The vertical circulation zones are unaffected by this layout and are simply an addition to the long corridor axis.

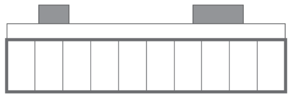


Figure 21 Single-loaded slab: Accommodation units positioned on single side with a corridor that connects to 2 shafts at both ends of the plan.

2.3.2 Double Loaded Slab

A double-loaded slab is one of the most common, efficient, and profitable typologies in hotel design. It allows views on two sides of the site and has a main corridor axis. The accommodation unit ratio can go as high as 70% in this type of accommodation (See Fig. 20.) Due to the density of the accommodation units on both sides of the corridor, vertical circulation zones are usually zones in the center, and both ends of the corridor.

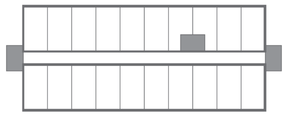


Figure 22 Accommodation units positioned on both sides of the main corridor axis and a central public accessibility shaft. Two shafts at both ends of the corridor for emergency exit.

2.3.3 Atrium

Although in terms of indoor spatial qualities, atria design can be highly appealing, in terms of efficiency and popularity, it is one of the least attractive options. With an accommodation unit ratio of 62%, it is one of the least dense accommodation typologies (See Fig. 21.)

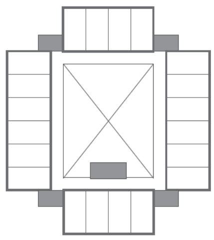


Figure 23 Atrium layout with hollow center. One primary shaft and 4 secondary shafts for emergency exit.

Guestroom Floor Analysis

Configuration	Rooms per Floor	Dimensions	Guestrooms (percent)	Corridor ft²(m²) Per Room	Comments
Single-loaded slab	Varies 12–30+	32 ft. (10 m) × any length	65%	80 ft.² (7.5 m²)	Vertical core usually not affected by room module
Double-loaded slab	Varies 16–40+	60 ft. (18 m) × any length	70%	45 ft.² (4.2 m²)	Economical; length limited to egress stair placement to meet building code
Atrium	24+	90 ft. + (27 m)	62%	95 ft.² (8.8 m²)	Open volume creates spectacular space, open corridors, opportunity for glass elevators; requires careful engineering for HVAC and smoke evacuation

Figure 24 Most common hotel design typologies: Single-loaded, Double-loaded and Atrium (De Roos, n.d.)

2.4. Design Decisions for a Hotel

Understanding priorities in hotel development can also determine the design decisions that can be made. According to spatial organization, program development and location selection several categories can be detected as overlapping themes. These themes focus on increasing the profitability of the hotel through various concepts but can also be impacted by passive design decisions made by the architect. These concepts can be summarized as:

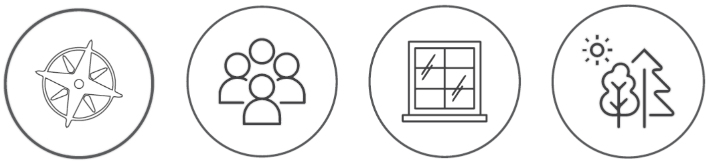


Figure 25 Four main design decision makers that are important for both hotel design and passive design. (left to right: Orientation, Amount of accommodation units, Facade openings and privacy & Landscape and outdoor activities)

2.4.1. Orientation

The hotel developments usually try to provide the best views to their visitors. These can affect the prices of the hotel rooms and determine the attractiveness of the hotel in general. Many tourism developments can also be developed simply based on attractive locations and views as an attraction point.

2.4.2. Number of Accommodation Units

Regardless of the style or context, to ensure profitability, hotels try to maximize their accommodation units. The number of guests that a hotel can hold is also dependent on the size of the site and location, however, the majority of the hotels aim to have at least 60% of the development on accommodation units(De Roos, n.d.).

2.4.3. Facade Openings & Privacy

Although connected to orientation, building openings are also important for hotel development as they define the boundaries of public and private. Hotel developments have a strong boundary between private and public zones yet still try to maximize the visual connection to the context. This is also something that increases the value of the accommodation units. However, building openings can also be impacted significantly by passive design strategies in terms of positioning, location, and shading.

2.4.4. Landscaping and outdoor activities

It is important for hotel development to ensure a home-like environment or offer various types of experiences for their guests(S&claw *et al.*, n.d.). This ensures that the guests can access public functions easily with a large variety. Therefore, site organization, landscape and outdoor space availability become important as well.

3.0 Passive Design in The Mediterranean Climate for Hotel Design

3.1.Orientation

The orientation of a building can be made to achieve different passive design strategies:

1. Minimizing Solar Heat Gain
2. Prevailing Winds

Minimizing solar heat gain is an important way to minimize the overheating of the building during summer and cooling in the winter. The cardinal rule is perhaps one of the most effective rules of thumb for orienting a building for passive design(Haggard *et al.*, 2016). If the goal is to minimize the energy consumption of the buildings for heating, cooling, and lighting, by orienting the building towards the equator these loads can be decreased significantly. This will ensure that the building will have minimized glare from east and west and prevent overheating in summer(Haggard *et al.*, 2016). This is also the best for the need for shading as well since facades facing east and west can cause high solar gains (See Chapter 3.2.) Therefore, it is optimal for a building to have a lesser west-east facing façade and a more north-south facing façade. The lack of orientation can also be improved through the integration of greenery as it will provide evaporative cooling and additional shading for the building and public spaces (See Chapter 3.) The plant placements can be maximized on the western side of the building to minimize heat gain as well (Climate Consultant.)

Maximizing the north-facing façade can also bring daylighting issues and consequently increase the lighting energy consumption of the building. Therefore, the amount of glazing on the north façade should be managed carefully (5% of the floor area) and have sufficient openings (Climate Consultant.)

3.2.Solar Passive Design

3.2.1 Solar Protection

Solar protection is one of the most important passive design strategies that can be implemented in a building design. It is significantly important to understand the effective ways of using shading depending on orientation. This will ensure that the placement and application of shading devices are used appropriately in terms of the amount of material use and cost effectiveness.

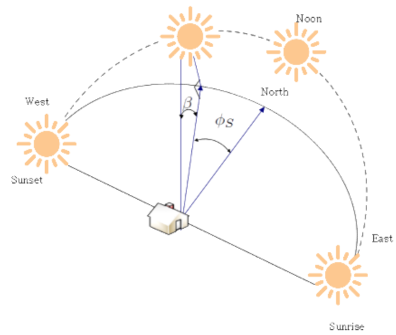
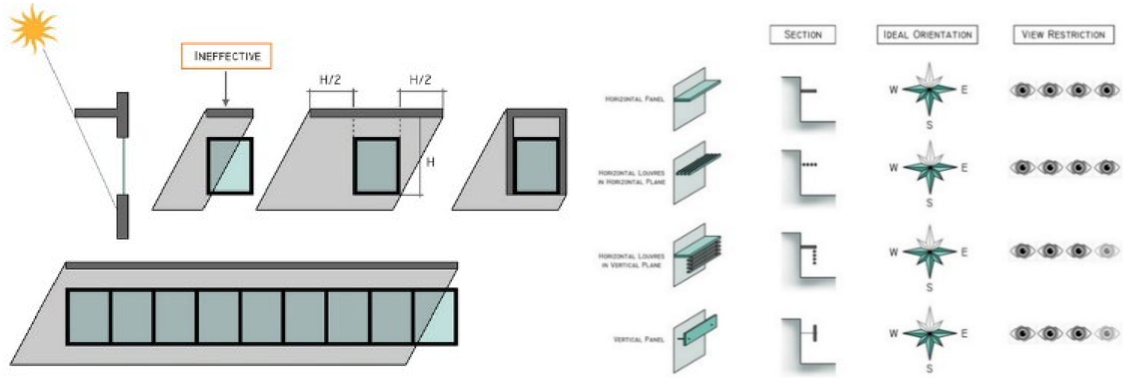


Figure 26 Solar angle throughout the day (Bravo Mahachi & Johan Rix, 2018)

Design Requirements

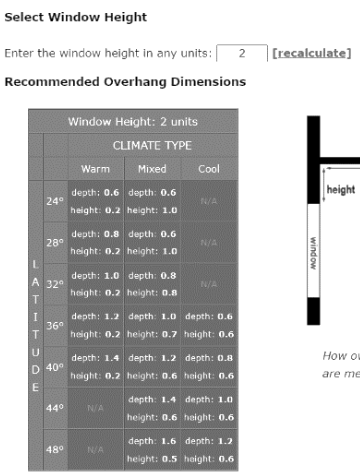
1. Shading devices for non-southern exposures

A challenge with west and east-oriented facades is the discomfort and heat gain that the building can take due to the low solar angle of altitude (Munshi, 2015)



2. Horizontal Shading devices for Southern exposures

Due to the angle of the sun on southern-oriented facades, it is ideal to have horizontal shading elements. These elements also have the least number of visual restrictions which makes it an ideal orientation and shading application for hotel typologies.

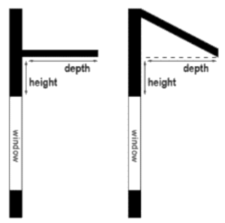


Select Window Height

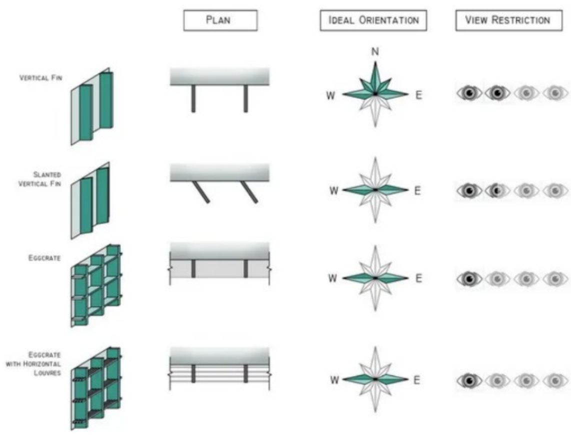
Enter the window height in any units: 2 [recalculate]

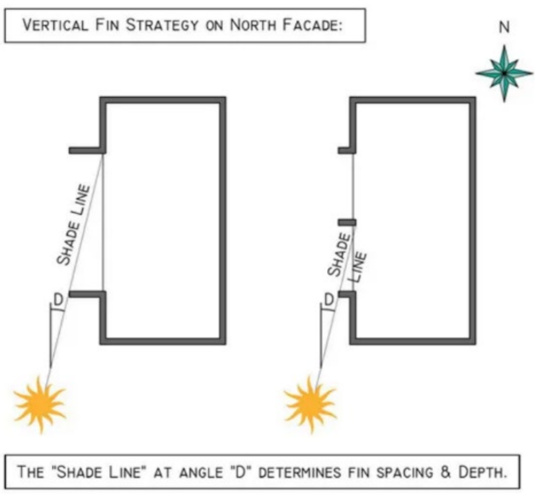
Recommended Overhang Dimensions

Window Height: 2 units				
		CLIMATE TYPE		
		Warm	Mixed	Cool
LATITUDE	24°	depth: **0.6** height: **0.2**	depth: **0.6** height: **1.0**	N/A
	28°	depth: **0.8** height: **0.2**	depth: **0.6** height: **1.0**	N/A
	32°	depth: **1.0** height: **0.2**	depth: **0.8** height: **0.8**	N/A
	36°	depth: **1.2** height: **0.2**	depth: **1.0** height: **0.7**	depth: **0.6** height: **0.6**
	40°	depth: **1.4** height: **0.2**	depth: **1.2** height: **0.6**	depth: **0.8** height: **0.6**
	44°	N/A	depth: **1.4** height: **0.6**	depth: **1.0** height: **0.6**
	48°	N/A	depth: **1.6** height: **0.5**	depth: **1.2** height: **0.6**



How overhang height and depth are measured for horizontal and pitched overhangs





3.2.2. Solar Exposure, shading and daylighting.

It is also relevant to understand the amount of shading needed per morphology and typology. This gives an overview of the amount of material that needs to be used in order to maintain a comfortable indoor environment through shading. This is done through calculating the relative façade area that has direct high solar exposure (more than 6 hours a day). Therefore, it is possible to understand the mandatory shading needed for each form.

Table 1 Need for solar protection for selected morphologies and typologies. (Surface are of facades over 6 hours of direct solar exposure relative to the rest of the facades. See appendix B for detailed information)

	Morphology				Typology		
	High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Need for Solar Protection (surface area need to shaded %)	30%	46%	36%	22%	23%	30%	25%
Solar Exposure (kWh/m2)	1000	1052	1166	976	840	848	847
Solar Exposure WARM HOURS (kWh/m2)	350	397	449	335	155	169	163

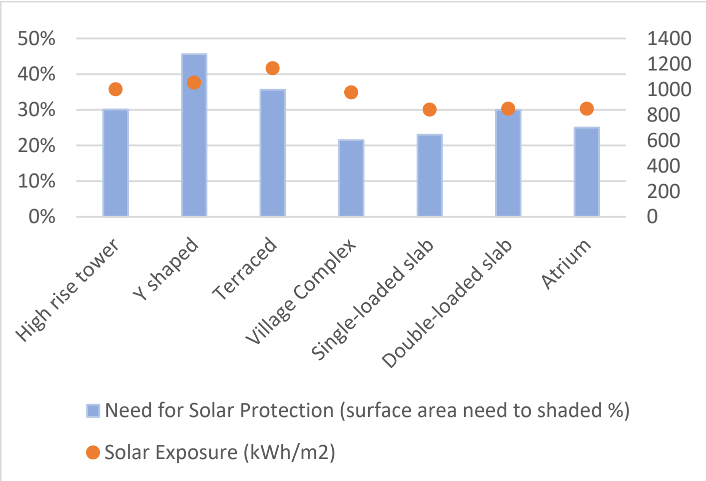


Figure 27 The relation between solar exposure and the need for solar protection for morphologies and typologies (See appendix B for detailed graphs)

Moreover, if the solar exposure is high and the need for solar protection is low, it can suggest a significant potential for daylighting. This can decrease the lighting energy demand for the buildings without causing overheating or using more material for shading. According to the relations in Figure 29, some of the best morphology options for daylighting are high-rise tower, terraced and village complex. For typologies the best option is single-loaded slab following with atrium.

Most Effective Typology & Morphology

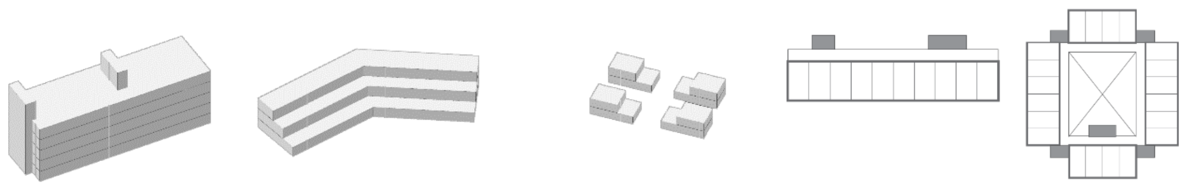


Figure 28 Most effective morphology and typologies for shading/daylighting: high-rise tower, terraced, village complex, single-loaded slab & atrium.

3.3 Direct Methods

3.1 Natural Ventilation Cooling

One of the complicated strategies is ventilation cooling due to various design constraints and requirements it comes with. It comes with considerations like airspeed, openings and their locations, orientation, and landscaping. These are also some of the common design deciders for hotel development as they focus on having attractive views and orientation. Therefore, it is important to understand the applicability and constraints of ventilation cooling.

These strategies are divided into various types: cross ventilation, stack ventilation, mixture, or courtyards/atria which are highly applicable in the Mediterranean. All these strategies have different levels of impact on the design deciding factors of a hotel such as maximizing accommodation units, orientation, and landscaping. Considering the repetitive stack of accommodation units in combination with an open ground level, these strategies can be applied to a hotel typology.

Cross Ventilation

Design Requirements[1]

Primary

- ☐ The building openings should be either.
    - Diagonal to each other on opposite sides
    - Adjacent to each other
- ☐ If the openings of the building are across from each other, the wind direction should be 45 degrees to the facade.
- ☐ If the openings are adjacent to each other, the wind should be directed towards the facade.

Secondary

- ☐ Consider having different heights for the openings (lower and higher placement) to maximize the airflow volume.
- ☐ Consider applying landscape elements to improve fresh air flow towards the building if the orientation is not optimal.
- ☐ Consider the application of shading devices or other façade elements to improve air patterns.

[1] (Altan et al., 2016; A.Y. Freewan, 2019; Chetan et al., 2020; Kumar, 2023)

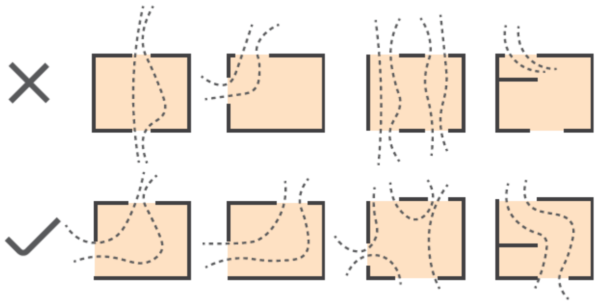


Figure 29 Appropriate positioning of openings for minimizing air pockets and good cross ventilation. (Haggard *et al.*, 2016)

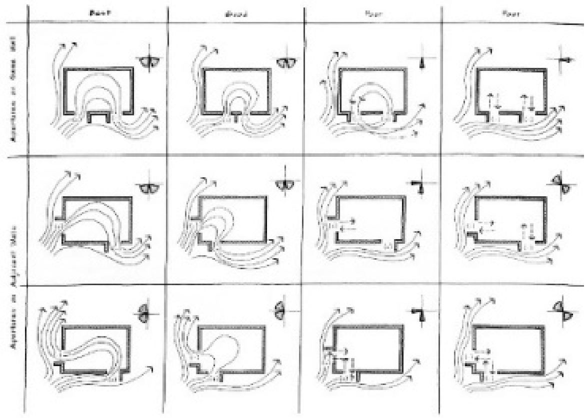


Figure 30 Different wing walls of better and worse effectiveness with 45-degree wind direction on adjacent walls (Brown and Dekay, n.d.)

Design Impact on Hotel Design

- For the double slab typology of a hotel (one of the most common), the accommodation zones are usually repetitive units with openings on both sides of the façade across from each other. So, the usual placement of openings for a hotel typology is highly prone to creating air pockets (less effective).
- Highly applicable for public zones of the hotel due to the open and accessible layout
- Landscaping supplement is less effective for high-rise hotel types.
- More applicable for single-loaded slab or atrium-type spatial organization.

Most Effective Typology & Morphology

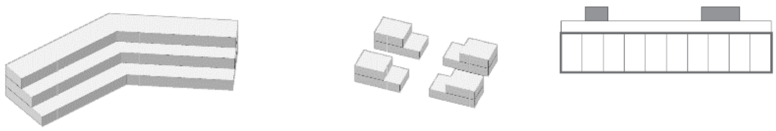


Figure 31 Most effective typology and morphologies for cross ventilation strategy: Single-loaded slab, terraced and village complex.

Stack Ventilation

Design Requirements[2]

- ☐ High-rise buildings or low-rise ones with high ceilings.
- ☐ Open ground level or airflow that connects to shafts.
- ☐ In the case of variable wind direction, a cowl on the roof can be used to collect wind from all directions.
    - o The roof vent should be placed at a lower pressure level.
    - o Wind exhaust supplements can be used.
- ☐ The stack effect can be achieved with a solar chimney.
    - o The cool air should be supplied from lower levels like basement or crawl space.
    - o For good performance, the chimney should be oriented 45-70 degrees for a latitude of 28.4 degrees.
    - o West or south-west orientation is the most optimal for hot summer climates.
    - o Most ideal to have two chimneys in a high-rise building (one on the west end)
- ☐ A stack effect can be achieved with an atrium.
    - o Ideally with a shaded inner walkway: single loaded typology can be most effective.

Design Impact on Hotel Design

- Ideal for high-rise hotel developments
- Requires an open ground level.
- Stairwells and other shafts can be utilized.
- For higher efficiency, the positioning of the shafts might restrict the design and orientation of the building.
- Less applicable for terraced morphology and single-loaded plan typology
- Height might create visual intrusion on the surrounding context.

Most Effective Typology & Morphology

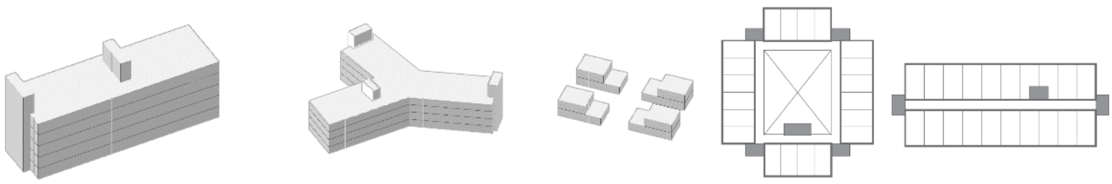


Figure 32 Most effective typology and morphologies for stack ventilation strategy: Atrium, double-loaded slab, high-rise, y-shaped and village complex

[2] (Altan *et al.*, 2016; A.Y. Freewan, 2019; Chetan *et al.*, 2020; Dehghani-Sanij *et al.*, 2015; Haggard *et al.*, 2016; Kumar, 2023; Matos *et al.*, 2022)

Underground construction

Design Requirements[3]

- ☐ Ideally at least 1.2m deep will allow a 10 Celsius degree difference in temperature.
- ☐ Openings should be directed towards the wind.
- ☐ The material of construction should have high thermal mass.
- ☐ Can be ideal for sites with different topography levels to integrate basements or submerged structures.
- ☐ Can be combined with wind towers, atria, or other stack effect strategies to extend the effects of underground cooling.
- ☐ This can be achieved through earth-to-air pipes that are submerged on earth or through air tunnels. The earth-to-air heat exchanger can maintain the cool airflow through the building.

Design Impact on Hotel Design

- Can be limited to integrating into all contexts (e.g. urban) since it depends on topography.
- Most of the service or back-of-house functions can be zoned underground which is an advantage.
- To access prevailing winds the orientation can be impacted.
- It is more effective in some morphologies like high-rise, y-shaped and especially terraced.

Most Effective Typology & Morphology

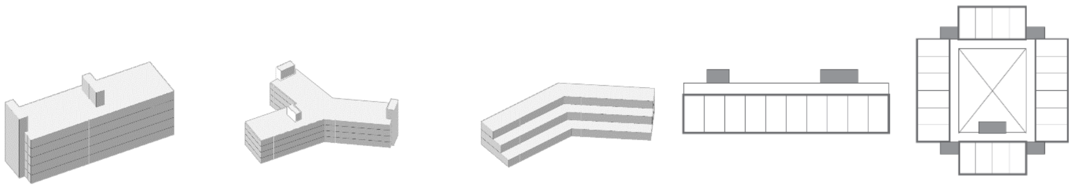


Figure 33 Most effective typology and morphologies for underground construction: Single-loaded slab, atrium, high-rise, y-shaped, terraced.

[3] (A.Y. Freewan, 2019; Beigli and Lenci, n.d.; Chetan *et al.*, 2020; Giabaklou and Ballinger, 1996; Haggard *et al.*, 2016; Kumar, 2023; Matos *et al.*, 2022; Santamouris, 2004)

Evaporative Cooling

Design Requirements[4]

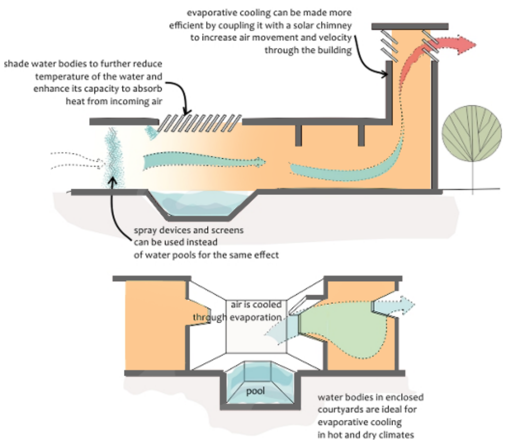


Figure 34 Evaporative cooling for low-rise buildings. Shown in two ways: In combination with a cooling tower and an atrium layout. This strategy is more applicable for low humidity areas which are also found in the Mediterranean Climate

- ☐ Evaporative cooling can be achieved through water sources (cool pools) or vegetation. These can be done through:
  - Swimming pools
  - Decorative ponds
  - Local vegetation
  - Coastal context
- ☐ Most effective with low-rise village complex, terraced or atrium buildings (See Fig. 34.)
- ☐ Shading devices can be used to further cool down the water source (See Fig. 35.)

Hybrid Applications (evaporative cooling & natural ventilation)

- ☐ Cooling Towers (effective for low humidity climates)

Climatic zone	Hot and dry	Hot and humid	Hot and dry	Hot and dry	Hot and humid	Dry and semi hot
Air direction	North-east	Breeze	North-west	North-west	South-west	North
Shape of cross-section	Square/rectangle hexagon, octagon	Square	Rectangle	Rectangle	Square	Square
Average dimensions (m)	0.5 × 0.8 0.7 × 1.1	1 × 1	0.5 × 0.15 1.20 × 0.60	-	1 × 1	1 × 1
Height (m)	3–5	3–5	1.80–2.10	One story above roof	5 And above	1.5 From roof
Direction according to the airblow	Diagonal	Diagonal	Ordinary	Ordinary	Diagonal	Ordinary
Ceiling of the Wind tower	45° Slope	30° Slope	45° Slope	30° Slope	45° Slope	30° Slope
Ventilated area	Dining room and basement	Dinning plus others	Only basement	Dinning plus one room	All rooms	All rooms
Airblow	Multi-side	Multi-side	One, two-side	One-side	One-side	One-side
Evaporative cooling	Sometimes	Never	Sometimes	Sometimes	Never	Never

Figure 35 Cooling tower dimensions used in different climates. The relationship between air direction, height and cross-section is shown (Dehghani-Sanij et al., 2015).

Design Impact on Hotel Design

- Can impact the positioning of pools or other leisure services to cool down the building.
- Highly beneficial to integrate with the orientation of the building for coastal hotel developments.
- Less applicable for urban hotel developments
- More applicable for day-time functions and ground-level cooling
- Less applicable for cooling accommodation units on higher levels
- Artificial ways of providing a water source can cause an increase in resource consumption for the hotel.
- Appropriate selection of vegetation can positively improve the biodiversity.

[4] (Altan *et al.*, 2016; A.Y. Freewan, 2019; Chetan *et al.*, 2020; "Evaporative Cooling - NZEB", n.d.; Giabaklou and Ballinger, 1996; Haggard *et al.*, 2016; Matos *et al.*, 2022)

Most Effective Typology & Morphology

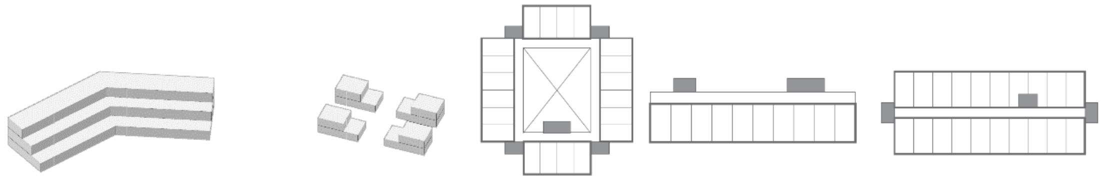


Figure 36 Most effective typology and morphologies for evaporative cooling: Atrium, single-loaded slab, double-loaded slab, terraced, village complex.

3.4. Indirect Methods

3.4.1 Night Ventilation Cooling

Design Requirements[5]

- ☐ Maintained sufficient wind temperature and flow.
- ☐ High thermal capacity (usually through floor slab) with materials like concrete, stone, brick etc.
- ☐ The ratio of area of thermal mass/area of solar aperture should be 9-14% (mainly cooling and slight heating)
- ☐ No occupation during the night

Design Impact on Hotel Design

- This can create conflict with the orienting the hotel for views.
- Nighttime cooling is beneficial when the building is not occupied during the night, which makes it less applicable for accommodation units. However, this strategy might be applicable for other functions with daytime or occasional usage such as ballroom, event space, conference room, meeting room, office space etc.
- Construction with high thermal mass materials is quite common in hotel construction in the Mediterranean.
- Highly sensitive to wind flow which might decrease the effectiveness.

Effectiveness on Typology & Morphology

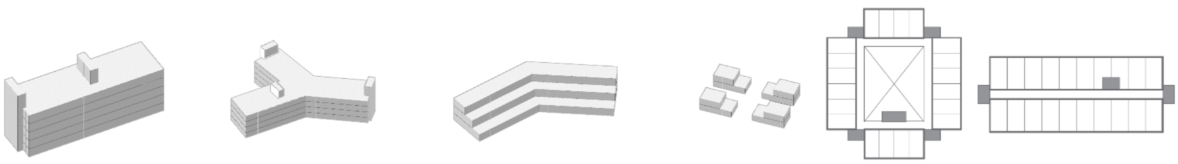


Figure 37 Most effective typology and morphologies for night ventilation: Atrium, double-loaded slab, high-rise, terraced, village complex.

---

[5] (Santamouris, 2004). (Matos *et al.*, 2022) (Haggard *et al.*, 2016).

3.4.2 Radiant Cooling

Design requirements[6]

- ☐ Climate with clear skies – highly applicable in the Mediterranean climate
- ☐ Use of high thermal mass building element – usually roof
- ☐ Use of High solar reflectance materials
- ☐ Implementation of one or more of these methods
    - ☐ Insulation
    - ☐ High thermal mass construction material
    - ☐ Water pipes on the roof
    - ☐ Roof ponds

Design Impact on Hotel Design

- Applicable for both daytime and nighttime cooling but more effective during the night
- Utilizes existing building structure/mass.
- Can bring design constraints for roof utilization.
- No significant impact on orientation selection

Most Effective Typology & Morphology

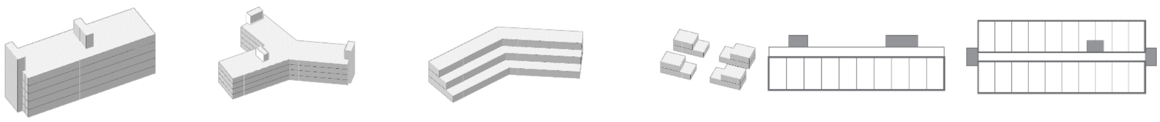


Figure 38 Most effective typology and morphologies for radiative passive design strategy: Single-loaded slab, double-loaded slab, high-rise, y-shaped, terraced, village complex.

[6] (Chetan *et al.*, 2020; Haggard *et al.*, 2016; Matos *et al.*, 2022)

4.0 Passive Design Effectiveness on Hotel Designs: Natural ventilation & solar passive design

The passive design effectiveness will be analyzed through the energy efficiency of solar and natural ventilation passive design strategies. These strategies will be tested on selected morphologies and typologies to provide an overview of the amount of energy that can be saved. These options can set design constraints, conditions, and advantages regarding passive design due to their orientation or spatial organization. Therefore, it is important to understand these conditions which might create significant differences in their energy performance. These technical evaluations will also come with architectural design opportunities as well.

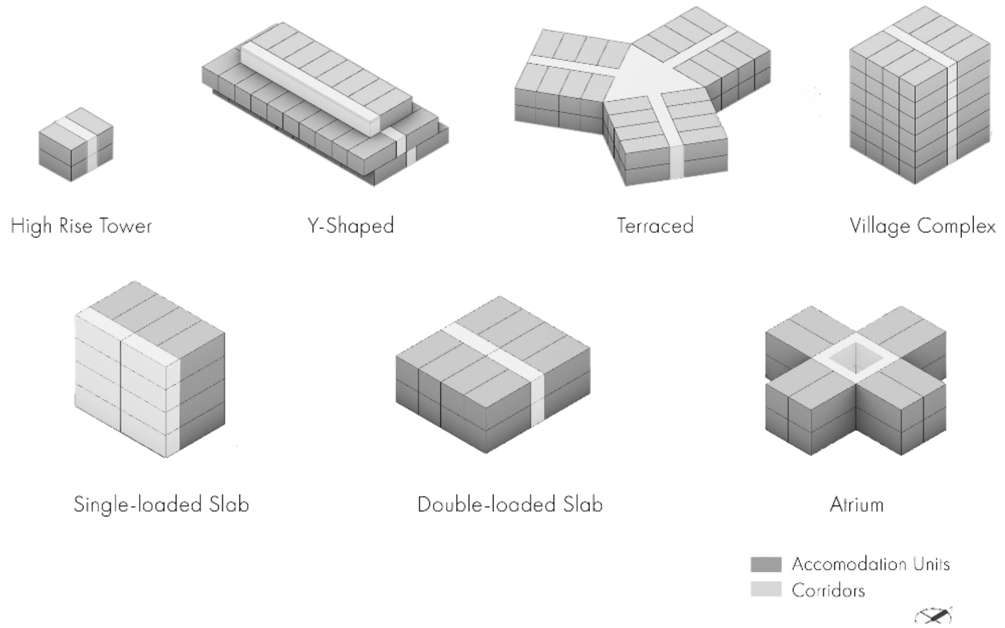


Figure 39 Accommodation and corridor areas of selected morphologies and typologies. These zones are used in the energy simulations.

Remarks on simulation scope & and hotel design

Focus on accommodation zones

The analysis focuses specifically on accommodation zones. These include the hotel rooms (accommodation units) and the corridors. The accommodation units are usually compact private zones in hotels that can vary in size and spatial organization. The occupancy of these zones is dependent on resident behaviour, but it can go up to 12 (or more) hours considering the nighttime occupancy for sleeping and daytime occupancy for relaxing and lounging. The energy use of these rooms is heavily dependent on user behavior, but these are also a reaction to the ambient conditions. So, if the ambient temperature can maintain acceptable thermal comfort (see Chapter 1.3), it can be possible to create a lower energy consumption trend. This is also important considering accommodation units make up at least 50-60% of a hotel which makes it one of the biggest energy-consuming and occupant-dependent zones for hotels (Neufert *et al.*, 2012, p. 171).

Size of the accommodation units & important exceptions

The hotel room units are chosen to be an average hotel room size that can occupy 2-3 guests across different hotel luxuries and contexts (see Appendix B).

Selected accommodation zone dimensions:

Length x Width x Height: 8x4x3.5m

Corridor width: 2.5m

Some morphologies may require their accommodation units to be in contact with the ground/earth (accommodation units starting from ground level). This can cause a significant difference in the energy simulation. Contact with the ground is mostly relevant for Terraced and Village Complex morphologies.

The morphologies and typologies maintain their main façade (where the openings of the accommodations units are) towards north and south. This aims to maintain the passive design orientations and minimize the west-east façade as recommended by the Climate Consultant for temperate climates. However, this may be less effective for some designs (e.g. Atrium where the units are equally distributed on all facades.)

Morphology

The process and content of the analysis will be elaborated for high-rise towers in detail. The rest of the detailed elaboration, graphs and statistics on other morphologies and typologies can be found in Appendix B and *The Setup, Statistics, Figures and Graphs in Appendix B.*

High rise

Accommodation: 86.5% Circulation 13.5%

Analysis

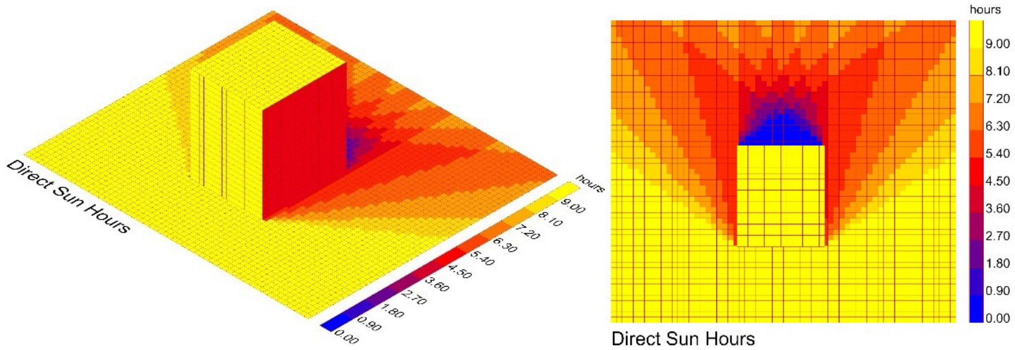


Figure 40 Hour based solar radiation map and cast shadow of high-rise morphology.

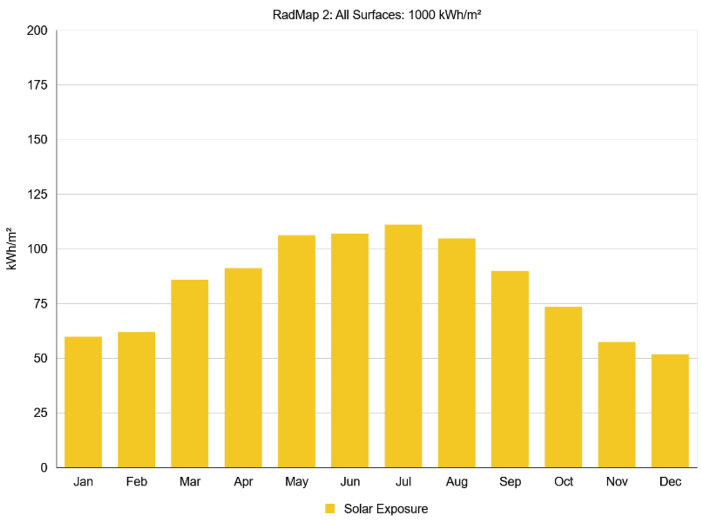


Figure 41 Annual solar exposure of high-rise morphology

Table 2 Solar passive design for high rise morphology. Need for solar protection (facade area over 6 hours of exposure) and overall solar exposure for daylighting.

	Morphology
	High rise tower
Need for Solar Protection (surface area need to shaded %)	30,19%
Solar Exposure (kWh/m2)	1000
Solar Exposure - warm hours (kWh/m2)	350

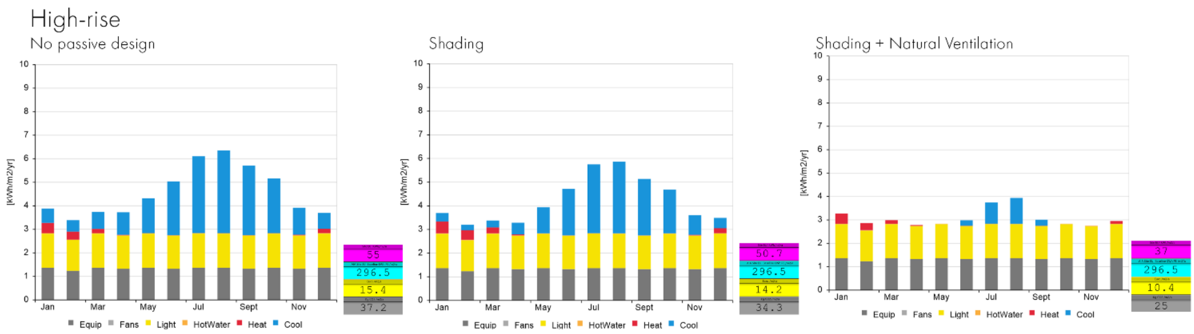


Figure 42 Decrease in energy load per application of passive design strategies.

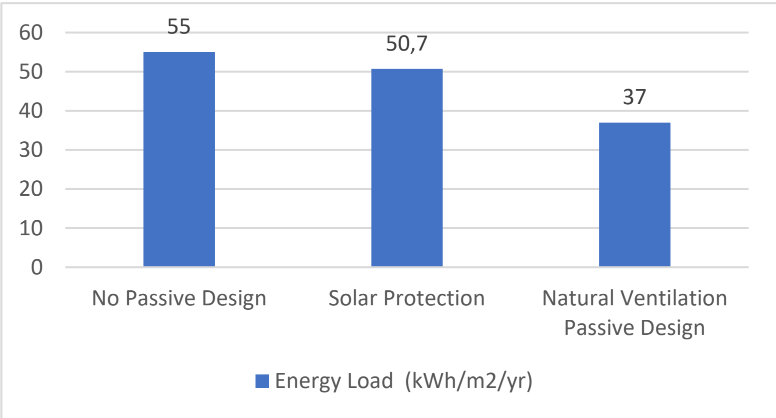


Figure 43 Decrease in annual energy load per area on each stage after passive design strategies (kWh/m2/yr)

Impact on Energy consumption

Need for Solar Protection (Facade areas with High Solar Exposure hours)	Solar Exposure	Remarks
30.2%	1000kWh/m2	Overall least need for solar protection for a high density & high rise design.
Solar Passive Design (decrease in kwh/m2/yr)	**Natural Ventilation Passive Design (decrease in kwh/m2/yr)**	**Remarks**
↓ 7.8%	↓ 27.0%	Overall most energy save for a high occupancy & multi story building

Figure 44 Energy consumption summary for high-rise morphology

Architectural design opportunities

- High-density accommodation and highly profitable
- Views can be offered through rooftop terraces.
- Most of the time public functions are zoned on the ground level which can be ideal for a strong boundary between public and private. This can be ideal for the urban context.
- Public functions can be implemented either on the highest or lowest levels due to privacy concerns.

- There is more potential for using multiple levels from the ground level to create an open and lively interior space rather than achieving this on the outside space.
- Usually, it is more convenient to place openings on two sides (such as north/south or east/west) which can bring certain constraints for façade design.

Figure 45 High rise lobby/ground level concept idea. (Nader Ibrahim, 2022)

Figure 46 High rise concept for integrating semi-public functions on upper levels. (Peacock, 2023)

Y-shaped

Accommodation: 74.2% / Circulation: 25.8%

Solar passive design – Solar Exposure & Cast Shadow

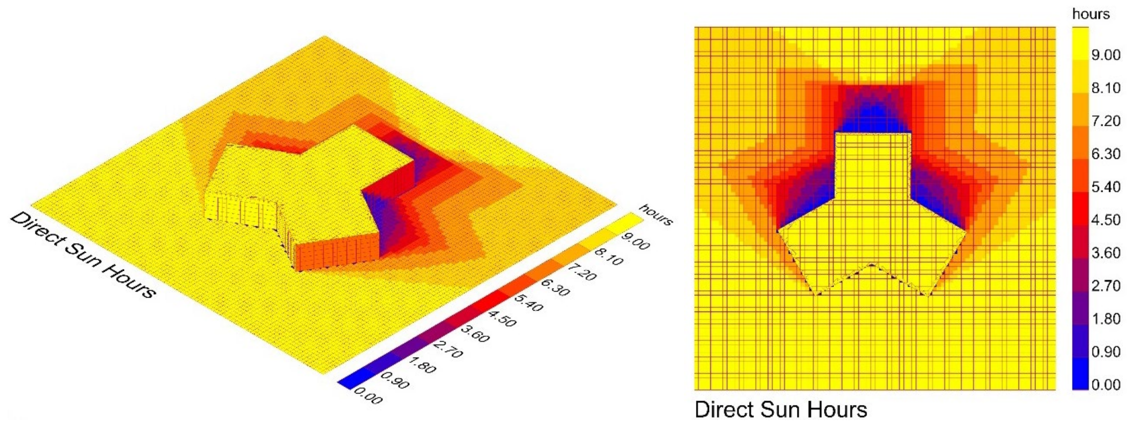


Figure 47 Hour based solar radiation map and cast shadow of y-shaped morphology.

Impact on Energy consumption

Need for Solar Protection (Facade areas with High Solar Exposure hours)

45.6%

Solar Exposure

1052 kWh/m2

Remarks

Overall most need for solar protection for a high density & high rise design.

Solar Passive Design (decrease in kwh/m2/yr)

↓ 7.0%

Natural Ventilation Passive Design (decrease in kwh/m2/yr)

↓ 27.1%

Remarks

Most energy save through Natural Ventilation Passive Design on a multi story building and second highest energy consumption per square meters

Figure 48 Energy consumption summary for y-shaped morphology

Architectural design opportunities

- Significant opportunities for ground-level outdoor activities and public functions due to shadow casting. This is highly appealing for warm and temperate climates.
- Orientation is highly appealing for providing a variety of views. For this reason, the project can also spread across the context and cover a significant amount of the built area.
- Concepts with various types of activities, both public and semi-public, can be highly appealing for this form. Zoning and activities can be easily grouped in in-between-spaces of the Y-shape which can provide a lively and hierarchical ground level.

- This morphology can bring requirements for openings to be placed on all facades rather than 2-side or single-side openings.

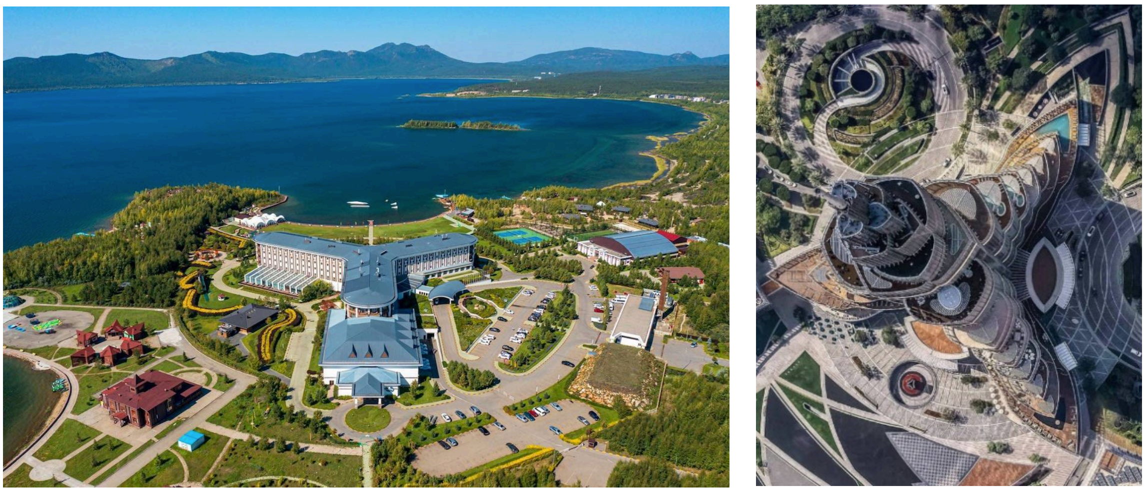


Figure 49 Hour based solar radiation map and cast shadow of terraced morphology.

Terraced

Accommodation: 83.7% / Circulation: 16.3%

Solar passive design – Solar exposure and cast shadow.

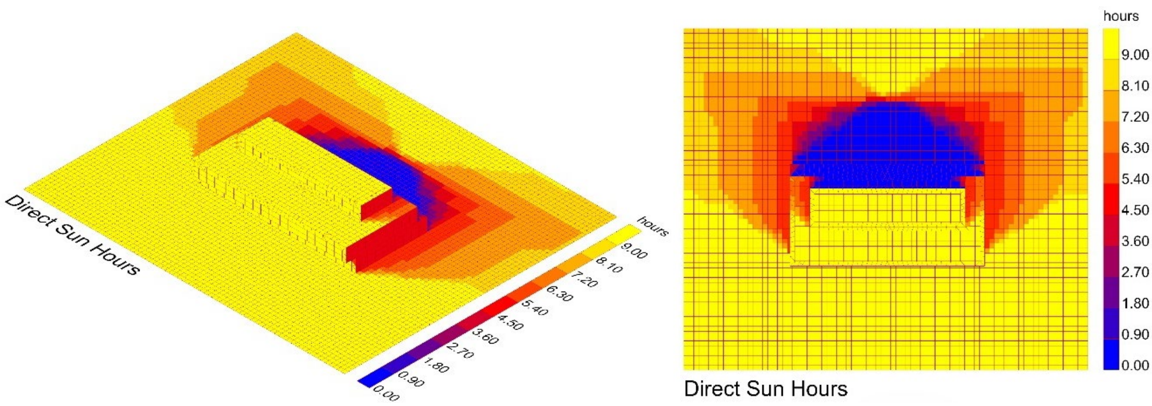


Figure 50 Hour based solar radiation map and cast shadow of terraced morphology.

Impact on Energy consumption

Need for Solar Protection (Facade areas with High Solar Exposure hours)

35,7%

Solar Exposure

1166kWh/m2

Remarks

Overall second least need for solar protection and highest solar exposure. High daylighting potential

Solar Passive Design (decrease in kwh/m2/yr)

Natural Ventilation Passive Design (decrease in kwh/m2/yr)

Remarks

↓ 4.3%   ↓ 25.4%   Overall least energy save and overall least energy consumption per square meters

Figure 51 Energy consumption summary for terraced morphology

Architectural design opportunities

- Can have significant limitations for the views and orientation of the building. The terraced morphology is usually ideal for contexts with steep topography however it can be possible to implement in other contexts too.
- It is also possible to achieve a high-density accommodation unit in this morphology.
- The morphology also allows the design to be spread over a context which can create potential for versatile landscaping and outdoor activities.
- It can be possible to implement high-rise morphologies with less intrusive height through terrace morphology. This can also offer privacy for the visitors.
- It is possible to divide accommodation zones and public zones in this typology more easily. The terraced typology can be done along an axis and public functions can be placed on the plinth and at the ends of the axis.
- Openings can also be limited to a specific direction as terraced morphologies are usually a single-directional design.
- Terraced typology might decrease the lighting load since it has less need for solar protection relative to its solar exposure.

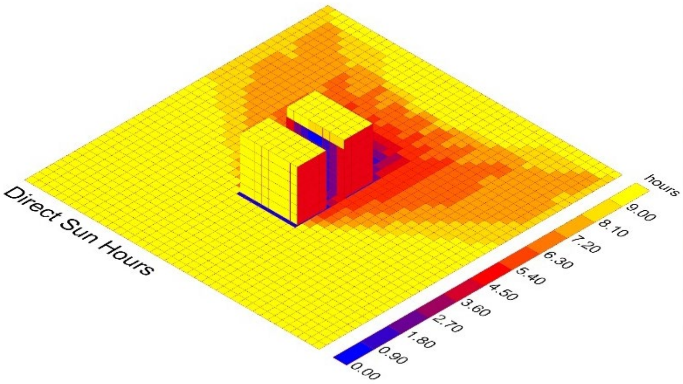

Figure 52 Terraced morphology concepts for public space and privacy (Astbury, 2019)

Figure 53 Potential for integrating different programs for terraced morphology and its impact on the context (C&K Architects, n.d.)

Village Complex

Accommodation: 76.2% / Circulation: 23.8%

Solar passive design – Solar exposure and cast shadow.



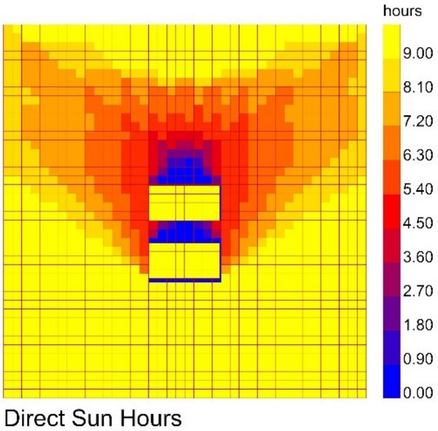


Figure 54 Hour based solar radiation map and cast shadow of village complex morphology.

Impact on Energy consumption

Need for Solar Protection (Facade areas with High Solar Exposure hours)	Solar Exposure	Remarks
21,5%	976kWh/m2	Overall least need for solar protection and lowest amount of solar exposure. Low daylighting potential
Solar Passive Design (decrease in kwh/m2/yr)	**Natural Ventilation Passive Design (decrease in kwh/m2/yr)**	**Remarks**
↓ 13.7%	↓ 38.8%	Overall highest energy save and highest energy consumption per square meter

Figure 55 Energy consumption summary for terraced morphology

Architectural design opportunities

- Village Complex type can offer design opportunities related to landscaping and outside activities. The organization of the villas can be made to create hierarchy and zonings.
- It also promotes a walkable hotel concept that can be integrated into nature.
- This morphology also offers a lot of privacy for the guests as the villas are spread out over a context and usually have a walkable distance between them.
- It is one of the least profitable options when it comes to the number of accommodation units.
- This type of morphology would require a separate building design where main public functions would take place such as lobby, restaurant, spa etc.

Figure 56 Potential atmosphere and spatial flow that can be created with village complex morphology (O'Hare, 2018)

Typology

Solar Passive Design - Solar exposure and cast shadow.

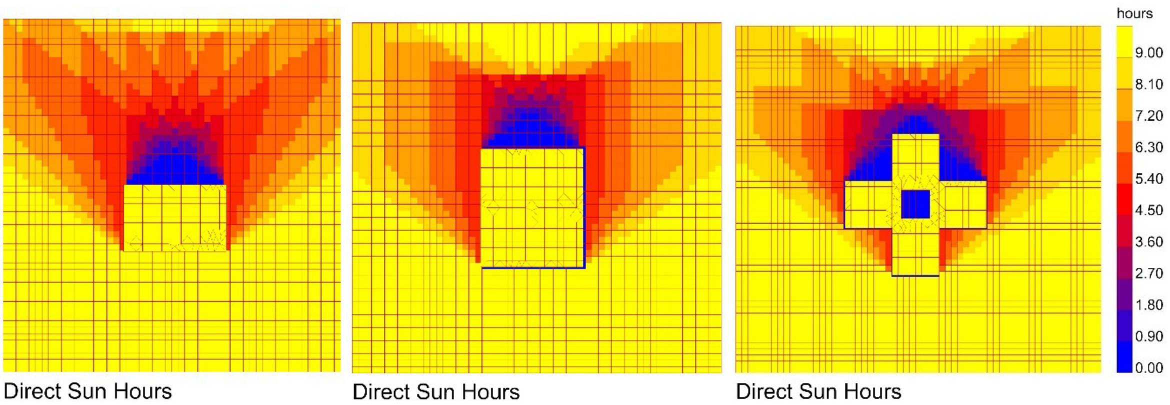


Figure 57 Hour based solar radiation map and cast shadow for all typologies. (left to right: single-loaded slab, double-loaded slab, atrium)

Impact on Energy consumption

	Solar Passive Design (decrease in kwh/m2/yr)	Natural Ventilation Passive Design (decrease in kwh/m2/yr)	Remarks
Single-loaded Slab	↓ 11,9%	↓ 30,2%	Overall most energy save and least amount of energy consumption per square meters
Double-loaded Slab	↓ 7,2%	↓ 27,4%	Overall least energy save for a high density accomodation type and second lowest energy consumption per square meters
Atrium	↓ 6,2%	↓ 29,7%	Overall second most energy save and highest energy consumption per square meters for all strategies.

Figure 58 Energy consumption summary for all typologies

Architectural design opportunities

- Location in urban context can benefit from an atrium design as it can offer a spacious atmosphere in a densely populated area.
- Single loaded slab can be highly beneficial to integrate corridors with no HVAC which can decrease the energy load significantly and offer an open architectural concept.
- Double loaded slab is highly dense and profitable. Due to its isolated corridor, various materials and interior elements can be used to add quality.
- These typologies can be combined with each other to offer multiple benefits. For example, an atrium and single loaded slab can work really well to offer a spacious and social environment.

Figure 59 Atrium design concepts for vertical connectivity and shading for inner courtyard. ("View of the Courtyard - Picture of Hotel El Convento, Puerto Rico", 2012)

Figure 60 Single loaded slab and double loaded slab atmospheres. (Flanagan, 2018; O'Hare, 2018)

5.0 Results

Solar Passive Design

The overall results for solar passive design vary significantly for each design type and it is important to point out the relation between solar exposure and the need for solar protection. Cases where solar exposure is higher than the 'need for solar protection' will be ideal as they can provide more daylighting and consequently decrease lighting energy loads. This is also important to decrease material needed for facade shading. Therefore, y-shaped morphology is the least appealing option due to its high need for solar protection relative to solar exposure. When it comes to multi-story morphologies, High-rise towers and terraced are the most ideal for daylighting and the amount of solar protection needed

Best options for solar passive design:

For morphologies:

1. Village Complex
2. High-rise tower
3. Terraced

For typologies:

1. Single-loaded slab
2. Atrium
3. Double-loaded slab

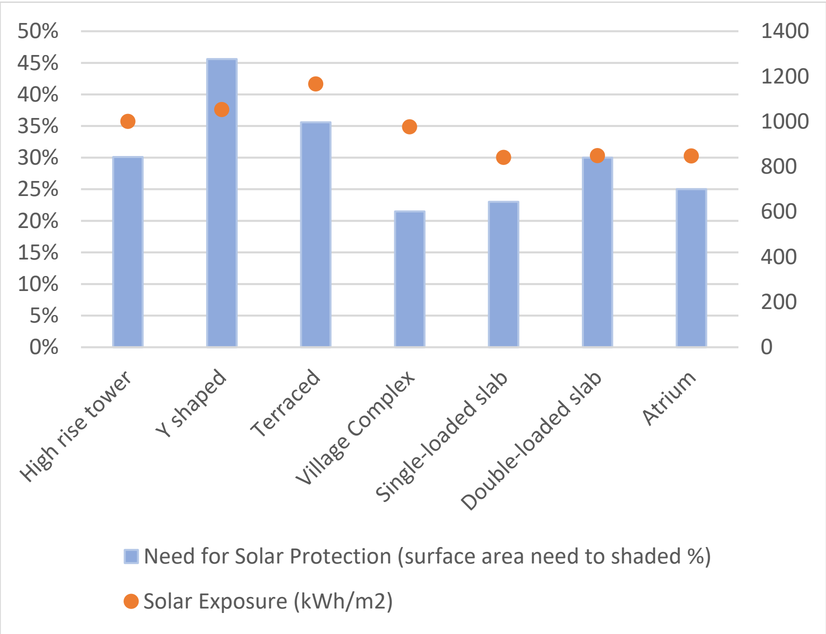


Figure 61 Comparison between needed solar protection ratio and overall solar exposure. The bigger distance between solar exposure and the need for solar protection shows a higher potential for daylighting.

Natural Ventilation Passive Design

In this evaluation, direct passive design methods have more weight due to their higher energy impact. In terms of passive design applicability, the village complex morphology has the most freedom in integrating passive design strategies due to the character of the design having separate units of accommodation. When it comes to the other morphologies, terraced morphology shows the next best potential with major drawbacks for cross ventilation potential. This success is also dependent on the orientation of the terraced morphology as it can be single-directional. High-rise towers and y-shaped morphologies show similarities in their concepts. However, for high-rise towers as the connection with the ground level is lesser, evaporative cooling may become challenging. This becomes a similar drawback for y-shaped in the case of multiple levels (for example over 5 levels.)

For typologies, the distinction is highly visible with single-loaded slab showing the most potential for overall passive design applications. This is followed by the atrium and double-loaded slab respectively. The biggest constraint is faced with double loaded-slab due to creating closed and compact spaces. Compactness can be useful in passive design as well; however, in terms of natural ventilation passive design, it is less appreciated.

Table 3 Overview of design applicability and restrictions for natural ventilation passive design on hotel morphologies and typologies

PASSIVE DESIGN APPLICABILITY ON MORPHOLOGY & TYPOLOGY								
Natural Ventilation Passive Design		Most prefered to least preferred by developers->				Most prefered to least preferred by developers->		
		Morphology				Typology		
		High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Direct Methods	Cross Ventilation	Moderate	Moderate	High	High	High	Low	Moderate
	Stack Ventilation	High	High	Low	High	Moderate	High	High
	Underground Construction	High	High	High	Low	Moderate	Indifferent	High
	Evaporative Cooling	Low	Moderate	High	High	High	Moderate	High
Indirect Methods	Night Ventilation Cooling	High	High	Indifferent	High	High	Indifferent	High
	Radiant Cooling	Moderate	High	Moderate	Moderate	High	High	Low

Table 4 Overview of energy efficiency and effectiveness of natural ventilation passive design on hotel morphologies and typologies (red highlights the overall lowest energy consumption per area annually)

Passive Strategies		Most prefered to least preferred by developers->				Most prefered to least preferred by developers->		
		Morphology				Typology		
		High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Only Solar Protection	Before (kWh/m2/yr)	55	55,2	51,5	71,7	57,4	55,9	62,9
	After (kWh/m2/yr)	50,7	51,3	49,3	61,9	50,6	51,9	59
	Impact (% kg CO2/m2/yr)	**8%**	**7%**	**4%**	**14%**	**12%**	**7%**	**6%**
Passive Ventilation Cooling (After solar shading)	Before (kWh/m2/yr)	50,7	51,3	49,3	61,9	50,6	51,9	59
	After (kWh/m2/yr)	37	37,4	36,8	37,9	35,3	37,7	41,5
	Impact (% kg CO2/m2/yr)	**27%**	**27%**	**25%**	**39%**	**30%**	**27%**	**30%**
	Total Decrease in Energy Load	35%	34%	30%	52%	42%	35%	36%

The village complex is the most effective with a 52% decrease in the energy load, terraced morphology becomes the lowest energy-consuming morphology per area. Therefore, in terms of energy efficiency, the lowest impact would be the most sustainable option for hotel development. This is the same case between double-loaded slab and atrium typologies. Although the total decrease in the energy load for the atrium is 36% (compared to 35% for the double-loaded) atrium typology has the highest energy consumption per area annually. This makes atrium typology a less preferable option for hotel design. However, atriums can still be integrated as solar chimneys to promote a stack effect rather than a complete building morphology.

Best options for natural ventilation passive design:

For morphology:

Design Applicability	Effectiveness
1. Village Complex 2. Terraced	1. Terraced 2. High-rise

Combined

1. Terraced
2. Y-shaped

For typology:

Design Applicability	Effectiveness
1. Single-loaded 2. Atrium 3. Double-loaded	1. Single-loaded 2. Double-loaded 3. Atrium

Combined

1. Single-loaded
2. Double-loaded = Atrium

Architectural Design Opportunities & Goals

Architectural design opportunities and goals are highly important criteria and can help achieve other goals related to hotel design. These opportunities can help promote healthier relationships with the stakeholders to create healthier communities, aware clients and overall, a more sustainable design vision for tourism developments. Therefore, the conclusion of this part is highly <u>dependent on the design goals, ambitions, and vision that the architect wants to prioritize in the design</u>.

The evaluations show that Y-shaped morphology has the highest potential by allowing opportunities for all design criteria. This is due to its radial spread over the context which allows opportunities for all-around views, zoning, landscaping, and creating different levels of public-private interactions. It is also a high-density accommodation morphology which makes it a profitable design choice for developers. The second-best option is the terraced morphology which achieves a multi-story quality without being intrusive to the context with stacked terraces and only facing limitations for orientation. From a design point of view, terrace morphology offers potential for social interactions and a seamless connection between ground level and upper levels. The last morphologies are equally the effective high-rise tower and village complex. The high-rise tower morphology shows potential for achieving high-density accommodation zones and allowing attractive views without privacy issues. This design morphology is especially weak with relating to its context due to the multi-story aspects. The village complex, however, shows strengths in weaker criteria of the high-rise tower: orientation and landscaping & outdoor activities. These are due to the scale of the accommodation zones being significantly smaller allowing flexibility for relating to the context. Village complex also offers opportunity for a more diverse masterplan with zoning and clustering

Table 5 Overview of architectural design potential for hotel morphologies and typologies

MORPHOLOGY & TYPOLOGY ARCHITECTURAL DESIGN POTENTIAL							
Architectural design criteria for hotel design	Most prefered to least preferred ->				Most prefered to least preferred ->		
	Morphology				Typology		
	High rise tower	Y shaped	Terraced	Village Complex	Single loaded slab	Double loaded slab	Atrium
Orientation							
Number of Accomodation Units							
Façade openings & privacy							
Landscaping & outdoor activities							

Best options for architectural design opportunities:

For morphology

1. Y-shaped
2. Terraced
3. High-rise = Village Complex

For typology

1. Single-loaded = double-loaded=atrium

Overview & Synthesis

According to the general overview, morphologies and typologies show the overall potential for hotel development in the Mediterranean climate. These results suggest significant potential for the terraced morphology, high-rise and village complex respectively. Especially considering the solar passive design and natural ventilation passive design terraced morphology becomes a superior option. This option, however, also comes with limitations related to the context as it needs accommodation units in contact with the ground level. So, it is an important detail to remember during the design phase. However, it is impossible to disregard the architectural opportunities that y-shaped morphology provides which makes it a useful morphology as well. Y-shaped morphology is consistently in the 3rd best position for natural ventilation as well.

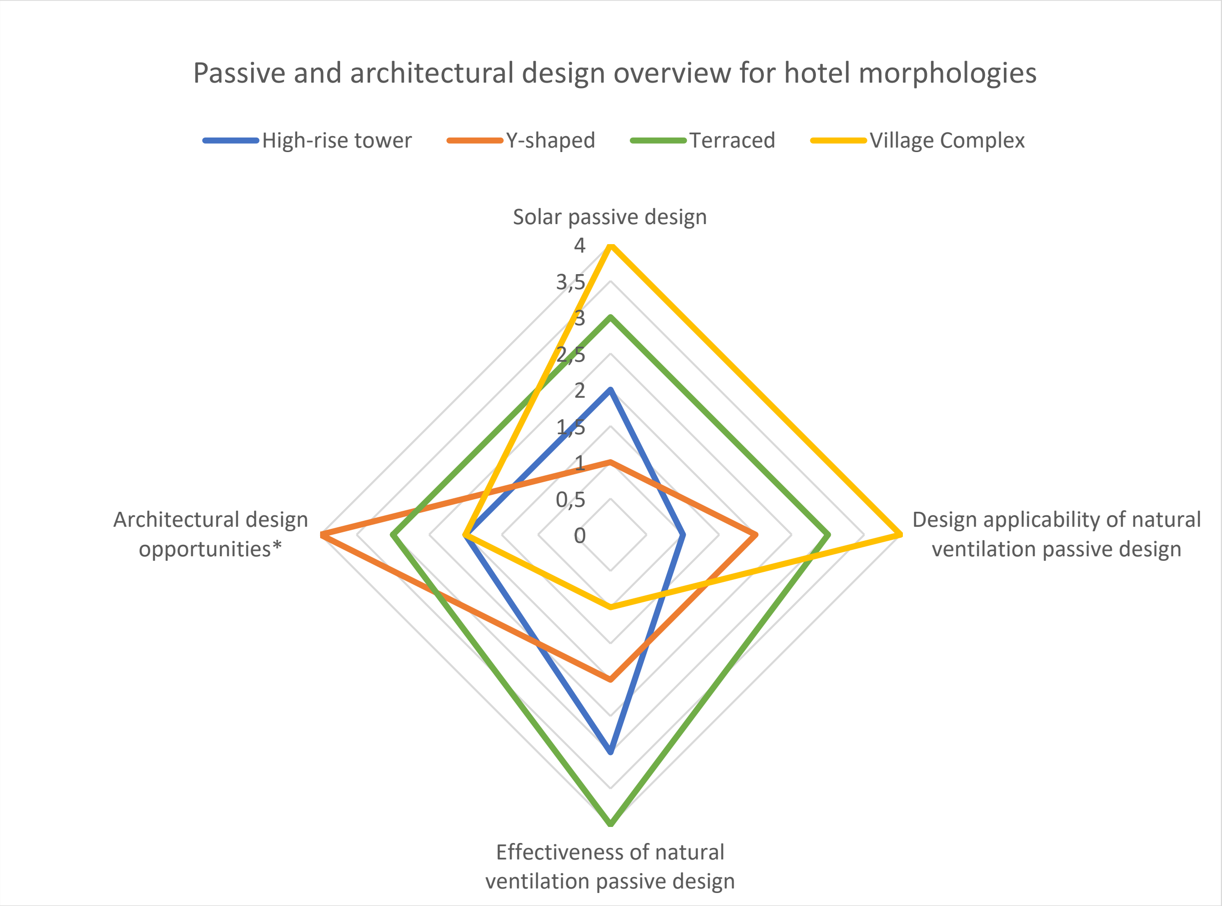


Figure 62 Passive and architectural design overview for hotel morphologies. The design criteria are based on the 4 criteria of hotel designs: orientation, number of accommodation units, façade openings & and privacy and landscaping & outdoor activities.

The overview of the typologies is significantly easier to summarize as the single-loaded slab shows the most potential for passive design interventions overall. It is important to note however that although atrium typology may be less appealing, it can still be possible to integrate atriums in specific zones of the building rather than as a whole. Not to mention, atrium typology is also one of the least preferred options for the number of accommodation units. Architectural design opportunities can be highly versatile with all of these typologies.

Although usually double-loaded slabs might cause more restrictions in architectural design for accommodation zones. In this case:

- Single-loaded slab has more design opportunities in number of accommodation units, façade openings & privacy and landscaping & outdoor activities.
- Double loaded slab has more design opportunities in orientation, number of accommodation units, façade openings & privacy.
- Atrium has more design opportunities in orientation, façade openings & privacy and landscaping & outdoor activities.

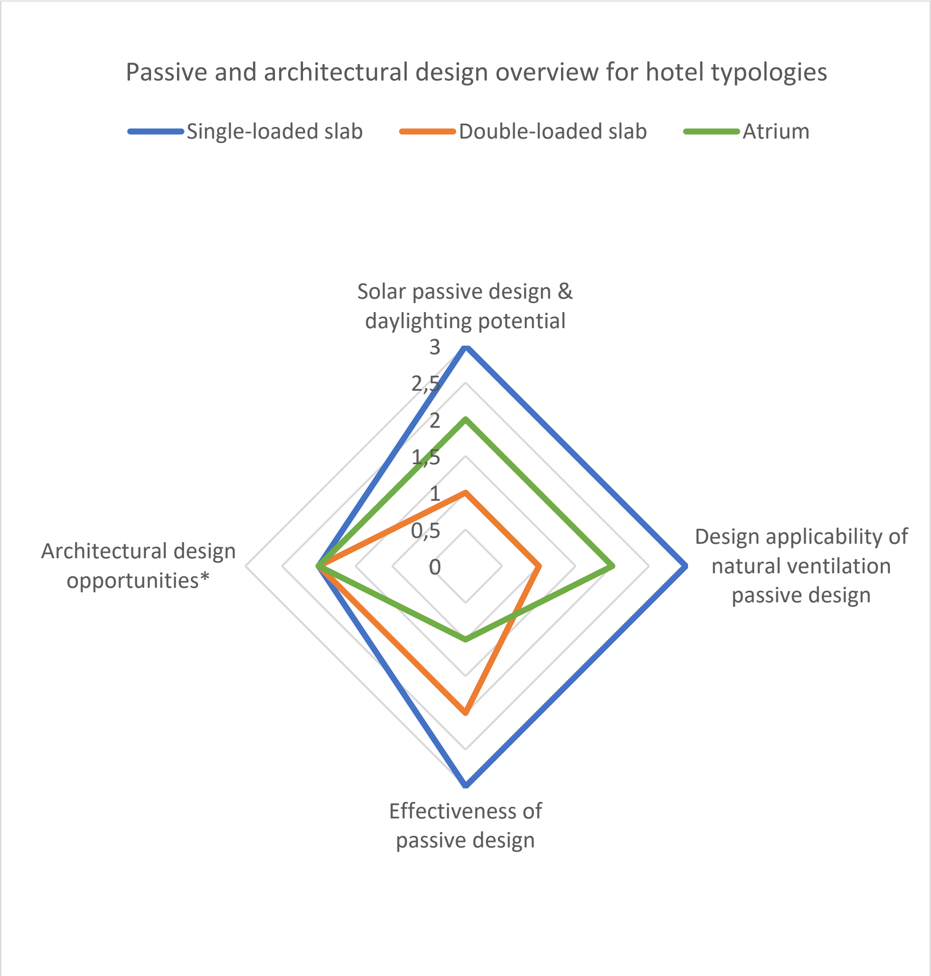


Figure 63 Passive and architectural design overview for hotel typologies. The design criteria are based on the 4 criteria of hotel designs: orientation, number of accommodation units, façade openings & and privacy and landscaping & outdoor activities.

6.0 Conclusion

From an architect's perspective, this design manual shows the limitations, benefits, and implications of adopting passive design strategies from various perspectives such as energy efficiency and design applicability. Although various shapes and compositions can be more efficient for tourism products like hotels, the importance of architectural integrity cannot be overlooked.

The results show that terraced morphology becomes a highly effective and efficient design option for hotel developments in the mediterranean climate. However, it is important to remember that this morphology also comes with design conditions (such as accommodation zones contacting the ground level) which might bring significant limitations. Y-shaped morphology on the other hand allows significant opportunities for architectural design freedom but also requires a significant plot size. For contexts with limited plot size and freedom, high-rise morphologies are more ideal and offer useful concepts for ground-level functions. Although high-rise morphology limited passive design applicability, the energy demand is still significantly improved. It is also possible to combine multiple morphologies to take advantage of their strengths. For example, high-rise towers can improve their relationship with the context by adding terraced elements on the plinth level. Another option can be combining y-shaped morphology with terraced morphology to take advantage of architectural design opportunities as well as implement more effective shading strategies through terraced morphology. Typologies also show potential for mainly single-loaded and atrium layout and allow opportunities for making atrium design more effective. These combinations can be made while considering the vision and goals of the project. So, it is possible to combine appropriate morphologies and typologies together to achieve the most effective, efficient, and aesthetic hotel development. For instance, in the case of large plots with less concern for accommodation zones village complex-double-loaded slab can be an effective combination. Projects that are located close to urban zones have a better advantage to combine high-rise morphology and several qualities of terraced to expand on the plinth. It is also more suitable to combine these with atrium and double loaded slab typologies. So, the combinations can be made relative to the need, context and strengths of the morphologies and typologies that are explained in the design manual.

These conclusions are also highly generalizable within the mediterranean region or other locations with mediterranean climate. Although the energy simulations are done on one location, the climate research shows no extremes that might divert the results. This suggests that the conclusions, concepts, and ideas that can be drawn from this research can be applicable to any location with mediterranean climate.

It is, however, clear that all the morphologies and typologies show energy load decrease between 20% to just over 50% and suggest potential for passive design strategies. These rates are only a minimum base for the effectiveness of the passive design strategies as this research doesn’t go deeper into daylighting potential reflected on energy load. It is important to mention that the effectiveness of the passive design strategies is also dependent on user behaviour which might affect the results. However, the research aims to achieve two conclusions: an overall comfortable indoor environment to minimize this need for climate control and already have an integrated vision for passive design strategies in the mediterranean climate.

Therefore, sustainability in hotel design should not only focus on sustainability through energy efficiency but also on sustainable interactions, impact and promoting a new tourism experience. This is highly relevant as tourism construction focuses on isolating its users from the outside world. These opportunities can also be utilized to create space for sustainable relations with the context, and outdoor activities, promote biodiversity, and minimize negative impact on local stakeholders. Therefore, the design manual offers the necessary technical and conceptual information to show the opportunities passive design offers. Passive design is especially relevant in this case because it needs to be implemented at the beginning of the design phase and therefore gives a significant amount of power to the designer. This puts an important responsibility on the designer to create appropriate nuances and balance between effective, efficient, and aesthetic (through design concept.)

Discussion & Further Research

Tourism's international expansion and how it may support a more sustainable construction industry still require major research and development. These projects are usually led by developers which might result in an unhealthy dynamic between profit and sustainability. This study seeks to comprehend how an architect within this ecosystem may intervene during the design process so that sustainability becomes a basis rather than an add-on. Therefore, looking into passive design becomes significant since it requires early design phase action to be implemented successfully. By making this information organized, accessible and available for architects, it is aimed to influence the design development phase of tourism projects. The key tourism product in this study is hotel design, which is acknowledged to be one of the most energy intensive items in tourism. From architectural integrity point of view, this manual does not suggest a final form, organization, composition, or option because the design manual should be filtered within the design vision of the architect. This suggests a significant responsibility on the architect making them closer to a developer position of decision-making. These decisions, however, are sustainability, efficient and design driven, which can save cost for the developer and the client as well.

Further research

The design manual focuses on deriving data related to the accommodation zones. Although from a design perspective, other programs like lobby, outdoor activities and privacy are mentioned, the research lacks detailed information on these zones. Therefore, the energy efficiency and design applicability of passive design strategies are not explored for other common areas like the lobby, restaurants, SPA, event halls and lounge areas. Therefore, further research can perform this analysis for a hotel as a whole for selected morphologies and typologies. It is also necessary to perform simulations that can include variety of parameters like different envelope properties, different type of façade shadings, impact of existing bodies of water (for evaporative cooling) and daylighting relative to solar exposure. This information can make the research more detailed and help create a clearer overview of passive design strategies on hotel designs.

7.0 List of Tables & Figures

List of Tables

8.0 References

Altan, H., Hajibandeh, M., Tabet Aoul, K.A. and Deep, A. (2016), “Passive design”, *Springer Tracts in Civil Engineering*, Springer, pp. 209–236, doi: 10.1007/978-3-319-31967-4_8.

Arena, J. (n.d.). “The installation of solar panels on every new or renovated building could become a legal requirement from next year”.

Astbury, J. (2019), “Planted terraces overlook the sea at the Grand Park Hotel by 3LHD”, 1 December.

Aston University - EU. (2012), *Sustainable Tourism in the Mediterranean*, doi: 10.2863/69472.

A.Y. Freewan, A. (2019), “Advances in Passive Cooling Design: An Integrated Design Approach”, *Zero and Net Zero Energy*, IntechOpen, doi: 10.5772/intechopen.87123.

Beigli, F. and Lenci, R. (n.d.). *Underground and Semi Underground Passive Cooling Strategies in Hot Climate of Iran*.

Brown, G.Z. and Dekay, M. (n.d.). *Sun, Wind & Light: Architectural Design Strategies*, 2nd ed.

Casals Miralles, C., Barioni, D., Mancini, M.S., Colón Jordà, J., Boy Roura, M., Ponsá Salas, S., Llenas Argelaguet, L., *et al.* (2023), “The Footprint of tourism: a review of Water, Carbon, and Ecological Footprint applications to the tourism sector”, *Journal of Cleaner Production*, Elsevier Ltd, 10 October, doi: 10.1016/j.jclepro.2023.138568.

Chapman, A. and Speake, J. (2011), “Regeneration in a mass-tourism resort: The changing fortunes of Bugibba, Malta”, *Tourism Management*, Elsevier Ltd, Vol. 32 No. 3, pp. 482–491, doi: 10.1016/j.tourman.2010.03.016.

Chetan, V., Nagaraj, K., Kulkarni, P.S., Modi, S.K. and Kempaiah, U.N. (2020), “Review of Passive Cooling Methods for Buildings”, *Journal of Physics: Conference Series*, Vol. 1473, Institute of Physics Publishing, doi: 10.1088/1742-6596/1473/1/012054.

C&K Architects. (n.d.). “The Verdala Terraces”, *2021*.

Dehghani-Sanij, A.R., Soltani, M. and Raahemifar, K. (2015), “A new design of wind tower for passive ventilation in buildings to reduce energy consumption in windy regions”, *Renewable and Sustainable Energy Reviews*, Elsevier Ltd, doi: 10.1016/j.rser.2014.10.018.

Dredge, D. (2022), “Regenerative tourism: transforming mindsets, systems and practices”, *Journal of Tourism Futures*, Emerald Publishing, Vol. 8 No. 3, pp. 269–281, doi: 10.1108/JTF-01-2022-0015.

Elaouzy, Y. and El Fadar, A. (2022a), “A multi-level evaluation of bioclimatic design in Mediterranean climates”, *Sustainable Energy Technologies and Assessments*, Elsevier Ltd, Vol. 52, doi: 10.1016/j.seta.2022.102124.

Elaouzy, Y. and El Fadar, A. (2022b), “Energy, economic and environmental benefits of integrating passive design strategies into buildings: A review”, *Renewable and Sustainable Energy Reviews*, Elsevier Ltd, 1 October, doi: 10.1016/j.rser.2022.112828.

England, R. and Heathcote, E. (2002), *Richard England*.

ERA (Environment & Resource Authority). (n.d.). *Maltese Geology*.

“Evaporative Cooling - NZEB”. (n.d.). .

Falquina, R., de la Vara, A., Cabos, W., Sein, D. and Gallardo, C. (2022), “Impact of ocean-atmosphere coupling on present and future Köppen-Geiger climate classification in Europe”, *Atmospheric Research*, Elsevier Ltd, Vol. 275, doi: 10.1016/j.atmosres.2022.106223.

Flanagan, K. (2018), *We’d Linger in These 10 Beautiful Hotel Hallways Well-Designed Hotels Are Wall-to-Wall Fabulous-Right down to the Guest Corridors*.

Giabaklou, Z. and Ballinger, J.A. (1996), *A Passive Evaporative Cooling System by Natural Ventilation*, *Budding OndEnoironmenr*, Vol. 31.

Gilson, E. (2021), *The Mediterranean Climate*.

Grid Arendal. (2013), *Tourism in the Mediterranean Countries*.

Haggard, K., Bainbridge, D.A. and Aljilani, R. (2016), *Passive Solar Architecture Pocket Reference*, Routledge, doi: 10.4324/9781315781327.

Imessad, K., Derradji, L., Messaoudene, N.A., Mokhtari, F., Chenak, A. and Kharchi, R. (2014), “Impact of passive cooling techniques on energy demand for residential buildings in a Mediterranean climate”, *Renewable Energy*, Elsevier Ltd, Vol. 71, pp. 589–597, doi: 10.1016/j.renene.2014.06.005.

Interreg Euromed. (n.d.). *Interreg Euromed - What We Do*.

Jesse Maida. (2023), “Global Sustainable Tourism Market 2019-2023 | Shift in Preference Towards Local and Authentic Experiences to Boost Growth”.

Kumar, R. (2023), *Passive Cooling*.

Lindeman, R. and Keuvelaar, J. (2004), “Fundamental Aspects of Thermal Comfort TU Delft”, in Itard, L.C.M. and Bluyssen, P.M. (Eds.), , TU Delft, Delft.

Lionello, P., Malanotte-Rizzoli, / P, Boscolo, ^ R, Alpert, ^ P, Artale, ^ V, Li, ^ L, Luterbacher,’, ^ J, *et al.* (n.d.). *The Mediterranean Climate: An Overview of the Main Characteristics and Issues*.

Martínez-Moreno, F., Solís, I., Noguero, D., Blanco, A., Özberk, İ., Nsarellah, N., Elias, E., *et al.* (2020), “Durum wheat in the Mediterranean Rim: historical evolution and genetic resources”, *Genetic Resources and Crop Evolution*, Springer, Vol. 67 No. 6, pp. 1415–1436, doi: 10.1007/s10722-020-00913-8.

Matos, A.M., Delgado, J.M.P.Q. and Guimarães, A.S. (2022), “Energy-Efficiency Passive Strategies for Mediterranean Climate: An Overview”, *Energies*, MDPI, 1 April, doi: 10.3390/en15072572.

Mejjad, N., Rossi, A. and Pavel, A.B. (2022), “The coastal tourism industry in the Mediterranean: A critical review of the socio-economic and environmental pressures & impacts”, *Tourism Management Perspectives*, Elsevier B.V., 1 October, doi: 10.1016/j.tmp.2022.101007.

Met Office Gov UK. (n.d.). *Malta Weather*.

Munshi, S. (2015), *SHADING DEVICES AND ITS UTILIZATION HORIZONTAL SHADING DEVICES-OVERHANGS*.

Nader Ibrahim, N. (2022), “Fluidity 2.0 High-Rise: A Mega Luxury Hotel and Office Hybrid Tower in Swiss Alps by Mariana Cabugueira Custodio dos Santos”.

Neufert, Ernst., Neufert, Peter. and Kister, J. (2012), *Architects’ Data*, Wiley-Blackwell.

O’Hare, M. (2018), “The world’s best boutique hotels for 2018”, 9 November.

Peacock, A. (2023), “WOHA cuts garden terraces supported by green columns into Pan Pacific Orchard hotel”, *Dezeen*, 1 November.

Ritchie, H., Rosado, P. and Roser, M. (n.d.). *Greenhouse Gas Emissions Which Countries Emit the Most Greenhouse Gases Each Year? How Do They Compare per Person?*

De Roos, J.A. (n.d.). *Planning and Programming a Hotel*.

Santamouris, M. (2004), *V Entilation I Nformation P Aper N° 4 Air Infiltration and Ventilation Centre © INIVE EEIG Operating Agent and Management Boulevard Poincaré 79 B-1060 Brussels-Belgium Inive@bbri.Be-Www.Inive.Org International Energy Agency Energy Conservation in Buildings and Community Systems Programme Night Ventilation Strategies*.

S&claw, A., Enz, C.A., Latham, T. and Washington, H.(. (n.d.). *Best Practices in Hotel Architecture*.

UCLA. (2015), “Phase change materials for zero-net energy buildings”, *Morrin-Martinelli-Gier Memorial Heat Transfer Laboratory*.

Vella, L. and Malta Tourism Authority. (n.d.). *Sustainable Tourism Challenges and Strategies in Malta*.

“View of the Courtyard - Picture of Hotel El Convento, Puerto Rico”. (2012), .

WeatherSpark. (2016), *Weather in Marsaskala Malta*.

WWF. (n.d.). *Background Information Tourism Threats in the Mediterranean Background on Tourism in the Mediterranean*.

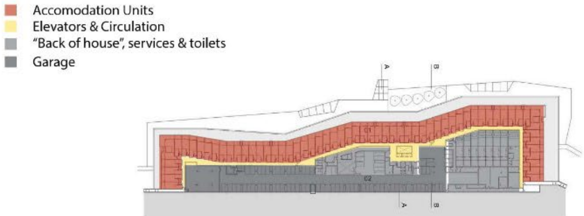
9.0 Appendix

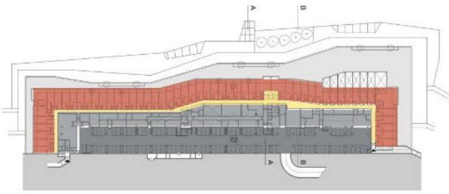
Appendix A: Case Studies on Hotels

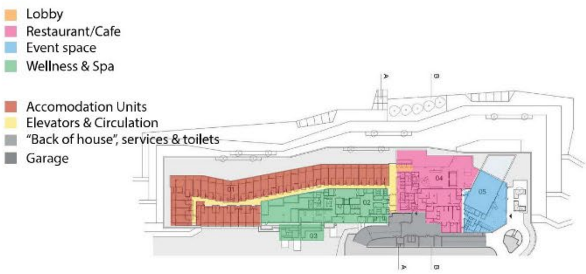
Grand Park Hotel Rovinj / 3LHD

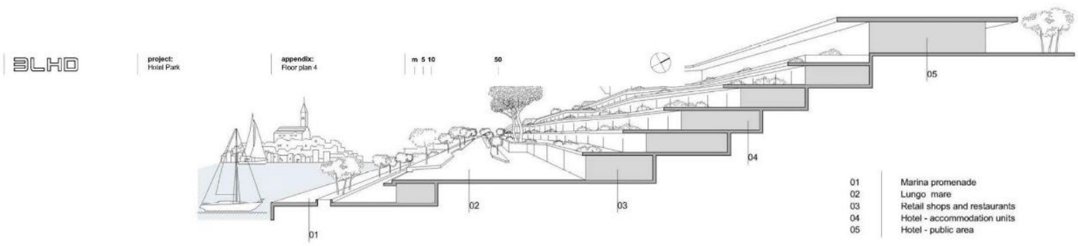
Location:Rovinj, Croatia
Area: 46813 m²

Accomodation Units: 45 %
Lobby: 1%
SPA: 5%
Back-of-house: 23%
Food & Bevarages: 14%
Retail: 3%





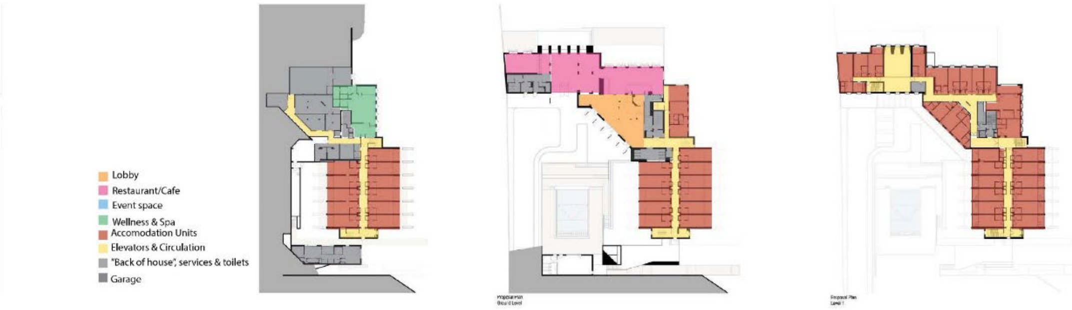




Aethos Ericeira Hotel / Pedra Silva Arquitectos

Location: Ericeira, Portugal
Area: 3750 m²

Accomodation Units: 50 %
Lobby: 4%
SPA: 8%
Back-of-house: 30%
Food & Bevarages: 14%



Casadelmar Hotel / Jean-Francois Bodin

Location:Porto-Vecchio, France
Area: -

Accomodation Units: 50 %
Lobby: 4%
SPA: 8%
Back-of-house: 30%
Food & Bevarages: 14%

Appendix B: The Simulation setup, results, figures & graphs

PASSIVE DESIGN MANUAL FOR ENERGY EFFICIENT TOURISM DEVELOPMENTS IN THE MEDITERRANEAN CLIMATE:

THE SETUP, RESULTS, FIGURES & GRAPHS

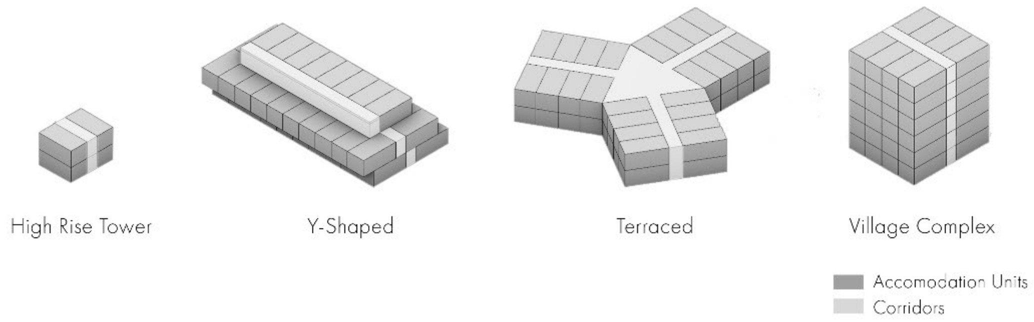
ZEYNEP YELKEN - 5724716
SUPERVISOR: CHRISTIEN JANSSEN
26/01/2024

Orientation

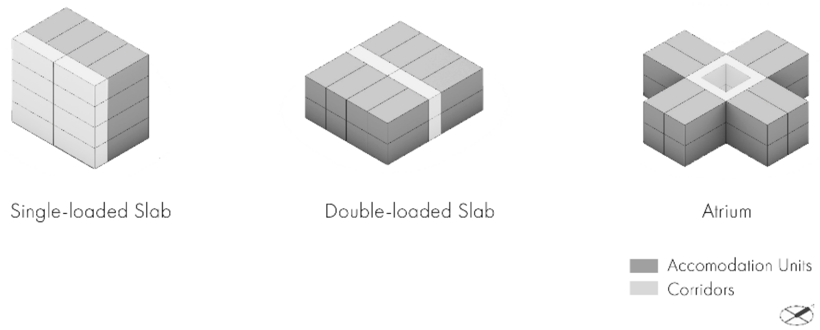
The orientation of the test geometry is positioned according to passive design orientation guidelines. This means that the majority of the occupied zones -accommodation units.

Geometry

For Morphologies

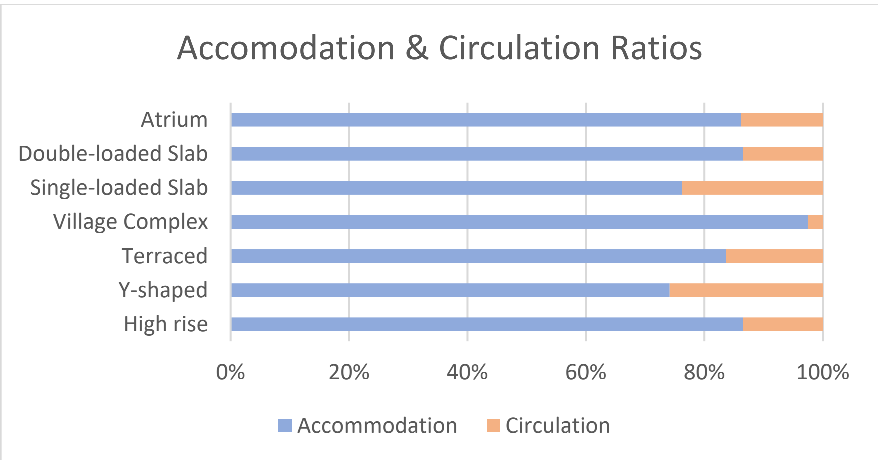


For Typologies



Due to these pre-selected design forms, the accommodation and circulation zone ratios might differ. The goal is to ensure the same square meters for accommodation units since these will consume the majority of the energy. However, this also gives a perspective on the amount of circulation that will be needed in order to achieve a specific form.

Table 6 Accommodation and circulation ratio of selected morphologies and typologies

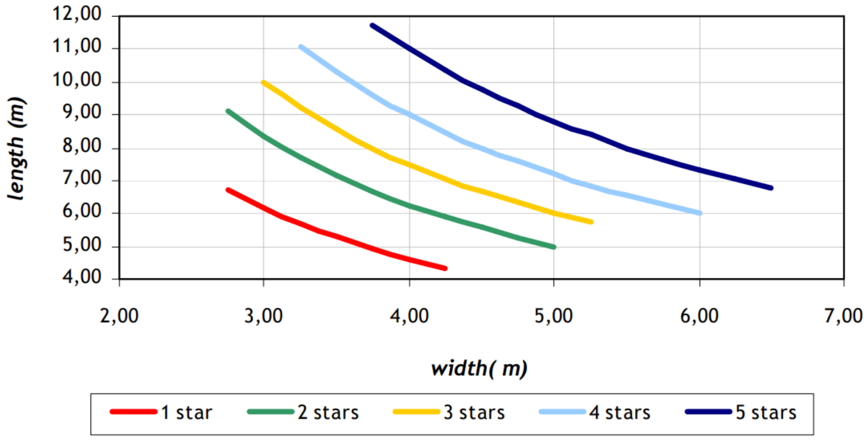


Remarks on simulation scope and hotel design

Selected accommodation zone dimensions:

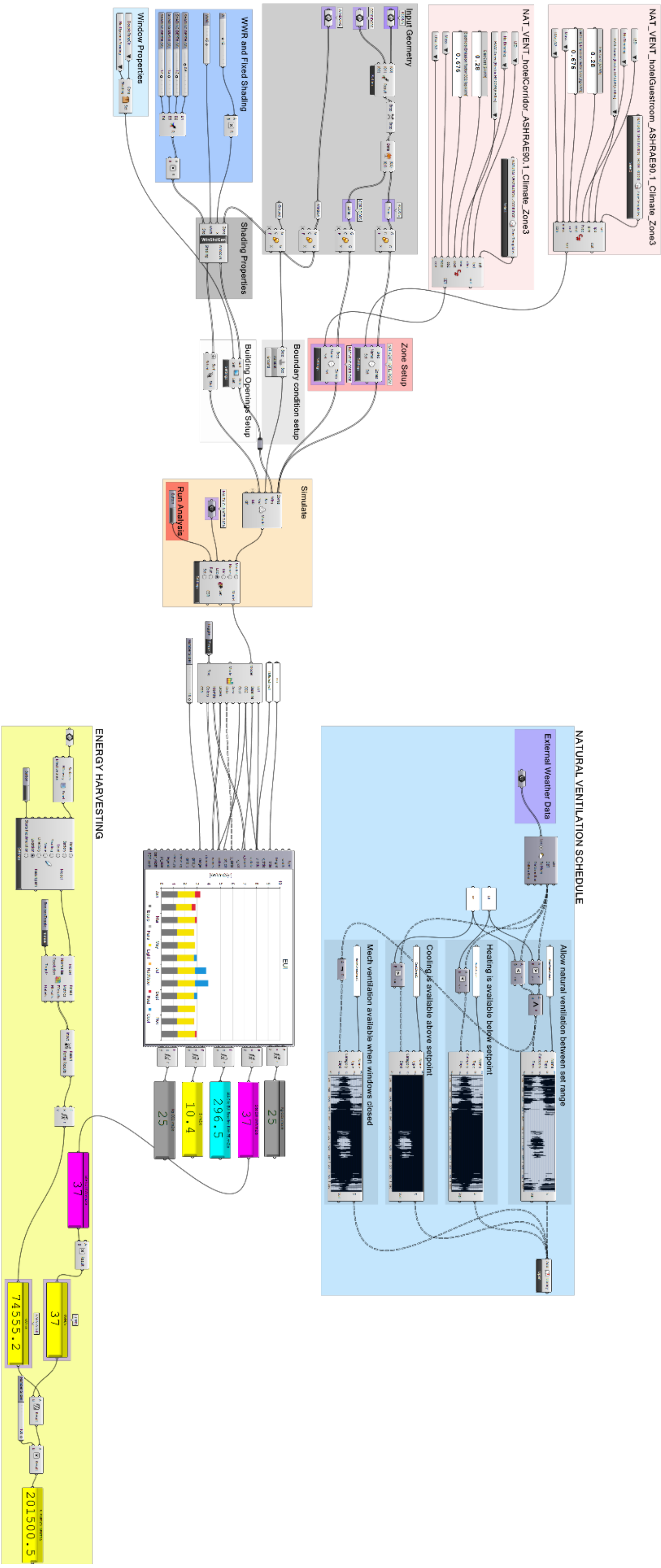
Length x Width x Height: 8x4x3.5m (Neufert *et al.*, 2012)

Corridor width: 2.5m



- For morphology, accommodation units are kept at 48 rooms with the exception of Village Complex having 4 units due to the difference in the concept of maintaining smaller separated accommodation zones.
- For typologies, the accommodation units are kept in 16 rooms.

Overall Script (Example on High-rise building morphology simulation with passive design strategies implemented)

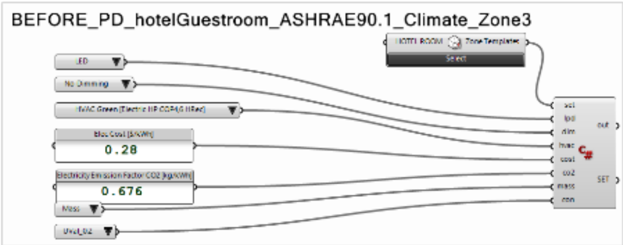


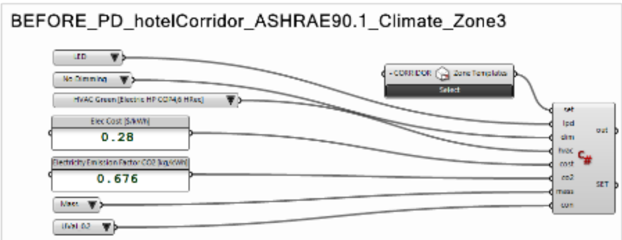
Simulation Setup

Orientation, Geometry & Envelope

The orientation of the test geometry is positioned according to passive design orientation guidelines. This means that the majority of the occupied zones -accommodation units-

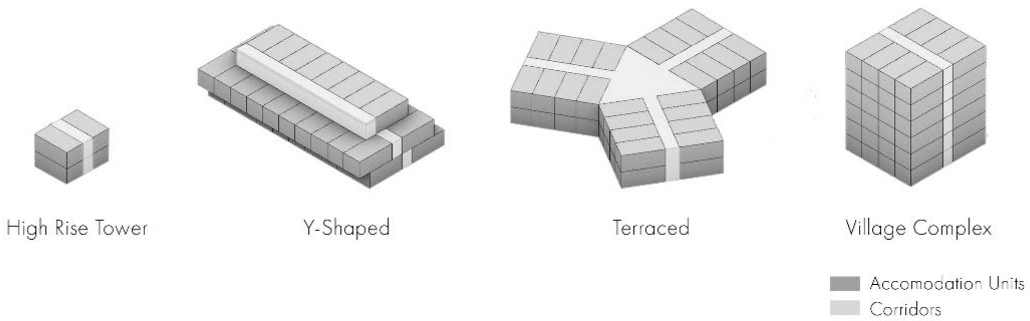
Program



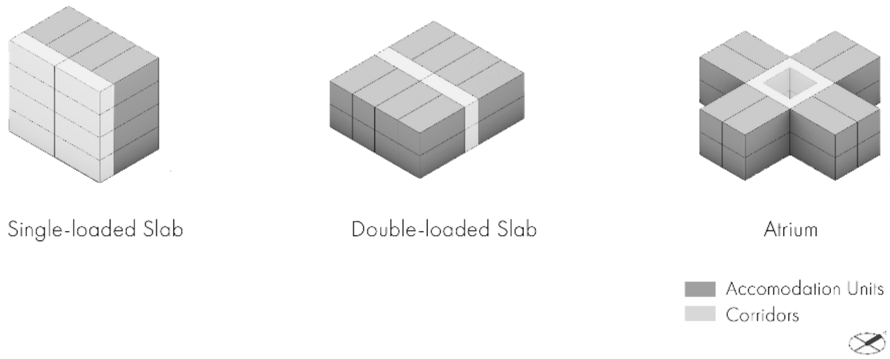


Geometry

For Morphologies



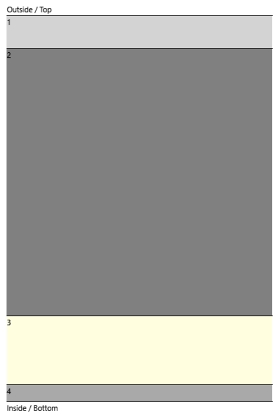
For Typologies



Envelope

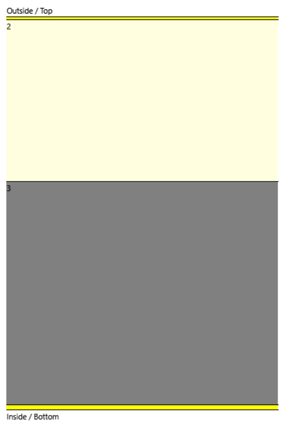
Infiltration (flow/exterior area) = 0.000568959710665963 m3/s/m2

Electricity CO2 rates = 0.624955708 Kg/kWh



90.1-2019 Non-residential CZ 3 Exterior Roof (Mass)
U-Value[W/(m^2·K)] = 0.215
R-Value[m^{2}K/W] = 4.516
Thermal Capacitance[kJ/K/m^2] = 471.138
Embodied Energy[MJ/m^2] = 815.501
Embodied Carbon[kgCO2/m^2] = 63.14
Layers: (Outside - Inside)
1 - Vapor permeable Felt 0.003 [m]
2 - XPS Board 0.147 [m]
3 - Concrete 0.203 [m]
4 - Acoustic Tile 0.005 [m]

90.1-2019 Non-residential CZ 3 Exterior Wall (Mass)
U-Value[W/(m^2·K)] = 0.624
R-Value[m^{2}K/W] = 1.432
Thermal Capacitance[kJ/K/m^2] = 540.408
Embodied Energy[MJ/m^2] = 399.98
Embodied Carbon[kgCO2/m^2] = 57.727
Layers: (Outside - Inside)
1 - Stucco 0.025 [m]
2 - Concrete 0.203 [m]
3 - Mineral Wool 0.053 [m]
4 - Plaster 0.013 [m]



Interior Slab (Mass)
U-Value[W/(m^2·K)] = 1.568
R-Value[m^{2}K/W] = 0.468
Thermal Capacitance[kJ/K/m^2] = 241.594
Embodied Energy [MJ/m^2] = 183.6
Embodied Carbon[kgCO2/m^2] = 24.48
Layers: (Outside - Inside)
1 - Acoustic Tile 0.005 [m]
2 - Concrete 0.102 [m]
3 - Carpet 0.02 [m]

Openings

In the simulation setting, the openings are added accordingly:

- Each accomodation units has one opening with WWR of 45%
- There are windows/openings at the end of each corridor

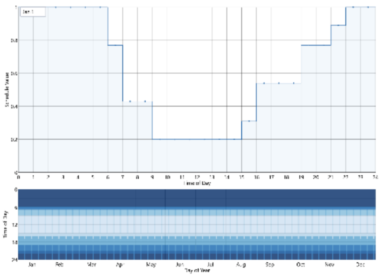
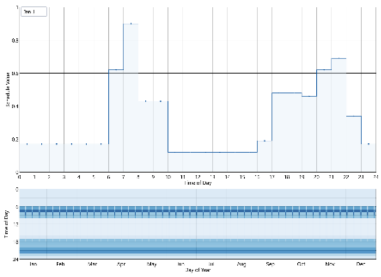
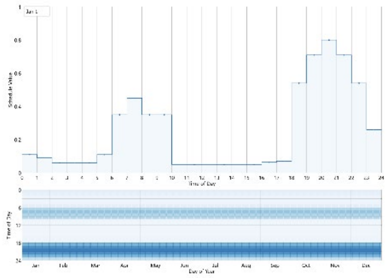
Occupancy & Ventilation Schedules

HVAC Schedules (ASHRAE 90.1 Large Hotel data from Climate Studio)

Guestroom

People: Dynamic Clothing Model ASHRAE55 used by ClimateStudio plug-in

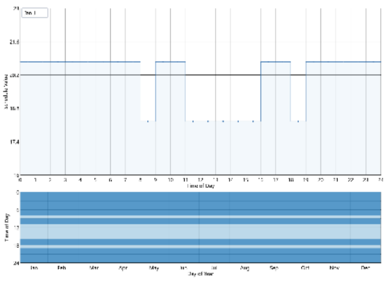
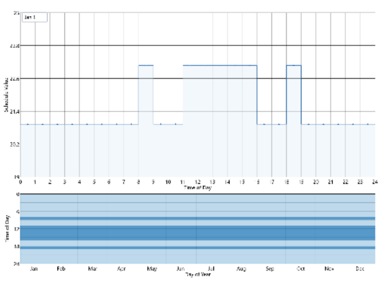
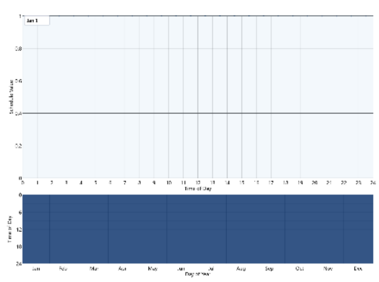
Occupancy, Equipment & Lighting Schedules

HVAC Before Natural Ventilation Passive Design

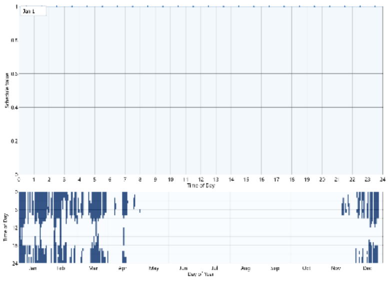
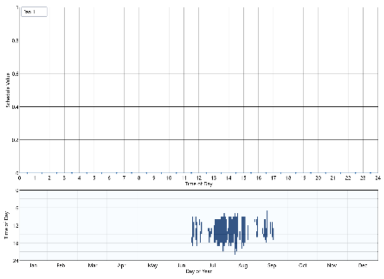
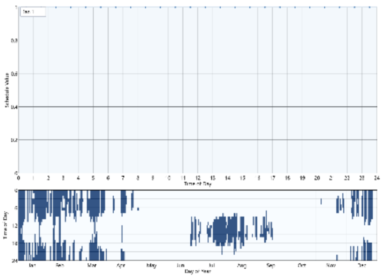
Heating, Cooling, and Mechanical Ventilation Schedules

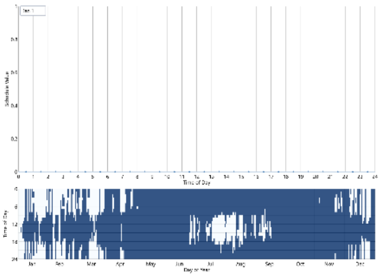
Natural Ventilation: OFF

HVAC After Natural Ventilation Passive Design

Heating, Cooling, Mechanical Ventilation Schedules, Natural Ventilation

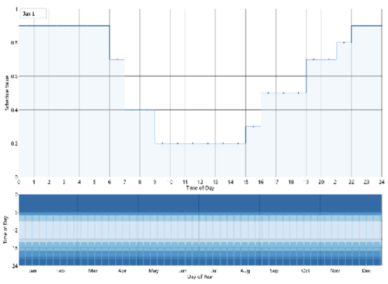
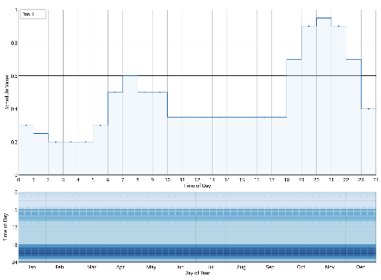
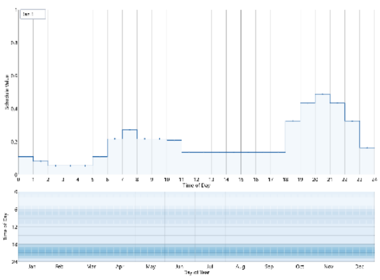






Corridor

People: Dynamic Clothing Model ASHRAE55 used by ClimateStudio plug-in

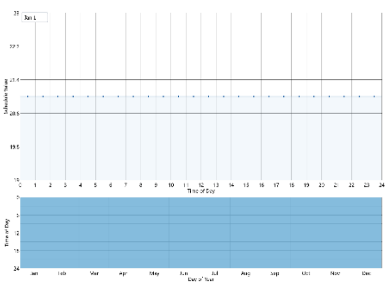
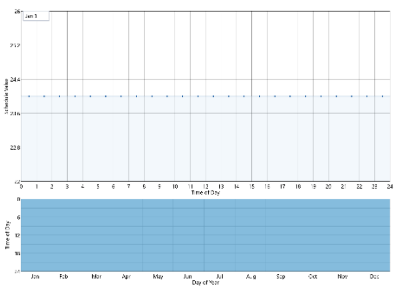
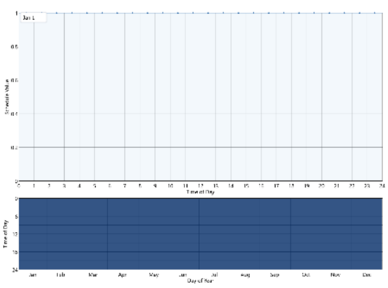
Occupancy, Equipment & Lighting Schedules

HVAC Before Natural Ventilation Passive Design

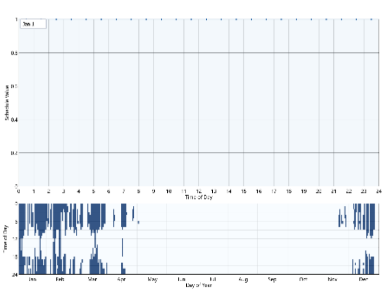
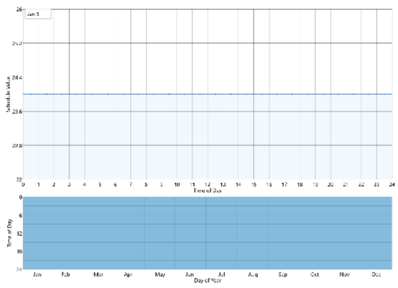
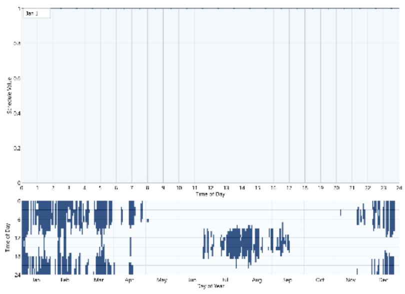
Heating, Cooling, and Mechanical Ventilation Schedules

Natural Ventilation: OFF

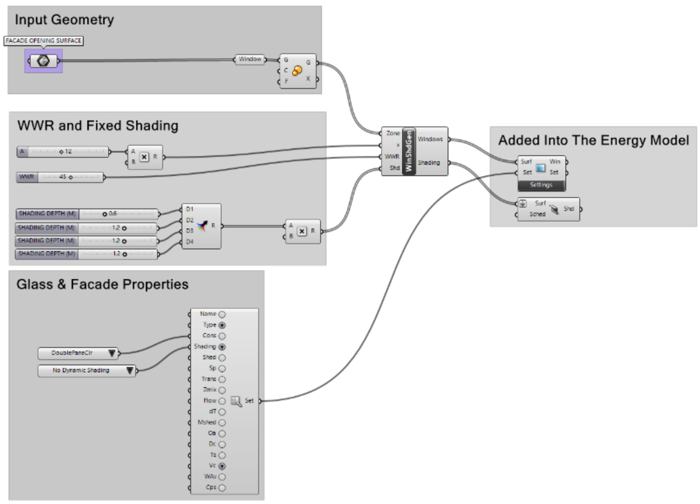
HVAC After Natural Ventilation Passive Design

Heating, Cooling, and Mechanical Ventilation Schedules, Natural Ventilation

Shading

Script



Window Properties

WWR: 45%

Double-glazed clear window.

U-value [2/(m2K)]: 2.272

SHGC= 0.764

TVIS= 0.812

Embodied Energy [MJ/m2] = 20

Embodied Carbon [kgCO2/m2] = 2

Shading Properties

Dynamic shading= OFF

According to calculations in Chapter 3.2.1. for shading depth:

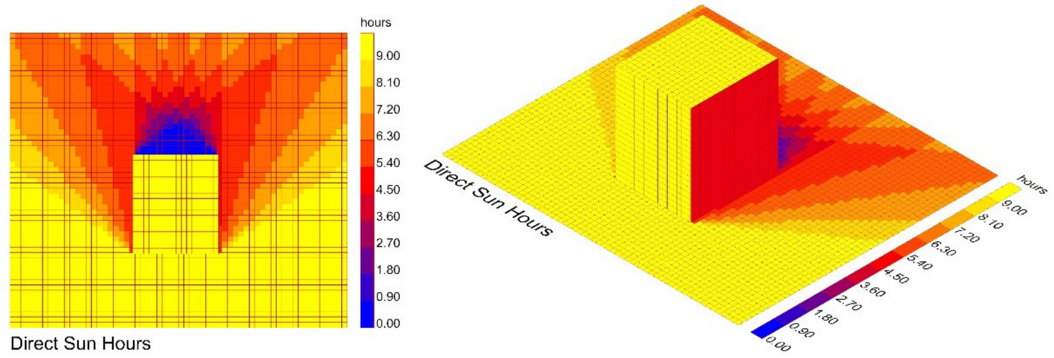
Shading Depth (East, South, West) [m]= 1.2

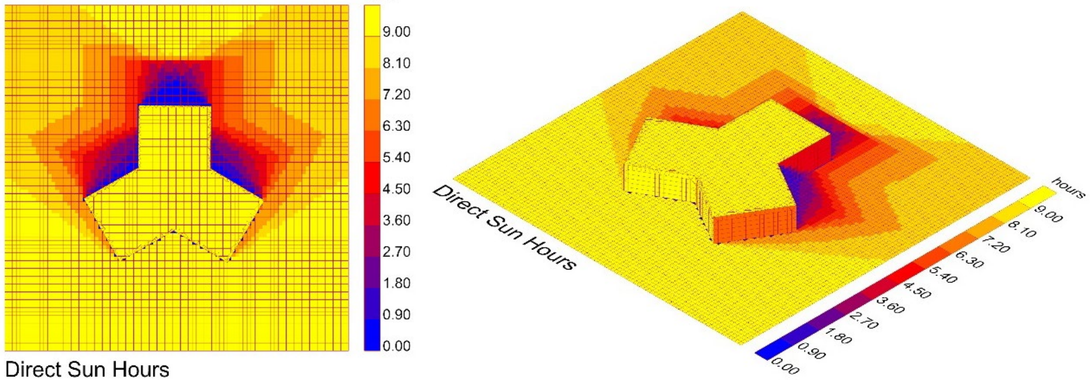
Shading Depth (North) [m] = 0.6

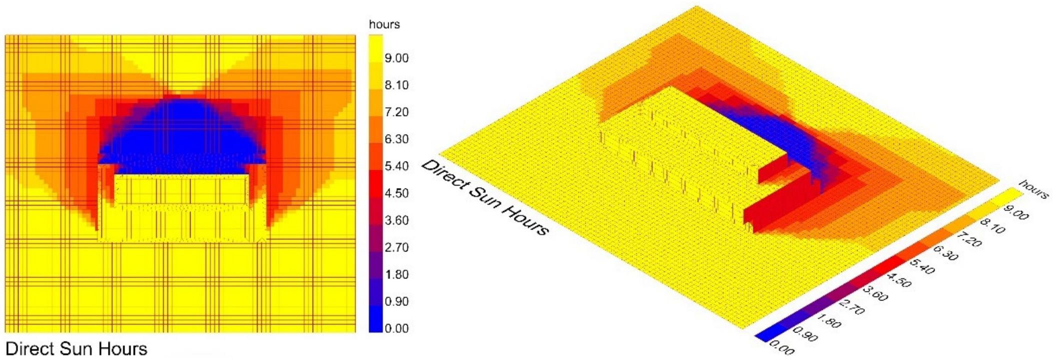
Results

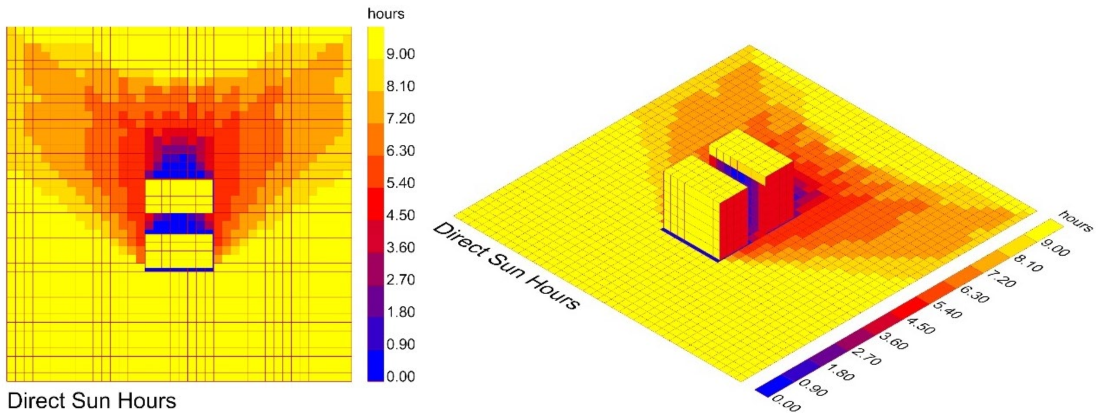
Solar passive design – Solar Exposure and cast shadows

Morphologies: High rise, y-shaped, terraced and village complex

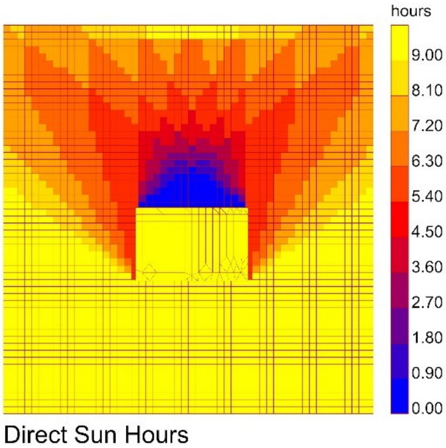


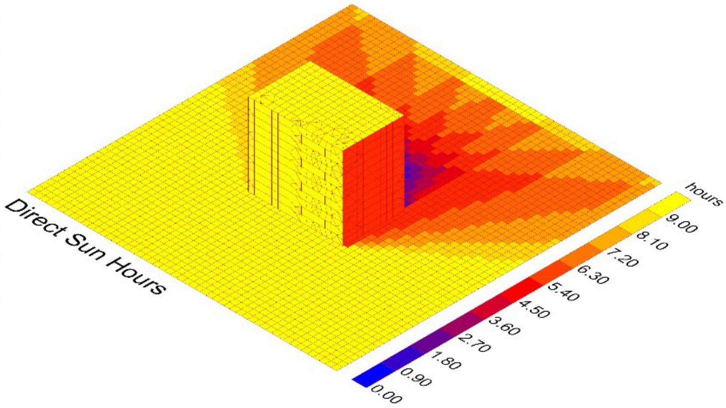


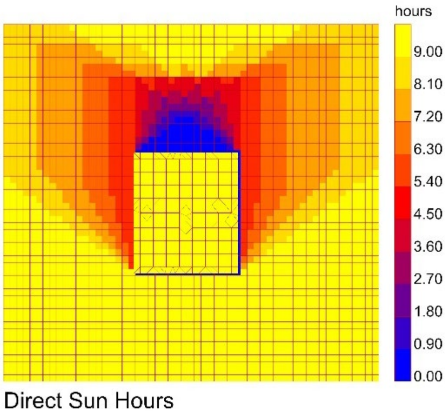


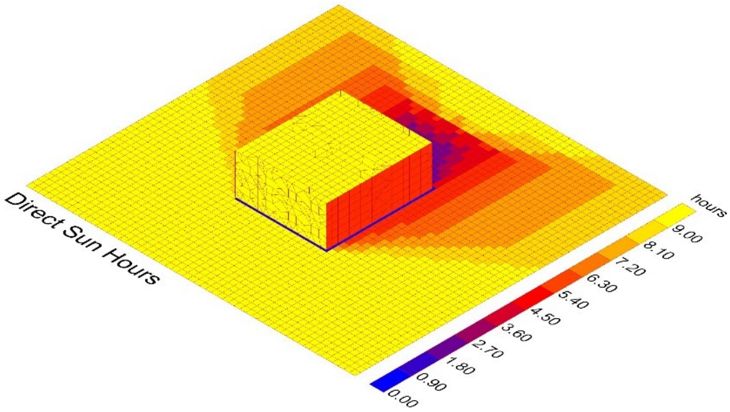


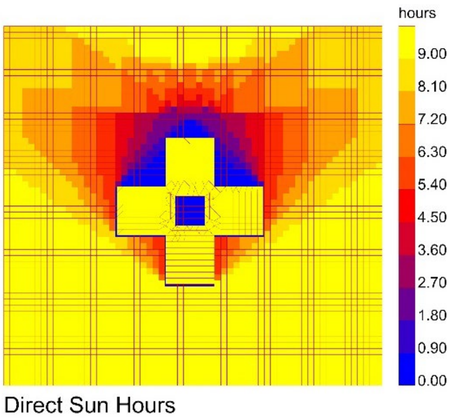
Typologies: Single-loaded, double-loaded, atrium

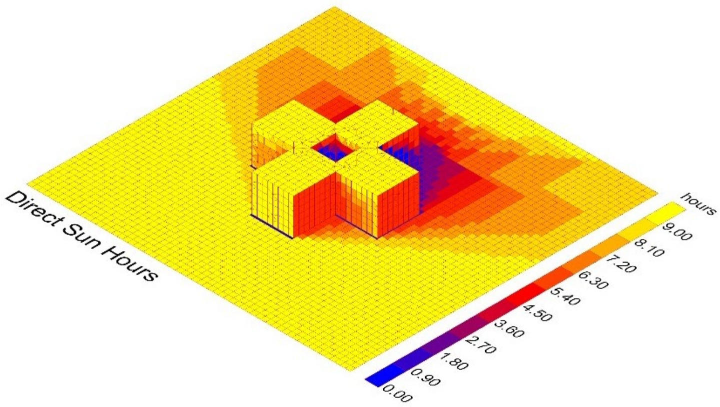




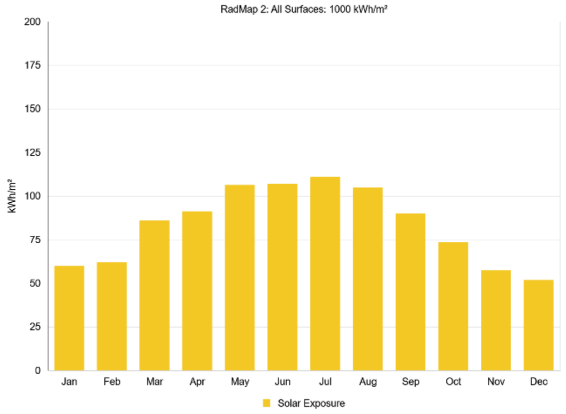




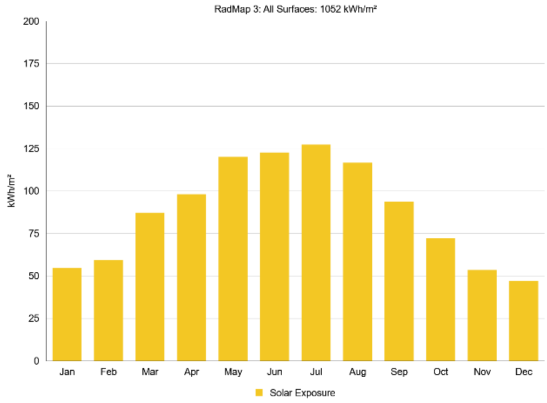




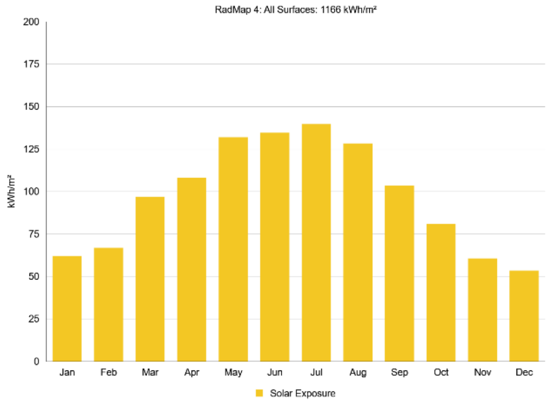
High rise



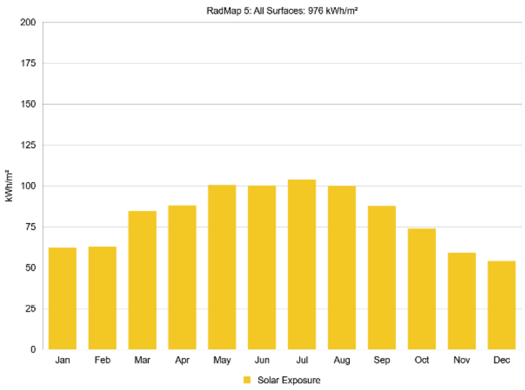
Y-shaped



Terraced



Village Complex

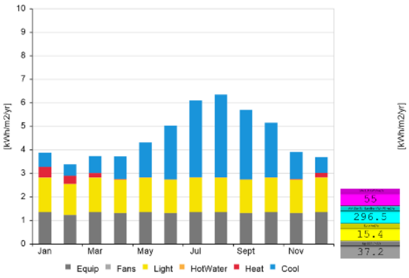


Solar & natural ventilation passive design – Energy demand improvements

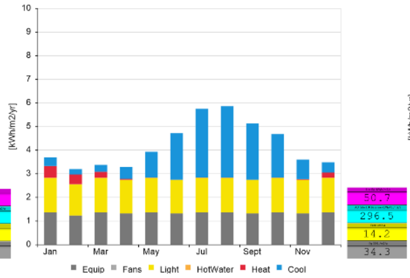
Morphologies

High-rise

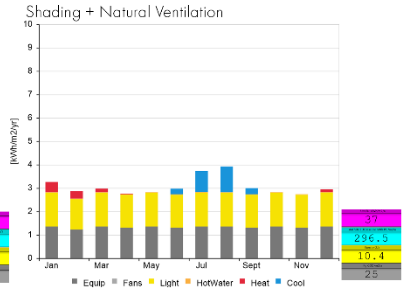
No passive design



Shading

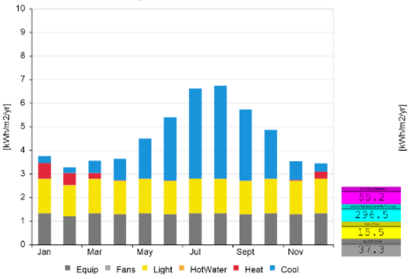


Shading + Natural Ventilation

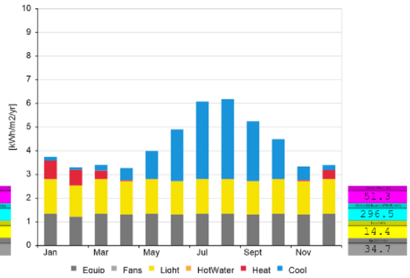


Y-shaped

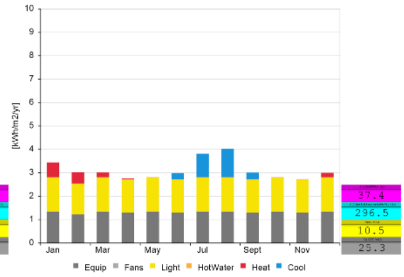
No passive design



Shading

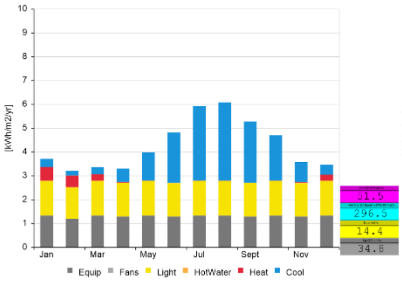


Shading + Natural Ventilation

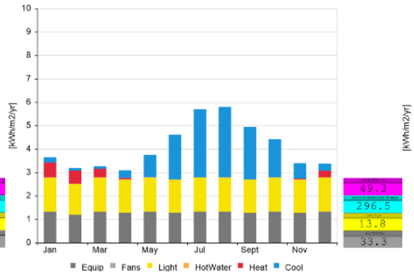


Terraced

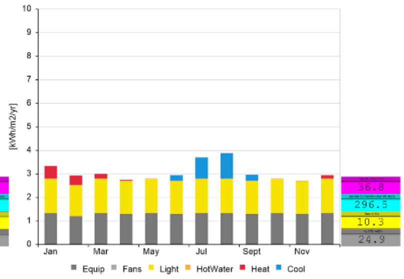
No passive design



Shading

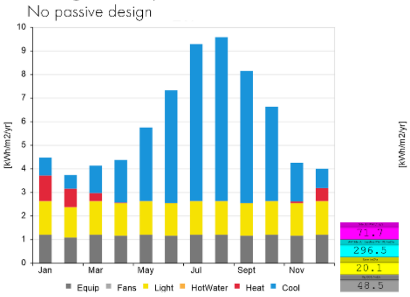


Shading + Natural Ventilation

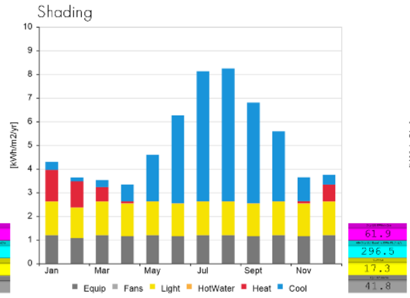


Village Complex

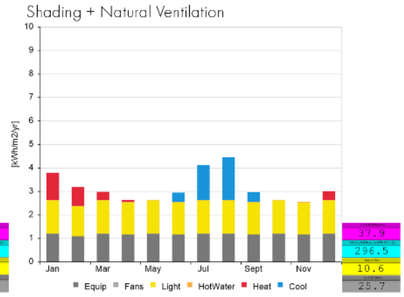
No passive design



Shading



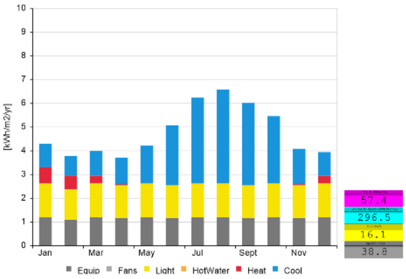
Shading + Natural Ventilation



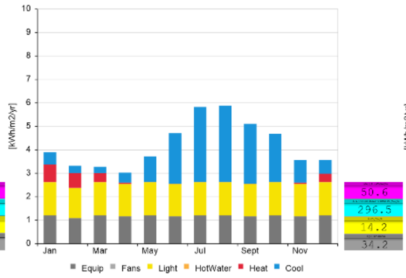
Typologies

Single-loaded Slab

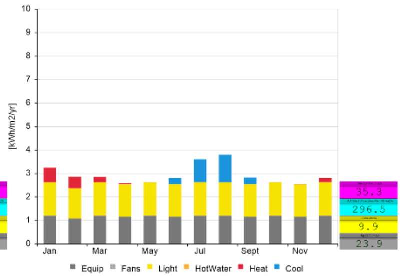
No passive design



Shading

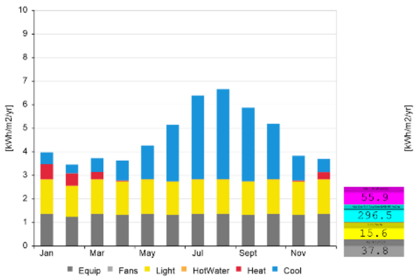


Shading + Natural Ventilation

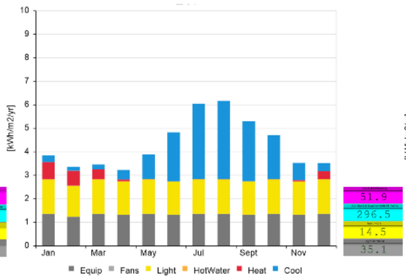


Double-loaded Slab

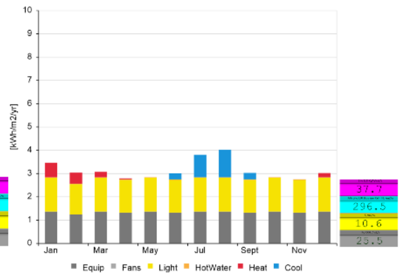
No passive design



Shading

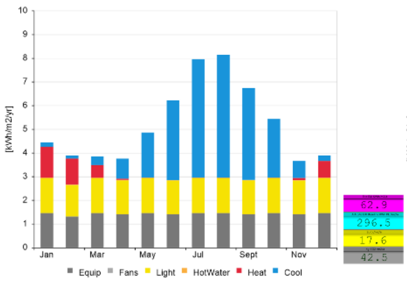


Shading + Natural Ventilation

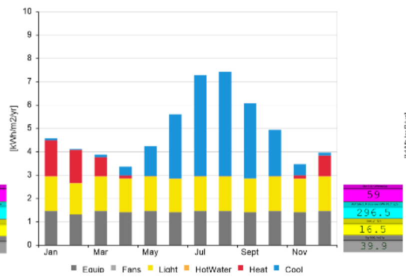


Atrium

No passive design



Shading



Shading + Natural Ventilation