Reducing Cooling Energy Demand of Coastal Hotels in Tropical Climate through ***Sustainable Façade Renovation Strategies***

P5 Report

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1.0 INTRODUCTION

1.1 Problem Statement

The Dominican Republic is one of the most vulnerable countries in the world facing the impact of Climate Change (Hallegatte et al., 2013). This reality was responsibly assumed by the country and responded by answering and committing to the call of the United Nations global mission of adaptation to Climate Change (United Nations Environment Programme, 2019). The evidence is the active elaboration to build stronger and resilient plans and strategies to improve resource efficiency and low-carbon technologies (United Nations Environment Programme, 2019).

The rising economy of the Dominican Republic benefits greatly from the millions of tourists that visit its coastal hotel resorts every year (unep, 2019). The Dominican tourism sector is mainly concentrated on the coasts of the country, where the main challenges of the present tropical climate are met. The main challenges of these coastal hotels are managing the cooling energy demands more efficiently because it represents 40% of the total energy use in the hotels (United Nations Environment Programme, 2019). Furthermore, also looking to shift to more sustainable investment options in order to reduce unnecessary expenses and become environmentally friendly in design and operation(Dominican Ministry of Energy and Minery, 2020).

Because of the large presence of recent and antique coastal hotels, a sustainable renovation plan should be the ideal approach to solve tackle these challenges for the Dominican tourism sector. Therefore, studying the ideal passive design strategy combined with sustainable materials can be a smart path to balance with other sustainable energy investments to provide a more efficient building design and therefore provide a better thermal comfort for its users.

1.2 Research Objective

Provide enough background information about the context to help identify the existing challenges of the coastal hotels building design that are affecting the cooling energy performance. Therefore, once identified each and every challenge, the researched information will help to further provide input data for the energy performance evaluation of the selected hotel and then facilitate the search for sustainable facade renovation strategies to tackle this aforementioned challenges.

1.3 Research question

Can the cooling energy demand of coastal hotels under tropical climate conditions be reduced by 50% by applying sustainable facade renovation strategies?

1.4 Research sub-questions

How does the climate of the Dominican Republic affect the design variable of façade design ?

Are the construction methods/materials of coastal hotels environmentally inefficient in the Dominican Republic ?

What is the average temperature of thermal comfort for guest rooms in coastal hotels in the Dominican Republic ?

What are the main aspects of a tropical building façade to be considered in order to reduce the cooling energy demand of the building ?

What’s the design threshold point where active design has to be applied to reinforce passive design strategies?

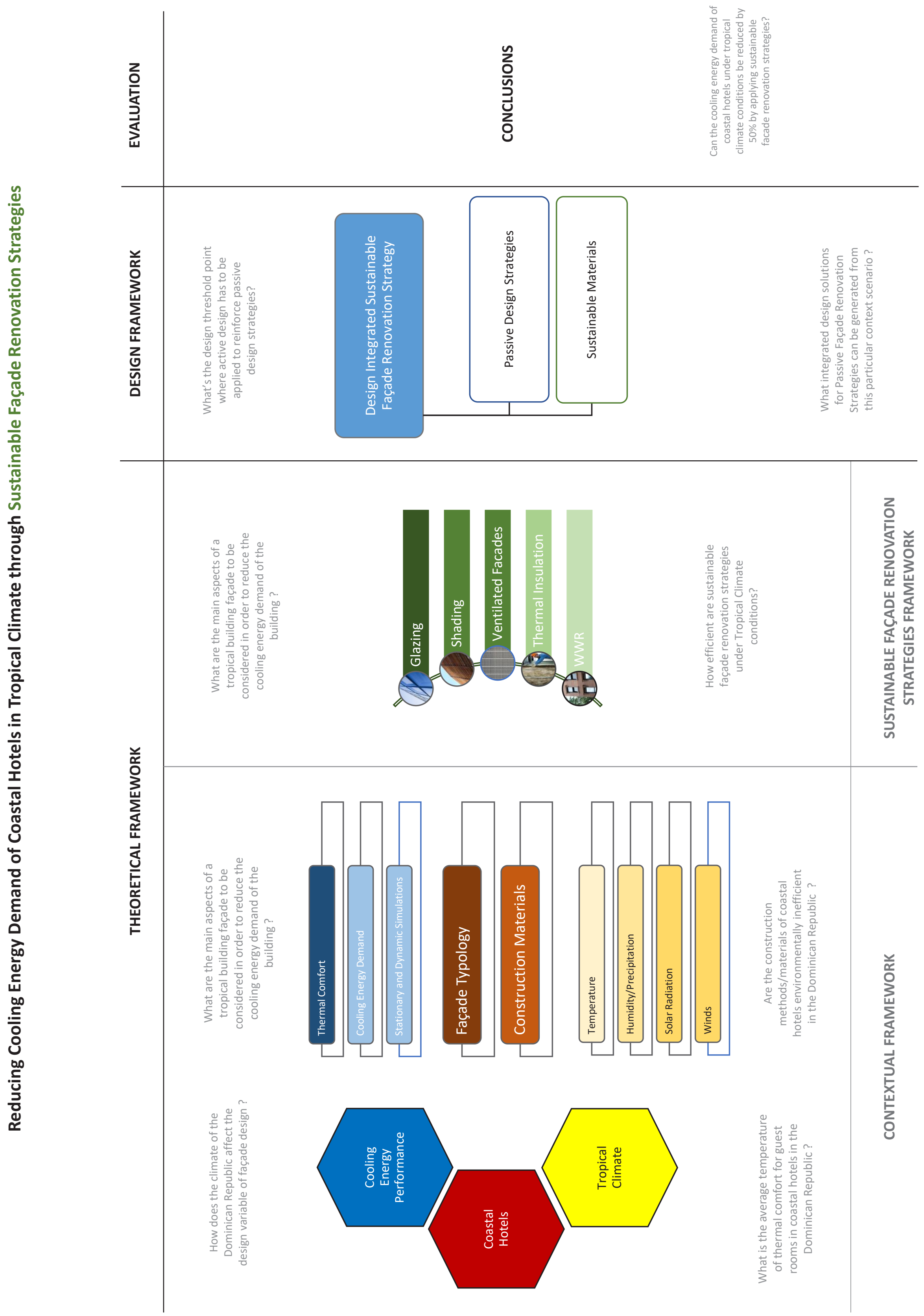
1.5 Research methodology

For the research part, the approach for application in the Dominican Republic will be based on comparative countries with similar climatic conditions. Firstly, because the amount of scientific research and qualitative data is insignificant compared to the existing amount of data such as i.e., South East Asia and other regions that share numerous studies under tropical climate conditions. This background research will be combined with practical architectural and construction knowledge and site visits of the author based on design and construction of coastal hotels in the Dominican Republic and Jamaica (which has a similar climate and construction methods as the Dominican Republic). After the study and analysis of research data, a site selection will be made based on a global representation of the main challenges and conditions of coastal hotels in the Dominican Republic. This includes solar radiation, humidity, precipitation and winds speed. It also has to represent a recently renovated coastal hotel to display the latest techniques and materials used in the Dominican Republic today. On the site of the selected hotel, the closest guest building block to the coastal line and the most vulnerable to the climate conditions will be selected, in order to provide the worst-case scenario for this study.

For the design part, the existing selected building block will be modeled in Revit in order recreate accurately the existing conditions and serve as the main frame for the design of the sustainable renovation. The first model and its components will be analyzed on the design builder software to evaluate the building's energy performance based on energy flow inward and outward and temperature difference.
The input data of average temperature set in the air conditioning by the guests and the average Kwh of energy consumption will be taken into consideration as well. Afterwards, the sustainable renovation strategies models will be designed and evaluated to be compared at the end with the original and current building of the hotel selected. In this part, a comparative chart with the main aspects of energy performance will be presented to see which strategies met the goal of reducing the cooling energy demand by half (from 40% to 20% of the hotel's total energy consumption). This and additional conclusions will be drawn in order to verify the efficiency of these strategies.

1.6 Thesis Structure

The thesis structure starts from the study and research of tropical climates, coastal hotels in the Dominican Republic and the approach of thermal comfort on these settings. From this point, later the application of sustainable passive design strategies is introduced to open the perspective of the possible solutions to the primary challenge. Afterwards, the next step would be selecting a case study building, perform an energy evaluation and then register the data. When the information is written, then the passive design strategies with sustainable materials would enter and energy performance evaluations would be in order to determine the variation from the previous one. Finally, conclusions will be drawn from the results.



2.0 BACKGROUND RESEARCH CONTEXT - SITE

2.1 Tropical Climate

Tropical Climate represents one of the most challenging climates that destabilizes thermal comfort for users due to the higher temperatures and levels of humidity that buildings have to manage in order to provide comfortable spaces for its users (Iwama et al., 2021). The tropical regions are located between the parallel limits of 15° N and S from the equatorial line, displaying a prevalent exposure for solar radiation throughout the year and a virtual absence of thermal seasons. The terms winter and summer have little meaning, but many locations annual rhythm is provided by the occurrence of wet and dry seasons. (Arnfield, 2020)

According to the Köppen climate classification, tropical climate fits under the classification type A, which are controlled mainly by the seasonal fluctuations of the trade winds, the inter-tropical convergence zone (ITCZ), and the Asian monsoon. This type A classification depicts 3 climates: Wet equatorial climate (Af), Tropical monsoon and trade-wind littoral climate (Am) and Tropical wet-dry climate (Aw). (Arnfield, 2020).

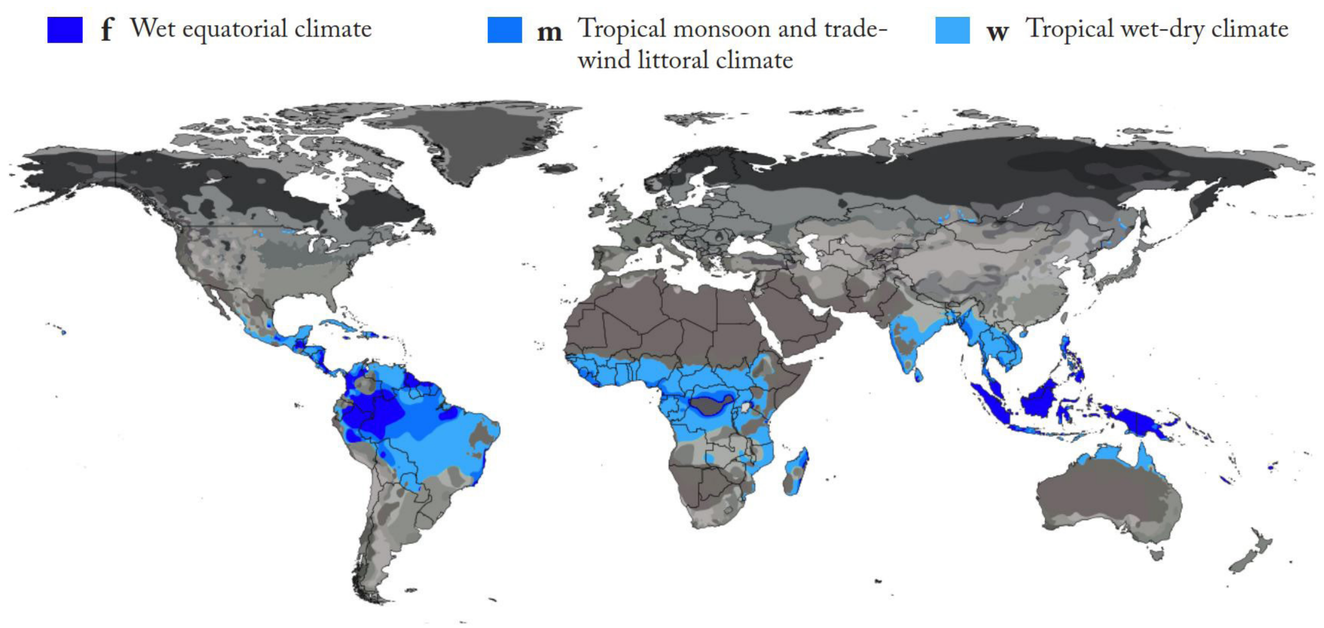


Figure 1: Köppen's classification Type A: Tropical Climate Zones. Source: Encyclopedia Britannica.

Wet Equatorial Climate (Af)

This climate is characterized by consistently high temperatures (around 30 oC [86 oF]), with plentiful precipitation (150-1,000 cm [59-394 inches]), heavy cloud cover, and high humidity, with very little annual temperature variation. Wet equatorial regions lie within about 12 oC latitude of the Equator. Wet equatorial regions lie within the influence of the intertropical convergence zone (ITCZ). Beyond this point, trade winds encounter coastlines backed by mountain barriers that stimulate the formation of precipitation as warm, moist tropical air is forced to ascend and cool. Some of these regions also may receive precipitation from tropical disturbances, including tropical cyclones (Encyclopedia Britannica, 2020).

Notable countries with wet equatorial climate (Af): Dominican Republic, Jamaica, Costa Rica, Cuba, Nicaragua Panama, Brazil, Colombia, Trinidad and Tobago, French Guiana, Guyana, Peru, Suriname, Honduras, USA (Florida), Guatemala, Belize, Mexico, Madagascar, Uganda, Liberia, Malaysia, Japan, Indonesia, Philippines, Sri Lanka, Taiwan, Thailand, Singapore, Australia, Fiji, USA (Hawaii), among others.

Tropical Monsoon and Trade-Wind Littoral Climate (Am)

This climate is characterized by small annual temperature ranges, high temperatures, and abundant precipitation (often more than wet equatorial, or Af, climates in annual total). Despite their resemblance to wet equatorial climates, tropical monsoon and trade-wind littoral climates exhibit a short dry season, usually in the low-sun ("winter") season, and the highest temperatures generally occur at the end of this clear spell. In the Americas and in Africa, Am climates are of the trade wind-wind variety. These areas receive precipitation on narrow coastal strips through orographic effects as the moist air of the trade winds ascends mountain chains. Seasonal migrations and changes in the intensity of these winds give rise to short, moderated dry seasons. Summer precipitation may be enhanced by tropical disturbances traveling in the trade winds (Encyclopedia Britannica, 2020).

Notable countries with tropical monsoon and trade-wind littoral climate (Am): Dominican Republic, Puerto Rico, Brazil, Mexico, USA (Florida), Maldives, Thailand, Indonesia, Philippines, Sri Lanka, Vietnam, Taiwan, India, Myanmar, Liberia, Nigeria, Sierra Leone, Bangladesh, Australia, among others.

Tropical Wet-Dry Climate (Aw)

This climate is characterized by distinct wet and dry seasons, with most of the precipitation occurring in the high-sun ("summer") season. The dry season is longer than in tropical monsoon and trade-wind littoral (Am) climate and becomes progressively longer as one moves poleward though the region. Temperatures in these regions are high throughout the year but show a greater range than wet equatorial (Af) and Am climates (19-20 °C [66-68 °F] in winter and 24-27 °C [75-81 oF] in summer). In addition, annual rainfall totals are less than in the Af and the Am climate types (50-175 cm [20-69 inches]), and most precipitation occurs as a result of convectional thunderstorm activity. (Encyclopedia Britannica, 2020)

Notable countries with tropical wet-dry climate: Dominican Republic, Colombia, Brazil, Ecuador, Jamaica, Cuba, Haiti, Honduras, El Salvador, USA (Hawaii), Trinidad and Tobago, India, China, Kenya, Mozambique, Australia, Bangladesh, Sri Lanka, Nigeria, Rwanda, Indonesia, Laos, Thailand, among others.

2.2 Climate of the Dominican Republic

The Dominican Republic is located in the continent of America, sharing an islandic territory with Haiti in the Caribbean region. It has a surface area of 48,670 km2, with a coastline length of 1,288 km. It has a moderate, relatively mild tropical climate; however, it is positioned well within the tropical zone. Tropical storms and hurricanes originate in the mid-Atlantic and southeastern Caribbean from August until October each year. These are a constant threat and have damaged the country in several occasions in the past, specially the hurricanes in 1930, 1954, 1979, and 1998 were particularly devastating (Wiarda, 2020).

According to the Long-Term Climate Risk Index (CRI), the Dominican Republic was listed as one of the world's top 10 countries most affected from 1997 to 2016 (Global Climate Index, 2018). This country is also listed as one of the most at-risk developing nations for impacts from climate change (Hallegatte et al., 2013).

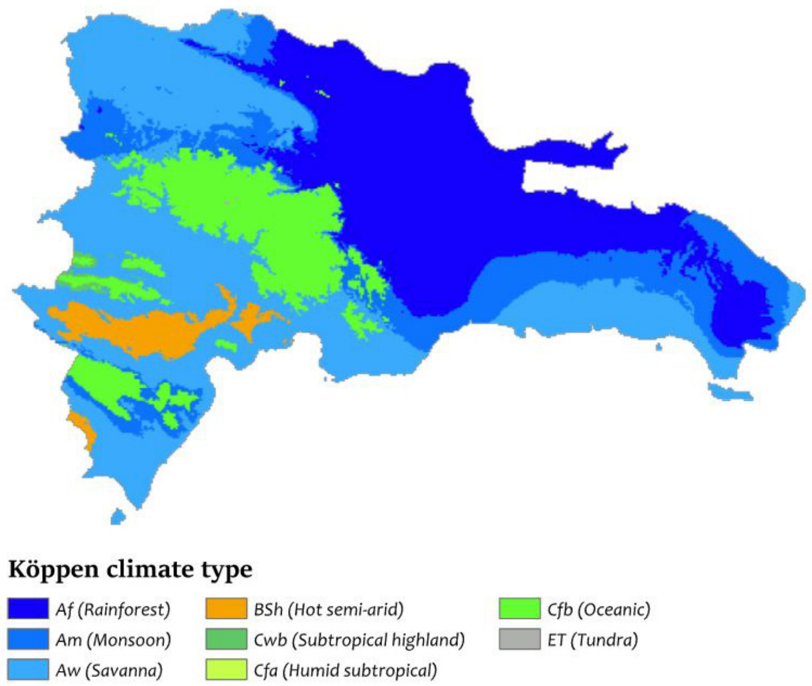


Figure 2: Köppen's climate types of the Dominican Republic. Source: worldclim.org

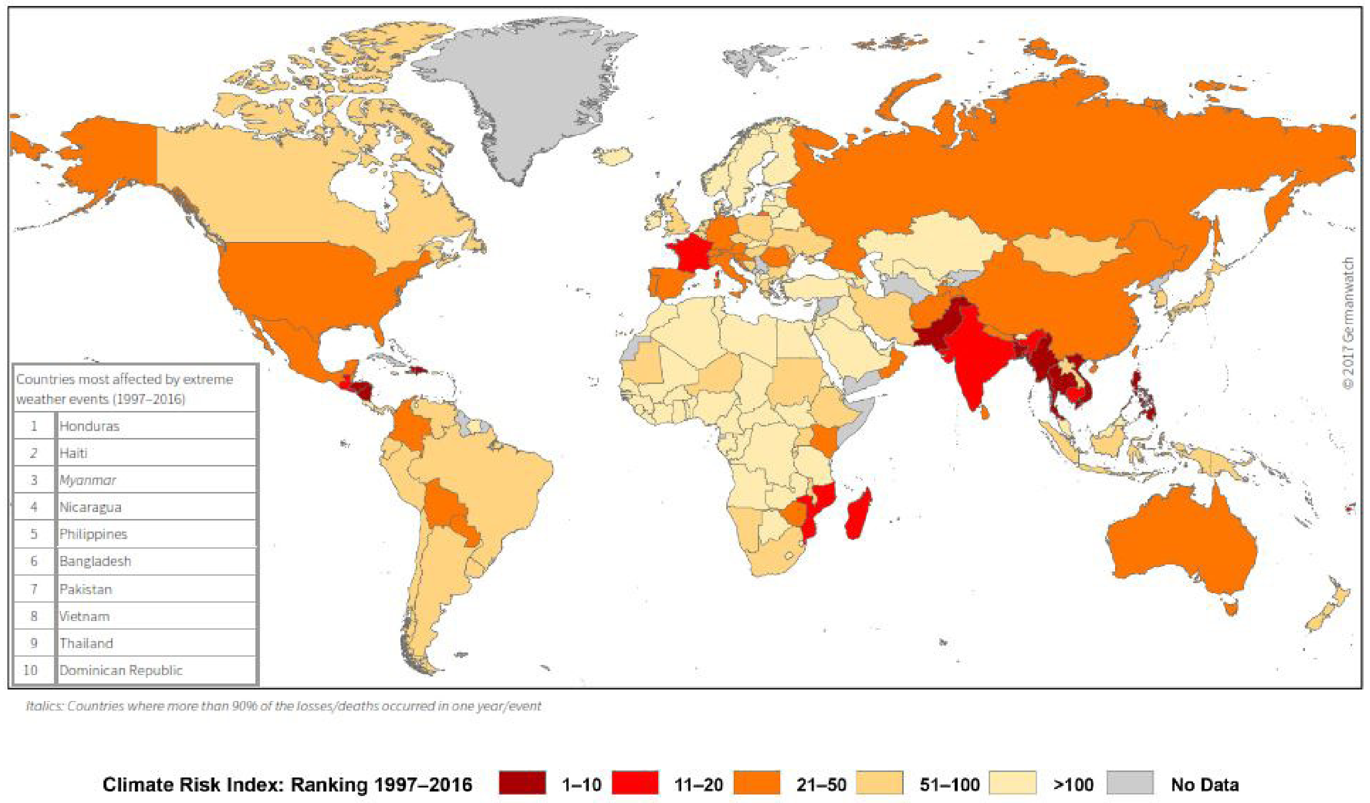


Figure 3: World map of the global climate risk index from 1997 to 2016. Source: germanwatch.org

For the purpose of this research on climates in coastal hotels, the focal points of the cities will be based on their economic and cultural impact on tourism, the number of hotels available for potential renovation and furthermore their symbolic reference for climatic and building typology. Therefore, the selected coastal cities are *Puerto Plata, Samana*, *Punta Cana*, *La Romana* and *Santo Domingo*. The most significant climatic variations of the most important coastlines regions are the following:

East and Southeast Region:

The east and south east of the Dominican Republic includes areas such as Punta Cana and La Romana. This is a region that's generally dry and sunny all year. While rain is more frequent in the summer, it rarely lasts after a quick tropical shower, unless there is a weather system lingering in the Caribbean (Girma, 2020).

North Region:

The north of the Dominican Republic includes Puerto Plata and Samana as one of its cities. This region enjoys a breezy Atlantic Ocean facing its long shoreline. It does get scorching hot here during the summer, which also brings more rain. With climate change, however, weather patterns have varied dramatically on the north coast. Some years have seen a significant drought, while others have seen flooding. Overall, it's becoming more difficult to predict how much rain will fall. In general, the weather is pleasant during winter and spring, while the summer boasts high humidity and temperatures (Girma, 2020).

Santo Domingo Metro Area:

Being the city capital and the country's largest and most populated city, Santo Domingo presents hot and humid temperatures all year, except for winter season when breezes bring cooler temperatures in the early morning and evening. After mid-March, temperatures reach the 90s Fahrenheit (32 °C) and the humidity is oppressive (Girma, 2020).

Figure 4: Coastal cities selected for climate evaluation in the Dominican Republic. Source: googlemaps.com

2.2.1 Sun Path

The city capital of Santo Domingo was used as reference for data input. The sun rises from the east and settles on the west tracing an inclined arc leaning towards the south, with an altitude of -59.10 °, azimuth of 257.13 ° and a declination of -22.48 ° on winter (January), while on summer (August) the altitude is -42.17 °, azimuth of 315.48 ° and the declination is 16.66 ° (sunclac.org).

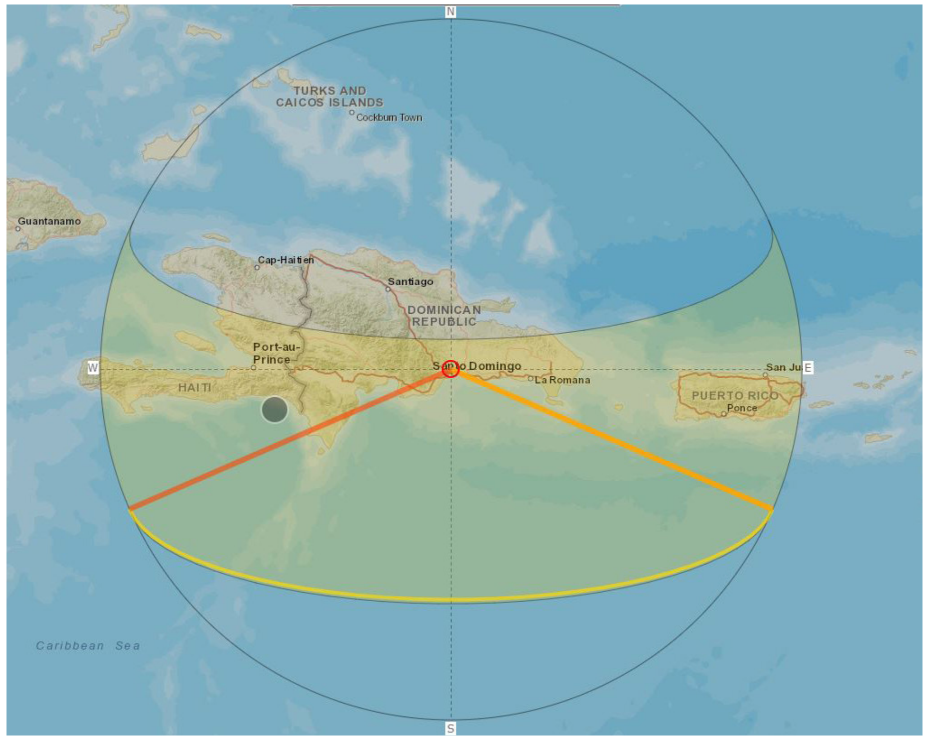


Figure 5: Sun path on winter (January). Source: sunclac.org

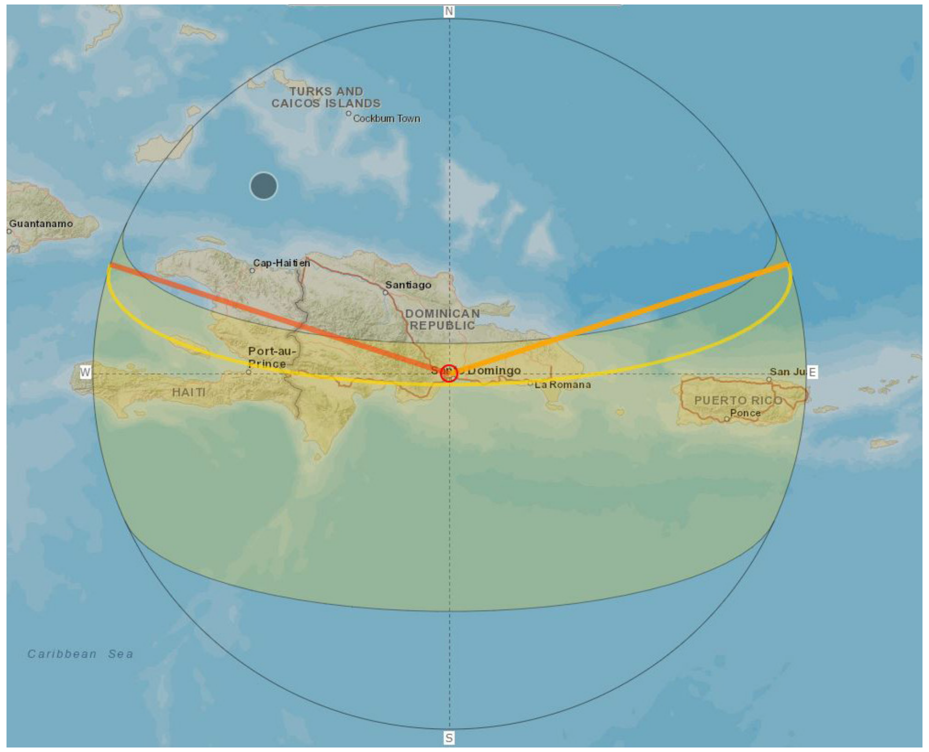


Figure 6: Sun path on summer (August). Source: sunclac.org

2.2.2 Temperature and Solar Radiation

In the Dominican Republic the annual mean temperature is 77 ºF (25 ºC); regional mean temperatures range from 69 ºF (21 ºC) in the heart of the Cordillera Central to as high as 82 ºF (28 ºC) on the coastal plains (Wiarda, 2020).

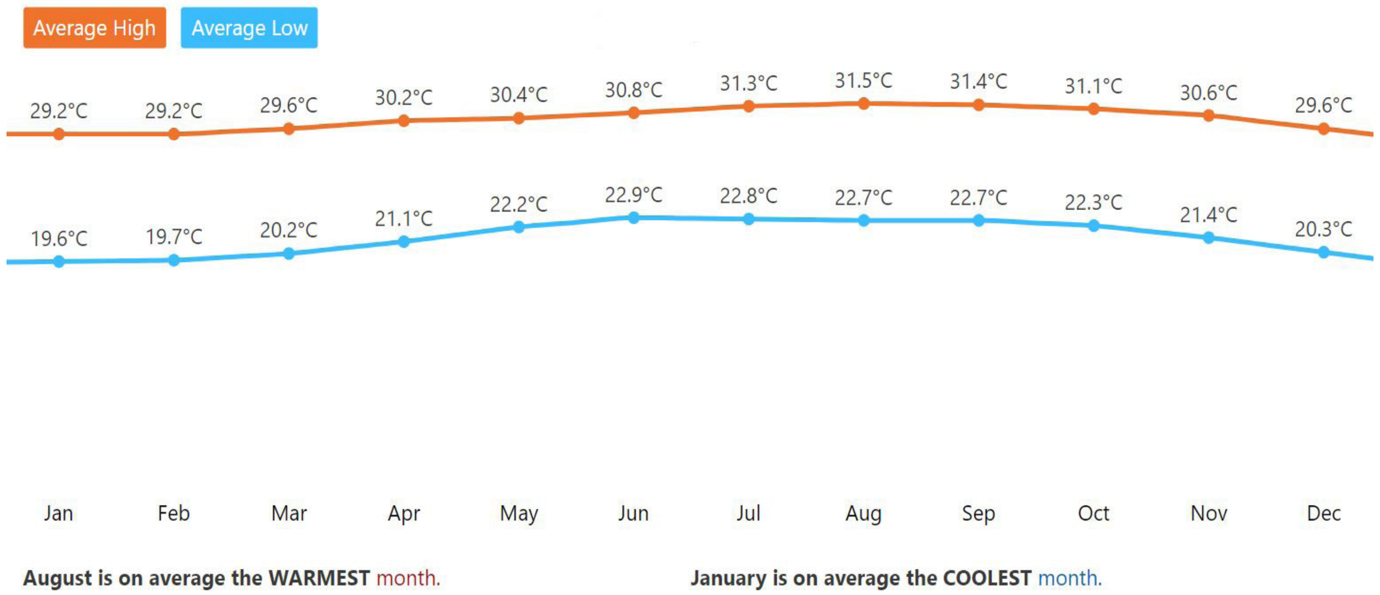


Figure 7: Temperature averages of Santo Domingo in 2020. Source: weather.com

A monthly analysis gathered by the nearest weather stations from each of the main coastal cities selected was revised and displayed here for further climatic reference to use in the energy calculations. The data gathered is from the averages registered in 2019 from these stations by weather-and-climate.com, using the parameters of temperature, precipitation, humidity and wind speed of the coastal cities of Puerto Plata, Samana, Punta Cana, La Romana and Santo Domingo.

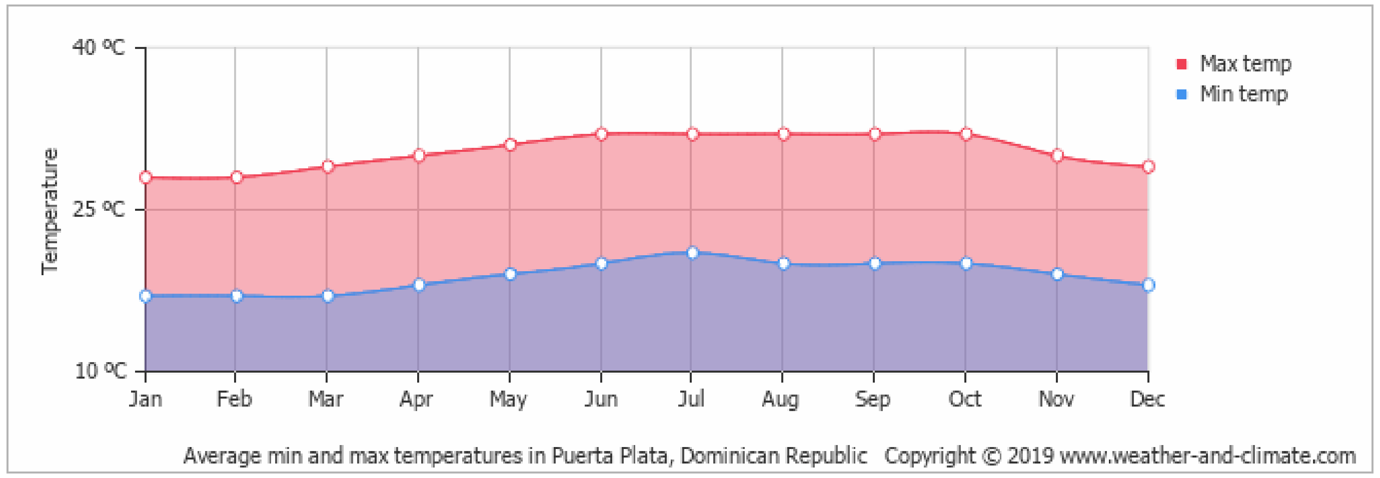


Figure 8: Temperature averages of Puerto Plata. Source: weather-and-climate.com

In Puerto Plata, the temperatures are always high. The warmest month is August and the coolest month is January. The average annual maximum temperature is 30.0 °Celsius (86 °Fahrenheit) and the average annual minimum temperature is 19.0 °Celsius (66.2 ° Fahrenheit).

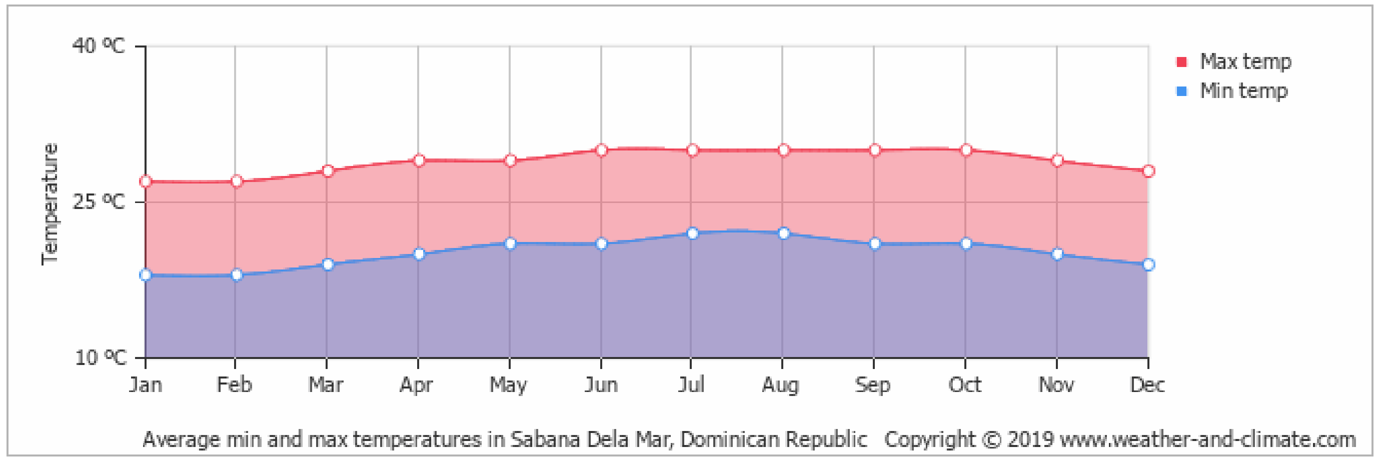


Figure 9: Temperature averages of Samana. Source: weather-and-climate.com

In Samana, the temperatures are always high. The warmest month is August and the coolest month is January. The average annual maximum temperature is 29.0 ° Celsius (84.2 ° Fahrenheit) and the average annual minimum temperature is 20.0 °Celsius (68 ° Fahrenheit).

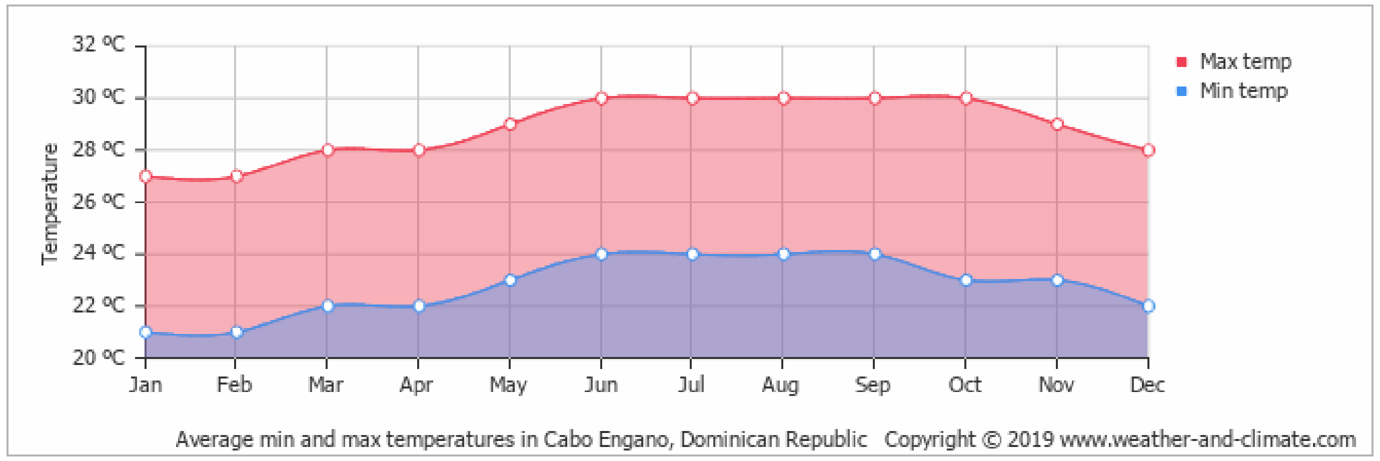


Figure 10: Temperature averages of Punta Cana. Source: weather-and-climate.com

In Punta Cana, the temperatures are always high. The warmest month is August and the coolest month is January. The average annual maximum temperature is 29.0 °Celsius (84.2 °Fahrenheit) and the average annual minimum temperature is 23.0 °Celsius (73.4 ° Fahrenheit).

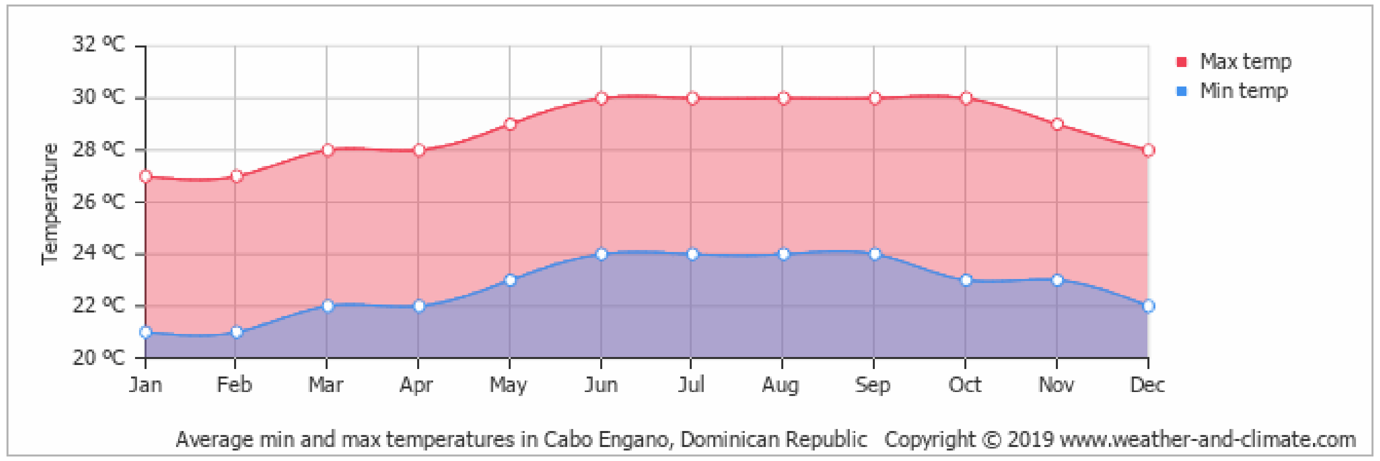


Figure 11: Temperature averages of La Romana. Source: weather-and-climate.com

In La Romana, the temperatures are always high. The warmest month is August and the coolest month is January. The average annual maximum temperature is 29.0 °Celsius (84.2 °Fahrenheit) and the average annual minimum temperature is 23.0 °Celsius (73.4 ° Fahrenheit). These values are similar to Punta Cana's due to its proximity and the use of the same weather station in Cabo Engano, 43 kms away.

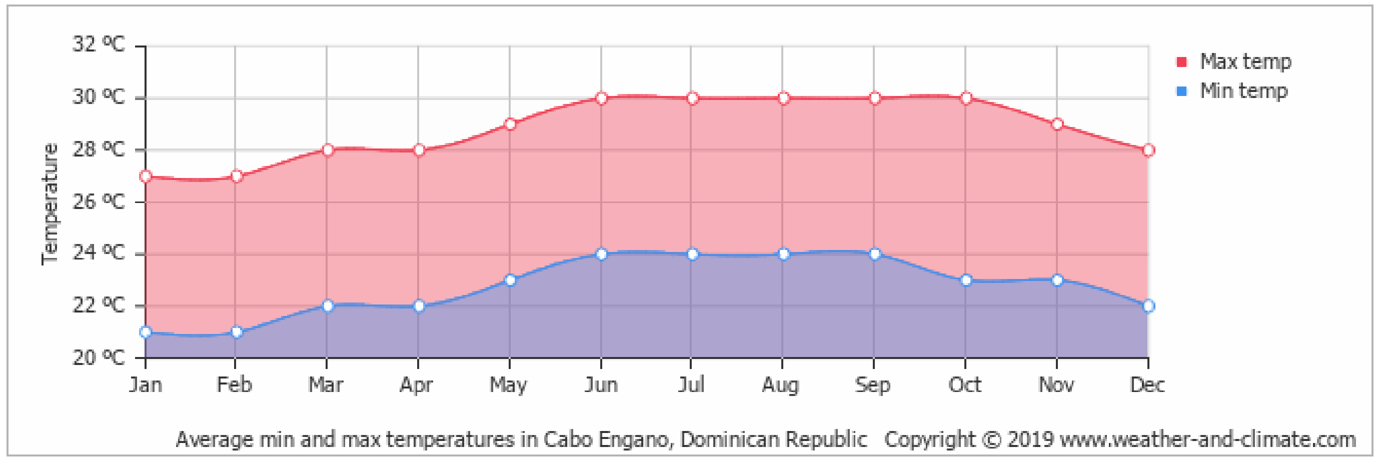


Figure 12: Temperature averages of Santo Domingo. Source: weather-and-climate.com

In Santo Domingo, the temperatures are always high. The warmest month is August and the coolest month is December. The average annual maximum temperature is 30.0 ºCelsius (86 ºFahrenheit) and the average annual minimum temperature is 21.0 ºCelsius (69.8 º Fahrenheit).

2.2.3 Precipitation and Humidity

The highest amount of precipitation is found in the mountainous northeast of the island. High amounts of torrential precipitation can be seen in all areas of the Dominican Republic but the majority of this type of rainfall occurs in short bursts.

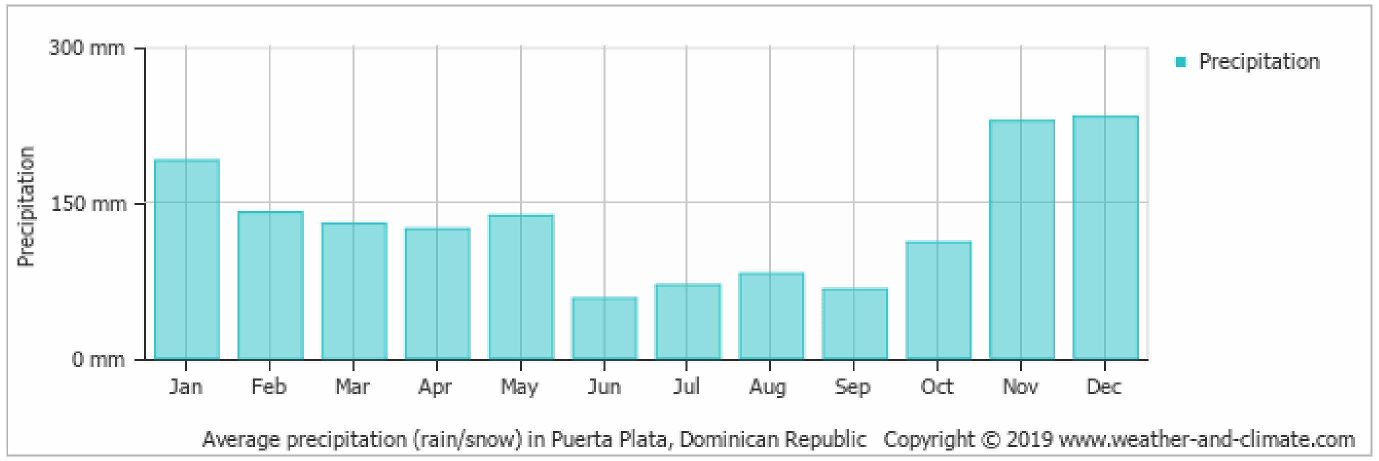


Figure 13: Precipitation averages of Puerto Plata. Source: weather-and-climate.com

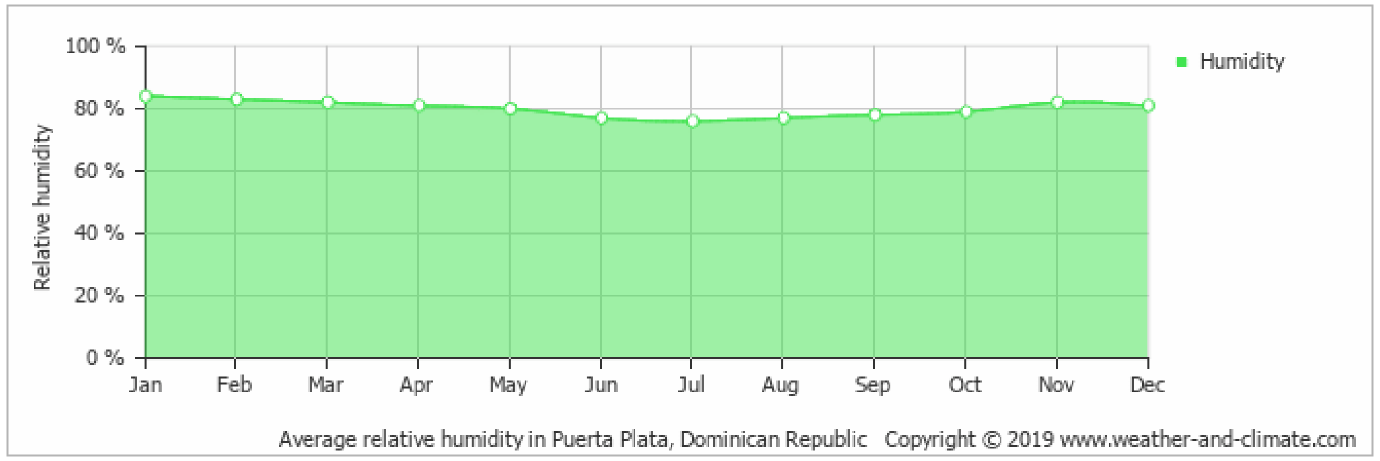


Figure 14: Humidity averages of Puerto Plata. Source: weather-and-climate.com

In Puerto Plata, the rainy season falls over the months of January, February, March, April, May, October, November and December. On average, December is the wettest month while June is the driest. The average amount of annual precipitation is 999.9 mm (39,37 in).

On regard of humidity, January is the most humid while July is the least humid month. The average annual percentage of humidity is 80.0 %.

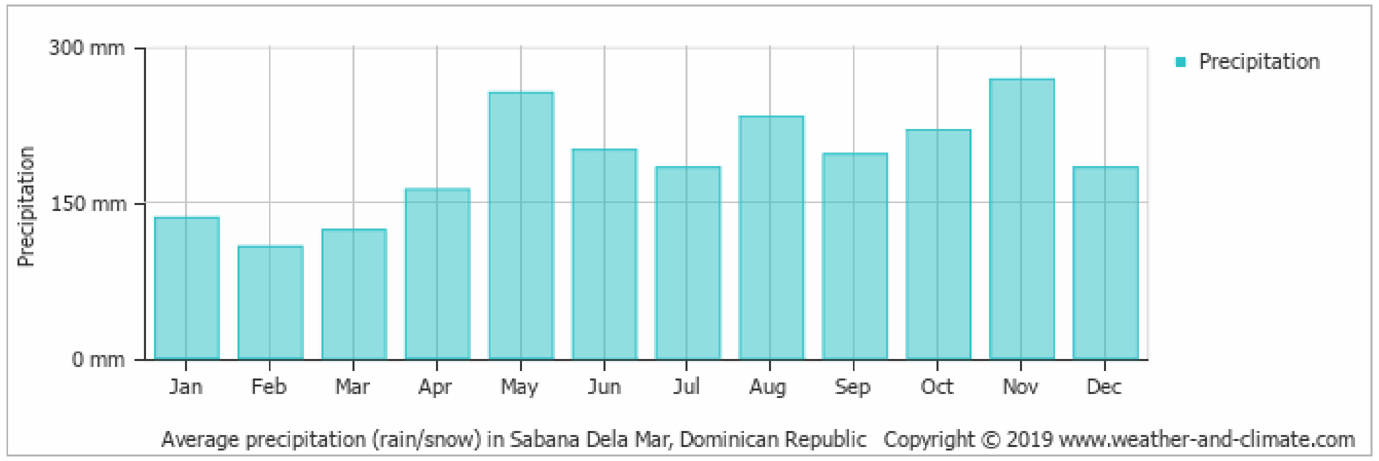


Figure 15: Precipitation averages of Samana. Source: weather-and-climate.com

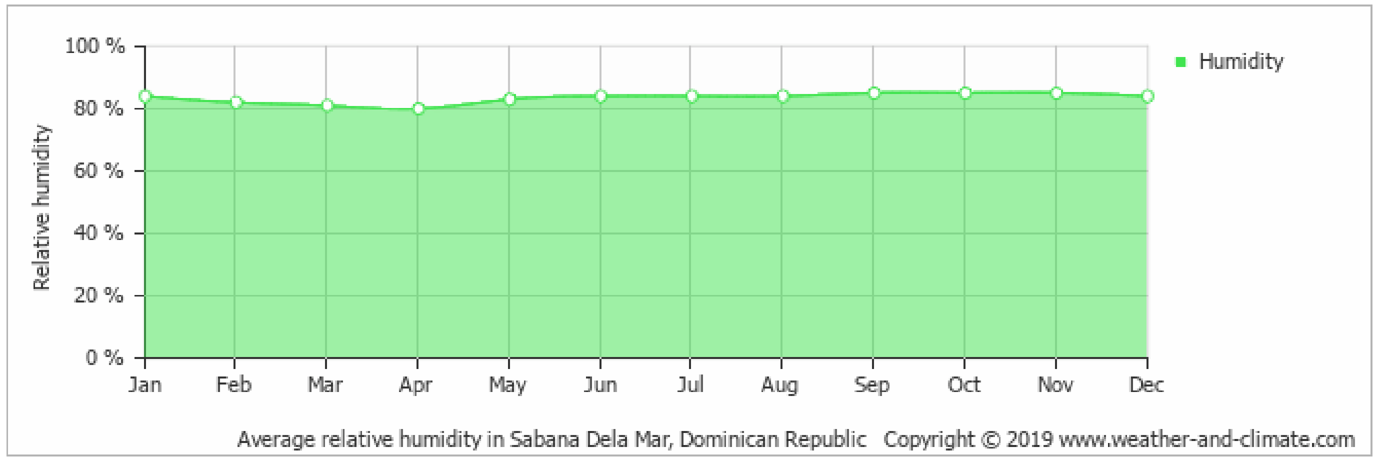


Figure 16: Humidity averages of Samana. Source: weather-and-climate.com

In Samana, it rains in practically every month of the year. On average, November is the wettest month while February is the driest. The average amount of annual precipitation is 999.9 mm (39,37 in).

On regard of humidity, September is the most humid while April is the least humid month. The average annual percentage of humidity is 83.0 %.

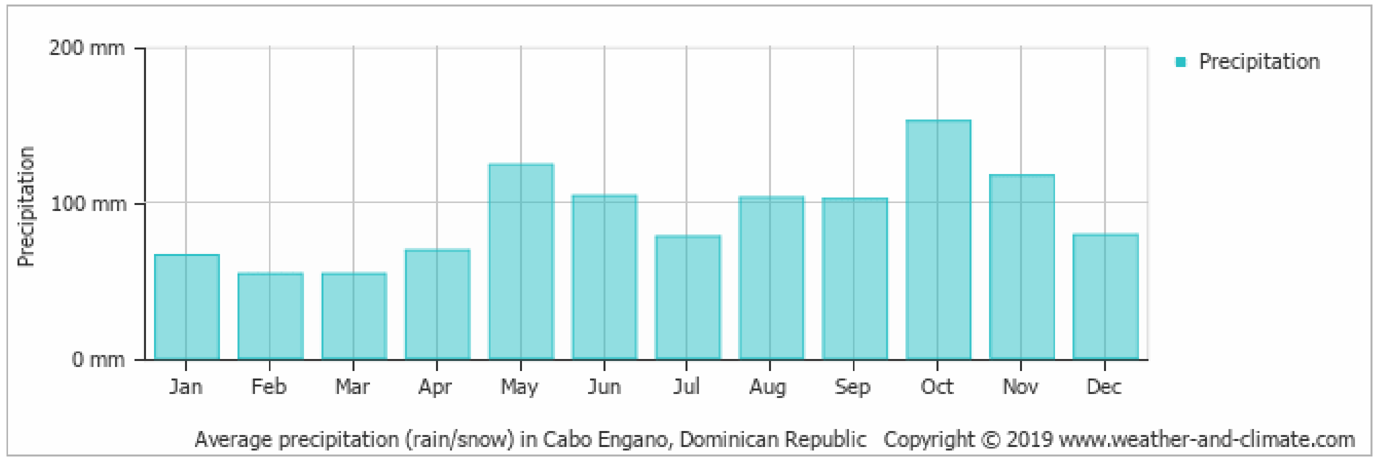


Figure 17: Precipitation averages of Punta Cana. Source: weather-and-climate.com

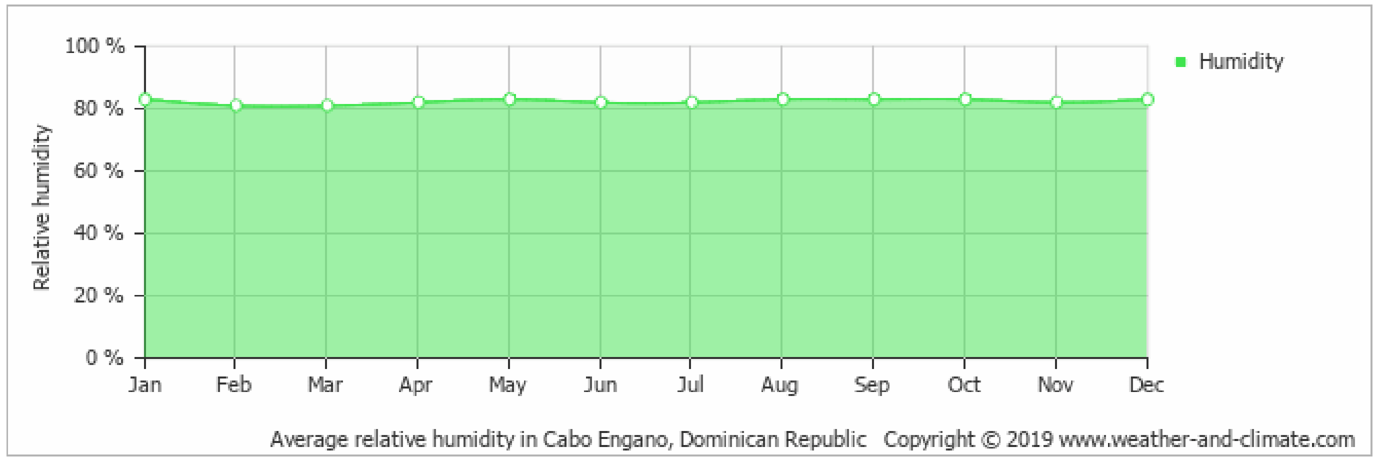


Figure 18: Humidity averages of Punta Cana. Source: weather-and-climate.com

In Punta Cana, the rainy season falls over the months of May, June, August, September, October and November. On average, October is the wettest month while March is the driest. The average amount of annual precipitation is 999.9 mm (39,37 in).

On regard of humidity, January is the most humid while March is the least humid month. The average annual percentage of humidity is 82.0 %.

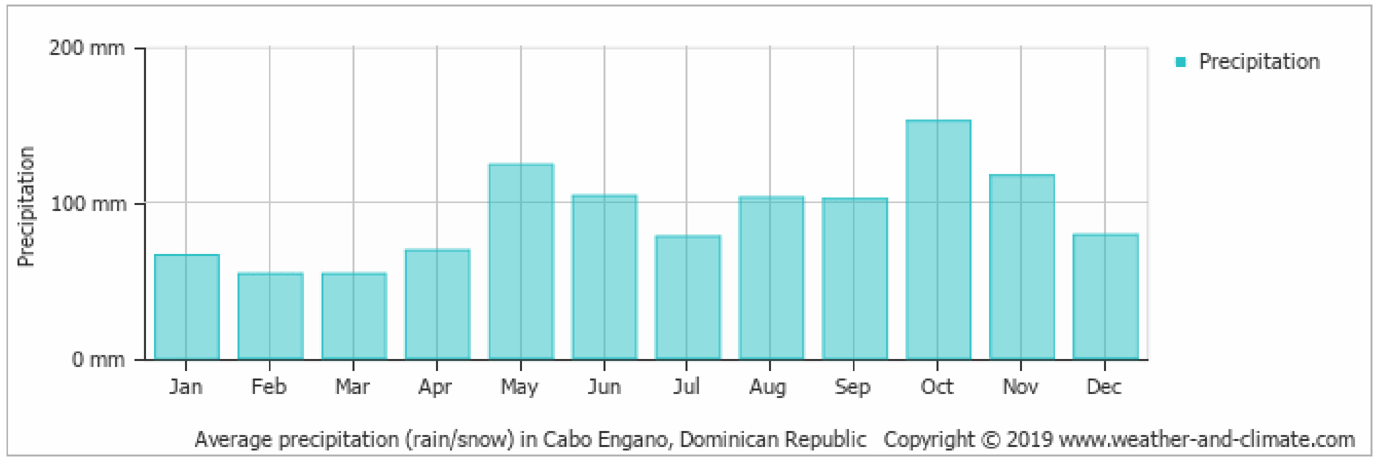


Figure 19: Precipitation averages of La Romana. Source: weather-and-climate.com

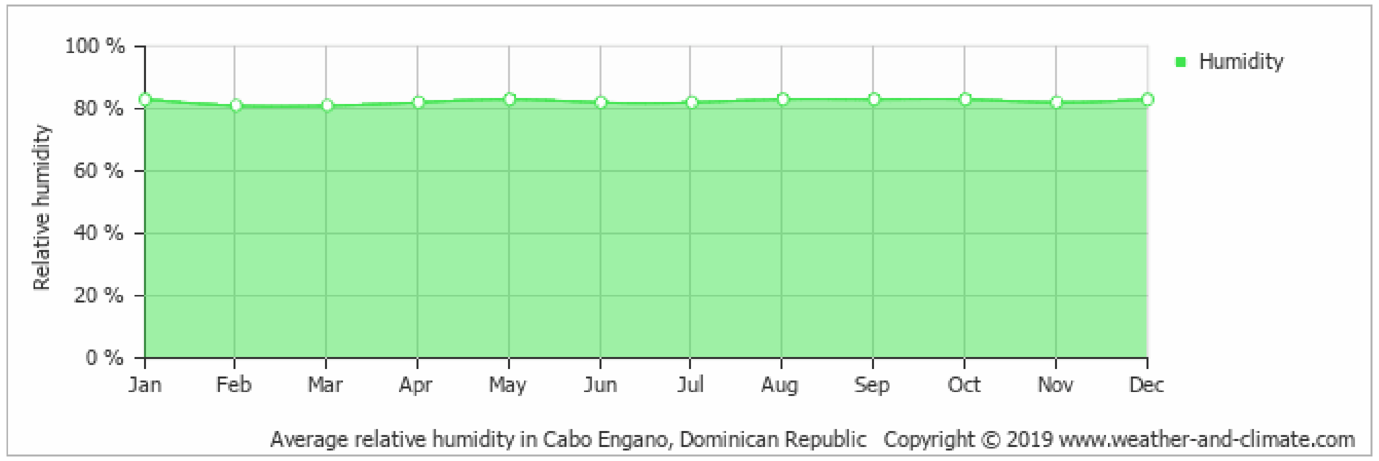


Figure 20: Humidity averages of La Romana. Source: weather-and-climate.com

In La Romana, the rainy season falls over the months of May, June, August, September, October and November. On average, October is the wettest month while March is the driest. The average amount of annual precipitation is 999.9 mm (39,37 in).

On regard of humidity, January is the most humid while March is the least humid month. The average annual percentage of humidity is 82.0 %.

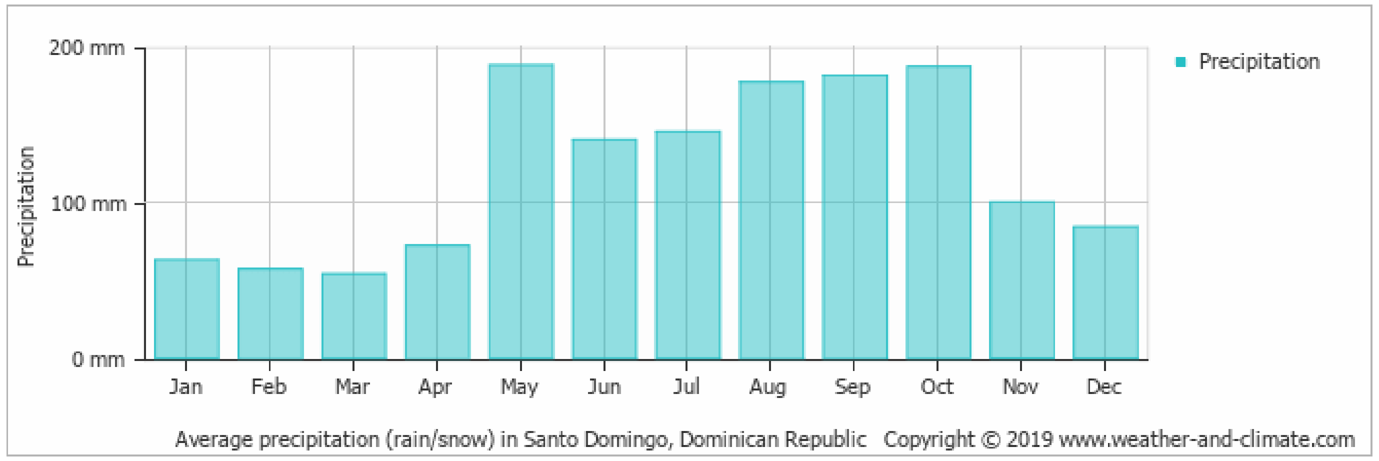


Figure 21: Precipitation averages of Santo Domingo. Source: weather-and-climate.com

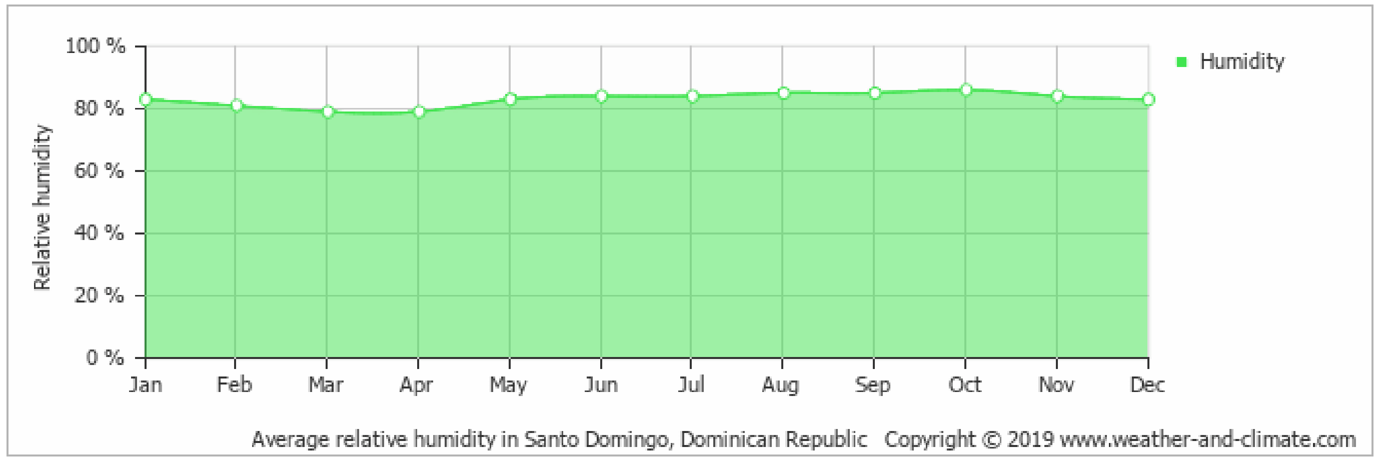


Figure 22: Humidity averages of Santo Domingo. Source: weather-and-climate.com

In Santo Domingo, the rainy season falls over the months of May, June, August, September, October and November. On average, May is the wettest month while March is the driest. The average amount of annual precipitation is 999.9 mm (39,37 in).

On regard of humidity, October is the most humid while March is the least humid month. The average annual percentage of humidity is 83.0 %.

2.2.4 Winds

The trade winds are the main orchestrators of the wind movement in the Dominican Republic. These winds are characterized by air currents moving from the southeast to the northwest in the southern hemisphere and from the northeast to the southwest in the northern hemisphere. These winds tend to be stronger during the summer but are generally constant in the tropics (Kerry, 2005).

Figure 23: Wind flow over the main coastal cities in the Dominican Republic. Source: weather.com

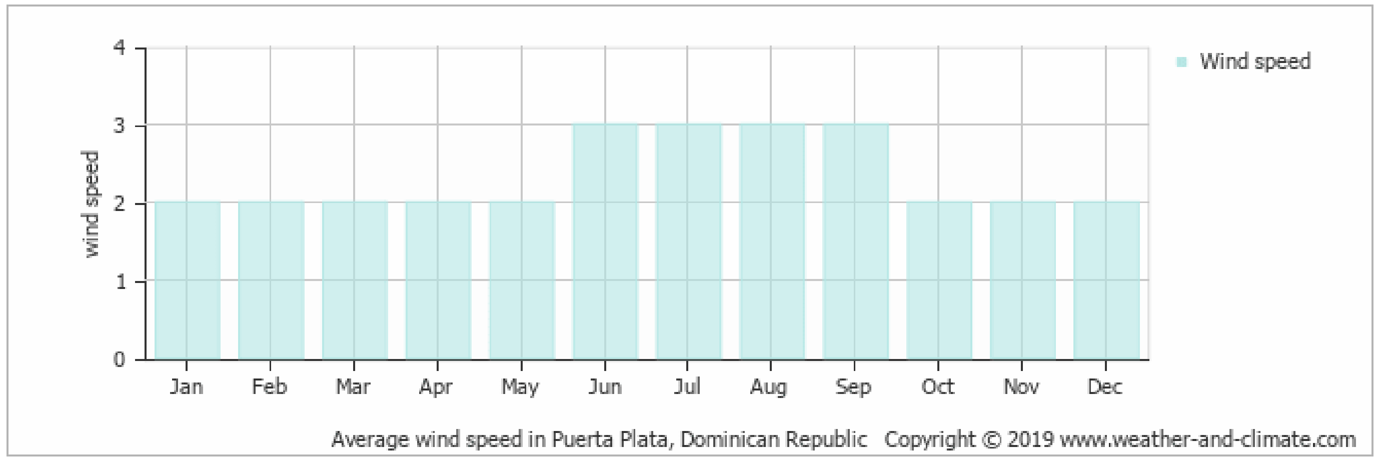


Figure 24: Wind speed averages of Puerto Plata (in m/s). Source: weather-and-climate.com

In Puerto Plata, on average the most wind is seen in August, while the least wind is seen in January.

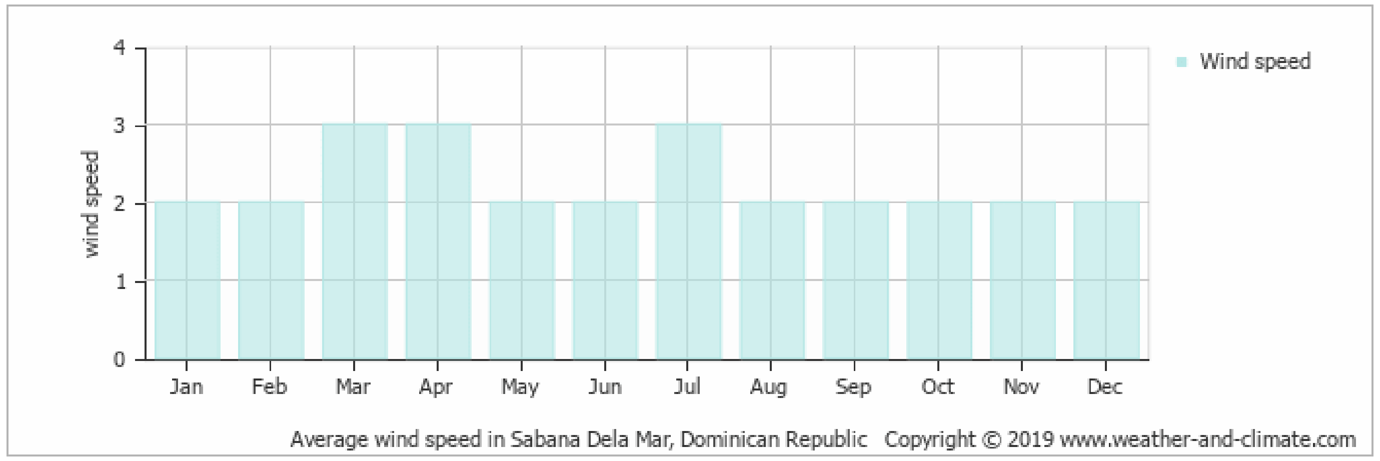


Figure 25: Wind speed averages of Samana (in m/s). Source: weather-and-climate.com

In Samana, on average the most wind is seen in July, while the least wind is seen in September.

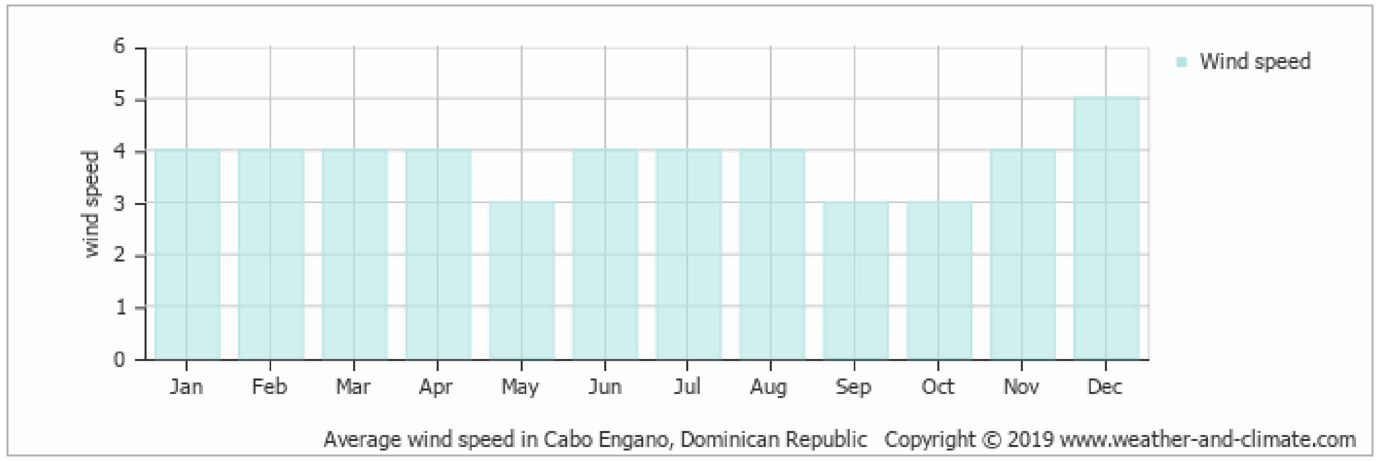


Figure 26: Wind speed averages of Punta Cana (in m/s). Source: weather-and-climate.com

In Punta Cana, on average the most wind is seen in December, while the least wind is seen in May.

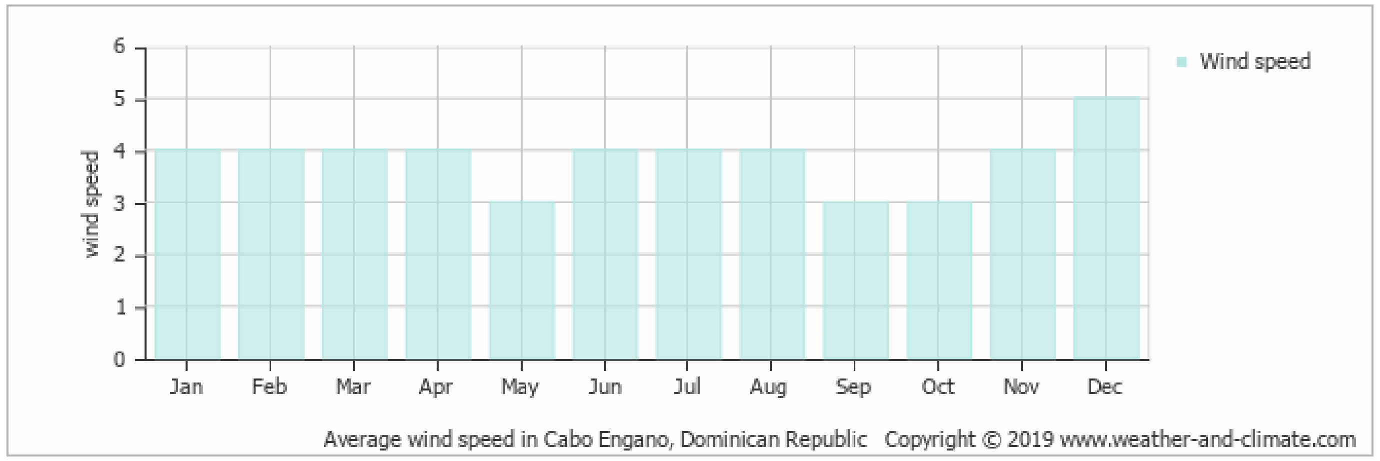


Figure 27: Wind speed averages of La Romana (in m/s). Source: weather-and-climate.com

In La Romana, on average the most wind is seen in December, while the least wind is seen in May.

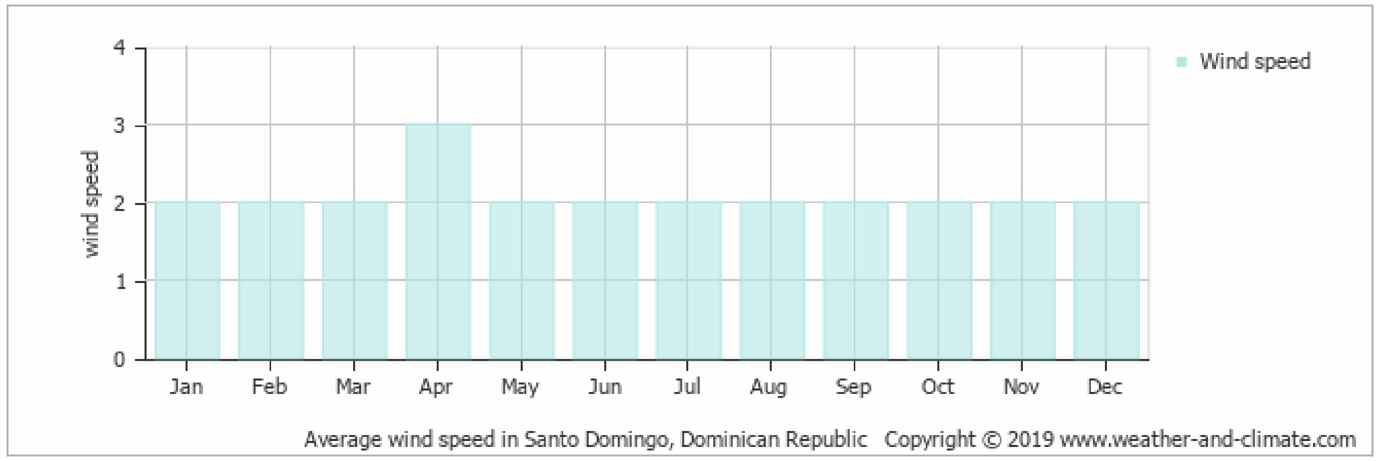


Figure 28: Wind speed averages of Santo Domingo (in m/s). Source: weather-and-climate.com

In Santo Domingo, on average the most wind is seen in April, while the least wind is seen in September.

2.2.5 Conclusions about climate

The tropical climate of the Dominican Republic is variable depending on its location. However, the variations between the coastal regions is not significant enough to consider a broad variation for interventions for renovation. After observing the climatic data collected from the selected coastal cities of Puerto Plata (north), Samana (northeast), Punta Cana (east), La Romana (southeast) and Santo Domingo (southeast); the average temperatures oscillate between 24.5 °C and 26 °C with an average global precipitation of 1000 mm and an average humidity of 82.4 %. The stronger winds can be seen in the cities of Punta Cana and La Romana with averages of 3 – 5 (m/s), while on the other three cities the averages are lower, oscillating between 2 – 3 (m/s). The global wind speed average is 3.1 (m/s). The monthly averages of the climate of the year 2019 was selected instead of 2020 for the purpose of presenting the worst case scenario under normal circumstances (amount of international and local tourists), which provide a more realistic number of the expected cooling energy consumption of a coastal hotel if compared to the affected year of 2020, due to the global pandemic of Covid-19.

2.3 Coastal hotels in the Dominican Republic

Accommodation sector accounts for 21% of the global CO_2 emissions and the competitiveness of tourism industry in future is primarily depended on hotel energy efficiency which plays a vital role in eco-efficiency of tourist operations (Rajapaksha, 2016). Tourism is one of the most important sources of income in the Dominican Republic. According to the United Nations World Tourism Organization (UNWTO), in the latest inbound tourism ranking (2019) the small island of the Dominican Republic positioned itself in the 5th position in the continent of America with 6.4 million of arrivals, sitting behind much bigger countries as United Stated, Mexico, Canada and Argentina. This reception of tourism in the country generated 7.5 USD billions that same year (UNWTO, 2020).

Figure 29: Iberostar Costa Dorada in Puerto Plata. Source: transat.com

The main tourist sites are Punta Cana, La Romana, and the colonial zone of Santo Domingo, which was designated a World Heritage site in 1990 (Wiarda,2020). Puerto Plata and Samana manage a lower flow of international tourists, compared to the previous three cities, but also manage a great number of local tourists due to lower prices on these accommodations.

One of the most attractive beacons for tourists around the world about the Dominican Republic, besides its warm and friendly climate during the winter period, are its beaches. Coastal hotels represent the safest and ideal platforms for visitors to enjoy the sand, sun and sea of the Dominican Republic. Through tourism, the country receives an average of 5.9 million of tourists a year with the possibility to occupy up to 815 hotels with 80,000 available rooms (UN Environment Programme, 2019).

According to the World Tourism Organization (2020), the hotel sector is one of the tourism industry's largest drivers of employment and economic revenue but at the same time it is one of the most energy-intensive. It's noted that hotels and other types of accommodation account for 2% of the 5% global CO_2 emitted by the tourism sector.

In relation for incentives for investments in renovations of hotels in the Dominican Republic, the United States Department of State released a report about 2020 investments climate statements where it stated: "for existing projects, hotels and resort-related investments that are five years or older are granted 100 percent exemptions from taxes and duties related to the acquisition of the equipment, materials and furnishings needed to renovate their premises. In addition, hotels and resort-related investments that are fifteen years or older will receive the same benefits granted to new projects if the renovation or reconstruction involves 50 percent or more of the premises."

2.3.1 Facade Typology

The coastal hotels in the Dominican Republic present a common standardized structure for guest rooms units that usually vary by the size of the rooms, openings and material finishings. The orientation play an important role, where architects usually try to avoid openings facing south, where the most important exposure for solar radiation is found in this geographical position. However, to all the cases, there are always exceptions.

Based on Dominican academic experience, work experience and presential visits to coastal hotels in the different cities selected, these following facade typologies represent the general main line of construction of each tourism beacon:

Puerto Plata:

This northern coastal city collects a high tourism flow from locals and internationals, compared to the coastal hotels from the east, its common to see a higher number of Dominican tourists because of the cheaper offers found here. Once one of the main tourism beacon point of the country in past decades, Puerto Plata lost the central governmental focus of attention for investment when it shifted to support the development of eastern part of the island along with an important group of investors. Today, tourism in Puerto Plata is gaining more strength because of the development of better roads and a cruise terminal named Amber Cove in a small town before reaching Puerto Plata.

Figure 30: Riviera Azul in Playa Dorada, Puerto Plata. Source: own

The facade presents a typical concrete portico structure reinforced with steel bars. The openings to the north display a single glazed sliding door system on every unit. Its also visible a set of exterior fabric curtains installed mainly for privacy and protection from the sun glare and rain. When the users are enjoying the facilities, is noticeable that the curtains remain open.

The structure is aesthetically finished with mortar and painted with two hands of white paint. On the top level, the social area (covered in the previous 2 floors with the floor above) is covered by a lightweight wooden roof structure. This expansion roof is sustained by wooden columns as well.

Samana:

This beautiful coastal city is located in a peninsula, which its geographical shape forms the Bay of Samana at its southern side and receives the northeastern winds from the Atlantic Ocean on the north end. The Bay of Samana is internationally famous for the visiting hunchback wales that come to reproduce every year in these warms waters from December to March.

The tourism here is characterized for a more singular construction approach. A great number of housing units can be found in this region, but the multi-level of modular unit type of coastal hotels have an important presence as well.

Figure 31: Riviera Azul facing the Atlantic Ocean in Playa Dorada, Puerto Plata. Source: own

Figure 32: Interior view of typical unit of Riviera Azul complex in Playa Dorada, Puerto Plata. Source: own

Figure 33: Hotel Bahia Principe Grand Cayacoa in Samana. Source: googlemaps.com

Figure 34: Interior of Hotel Bahia Principe Grand Cayacoa in Samana. Source: googlemaps.com

This facade also presents the typical concrete portico structure reinforced with steel bars. The openings are facing south east and south west to maximize the views to the sea. However, these openings are using the also typical single glazed sliding door system on every unit which exposes too much solar radiation to the interior. It seems that the alternative layer for protection of the thermal comfort is an ornamental interior curtain.

The structure is aesthetically finished with a traditional double layer of beige paint, still a warm color to blend better in this type of climate. This simple type of facades can be seen all over the city. This facade approach is basically preferred for economical reasons because paint is cheaper to apply and maintain than any other facade cladding material. This might change due to the new investment plan for sustainable tourism from the Dominican government and its allied organisms.

Punta Cana:

The famous Punta Cana is the most visited destination in the Dominican Republic, receiving 67% of all international arrivals in its airport (United Nations Environment Programme, 2019). Because Punta Cana is an elite destination, the variety of architectural quality varies and its visible a bigger quantity of high rated coastal hotels. One of the most famous hotels of Punta Cana is the Hard Rock Hotel and Casino.

Figure 35: Facade view of a guest block in Hard Rock Hotel & Casino, Punta Cana. Source: own

Figure 36: Interior balcony view from a suite in Hard Rock Hotel & Casino, Punta Cana. Source: hardrockhotels.com

This facade uses the typical concrete portico structure reinforced with steel bars. The openings are facing south east and north west, in this case, most of the buildings are not open to the ocean view. The balconies have more generous spaces between the exterior edge to the double glazed sliding door. In these type of hotels, it can be noticed the particular investment in double glazed sliding doors to reduce the cooling energy demand.

The structure is aesthetically finished with traditional double hand paint with two different colors, where in some sections of the facade it can be seen the coralline limestone, a local material that can be found in the east region of the country.

La Romana:

The south eastern part is also a very famous location in the Dominican Republic. The coastal city of La Romana counts with Casa de Campo, a big resort complex with inner streets and neighborhoods that possesses a rich heritage and tradition with its beautiful houses, villas, golf courses, restaurants, inner ponds, a port and a commercial center for its users.

Figure 37: Facade view of hotel units in La Marina, Casa de Campo, La Romana. Source: own

Figure 38: Interior view of a guest room in Casa de Campo, La Romana. Source: own

This facade uses a concrete portico structure reinforced with steel bars. The openings are facing towards multiple directions because the design plan is very organic. The area is very green, strategically planted with trees around to mitigate the direct solar radiation. In the first image, some windows have aluminum shutters. In the second image is also visible a three layer sliding glazing door, a wooden louver sliding doors and in the most external face a net door to prevent the pass of mosquitoes to the inside. The use of wood is very frequent in the prototype design and aesthetics of the units.

Santo Domingo:

Santo Domingo is the economical motor of the country, having approximately 4 million inhabitants and an ever-growing economy, the most powerful in the Caribbean.

For the capital city of the Dominican Republic, two examples of hotel prototypes are going to be presented: the hotel boutiques of the colonial zone and the executive hotels in the coastal road of El Malecon, facing the beautiful and warm waters of the Caribbean Sea.

Figure 39: Interior patio of El Beaterio Hotel, Colonial Zone, Santo Domingo. Source: own

Figure 40: Interior view of El Beaterio Hotel, Colonial Zone, Santo Domingo. Source: own

Figure 41: Facade view of El Beaterio Hotel, Colonial Zone, Santo Domingo. Source: googlemaps.com

Figure 42: Facade view of the Crowne Plaza Hotel in Santo Domingo. Source: guestreservations.com

Figure 43: Interior view of a guest room at the Crowne Plaza Hotel in Santo Domingo. Source: guestreservations.com

El Beaterio hotel is a great example of the many hotels boutique that are providing accommodations throughout the Colonial Zone. Their design consist in renovations of old and historic buildings that have been there for hundreds of years. The Ministry of Culture is very active on the value and preservation of this structures, where their facades are considered patrimony of humanity. Therefore, the high quality renovations need to follow very strict protocols to avoid damage or loss of any important heritage existing in these buildings.

Its visible the preservation of stone and brick facades with a high thickness, using steel bars for protection from delinquency and an internal swinging wooden window with glass squares. Because of the high thermal mass of this frontal facades, the areas are well insulated in this part, unfortunately, the guest rooms are in the back and are accessed through interior hallways, where the only light or window access to the room is from the internal patio area.

The Crowne Plaza was constructed with the typical concrete portico structure reinforced with steel bars. The openings are carefully protected by design to avoid the torched sun from the south and the increased thermal sensation due to the high humidity levels. As the rest of the other buildings, the primary element of the facade is plain mampostery walls assembled with cement blocks. Furthermore, the combining material is the single thick glazing of the fixed windows and sliding glazed doors, depending on the type of suite and its view.

2.3.2 Construction Materials for facade

The Dominican Republic uses the materials in construction through different ways, depending on the type of building, location, budget and accessibility. These are the main materials used for facades in the Dominican construction:

Concrete Wall Facade

In the Dominican Republic, its common to visualize heavy constructions due to the seismic history and the cultural belief that a concrete building is a safer refuge for its user. On coastal hotels though, is rare to see steel made structures because of the saltpeter originated from the sea. This mineral produce great harm or at least forces the application of recurrent maintenance, which from an investment point of view is not convenient. Therefore, concrete structures made of reinforced cast-in concrete combined with mampostery of cement blocks are the core cultural practice in Dominican construction.

Figure 44: Practical examples of cast-in concrete and block mampostery in the construction of a coastal hotel in Jamaica. Source: own

Sliding Glass Door + Concrete Wall

Another typical façade element are the openings towards the beach with a full sliding glass panel door. The intention with this design element is to focalize and maximize the users view of the exteriors. The usual disadvantage is that glass in tropical climate allows high thermal transmittances to the inside space and also fails to retain comfort temperatures when using air conditioning. The typical type of sliding glass door is usually single glazing because of its price, therefore the common practice is to buy a thicker glass, not considering the improvements of the double and triple glazing with cavity use.

Figure 44: Practical examples of single glazing panels and sliding glass doors in coastal hotels. Source: own

Wooden Structures

Other variation that complements the traditional concrete portico structure reinforced with steel bars are the lightweight wooden structures. These are usually designed as an extension from the main portic structure to create a buffer space as a passive design approach. Furthermore, is also used on the top floor of building structures to cover or bound and open space. The works with good are usually more expensive due to the labor workers (carpenters) and the recurrent maintenance is needed. This last part is a big concern on the coastal construction due to the high solar radiation and humidity levels present.

Figure 45: Practical examples of wooden structures under tropical climate. Source: own

Steel Structures

Steel structures are the least used structures on coastal climates due to the high costs of the material itself and the recurring maintenance needed to prevail the hot and humid climate of the coasts. However, their versatility as a material is highly appreciated and it's use is growing because of its clean and easy installation along with the space versatility it brings by supporting larger distances from column to column, such as in portico structural systems.

Figure 46: Practical examples of steel beams inside a workshop. Source: own

Stone Cladding

Stone facades are a symbol of elegance in Dominican construction. Because the usual approach to provide a finishing to a facade is paint, a stone wall adds a more natural image as a decorative material. There are certain types of stones that are known to work as great thermal insulators. This is the case of the coralline limestone, which is a sedimentary marine stone that has been reaching higher popularity throughout the years, specially in the contemporary architecture in the Dominican Republic.

Figure 47: Practical examples of regular stone cladding and coralline limestones. Source: own

2.3.3 Conclusions about Coastal Hotels Facades and its Constuction Materials

Based on the design and observations of own experience, the Dominican Republic have an existing building infrastructure based on portico structural systems with reinforced cast-in concrete. On secondary opportunities, lightweight wooden structures are often found complementing these structures as a roof-terrace expansion. Facades decorated with stone cladding are also found more often but usually in certain areas to complement the overall design. The exterior painting over mortar-finished surfaces are the most often solution in coastal hotels in the Dominican Republic. For means of thermal impact as a material compared with the other facade materials, the paint was not considered in the material chart for analysis. The following chart represents the thermal properties of the typical materials present in most facades of coastal hotels.

Material	Layer	Thickness (m)	Thermal Conductivity (W/m-K)	Density (Kg/m3)	Specific heat capacity(J/kg K)	Embodied Carbon ($KgCO_2$)
Mortar	1st	0.02	0.5	1300	1000	0.12
Concrete Block	2nd	0.15	1.63	2300	1000	0.08
Mortar	3rd	0.02	0.5	1300	1000	0.12

Table 1:Thermal properties of main building materials of the facade of coastal hotels. Source: CES 2019 and Nematchoua et al. (2020)

2.4 Thermal Comfort

According to an indoor thermal comfort study made with a sample data of millions of habitants of multiple countries under tropical climate conditions by Rodriguez and D'Alessandro (2019), it was found that people in tropical hot and humid regions are generally adapted to high indoor temperatures, heat stress and humid environments, while they have a lower tolerance to colder conditions than predicted.

Regarding relative humidity, high level of humidity can cause a negative effect on thermal comfort (Jing et al., 2013; Zhang et al., 2017). Therefore, according to Yau et al., (2011) it is suggested that optimal ranges are found between 50 and 60% RH. However, these values might vary depending on the particular preference of each user, as other studies have registered that high relative humidity effects the thermal sensation of the occupants only when the indoor temperature is relatively high (26-27 °C) (Yamtraipat et al., 2005).

In other cases, is also discussed that indoor high relative humidity might be acceptable in the humid tropics, with optimum comfort close to 73%. (Djamila et al., 2014). Literature from Thailand recommended a comfort zone with temperatures ranging from 25.6 to 31.5 °C and a RH between 62.2 and 90.0 % (Rodriguez and D'Alessandro, 2019).

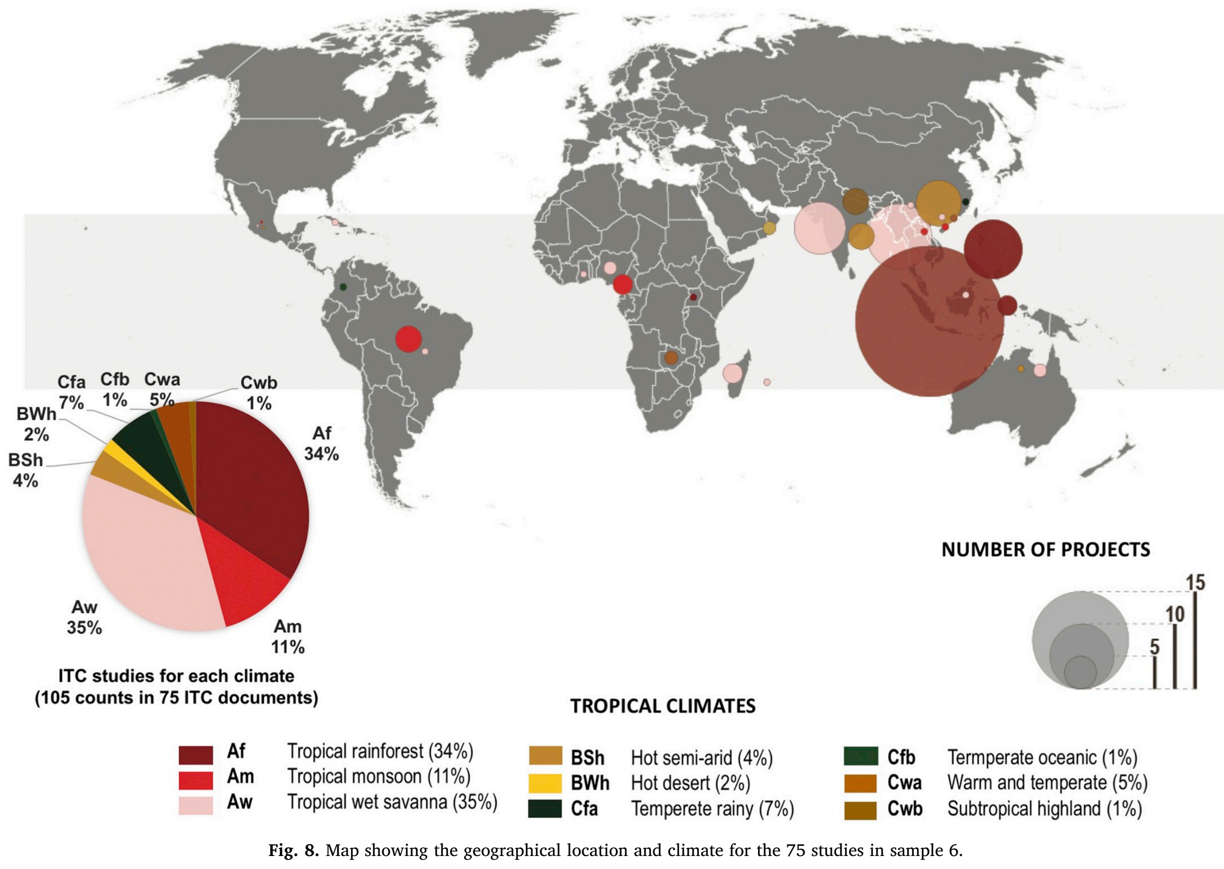


Figure 48:Indoor thermal comfort studies for each type of tropical climates source. Source: Rodriguez and D'Alessandro (2019)

2.4.1 Cooling Energy Demand

Based on own experience, Coastal Hotels in the Dominican Republic usually operates 2 main types of HVAC systems based on the size and typology of the guest rooms, restaurants, lobby, shops, kitchen, service areas, among others complementary areas. These types are the split units for smaller, isolated areas and centrally air-conditioned systems, using and maintaining their own chiller plant stations. Other types of refrigeration are similar to the models that are operated in hotels of Singapore, where large public areas like the lobby or the restaurant are usually conditioned with constant air volume (CAV) or variable air volume (VAV) systems, whereas fan coil units (FCU) are often used to serve guest rooms (Pryadarsini et al., 2009).

The direct challenges that comes to this scenario are the economic investment made every year to maintain the standard level of comfort, mainly from cooling energy performance. The average cooling energy costs represents 40% of the total energy usage in coastal hotels (United Nations Environment Programme, 2019).

2.4.2 Thermal Comfort and Cooling Energy Demand of the case study : Hotel Emotions by Hodelpa, Puerto Plata, Dominican Republic.

For research purposes, site visits and an interview with the manager of energy maintenance was held on January 2021. The main questions of the interview where directed to understand how the energy of the hotel was managed and what has been the experience with the tourists in relation of the use of air conditioning in the guest rooms.

According to the manager (2021), the air conditioning system used in the hotel is a network of independent room-based split units with inverter technology. They have three types of guest rooms, where they adjust 3 variations of split units depending on the size of the room. For the smaller room type with a single bed, the junior suite, a model of 18,000 BTU/h cools the room. For the family suite, a bigger room with two beds, a single unit of 24,000 BTU/h is installed. Lastly, the full apartment, is composed by three room areas: two bedrooms and a living room with a kitchen. Here, every bedroom has its own unit of 12,000 BTU/h and the living room, depending on if is the top floor or one of the floor below, have either a 18,000 or a 24,000 BTU/h unit installed.

The manager also mentioned that the group of tourists that most frequently visit this hotel come from Canada, United States, Germany, Russia and locals from the Dominican Republic itself. The room temperature at which the hotel set the split units range between 22 to 24 °C. However, they registered that the average temperature on which the tourists set the air conditioners for thermal comfort is 18 °C. This is close to lowest temperature possible by the units (16 °C). This means that because the thermal comfort of the tourists is set on an average temperature of 18 °C, the units tend to consume more electric energy than they're designed to work on average (22 - 24 °C).

For the purpose of compiling data for the energy performance analysis in the next stage, the worst climate scenario and highest monthly energy consumption records where considerated. Also the registry of the summer of the year 2019 was considered, given that the abnormal circumstances of the global pandemic of Covid-19 in 2020 affected the yearly numbers of tourist, which wouldn't do justice to this research in order to get the most challenging conditions for the design stage.

Therefore, the worst case scenario is on the hottest month of August, which is also the most visited during the summer. August has a maximum temperature average of 30 °C with a RH of 80 %. The building selected for the case study is the Guest Block 16, which has 4 levels of 12 rooms per each floor, for a total number of 46 rooms. The following chart displays the Kw/h produced by each floor on average for the month of August 2019. An estimated 40 - 43% of the average energy consumption is directly accounted by the cooling energy demand.

Floors	Average Kw-day	Average Kwh	Cooling Energy Demand Kwh
Level 1	32658	13063.2	544.3
Level 2	38082	15232.8	634.7
Level 3	34470	13788	574.5
Level 4	64800	25920	1080

Table 2: Average energy consumption and cooling energy demand of Guest Block 16 in the month of August, 2019. Source: Emotions by Hodelpa, Puerto Plata (2021)

Figure 48: Condensators and evaporator units (split) as cooling energy technology used in the Hotel Emotions. Source: own

2.4.3 Thermal Comfort: Building Physics of the Stationary and Dynamic Simulations.

To understand the thermal comfort in a room model, the application of stationary and dynamic calculations presents a useful calculating tool to comprehend the building physics of the heat flow between this space and the exterior.

The stationary simulations are independent of time, which mainly consider the required power for heating and cooling based on the construction factors of insulation, the quantity and type of glass and the amount of ventilation that circulates the space (Bokel, 2019). This type of calculations is helpful to determine the temperature in a room when the conditions of the interior and the exterior spaces are constant, but not provide an answer for the energy demand of a room or a building over a certain time. On the other hand, the dynamic simulations do provide answers for time-dependent calculations, principally for room spaces that present large solar load or a large internal heat production.

Another important factor present on the dynamic simulations is the effect of the thermal mass in the calculations. This is because the thermal mass can moisten the indoor temperature, measurable in a time-dependent process (Bokel, 2019).

The calculation of non-stationary or time-dependent heat flows considering realistic outdoor scenarios become more complex as more factors are to be included in the estimations. Therefore, computer models such as Design Builder have been developed to obtain more accurate results to make better design choices for the energy performance of a room or a building.

A simple way to explain the principles of the dynamic simulation is through a simplified one-node model of a room. The factors to be evaluated for the thermal mass node in summer conditions are the heat storage in the room air, internal walls, ceilings, floors, and furniture. The temperature of the node is assumed to be equal to the operative indoor temperature (Bokel, 2019). The starting-up values of the stationary heat balance are the following:

1) $\mathbf{Q_{transmission}}$, representing the energy gain or loss per time by transmission between the room and the exterior in watts (W). The main factors considered are the area of the windows (A_{window}), the u-value of the windows (U_{window}), the area of the walls (Awall), the u-value of the walls (U_{wall}), and the temperature difference between the outside and the inside.

Its formula is: $Q_{transmission} = (A_{window} \times U_{window} + A_{wall} \times U_{wall}) \times (T_{out} - T_{in})$

2) $\mathbf{Q_{intern}}$, representing the internal heat production inside the room by people, equipment, and lighting in watts (W).

Its formula is: $Q_{intern} =$ amount of (persons/equipment/lighting) x specific heat production of the indicated object/person. (i.e., when only 2 people present in a room with a 80W heat production, the Q_{intern} is: 2 x 80W = 160W.

3) $\mathbf{Q_{sun}}$, represents the internal heat production inside the room by the influence of the sun through the transparent surfaces (i.e., the windows) of the façade into the room in watts (W). The main factors to be evaluated are the solar incidence, based on the geographical position (qSun), the area of the window where it irradiates through (A_{window}) and the g-value of the window (g-value$_{window}$).

Its Formula is: $Q_{sun} = qSun \times A_{window} \times g\text{-value}_{window}$

4) $\mathbf{Q_{ventilation}}$, representing the energy gain or loss per time by ventilation between the room and the exterior in watts (W). The main factors to be evaluated are the density of the air (P_{air}), the specific heat of the air (c_{air}), the number of air changes in the room (n), the volume of air in the room (V_{air}) and the temperature difference between the outside and the inside.

Its Formula is: $Q_{ventilation} = (p_{air} \times c_{air} \times n \times V_{air}) \times (T_{out} - T_{in})$

5) Therefore, for the thermal mass to take place in the time-dependent simulation or dynamic simulation, other combination of these values are considered. For instance, value of **M** is contemplated for the thermal mass properties. The value that represents the energy loss(or gain) per time by both transmission and ventilation between the room and the exterior is expressed by: $\mathbf{Q_{transmission\_ventilation}(t)}$. Furthermore, the addition of $\mathbf{Q_{intern}}$ and $\mathbf{Q_{sun}}$ are represented by the expression **W(t).** For the situation of **M,** the total thermal mass is the sum of component n with mass m_n and specific heat capacity C_n (i.e., air volume, furniture, inner several cm's of the walls, floor and ceiling) (Bokel, 2019).

The formula for **M** is the following:

$M = \sum_n (m_n x\ c_n)$... which later combined together with the dependence on the temperature with time $[dT_i (t)/dt]$, gives the time dependent heat balance equation:

$$+ Q_{transmission\_ventilation}(t) + W(t) - M\ dT_i (t) / dt = 0 \ ... \quad \text{where } (J/s = W).$$

This ecuation simplifies by using the term H_e , where transmission and ventilation are grouped together as follows:

$$Q_{transmission\_ventilation}(t) = H_e [T_e(t) - T_i(t)] \ .... \quad \text{where } H_e = \sum U_eA_e + q_vp_lc_l$$

These formulas can later be applied in the **semi-analytical scheme**, where its possible to assume that the outside temperature (**Te**) is constant. This then is interpreted in the following differential equation:

$dT_i(t)/dt = - H_e/M \times T_i(t) + W+H_eT_e/M$ ... where " **t** " is a continuous **time** variable and W, H_e T_e and M are constants. Furthermore, the exact solution for the temperature from time " **t** " onwards is described as:

$$T_i(t) = Ae^{Bt} + C$$

The next step is to identify A, B and C. Therefore, in general **B** is the term before $T_i(t)$, meaning that: $B = -H_e/M$

Then **C** is the temperature that is reached after a very long time (t-> ∞). This temperature can be calculated by setting $dT_i(t)/dt = 0$ in the differential equation. Therefore:

$$C = W/H_e + T_e$$

Subsequently, **A** is the initial temperature minus the temperature reached after a very long time, resulting in:

$A = T_e - [T_e + W/H_e] = - W/H_e$ ... which leads to:

$$T_i (t) = - W/H_e \times e^{- He/M \times t} + W/H_e + T_e$$

Or expressed in a different form:

$$T_{in} = T_{out} + W/H (1 - e^{- H/M \times t})$$

2.4.4 Conclusions of Thermal Comfort

The efficiency of the actual facade of the Guest Block 16 of the Hotel Emotions will be placed on the evaluation platform. Is evident that the energy consumption is high and the average thermal comfort temperature that tourists have stablished in 18 °C reflects an expensive challenge for the split units to maintain that room temperature. An average consumption of 708.4 Kw/h is assumed from the average cooling energy demand of the entire Guest Block 16, resulting from the average number of the cooling energy consumption of each floor.

To identify the main factors that revolve around the cooling energy consumption in the rooms, a calculation approach of stationary and a dynamic simulations are contemplated to firstly, understand which surfaces (opaque or transparent) have higher thermal influence on the internal room space by the climatic and environmental forces on the exterior and secondly, to use these calculation results to elaborate on passive design strategies that could fit into solving these cooling energy challenges by using a more elaborated energy simulation software to provide more precise numbers.

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3.0 BACKGROUND RESEARCH – SUSTAINABLE FAÇADE RENOVATION

3.1 Passive Design Strategies

Research usually showed that passive strategies had low extra capital investment cost compared to the potential benefit in energy saving and therefore, passive design is recommended in many green and sustainable design guidelines (Sun et al., 2018).

According to the conclusion of a study made by Prieto et al, (2018), the passive design strategies should be the initial step in designing an energy efficient building, before considering active approaches for the means of mechanical equipment driven by fossil fuels. Therefore, using these agreed conclusions, the passive design strategies that will be discussed in this chapter will be based on the following strategies:

Glazing

Glazing in buildings allow the pass of natural light into an internal space. Also, it allows the user to interact and read the external environment, and control the flux of ventilation if the window or glass door are not fixed. On the other hand, the thermal properties of the glass are usually lower when compared to other facade materials. However, nowadays exist new technologies that include the integration of low-e coating and air spaces insulations providing better solar protection for the glass facade. (Konstantinou and Prieto, 2018).

According to Prieto et al. (2018), the use of different glazing types shows the lowest energy saving potentials. Therefore, in hot and humid climates, the mean and median values are at 12% and 10%. Furthermore, the maximum energy saving potential was found under humid subtropical climates with values rounding 40%. To conclude, the authors stated that the increasing number of glass layers and changes in color properties don't have much effect on cooling demand savings but when both are combined its saving potential increases. (Prieto et al. 2018)

Shading

Shading a facade is one of the most efficient methods to block invasive solar radiation before it reaches any material of the building's envelope with low thermal resistance. The method of shading can be sub-divided into internal or external and fixed or movable. The most effective shading system is the external, due that it blocks a higher solar radiated surface space than the internal shading. As a result, the interior space its not affected by any solar influence. The negative part of this system is its higher maintenance costs. The movable shading system is more versatile for adapting to more specific circumstances, however, it requires high maintenance as well. The orientation is a defining factor in the positioning of the shading. According to Konstantinou and Prieto (2018), vertical louvers are more suitable for the east and west facades due to the low altitude sun angle, which in the opposite case of using an horizontal louver, the shading body would block the direct solar radiation coming from the south side without interfering with the visuals.

In relation to a literature review made by Prieto et al (2018), shading strategies in warm and humid climate like the tropics display a similarly high mean and median values when compared with the glazing type or window to wall ratio strategy. Based on it also concludes that the maximum value reach 55.6% on a study made in Bangkok.

Window to Wall Ratio (WWR)

The amount of daylight and heat that crosses through transparent materials add to the thermal entry load of a room. If this relation can be controlled by the shape and size of this material, it can definitely alter thermal performance of that given space. Therefore, following the guidelines of the data collected by Prieto et al, (2018) it was found a mean of 18% and a median value of 14% of energy saving potential in a warm and humid climate. It aslo reflected that in extreme climates of Riyadh and Singapore, both within the harsh characteristics of a Tropical Climate, the window to-to-wall ratio obtained its best results of evaluation of cooling energy demand savings with a 52% and a 34% respectively.

In conclusion, it was discussed and agreed that a cooling energy demand savings tends to be higher as the relative window sizes decrease. Following these references and results made in similar climates, such as Singapore, the window to wall ratio will be explored on the further evaluation stages using a 50% reduction from the actual proportion of the selected scenario.

Ventilated Facades

A study made by Barbosa et al., (2015) about thermal comfort in naturally ventilated buildings with double skin façade under tropical climate conditions indicated that a narrow cavity depth for ventilated facades of air conditioned buildings is preferred as it demands less energy consumption due to accentuated stack effect occurring in the cavity, which reduces the heat transmission to inside the occupied space. It also added that a taller cavity produces a stronger buoyancy force, creating a greater airflow rate to be extracted on the top.

This study also concluded that is recommended that the solar chimney reflected on this air cavity should surpass the height of two floors. In other words, this would be more benefitial for buildings of more than two floors.

Thermal Insulation

Thermal insulation is defined by the Bristish Standar Institution, B ISO (1996) as a constant event of heat flow passing through a unit surface area induced by a 1 Kelvin degree of difference of temperature and it also considers radiative and convective heat transfers.

A study made by Al-Sanea et al., (2012) discussed the evaluations of different effects of thermal mass on performance of insulated building walls and the concept of energy savings potential. They concluded that for Δ in the range 70–99% of cooling energy savings, the thickness of the insulation provided better savings starting from the ranges between 6 and 30 cm of thickness of the insulating material.

They also recommended after the tests that building walls should contain as a minimum critical amount of thermal mass that correspond to energy savings potential within the range of 90% and 97% and that the insulation layer should be placed on the outside for applications with continuously operating air conditioner.

3.2 Sustainable Materials for Facade Renovation

In order to provide a set of adecuated Sustainable Facade Renovation Strategies, the passive design strategies mentioned in the past chapter must be combined with an effective use of sustainable materials. The following chart represents a group of sustainable materials as construction products, evaluating them through the lens of thermal transmittance (to determine better quality materials for replacement or reinforcement of the existing hotel facade); embodied energy (to consider that the energy needed for a material to be manufactured is important to consider for the CO_2 emissions); CO_2 footprint (directly a result of the embodied energy of the material, the amount of carbon emissions is an important factor for sustainability evaluation); thermal mass (displaying the capacity of the material to store heat); recyclability percentage (to evaluate how to manage the lifecycle of the material while considering further reuses, if possible); and weight (to determine how heavy the product can be after manufacturing, to transport to the building site and therefore be feasible to install on the renovation). The selection criteria for this list of materials are based on the experience recollected from multiple projects and research work during this masters of Building Technology, specially from the lessons learned from Materials Science.

The sources are the data base of CES Edupack 2019, the product sheets of rockpanel.com, and biofoam.com.

Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	CO2 Footprint Primary Production (Kg/Kg)	Recyclability (%)	Density (Kg/m^3)	Weight* (Kg)
OSB	0.0127	1552	0.13	1.84e7 – 2.03e7	0.84 - 0.93	1.34 – 1.48	650	8.3
Glulam	0.10	1200	0.38	1.92e^7 – 2.12e^7	0.805 – 0.888	1.34 – 1.48	550	11
BioFoam	0.05	480	0.034	8.86e^6 – 1.01e^7	2.55 – 3.48	100	660	26.4
Cork	0.10	1200	0.042	3.81e^6 – 4.20e^7	0.192 – 0.211	100	240	19.2
Hemp	0.05	1600	0.056	1.00e^6 – 1.20e^6	0.37 – 0.41	0.1	860	34.4
Steel	0.175	480	50	7.71e^6 – 8.51e^6	0.606 – 0.668	95	8050	56.4
Bamboo	0.10	1008	0.18	1.43e^4 – 1.58e^4	0.0019 – 0.0021	1.3 – 1.5	1160	9.3
Rockpanel	0.008	920	0.37	9.27E+07	1.43 – 2.10	100	1050	8.4

* Weight is based on a 1m^2 model panel

Table 3: Sustainable Materials selected for their notable sustainability properties. Sources: CES 2019, bewisynbra.com, rockpanel.com, biofoam.com.

3.3 Conclusions

For this research, the tactics that define a Sustainable Facade Renovation are based on passive design strategies and its combination with sustainable materials.

For glazing, multiple layers will be explored and a model type will be selected from the Design Builder library, based on its performance in relation to its U-value to evaluate thermal insulation performance when renovating the sliding glass doors and windows of the facade. The addition of a cavity and another layer of glass could improve the current single glazing use of an average of 1/2 inch thick glass, which might be an important factor to discover in the calculations stages.

For shading, a versatile sun blocker design could open the posibilities of replacing the popular curtains that are often used inside the hotel units. An external shading strategy could be more beneficial to avoid any sort of refractated solar radiation to enter the room, based on the conclusions from the study of Konstantinou and Prieto (2018).

For thermal insulation, the commercial sizes of insulating panels will be explored and the energy savings concept from the study of Al-Sanea et al., (2012) will be followed to make a desition with the final thickness to use for the evaluations . The approach here will be based first on the sustainability of the insulating materials and then on the thermal transmittance.

For window to wall ratio (WWR), the optimization of the size of the windows can help reduce the cooling energy demands according to Prieto et al, (2018). Therefore, for the design stage, the evaluation of a reducing the window to wall ratio by half will be applied to discover if there would be a significant difference in cooling energy savings.

In regard of the sustainable materials selected for the facade renovation, this table chart will serve as a reference to compare and select the ideal material depending on its function to work better with the passive design strategy applied in the design stage. The main purpose of this selection is to offer material options that can be potentially produced locally to serve as a model parameter for the local construction businesses in the Dominican Republic and the Caribbean.

The application of the passive design strategies with effcient sustainable materials can serve as a principle for applying sustainable facade renovation strategies. At the conclusions segments, the results would indicate how efficiently worked this combination to reduce the cooling energy demands of coastal hotels under tropical climate to and hypotetical 50% from its current consumption level, if possible.

4.0 BACKGROUND RESEARCH – CASE STUDY TO RENOVATE

4.1 Guest Block 16 of Emotions by Hodelpa in Puerto Plata, Dominican Republic

The recently renovated coastal hotel Emotions by Hodelpa is located in the touristic complex of Playa Dorada, in the city of Puerto Plata, Dominican Republic. The elegance and atractive aesthetics of the new design has caught up the attention and interest on this hotel by both locals and international visitors.

Figure 49: Sky view of coastal hotel Emotions by Hodelpa in Playa Dorada, Puerto Plata. Source: expedia.com

The areas of focus of the case study are the guest blocks, which represent a prototype model that is replicated throughout the site plan of the hotel. These Guest Blocks posses each 12 rooms per floor distributed in 4 levels. The last floor have penthouses.
The renovation of this hotel was finished in 2017, where the architects preserved the concrete structure from the previous functions and added more decorative materials to improve the aesthetics. However, the facades where barely considered for mayor renovation and lastly the mayor change was made on the balconies, replacing the railings from decorative cement molds to a contemporary glass railing design. The exterior wall was just painted in a different color and preserved its appearance. The sliding doors and windows were replaced for newer products, without adding any other layer besides the single existing glazing.

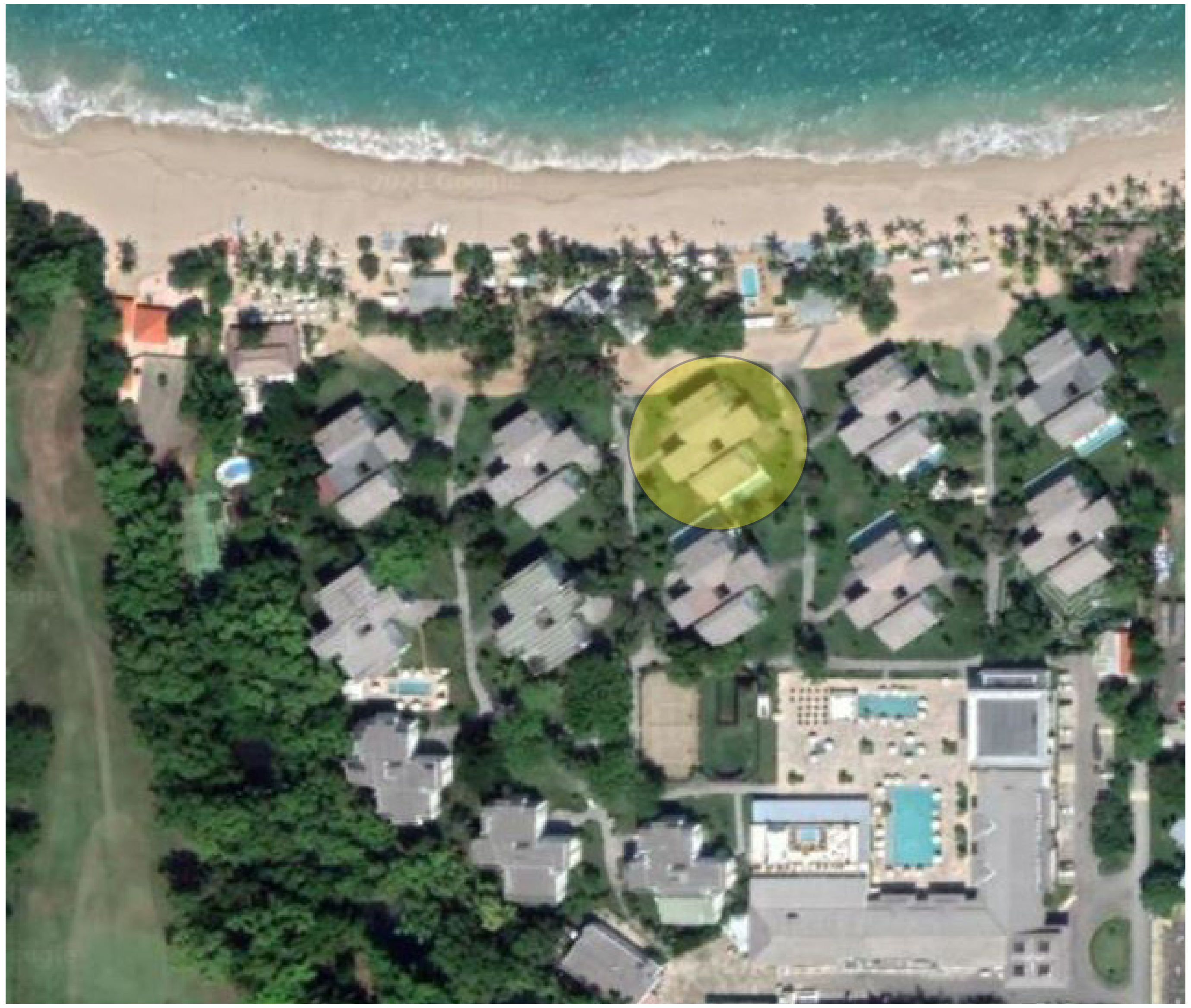


Figure 50: Location of Guest Block 16. Source: google maps

Figure 51: Side and Frontal views of Guest Block 16. Source: own

4.2 Selection Criteria

The coastal hotel Emotions by Hodelpa in Puerto Plata was selected for the following reasons:

- *Recently renovated (2017).*
- *Display the common portico structure.*
- *Display the common brick plus mortar facade (finished with paint).*

The parameters considered to select Guest Block 16 are the following:

- *Proximity to the beach.* For the most critical scenario against climatic challenges (hurricanes, tsunamis, moisture, humidity levels and saltpeter).

- *Least protection from the shading of exterior vegetation.* From the 5 building blocks that are facing the beach, Guest Block 16 is the least protected from natural sun shading. Therefore is more vulnerable to the effects of direct solar radiation on the facade.

- *Highest energy consumer (Kw/h)* of the beach line building blocks when operating at full capacity.

Figure 52: North view of Guest Block 16. Source: own

4.3 Architectural Drawings

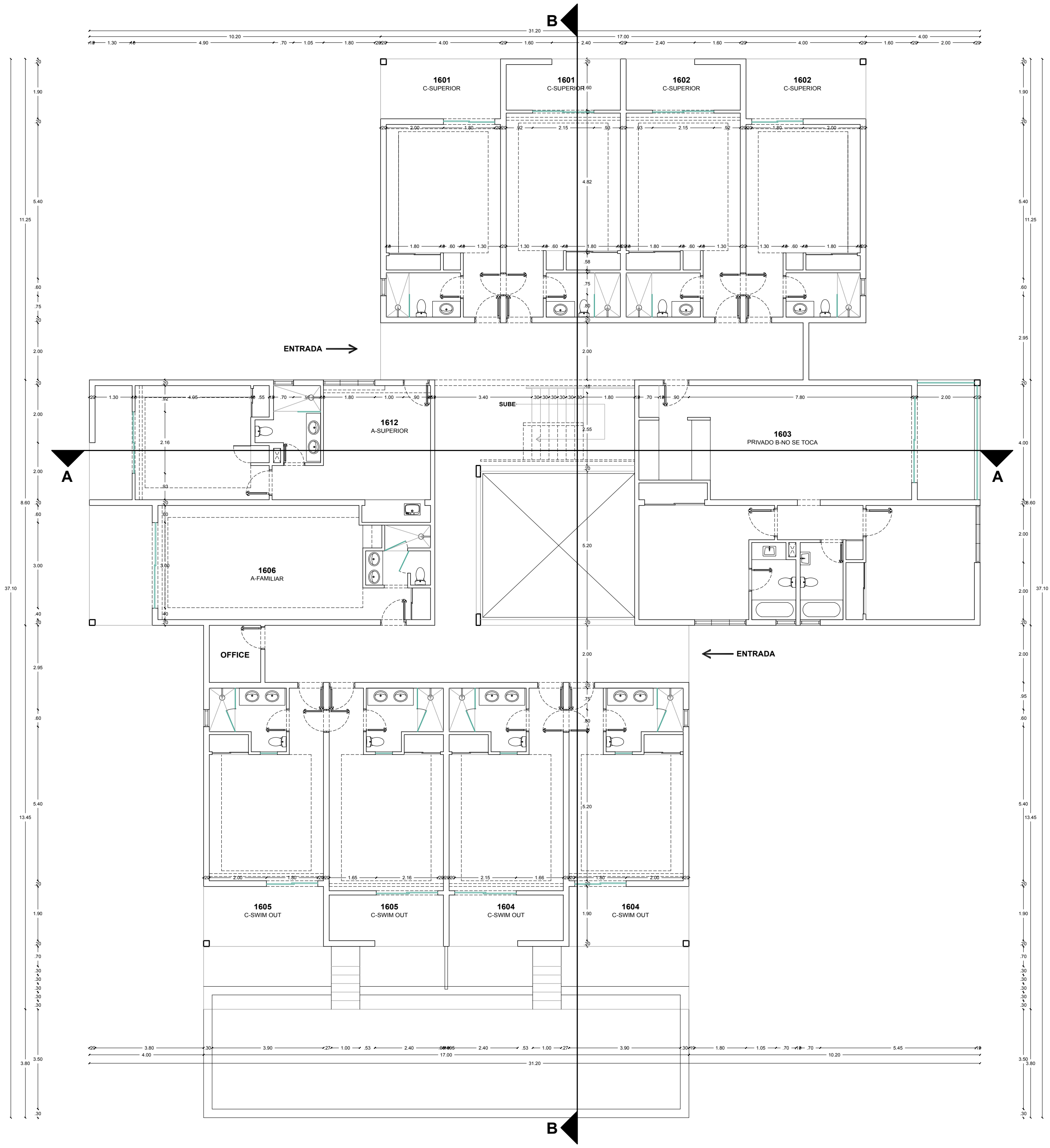


Figure 53: Dimensioned Ground Floor Plan of Guest Block 16. Source: Emotions by Hodelpa (2021)

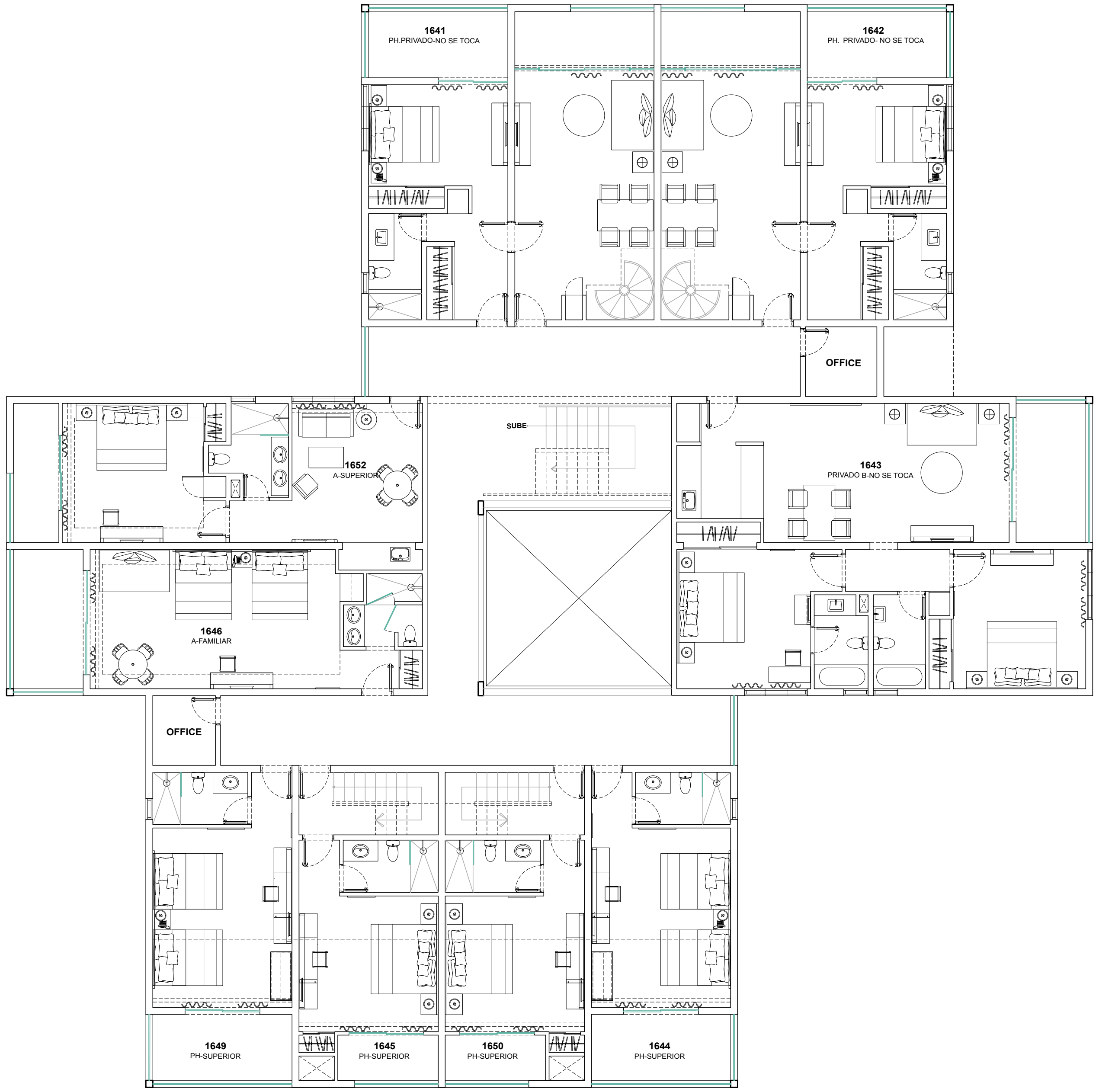


Figure 54: Second Floor Plan of Guest Block 16. Source: Emotions by Hodelpa (2021)

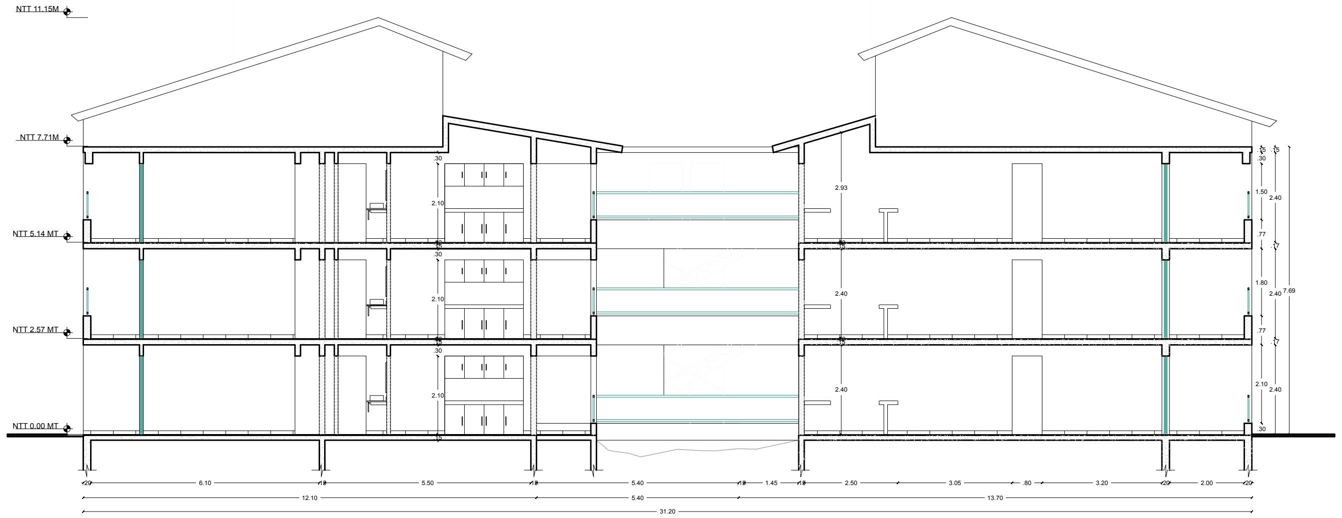


Figure 55: Section Plan A-A of Guest Block 16. Source: Emotions by Hodelpa (2021)

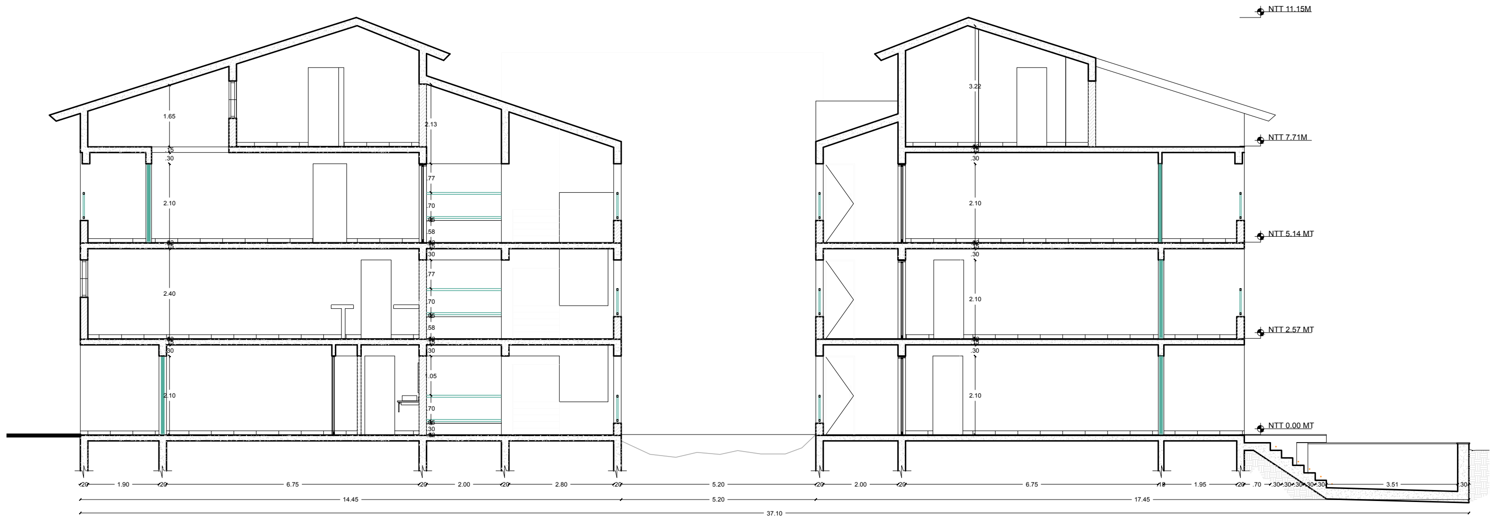


Figure 56: Section Plan B-B of Guest Block 16. Source: Emotions by Hodelpa (2021)

Figure 57: South Elevation of Guest Block 16. Source: Emotions by Hodelpa (2021)

Figure 59: East Elevation of Guest Block 16. Source: Emotions by Hodelpa (2021)

Figure 58: North Elevation of Guest Block 16. Source: Emotions by Hodelpa (2021)

Figure 60: West Elevation of Guest Block 16. Source: Emotions by Hodelpa (2021)

5.0 SUSTAINABLE MATERIALS EVALUATION

5.1 Sustainable Material Evaluation Method

To establish a criterion by which a material is considered sustainable, it must be subjected to certain parameters that regulate its efficiency within this criterion. The benchmark encompass the physical properties of the material, how it is harvested or obtained, how much energy is consumed in its manufacture, how harmful it is to the environment, how much it weights for transportation and installation concerns and how effective it is to be recycled and potentially used as a valuable element within the circular market. The values used here where obtained from CES Edupack 2019, Rockpanel.com and Biofoam.nl.

Furthermore, the categories that best comply with these sustainability parameters that were mentioned will be presented, following the sources and the works carried out within this Master of Building Technology, especially on the content of Materials Science. Additionally, the thermal transmittance properties will be incorporated to also consider how effective and insulating the material can be when grouped with the sustainable parameters. The boundary of this analysis of sustainable materials is to evaluate the performance of the layers, not the type of connections or techniques to installation. These latter should be determined by the fabricators, architects or engineers based on whats more feasible for their products or projects. What it needs to be ensured is the adition of a vapour barrier to keep the humidity on the outside (placed right after the insulation layer) and to guarantee the total sealing of every sandwich panel to avoid thermal bridges or transference of thermal energy between the inside and outside layers.

The grading evaluation is based on qualitative assessment relative to the range in which the material is performing best on the sustainable parameters that were already presented. The weight is based on a panel of 1 m^2 to be assembled as a sandwich panel wall.

SUSTAINABLE MATERIALS GRADING						
Weight* (Kg)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	Total CO2 emitted per panel (kg)	Recyclability (%)	Grade
0 - 10	1500 - <	0 – 0.10	0 – 1.00e6	0 – 10	75 – 100	++++
10 - 20	1000 - 1500	0.10 – 0.20	1.00e6 – 1.50e7	10 – 20	50 – 75	+++
20 - 30	500 - 1000	0.20 – 0.30	1.50e7 – 1.00e8	20 – 30	25 – 50	++
30 - <	0 - 500	0.30 – <	$1.00e^8$ – <	30 – <	0 – 25	+

Table 4: Sustainable materials grading method. Source: Own.

The evaluation will be tested by analysing the performance of the layers of each material. The order of assembly will be determined by an interior layer, an insulation layer, a structural layer and an exterior layer. This composition is considered this way in order to provide a more efficient layering composition than the inneficient layering of the existing walls, which are composed by an interior layer of concrete mortar, cement blocks in the middle and another layer of concrete mortar on the exterior. The composition idea of the new layering approach is derived from thermal efficiency excercices made on the course of Facade Design in the renovation plan for the facade of the Calypso building in Rotterdam, Netherlands.

The conclusions of these excercices might provide a clear understanding on the thermal insulation benefits of the facade, which prevent high energy losses if the materials used are selected wisely and with better sustainable criteria, which is the intention of this chapter.

The following chart indicates the amount of CO_2 footprint generated per the total amount of weight based on the integration of the materials for a 1 m^2 panel. This values are placed to identify the grading section of CO2 footprint Primary production of amount of CO2 in Kilograms per Kilograms of the indicated material. Since the values given for CO2 footprint from the CES database and the technical sheets of rockpanel and biofoam are in ranges, for this evaluations, the numbers used for the specific calculations of the weight of each material were based on the average value between these ranges.

CO2 Production of Materials per 1m^2 panel					
Material	Thickness (m)	Density (Kg/m^3)	Weight* (Kg)	CO2 Footprint Primary Production (Kg/Kg)	Total amount of CO2 emitted per 1 m^2 panel weight (Kg)
OSB	0.0127	650	8.3	0.88	7.3
Glulam (for interior boards)	0.05	550	27.5	0.84	23.1
Glulam (for structure)	0.10	550	11	0.84	9.2
BioFoam (comercial size A)	0.025	660	16.5	3.00	49.5
BioFoam (comercial size B)	0.05	660	26.4	3.00	79.2
Cork (comercial size A)	0.05	240	12	0.20	2.4
Cork (comercial size B)	0.10	240	24	0.20	4.8
Hemp (comercial size A)	0.05	860	43	0.39	16.8
Hemp (comercial size B)	0.10	860	86	0.39	33.5
Steel (structure)	0.175	8050	56.4	0.63	35.5
Bamboo	0.10	1160	9.3	0.002	0.019
Rockpanel	0.008	1050	8.4	1.75	14.7

* Weight is based on a 1m^2 model panel

Table 5: Total amount of CO2 generated per 1m^2 panel weight per material product. Source: Own.

The order of the layering previously mentioned is to group and evaluate each material for its intended use, meaning that the evaluation will gather the materials that are more effective and efficient on the layering space that is required. Therefore, the comparison between layers from the same group can provide a clearer understanding of where they can perform better. The thicknesses selected are based on the most abundant and popular commercial products during the research of the products and their prices in The Netherlands and Europe.

A possible raised question from the strategy of analysing these layers and assembling them in sandwich panels of 1m^2 as a refrence point can be where they're going to be installed in a renovation. For the intended renovation phase of the sustainable facade sandwhich panels, two strategies will be considered. First, the replacement of the inneficient existing walls with the better assembled sustainable product of sandwich panel wall system and another with the addition of part of the layering (insulation, substructure and exterior layer) on the existing exterior facade walls.

The discussions generated from this phase will be the sustainability aspect of the first strategy of replacement of the walls and the functionality conflict of adding an additional set of layers to this walls. Evidently, replacing the walls affects directly in the costs for demolition, which can be evicted on the subsequent strategy. However, the only guarantee to avoid thermal bridging in the energy costs relies on the higher quality of the assemblance of the new layering products.

Furthermore, the removal of the cement block walls could be recycled and sold to a local agregatte company, as a study made by Soutsos et al., (2011) about concrete building blocks made with recycled demolition aggregate concluded that factory trials showed that there were no practical problems or strength reduction with the use of recycled demolition aggregate to make new recycled blocks. They also indicated that there would be no additional cost to the manufacturers if they were to use recycled aggregates for their routine concrete building production.

Therefore, is a matter of discussion between the contratist and the client on the renovation goals, since demolition in this case can have a sustainable path through the recycling of the materials, if they don't want to sacrifice fucntionality of the perimetral extra space needed to add the additional new layers on the existing walls. This is the reason why both replacement and addition to the external side of the existing wall strategies will be performed.

MATERIALS FOR INTERIOR LAYERS								
Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	Total CO2 emitted per panel (kg)	Recyclability (%)	Weight* (Kg)	Average Grade
OSB	0.0127	1552	0.13	1.84e7 – 2.03e7	7.3	1.34 – 1.48	8.3	+++
Glulam	0.05	1200	0.38	$1.92e^7 – 2.12e^7$	23.1	1.34 – 1.48	5.5	++

Table 6: Sustainable materials grading of interior layers. Source: Own.

MATERIALS FOR INSULATION LAYERS								
Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	Total CO2 emitted per panel (kg)	Recyclability (%)	Weight* (Kg)	Average Grade
BioFoam	0.025	480	0.034	$8.86e^6 – 1.01e^7$	49.5	100	26.4	+++
BioFoam	0.05	480	0.034	$8.86e^6 – 1.01e^7$	79.2	100	26.4	+++
Cork	0.05	1200	0.042	$3.81e^6 – 4.20e^7$	2.4	100	19.2	++++
Cork	0.10	1200	0.042	$3.81e^6 – 4.20e^7$	4.8	100	19.2	++++
Hemp	0.05	1600	0.056	$1.00e^6 – 1.20e^6$	16.8	0.1	34.4	+++
Hemp	0.1	1600	0.056	$1.00e^6 – 1.20e^6$	33.5	0.1	34.4	+++

Table 7: Sustainable materials grading of insulation layers. Source: Own.

MATERIALS FOR STRUCTURE LAYERS								
Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	Total CO2 emitted per panel (kg)	Recyclability (%)	Weight* (Kg)	Average Grade
Steel	0.175	480	50	$7.71e^6 – 8.51e^6$	35.5	95	56.4	++
Glulam	0.10	1200	0.38	$1.92e^7 – 2.12e^7$	9.2	1.34 – 1.48	11	++
Bamboo	0.10	1008	0.18	$1.43e^4 – 1.58e^4$	0.019	1.3 – 1.5	9.3	+++

Table 8: Sustainable materials grading of structure layers. Source: Own.

MATERIALS FOR EXTERIOR LAYERS								
Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	Total CO2 emitted per panel (kg)	Recyclability (%)	Weight* (Kg)	Average Grade
Glulam	0.05	1200	0.38	$1.92e^7 – 2.12e^7$	23.1	1.34 – 1.48	11	++
Bamboo	0.10	1008	0.18	$1.43e^4 – 1.58e^4$	0.019	1.3 – 1.5	9.3	+++
Rockpanel	0.008	920	0.37	9.27E+07	14.7	100	8.4	+++

Table 9: Sustainable materials grading of exterior layers. Source: Own.

In order to have a clear idea of the price of the materials for the assemblance of the sustainable facade layers, a research was made through different sources to calculate the total cost of each material based on the price for their weight in euros. In regard of the use of the prices in euros, the intention is to provide a comparable idea of how much the assemblance could cost compared to other materials of the list.

This list can also be potentially used to define how much would cost the meter square of the intended sustainable facade strategies in order to create a comparable margin between each strategy. The cost-effective parameters would be an interesting approach to further evaluate its feasibility when the budget is also considered besides the energy performance.

Prices of Materials (in Euros per Kg)					
Material	**Thickness (m)**	**Weight* (Kg)**	**Price (€ per Kg)**	**Total cost (per 1m^2 panel)**	**Source**
OSB	0.0127	8.3	€ 0.94	$ 7.76	Pontmeyer.nl
Glulam (for interior boards)	0.05	27.5	€ 2.88	$ 79.20	CES Edupack 2019
Glulam (for structure)	0.10	11	€ 2.88	$ 31.68	CES Edupack 2019
BioFoam (comercial size A)	0.025	16.5	€ 0.76	$ 12.54	Isolatie.net
BioFoam (comercial size B)	0.05	26.4	€ 0.76	$ 20.06	Isolatie.net
Cork (comercial size A)	0.05	12	€ 6.62	$ 79.44	CES Edupack 2019
Cork (comercial size B)	0.10	24	€ 6.62	$ 158.88	CES Edupack 2019
Hemp (comercial size A)	0.05	43	€ 1.09	$ 46.87	CES Edupack 2019
Hemp (comercial size B)	0.10	86	€ 1.09	$ 93.74	CES Edupack 2019
Steel (structure)	0.175	56.4	€ 0.66	$ 37.19	CES Edupack 2019
Bamboo	0.10	9.3	€ 1.50	$ 13.92	CES Edupack 2019
Rockpanel	0.008	8.4	€ 12.20	$ 102.48	Pontmeyer.nl

* Weight is based on a 1m^2 model panel

Table 10: Prices of sustainable materials in Euros per kg. Source: Indicated on table.

5.2 Sustainable Material Selection for Sandwich Panel Wall

The materials selected were OSB (Oriented Strand Board) for the interior layer, Cork (low density) as the insulation layer, bamboo (10cm of diameter) as the structure and Rockpanel as the exterior layer. The arguments of the selection were the following:

OSB: Besides the better grade obtained overall when compared to glulam boards of 5 cm tick, the sheets of OSB have a thinner product thickness, which makes for a higher volume of boards to store for transportation in each travel point. It also has a lower thermal transmittance than glulam boards, which is imperant for the insulation properties that are sought to minimize the transittion of thermal energy between layers and create a more insulated environment when the cooling units are operating inside the rooms. On the other aspects, the similarities between each wood-based product are not that different or relevant for the criteria. (CES, 2019)

Cork: The insulating properties of cork are paramount, and the combination of it with the amount of CO^2 per kg that it generates from its primary production makes it an effcient sustainable option above Biofoam and Hemp. Adding to it that its the lightest in weight, the versatility for transportation and instalation is a plus. (CES, 2019)

Bamboo: On own experience, the use of bamboo in the Dominican Republic is being more frequent in arquitecture at this date, and has been around for decades on the Caribbean Region. Its structural versatility and rapid growth makes it ideal for a sustainable structure material. The thermal transmittance is the best of the group as well, making it the ideal choice in this criteria.

Rockpanel: This material is one of the most innovative sustainable exterior cladding product used today in Europe. Its mayor composition materials are basalt rock, which is combined with slags residues and other recycled-waste materials to create a versatile product that is almost 100% recyclable, with a long lifespan of 60 years with a water-based coating. This material is also insensitive to moisture, has a high colour and UV resistance and is low maintenance. Furthermore, is lightweight and friendly to standard tools for installation. This characteristics are hard to match when compared with glulam and bamboo. Their performance as exterior cladding facing solar radiation, moisture, rain and other harsh tropical climatic conditions make them hard to maintain. Plus, the exposure to be replaced more often makes them a risky choice for the amount of waste generated and the low recyclability perecentage they possess. Finally, the thickness and weight of the material is easier to handle for transportation and installation. (Rockpanel.com)

These materials represented the most balanced grades in sustainability. The insulation thickness value of 10 cm of cork was chosen over the value of of 5 cm because of the conclusions of the study made by Al-Sanea et al., (2012) about discussing the evaluations of different effects of thermal mass on performance of insulated building walls and the concept of energy savings potential. They concluded that the thickness of the insulation provided better savings starting from the ranges between 6 and 30 cm of thickness of the insulating material.

The following chart represent the cost of one sandwich panel wall, based on their price per kilograms in Euros as the currency of reference.

Price of the m^2 selected Sandwich Panel (in Euros per Kg)					
Material	**Thickness (m)**	**Weight* (Kg)**	**Price (€ per Kg)**	**Total cost (per $1m^2$ panel)**	**Layer Position**
OSB	0.0127	8.3	€ 0.94	$ 7.76	Interior
Cork (comercial size B)	0.10	24	€ 6.62	$ 158.88	Insulation
Bamboo	0.10	9.3	€ 1.50	$ 13.92	Structure
Rockpanel	0.008	8.4	€ 12.20	$ 102.48	Exterior
Total	**0.12**	**49.9**		**$ 283.04**	

* Weight is based on a $1m^2$ model panel

Table 11: Price per panel of the selected sustainable materials to assemble the sandwich panel wall. Source: Own.

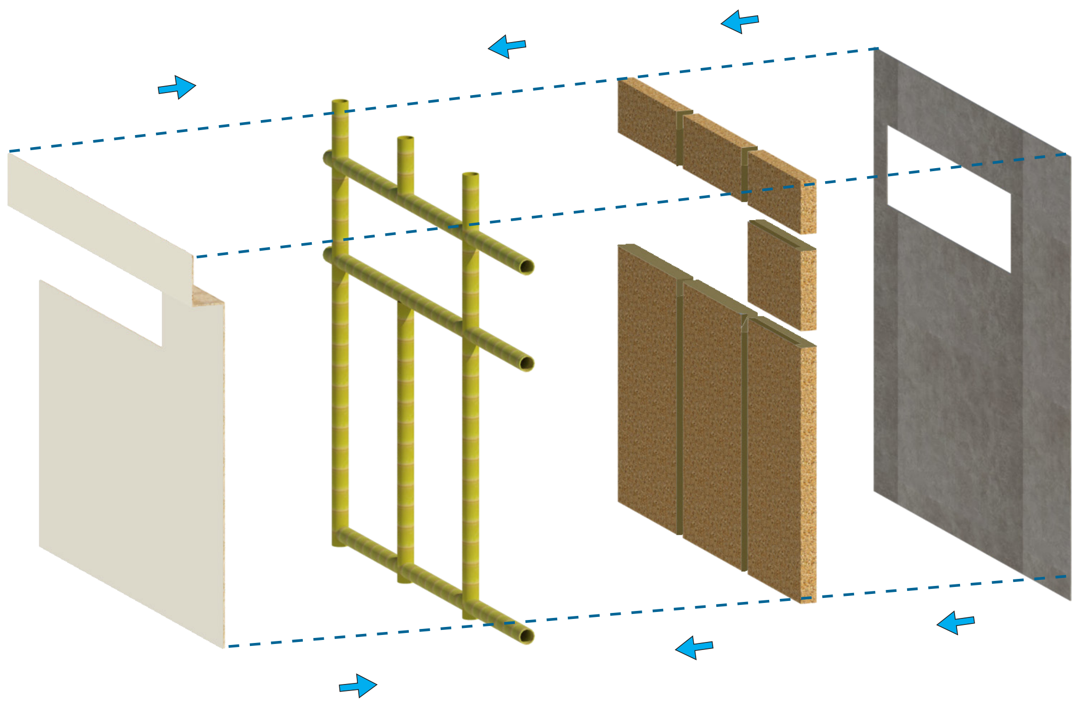


Figure 57: Assembly of layers selected as the Sustainable Sandwich Panel Wall. Source: own.

SUSTAINABLE MATERIAL SANWICH PANEL WALL*									
Material	**Thickness (m)**	**Thermal Mass (J/kg*K)**	**Thermal Transmittance (W/m*K)**	**Embodied Energy (J/Kg)**	**Total CO2 emitted per panel (kg)**	**Recyclability (%)**	**Weight* (Kg)**	**Average Grade**	**Layer Position**
OSB	0.0127	1552	0.13	1.84e7 – 2.03e7	7.3	1.34 – 1.48	8.3	+++	Interior
Cork	0.10	1200	0.042	$3.81e^{6}$ – $4.20e^{7}$	4.8	100	19.2	++++	Insulation
Bamboo	0.10	1008	0.18	$1.43e^{4}$ – $1.58e^{4}$	0.019	1.3 – 1.5	9.3	+++	Structure
Rockpanel	0.008	920	0.37	9.27E+07	14.7	100	8.4	+++	Exterior

*Based on a 1 m^2 model panel as reference

Table 12: Selected sustainable materials to assemble the sandwich panel wall. Source: Own.

6.0 Guest Block 16 Building Evaluation

6.1 Floor Plan Distribution

The building contains different types of rooms distributed over it's 4 levels. The architectural design is shaped by four big blocks of rooms, each block placed on each cardinal point (north, suth, east and west). The North block contains 4 rooms in each of the first 3 levels. over the last floor, two of those rooms connects to the other two pent-house top rooms in the fourth level.
The south block presents the same design structure as the north block, including the connection to the last two pent-house top rooms in the fourth level. In change, the east and west block portray a similar structure between them, which are an apartment composition of a living room and two rooms each. The standard height on each room is 2.40 meters.

These 4 blocks are connected throughout all floor with an open "H" shaped series of hallways and a core of stairs. The condensator units of the HVAC systems are located vertically on the outside gap between the north and east block and the rest are placed over the roof of the hallways of the 3rd floor.

Figure 59: Content of a Living Room in Guest Block 16. Source: own.

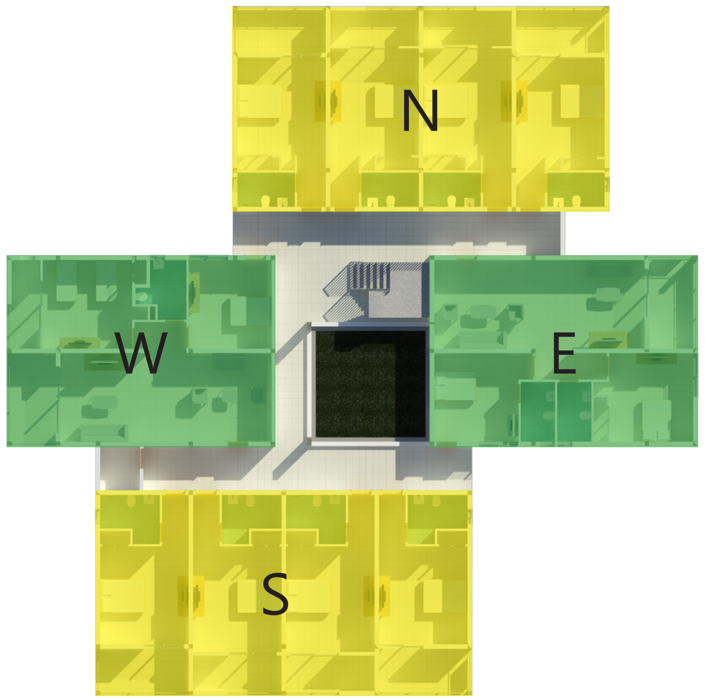


Figure 58: Block of rooms distribution of Guest Block 16. Source: own.

Figure 60: Internal view of a room of Guest Block 16. Source: own.

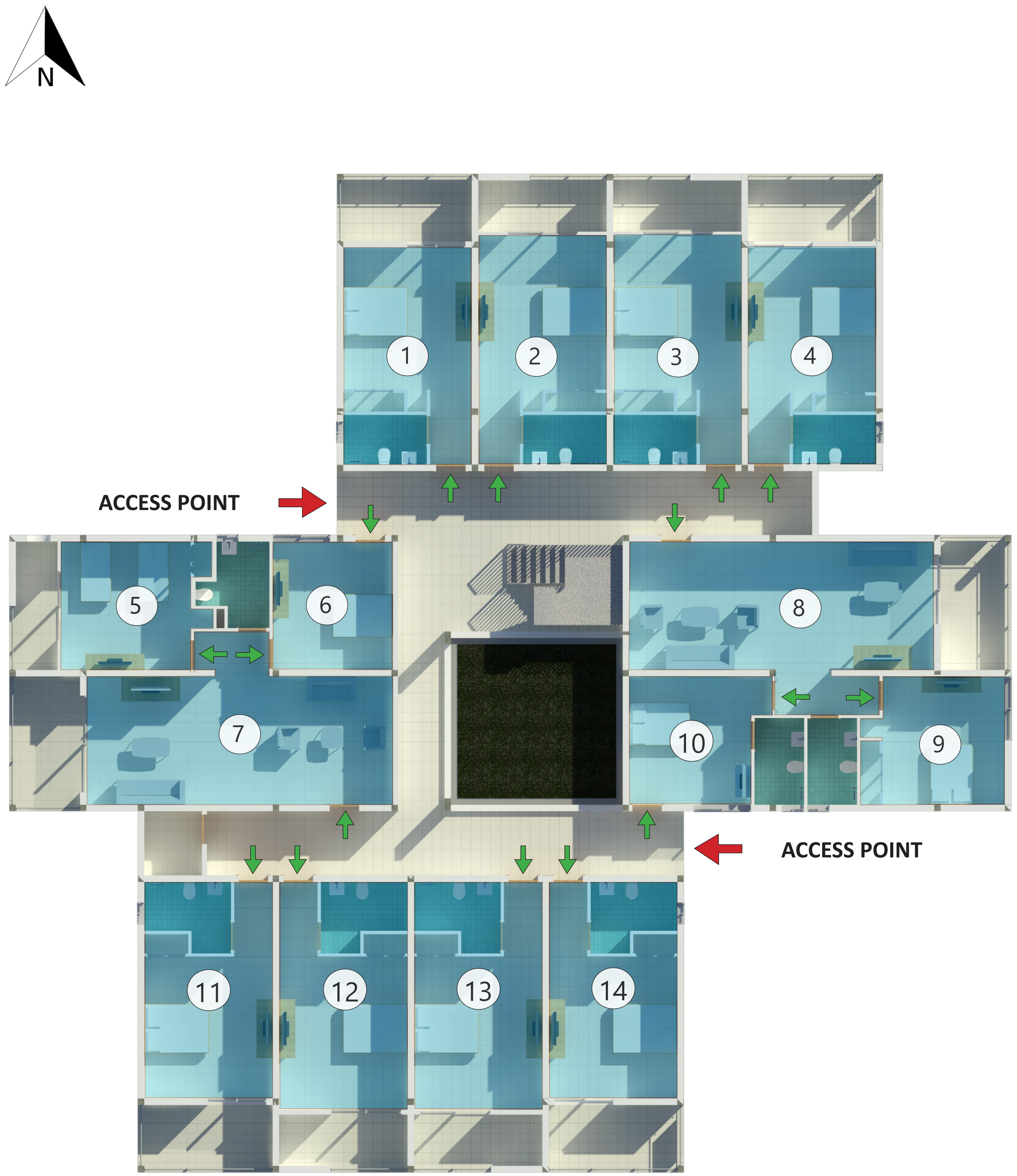


Figure 61: Room distribution plan view of the first level of Guest Block 16. Source: Own

Level 1

Room 1

Room 2

Room 3

Room 4

Room 5

Room 6

Room 7

Room 8

Room 9

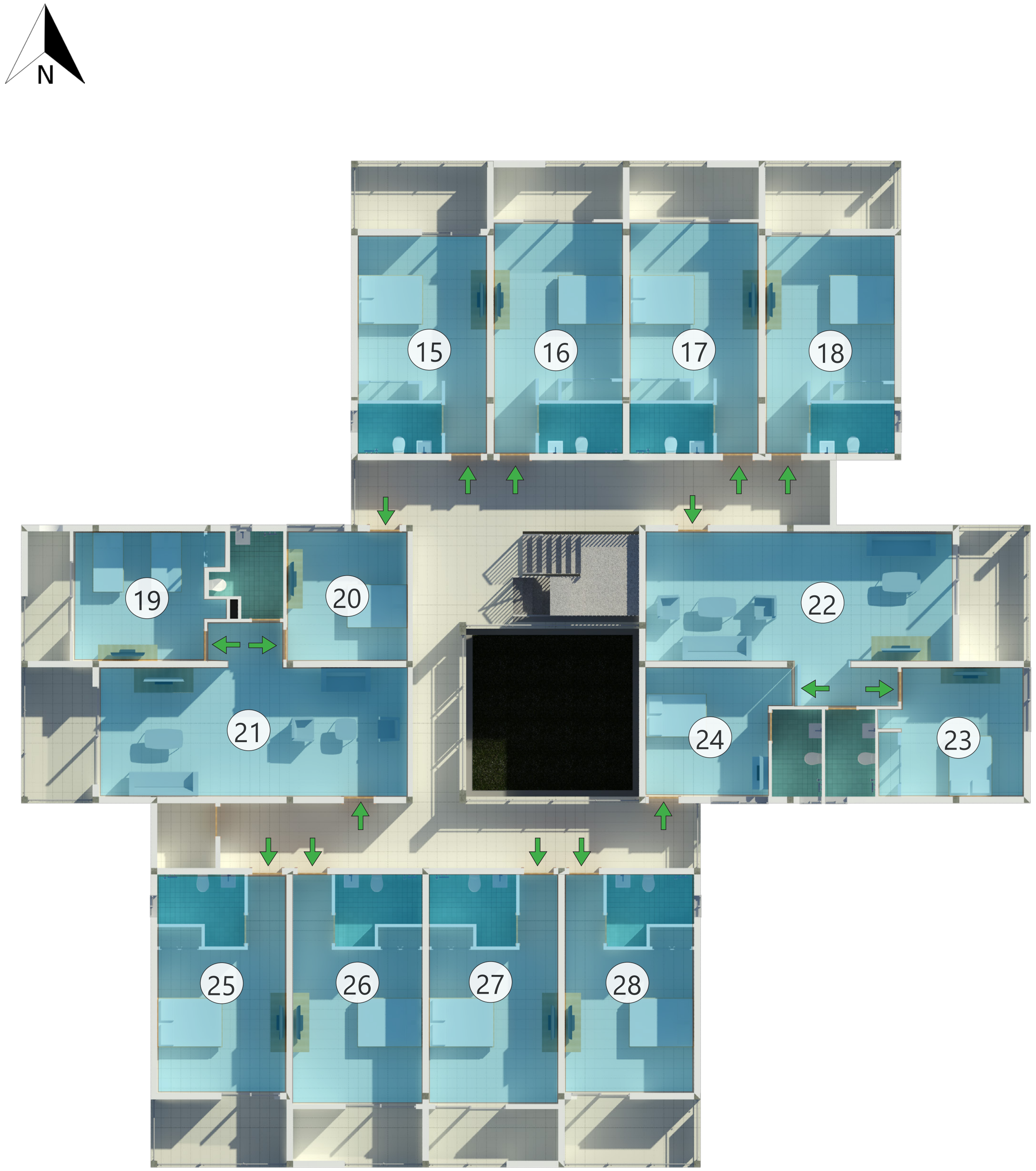
Room 10

Room 11

Room 12

Room 13

Room 14



Level 2

Room 15

Room 16

Room 17

Room 18

Room 19

Room 20

Room 21

Room 22

Room 23

Room 24

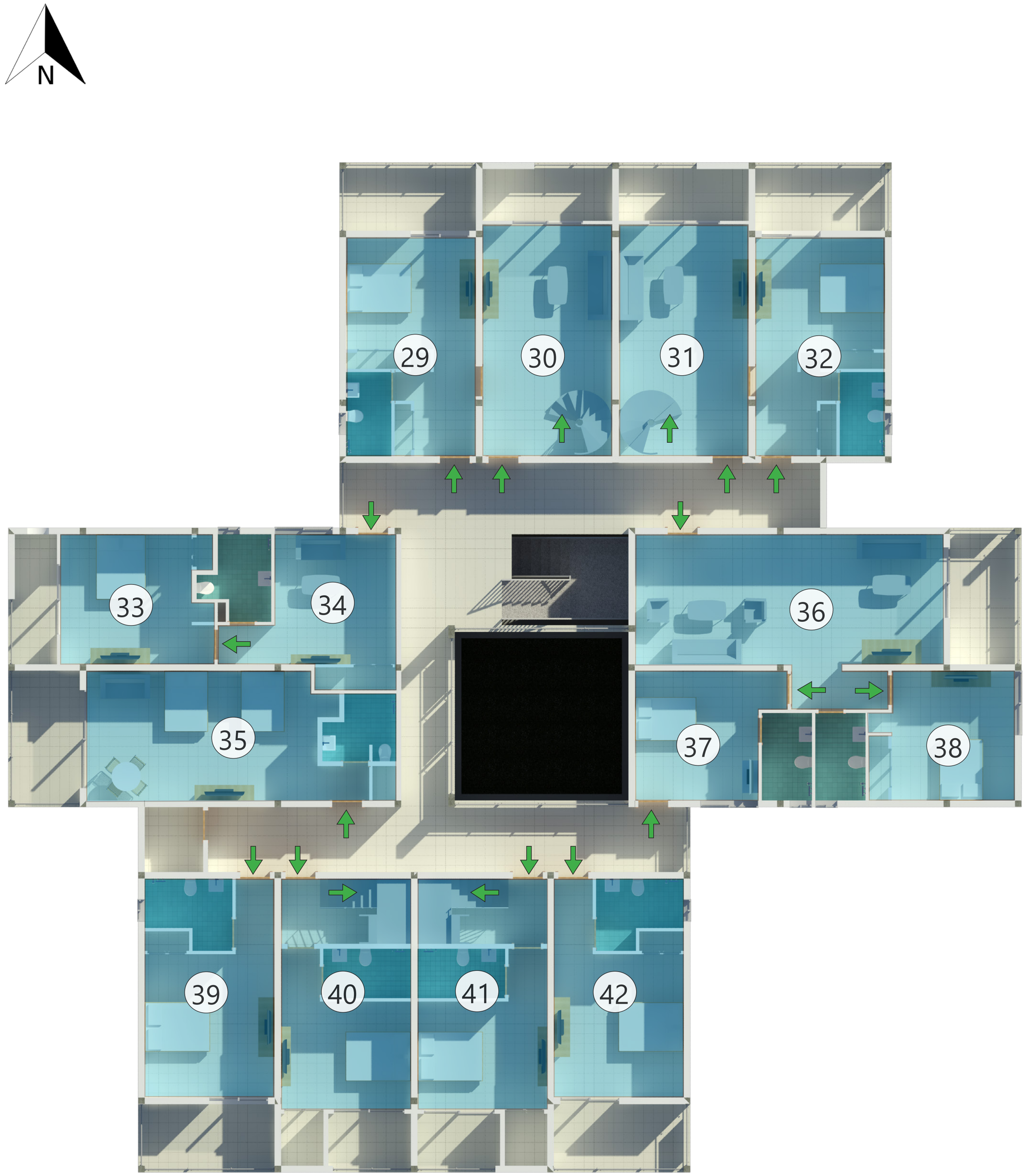
Room 25

Room 26

Room 27

Room 28

Figure 62: Room distribution plan view of the second level of Guest Block 16. Source: Own



Level 3

Room 29

Room 30

Room 31

Room 32

Room 33

Room 34

Room 35

Room 36

Room 37

Room 38

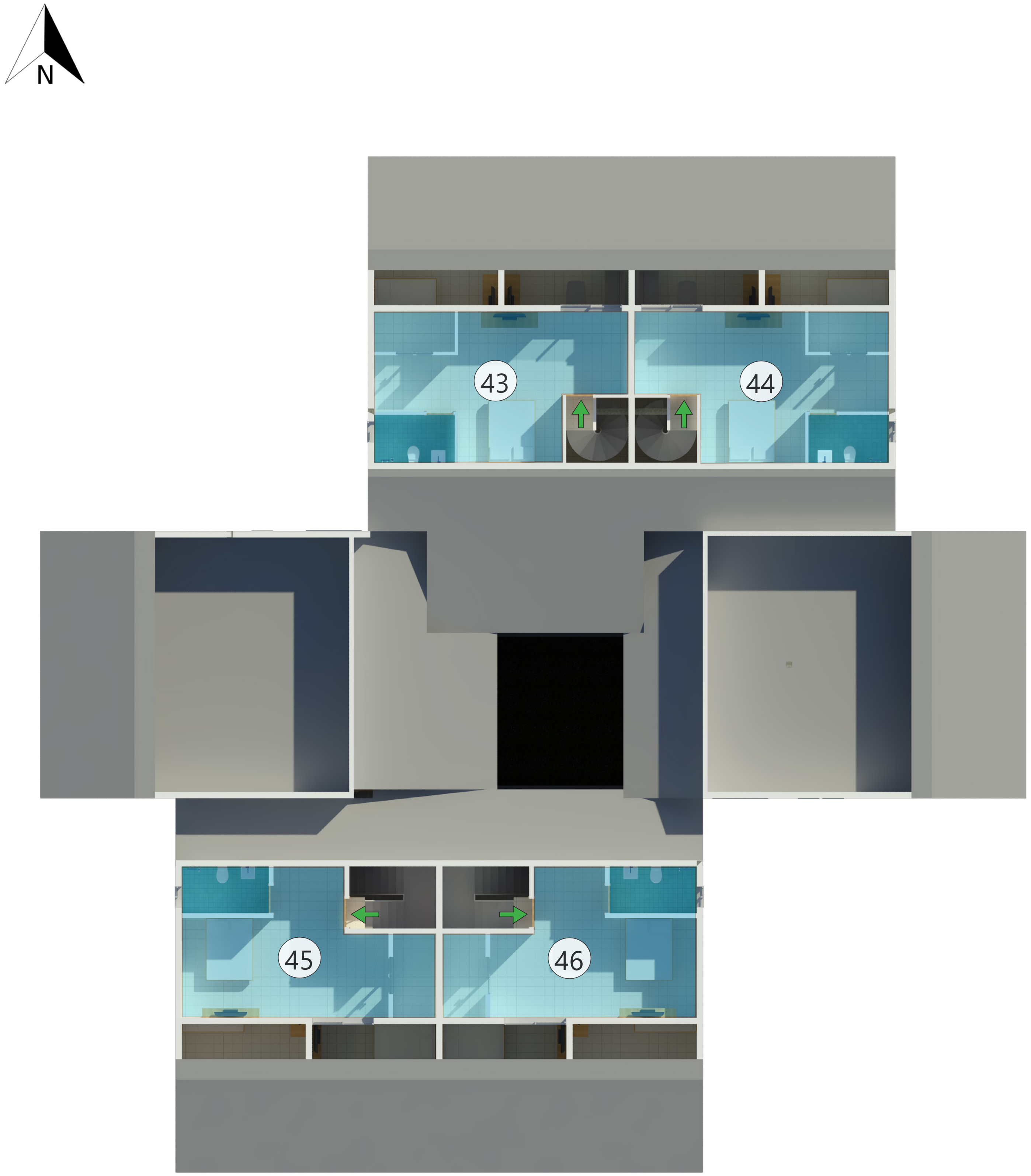
Room 39

Room 40

Room 41

Room 42

Figure 63: Room distribution plan view of the third level of Guest Block 16. Source: Own



Level 4

Room 43

Room 44

Room 45

Room 46

Figure 64: Room distribution plan view of the fourth level of Guest Block 16. Source: Own

6.2 Room Types

JUNIOR SUITE

Description: These suites range from 27.4 m^2 to 29.4 m^2. Their distribution is set between the north and south facades of the building. They usually contain a bathroom with an open gap on the top of the wall to allow the air of the room to reach the bathroom as well. It usually contain one king size bed, a closet and a television. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Junior Suites: 1,2,3,4,11,12,13,14,15,16,17,18,25,26,27,28.

HVAC model: Inverter split-unit

HVAC unit size: 18000 BTU/hr (5.27 KWh)

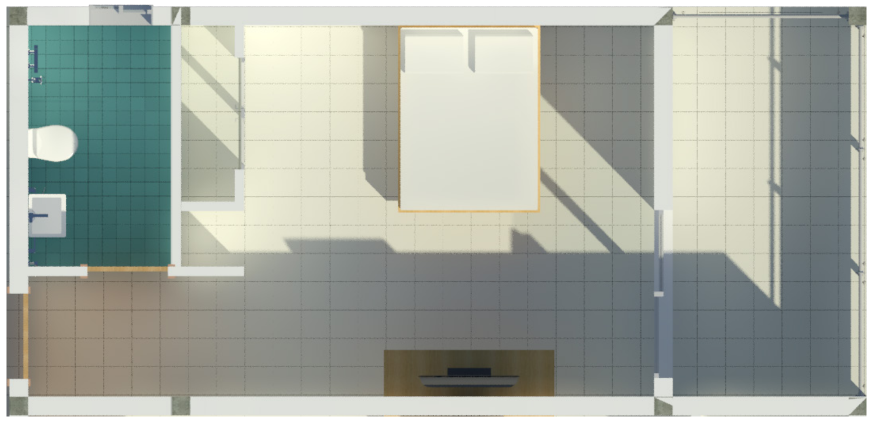


Figure 65: Plan view of a Junior Suite. Source: Own

SINGLE ROOM

Description: These rooms range from 15.0 m^2 to 17.2 m^2. Their distribution is mainly set between the west and east facades of the building. It usually contain one king size bed, in othe cases two twin size beds. Furthermore, it contain a closet, a space for the luggage and a television. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Single Rooms: 5,6,9,10,19,20,23,24,33,34.

HVAC model: Inverter split-unit

HVAC unit size: 12000 BTU/hr (3.51 KWh)

Figure 66: Plan view of a Single Room. Source: Own

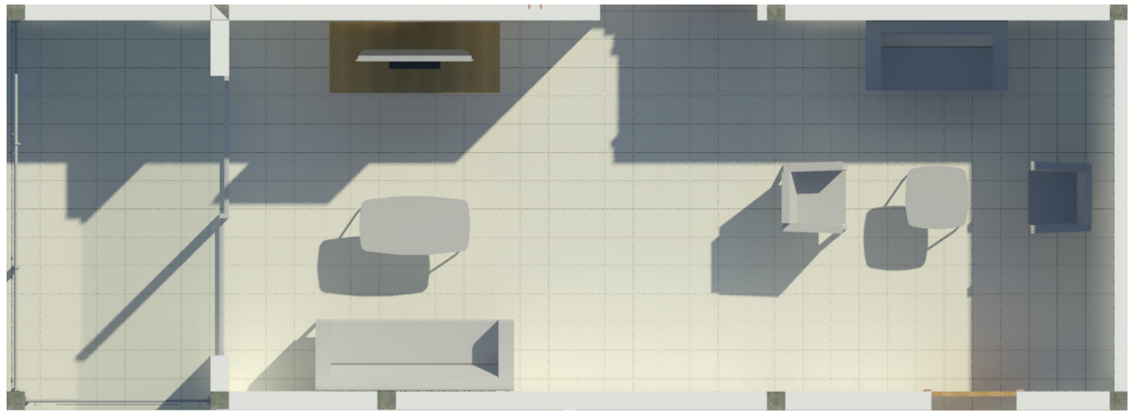


Figure 67: Plan view of a Living Room. Source: Own

LIVING ROOM

Description: These suites range from 38.3 m^2 to 38.5 m^2. Their distribution is set between the west, south and east facades of the building. They usually serve as the intermidiate space to access the single rooms. It usually contain two areas, the first set with a couch, coffee table and a table with a television and the second a small living room set of furnitures. These areas are rare of use because the hotel is all-inclusive. This room has access to an independent balcony through a double paneled-single glazed sliding door.

Rooms identified as Living Rooms: 7,8,21,22,36.

HVAC model: Inverter split-unit

HVAC unit size: 24000 BTU/hr (7.03 KWh)

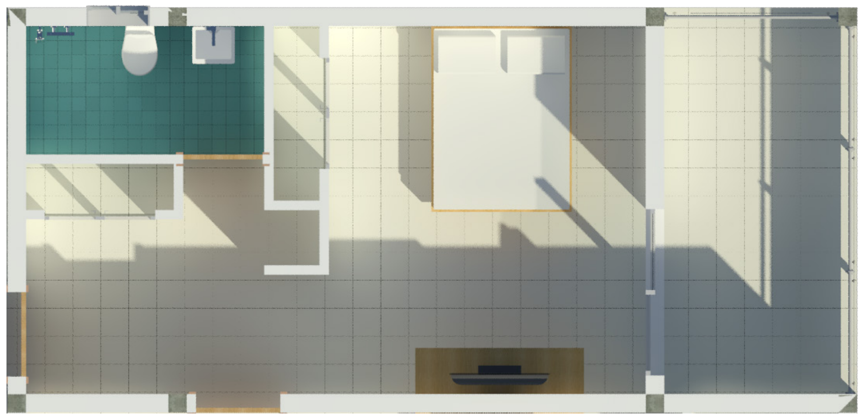


Figure 68: Plan view of a Deluxe Suite. Source: Own

DELUXE SUITE

Description: These rooms contain a standard dimension of 27.4 m^2. Their distribution is mainly set between the west and east facades of the building. They usually contain a bathroom with an open gap on the top of the wall to allow the air of the room to reach the bathroom as well. It also contain two closets, a table and a television. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Deluxe Suites: 29,32,39,42.

HVAC model: Inverter split-unit

HVAC unit size: 18000 BTU/hr (5.27 KWh)

DELUXE DOUBLE SUIT

Description: This suite has a dimension of 38.5 m^2. Its location is found on the west and south facades of the building. They usually contain a bathroom with an open gap on the top of the wall to allow the air of the room to reach the bathroom as well. It contains two queen size beds, a couch, a space for the luggage, a dinning table and a television. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Double Delux Suites: 35.

HVAC model: Inverter split-unit

HVAC unit size: 24000 BTU/hr (7.03 KWh)

Figure 69: Plan view of a Double Deluxe Suite. Source: Own

PENT-HOUSE LIVING ROOM

Description: These rooms have a standard dimension of 29.5 m^2. Their distribution is set on the north facade of the building. It contains a living room area with a couch, coffee table and a television and an open circular staircase to the Pent-House Top Room. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Pent-House Living Rooms: 30,31.

HVAC model: Inverter split-unit

HVAC unit size: 18000 BTU/hr (5.27 KWh)

Figure 70: Plan view of a Pent-House Living Room. Source: Own

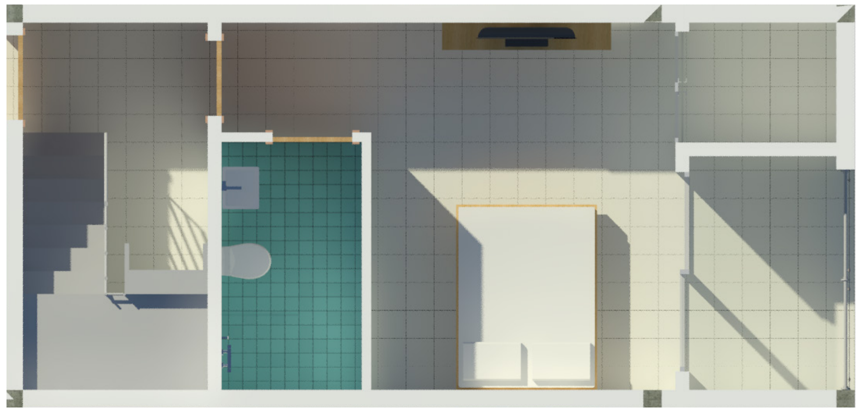


Figure 71: Plan view of a Pent-House First Room. Source: Own

PENT-HOUSE FIRST ROOM

Description: These rooms have a standard dimension of 29.4 m^2. Their distribution is set on the south facade of the building. They usually contain a bathroom with an open gap on the top of the wall to allow the air of the room to reach the bathroom as well. It usually contain one king size bed, a walking closet and a television. This room has access to a private balcony through a double paneled-single glazed sliding door and to an enclosed staircase to a Pent-House Top Room unit.

Rooms identified as Junior Suites: 40,41.

HVAC model: Inverter split-unit

HVAC unit size: 18000 BTU/hr (5.27 KWh)

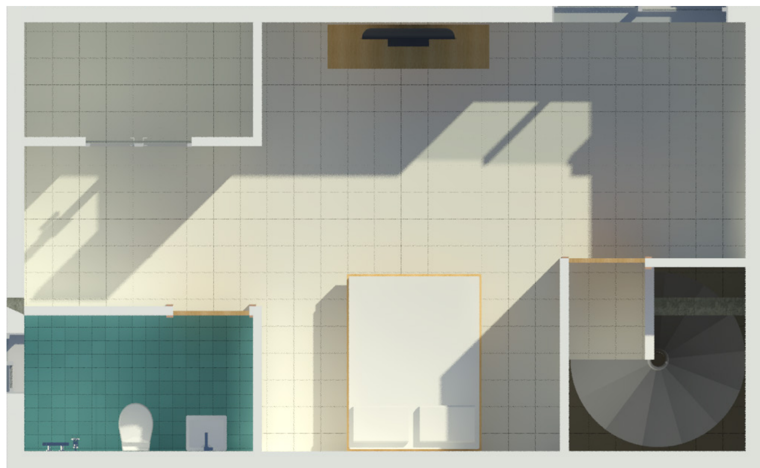


Figure 72: Plan view of a Pent-House Top Room. Source: Own

PENT-HOUSE TOP ROOM

Description: These rooms range from 36.1 m^2 to 37.4 m^2. Their distribution is mainly set between the north and south facades of the building. They are accesed by an enclosed staircase area. They usually contain a bathroom with an open gap on the top of the wall to allow the air of the room to reach the bathroom as well. It usually contain one king size bed, a walking closet and a television. This room has access to a private balcony through a double paneled-single glazed sliding door.

Rooms identified as Single Rooms: 43,44,45,46.

HVAC model: Inverter split-unit

HVAC unit size: 18000 BTU/hr (5.27 KWh)

Activity of Guest Block 16	
Floor Areas and Volumes	
Ocuppied Floor Area (m^2)	1403.1
Ocuppied Volume (m^3)	3143.3
Occupancy	
Occupancy Density (people/m^2)	0.05
Schedule	On 24/7
Metabolic	
Activity	Bedroom (other, cell, etc)
Factor (men= 1.0, women= 0.85, children= 0.75)	0.90
Environmental Control	
Cooling Setpoint Temperatures	
Cooling (°C)	18
Cooling setback (°C)	22
Humidity Control	
RH Humidification Setpoint (%)	20
RH Dehumidification Setpoint (%)	80
Minimum Fresh Air	
Fresh air (l/s-person)	10.0

Table 13: Activity set up data for the calculations of cooling energy consumption of Guest Block 16. Source: Design Builder 2021.

6.3 Guest Block 16 Design Builder Calculations Parameters

Activity

The fist parameter of the calculations is the definition of which activities take place on each room of the building. According to the manager of maintenance of Emotions (2021), since the users enjoy the all-inclusive service of the hotel, the recurrent common behavior is to go outside to have breakfast, lunch and dinner. Most of them enjoy the beach during the morning and another smaller group spend time in the beach after 4 pm. This behavior is altered significantly on summer, because the humidity and temperature influence significantly the thermal comfort of the tourists. Therefore, during the summer the tourist spend less time in the beach and more inside their rooms, enjoying the cooler temperature that the HVACs provide.

For this reason, the room's usage and by consecuence the cooling energy demand is higher over this period of time. Furthermore, this behavioral patterns and reports from maintenance also describe that August is their highest consumer of energy on average since 2016 to 2019. On 2020, because of the pandemic, the tourism experience significant reductions on their average visitors.

The maintenance reports also described that the average cooling energy setpoint temperature managed on the split units by the users is 18 ºC, while the hotel personel by average leave the room prepared for the visitors with a cooling energy setpoint temperature of 22 ºC. The dehumidification setpoint is set from 80% to 20%.

The rest of the data was set up for the average activity on a hotel and by the amount of people per meter square under these circunstances and usage.

Construction

The model of Guest Block 16 was carefully redesigned on Revit 2021 based on the latest architectural drawings used for the renovation of 2017. These documents were provided by the Architecture and Supervision Department of Hodelpa.

As previously described, the structure of the building is based on a portic system of concrete that covers its perimetral openings with heavyweight concrete block walls, plastered on both sides (exterior and interior faces). The interior walls are defined by a lighter type of concrete block walls, also plastered on both sides.

The slabs are made of concrete and on each of the next floors after Level 1 they serve as the ceiling limit for each room.

The flooring used over the concrete slabs are ceramic tiles. These are used as the common flooring tile for either the hallways and all the rooms, except for the bathrooms, which have a different type of ceramic tiles.

The exterior pitched roofs are also made of casted concrete, but in addition for solar and rain protection, posses other impermeable layers.

The values and characteristics of the materials used for the construction modeling are described on the next table.

Construction of Guest Block 16			
Category	**Type**	**Thickness (cm)**	**U-Value**
Exterior Walls	Heavyweight concrete block plastered	20	U = 2.14
Interior Walls	Light-weight concrete block plastered	15	U = 1.92
Ceilings	Concrete slab	15	U = 0.41
Floors	Passive floor, no insulation, tile or vinyl	3	U = 2.95
Slabs	Concrete Slab	15	U = 0.41
Exterior Roof	Waterproof Covering, Polyurethane, Screed, Concrete and Plaster	20	U = 0.53

Table 14: Construction set up data for the calculations of cooling energy consumption of Guest Block 16. Source: Design Builder 2021.

Openings

The design layout of the units has as one of its main features the visual accesibility to the exterior by its characteristic double-paneled single glazed windows. Their sizes vary depending on which unit they are located. For instance, the junior suites usually have the typical 2.10 m height glass panel adjusted inmediately under the concrete beam of the portic system whyle their widths are variable depending if they are on the ends of the rooms block or in the center. For these circumstances, a 1.80 m, a 2.16 m and a 3.00 m withs options are present in these variations of positions of the rooms.

For the situation of the windows of the bathrooms, the smaller sizes of them all are asigned.

The other type of windows are seen on the single rooms, which by design they do not have a private balcony as most of the other rooms, with the exception of the pent-house top rooms, which also have the similar 1.0 m height per 1.80 m or 2.00 m with difference.

The values of the dimension, thickness and U-values are presented in the next table.

Openings of Guest Block 16			
Windows			
Glazing Type	**Dimensions (m)**	**Thickness (cm)**	**U-Value [W/(m^{2}K)]**
Sliding Window Balcony A (Single Glazing)	2.10 x 1.80	0.127	U = 5.56
Sliding Window Balcony B (Single Glazing)	2.10 x 2.16	0.127	U = 5.56
Sliding Window Balcony C (Single Glazing)	2.10 x 3.00	0.127	U = 5.56
Sliding Window Room A (Single Glazing)	0.70 x 0.70	0.127	U = 5.56
Sliding Window Room B (Single Glazing)	1.00 x 1.80	0.127	U = 5.56
Sliding Window Room C (Single Glazing)	1.00 x 2.00	0.127	U = 5.56
Doors			
Door Type	**Dimensions (m)**	**Thickness (cm)**	**U-Value [W/(m^{2}K)]**
Solid Core Oak	0.90 x 2.13	5.1	U = 2.61

Table 15: Openings set up data for the calculations of cooling energy consumption of Guest Block 16. Source: Design Builder 2021.

HVAC System Data

The template used for the HVAC system to operate in the hotel was the split system + mechanical ventilation. The data was verified to be adjusted to the realistic split model with inverter technology that is used today at Emotions.

The performance scenario was set to 24/7 due to the constant use of the air conditioner on the rooms. According the manager of maintenance of the hotel, these units are rarely turned off during the time the tourists use the rooms. Furthermore, he also added that even when they go outside to eat or to enjoy the beach, they leave the units operating to have the pleasant surprise to find a cooled room when they return to the rooms.

As was described in the previous chapters, each room has an individual inverter HVAC system. One evaporator on the inside and one condensator on the outside of the building. To calculate the cooling energy performance, objectively under this critical scenario of the hottest month of the summer of 2019 in the Dominican Republic, the minimum air temperature of operacion of the HVAC was set in the average cooling temperature set point of 18 ^{o}C .

The cooling limit type was set by the capacity of the unit size for each room, previously described on each of the room types. The mechanical ventilation was added to simulate the air extractor placed on the bathrooms. These values were assigned under the criteria of the minimum fresh air sum per person plus the area.

HVAC System Data of Guest Block 16	
HVAC Template	
Template	Split + Mechanical Ventilation
Mechanical Ventilation	
Outside air definition method	Minimum fresh air (Sum per person + per area)
Operation	On 24/7
Cooling	
Cooling System	Individual Inverter Split Units
Fuel	Electricity from grid
Minimum supply air temperature (^{o}C)	18
Cooling limit type	By capacity
Schedule	On 24/7

Table 16: HVAC System set up data for the calculations of cooling energy consumption of Guest Block 16. Source: Design Builder 2021.

Figure 73: Render view of north facade of Guest Block 16 facing the Atlantic Sea. Source: Own

6.4 Cooling Energy Calculations of All the Rooms

For this stage of the cooling energy calculations, a comparison chart was generated to provide a comparison between the simulated cooling energy consumption and the cooling energy consumption reported by the maintenance of the hotel from the month of August in 2019. The purpose of this chart is to provide context and the factual information about the relation of reality vs virtual simulation. The margin of error indicates how close were the calculations in relation to the 10% set for this parameters.

The calculations were set to prioritize the results based on KWh per m^2 for the further selection of the three most critical cooling energy consumption of the 46 rooms. This criteria is based on the consideration of how effective the cooling energy performance is evaluated per floor area. With this is considered that the height of all the rooms has a dimension of 2.4 m. The chart that follows the comparative cooling energy chart presents the three selected most critical rooms. The values contemplated in the chart describes well the humidity levels contemplated, the cooling set point and setback temperatures based on the thermal comfort reported of the users, and the particular characteristics of each room to understand how the exterior and positional conditions affects the cooling energy performance on each one.

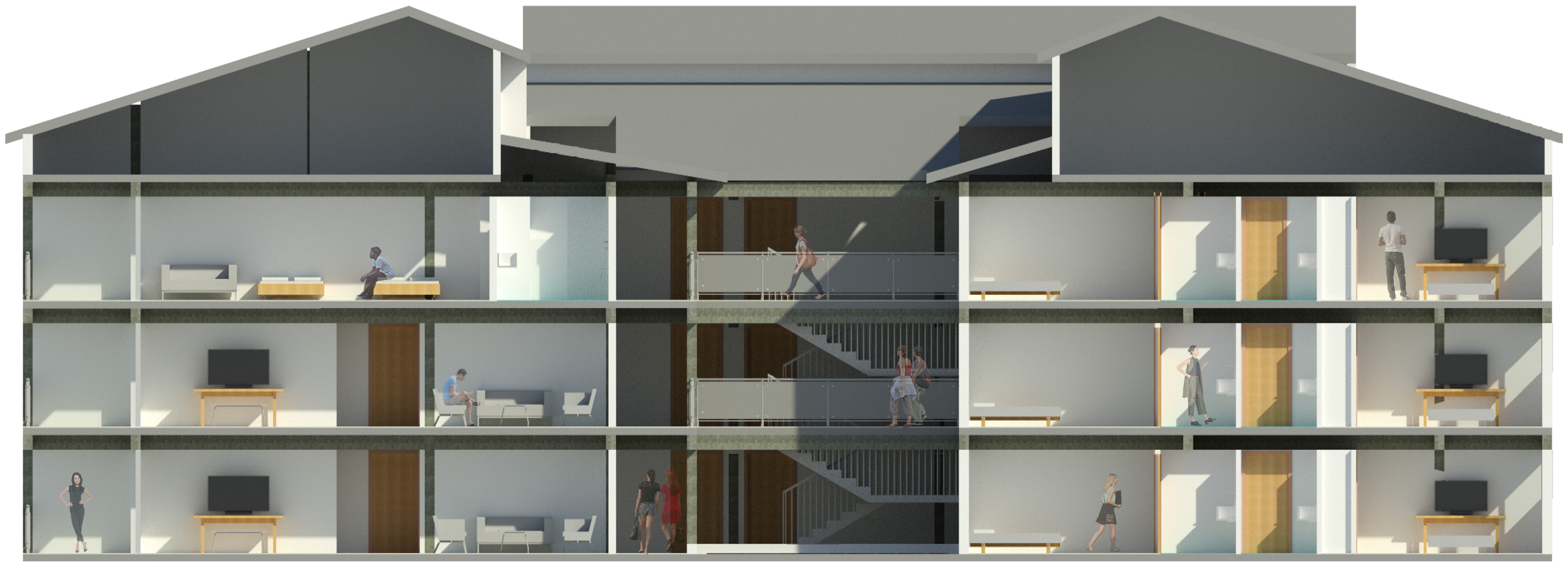


Figure 74: West-east section view of Guest Block 16. Source: Own

Cooling Energy Consumption of Guest Block 16 in the Month of August, 2019 Existing (Registered vs Virtual Calculations)									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Registered Zone Air Sensible Cooling Energy (KWh)	Registered Cooling Load per Area (Kwh/m^2)	Virtual Zone Air Sensible Cooling Energy (KWh)	Virtual Cooling Load per Area (Kwh/m^2)	Margin of Error (%)
Level 1									
Room 1	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	501.9	18.3	549.9	20.1	8.7
Room 2	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	381.1	12.9	403.2	13.7	5.5
Room 3	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	472.1	16.1	499.7	17.0	5.5
Room 4	57.8	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	678.9	11.7	705.9	12.2	3.8
Room 5	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	457.7	25.9	506.4	28.6	9.6
Room 6	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	401.3	23.3	433.5	25.2	7.4
Room 7	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	749.5	19.5	799.2	20.8	6.2
Room 8	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	817.3	21.3	831	21.7	1.6
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	536.2	35.7	558.8	37.3	4.0
Room 10	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	398.9	24.5	420.7	25.8	5.2
Room 11	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	633.3	23.1	665.9	24.3	4.9
Room 12	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	467.4	15.9	473.6	16.1	1.3
Room 13	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	466.1	15.9	475	16.2	1.9
Room 14	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	658.4	24.0	691.4	25.2	4.8
Level 2									
Room 15	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	850.9	31.1	905.7	33.1	6.1
Room 16	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	702.1	23.8	737	25.0	4.7
Room 17	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	351.9	12.0	377.5	12.8	6.8
Room 18	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	874.5	31.9	902.8	32.9	3.1
Room 19	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	517.4	29.2	555.5	31.4	6.9
Room 20	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	425.6	24.7	474.9	27.6	10.4
Room 21	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	887.3	23.0	953.4	24.8	6.9
Room 22	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	906.8	23.7	1010.4	26.4	10.3
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	609.9	40.7	658	43.9	7.3
Room 24	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	466.6	28.6	506	31.0	7.8
Room 25	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	682.7	24.9	735	26.8	7.1
Room 26	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	483.2	16.4	541	18.4	10.7
Room 27	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	333.9	11.4	356.5	12.1	6.3
Room 28	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	792.6	28.9	833.5	30.4	4.9
Level 3									
Room 29	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NW	402.7	14.7	431.6	15.8	6.7
Room 30	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	375.2	12.7	398.3	13.5	5.8
Room 31	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	395.6	13.4	402.6	13.6	1.7
Room 32	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NE	422.4	15.4	449.1	16.4	5.9
Room 33	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	581.7	32.9	610.8	34.5	4.8
Room 34	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	490.8	28.5	540.2	31.4	9.2
Room 35	38.5	Deluxe Double Suite	24000 BTU/hr (7.03 KWh)	SW	540.1	14.0	578.5	15.0	6.6
Room 36	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	997.8	26.1	1053.7	27.5	5.3
Room 37	16.3	Single Room	12000 BTU/hr (3.51 KWh)	SE	519.7	31.9	528.4	32.4	1.6
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	637.7	42.5	667.2	44.5	4.4
Room 39	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SW	715.1	26.1	781.2	28.5	8.5
Room 40	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	555.4	18.9	594.5	20.2	6.6
Room 41	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	603.8	20.5	619.3	21.1	2.5
Room 42	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SE	804.9	29.4	832.4	30.4	3.3
Level 4									
Room 43	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1072.3	28.7	1189.5	31.8	9.9
Room 44	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	1226.8	32.8	1256.9	33.6	2.4
Room 45	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1028.4	28.5	1132.4	31.4	9.2
Room 46	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	992.6	27.5	1068	29.6	7.1
Totals	**1288.4**	-	-	-	**28868.5**	**22.4**	**30696**	**23.8**	**6.0**

Table 17: Registered vs Virtual cooling energy consumption data of Guest Block 16. Source: Emotions Puerto Plata Manintenance Records, Design Builder 2021.

Cooling Energy Consumption of Guest Block 16 in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Outside Humidity (%)**	**Cooling setpoint temperature**	**Cooling setback setpoint temperature**
Level 1									
Room 1	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	549.9	20.1	80%	18 °C	22 °C
Room 2	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	403.2	13.7	80%	18 °C	22 °C
Room 3	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	499.7	17.0	80%	18 °C	22 °C
Room 4	57.8	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	705.9	12.2	80%	18 °C	22 °C
Room 5	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	506.4	28.6	80%	18 °C	22 °C
Room 6	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	433.5	25.2	80%	18 °C	22 °C
Room 7	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	799.2	20.8	80%	18 °C	22 °C
Room 8	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	831	21.7	80%	18 °C	22 °C
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	80%	18 °C	22 °C
Room 10	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	420.7	25.8	80%	18 °C	22 °C
Room 11	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	665.9	24.3	80%	18 °C	22 °C
Room 12	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	473.6	16.1	80%	18 °C	22 °C
Room 13	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	475	16.2	80%	18 °C	22 °C
Room 14	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	691.4	25.2	80%	18 °C	22 °C
Level 2									
Room 15	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	905.7	33.1	80%	18 °C	22 °C
Room 16	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	737	25.0	80%	18 °C	22 °C
Room 17	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	377.5	12.8	80%	18 °C	22 °C
Room 18	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	902.8	32.9	80%	18 °C	22 °C
Room 19	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	555.5	31.4	80%	18 °C	22 °C
Room 20	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	474.9	27.6	80%	18 °C	22 °C
Room 21	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	953.4	24.8	80%	18 °C	22 °C
Room 22	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	1010.4	26.4	80%	18 °C	22 °C
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	80%	18 °C	22 °C
Room 24	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	506	31.0	80%	18 °C	22 °C
Room 25	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	735	26.8	80%	18 °C	22 °C
Room 26	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	541	18.4	80%	18 °C	22 °C
Room 27	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	356.5	12.1	80%	18 °C	22 °C
Room 28	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	833.5	30.4	80%	18 °C	22 °C
Level 3									
Room 29	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NW	431.6	15.8	80%	18 °C	22 °C
Room 30	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	398.3	13.5	80%	18 °C	22 °C
Room 31	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	402.6	13.6	80%	18 °C	22 °C
Room 32	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NE	449.1	16.4	80%	18 °C	22 °C
Room 33	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	610.8	34.5	80%	18 °C	22 °C
Room 34	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	540.2	31.4	80%	18 °C	22 °C
Room 35	38.5	Deluxe Double Suite	24000 BTU/hr (7.03 KWh)	SW	578.5	15.0	80%	18 °C	22 °C
Room 36	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	1053.7	27.5	80%	18 °C	22 °C
Room 37	16.3	Single Room	12000 BTU/hr (3.51 KWh)	SE	528.4	32.4	80%	18 °C	22 °C
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	80%	18 °C	22 °C
Room 39	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SW	781.2	28.5	80%	18 °C	22 °C
Room 40	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	594.5	20.2	80%	18 °C	22 °C
Room 41	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	619.3	21.1	80%	18 °C	22 °C
Room 42	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SE	832.4	30.4	80%	18 °C	22 °C
Level 4									
Room 43	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1189.5	31.8	80%	18 °C	22 °C
Room 44	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	1256.9	33.6	80%	18 °C	22 °C
Room 45	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1132.4	31.4	80%	18 °C	22 °C
Room 46	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	1068	29.6	80%	18 °C	22 °C
Totals	**1288.4**	-	-	-	**30696**	**23.8**	-	-	-

Table 18: Virtual simulation of cooling energy consumption data and indentification of the three most critical rooms of Guest Block 16. Source: Design Builder 2021.

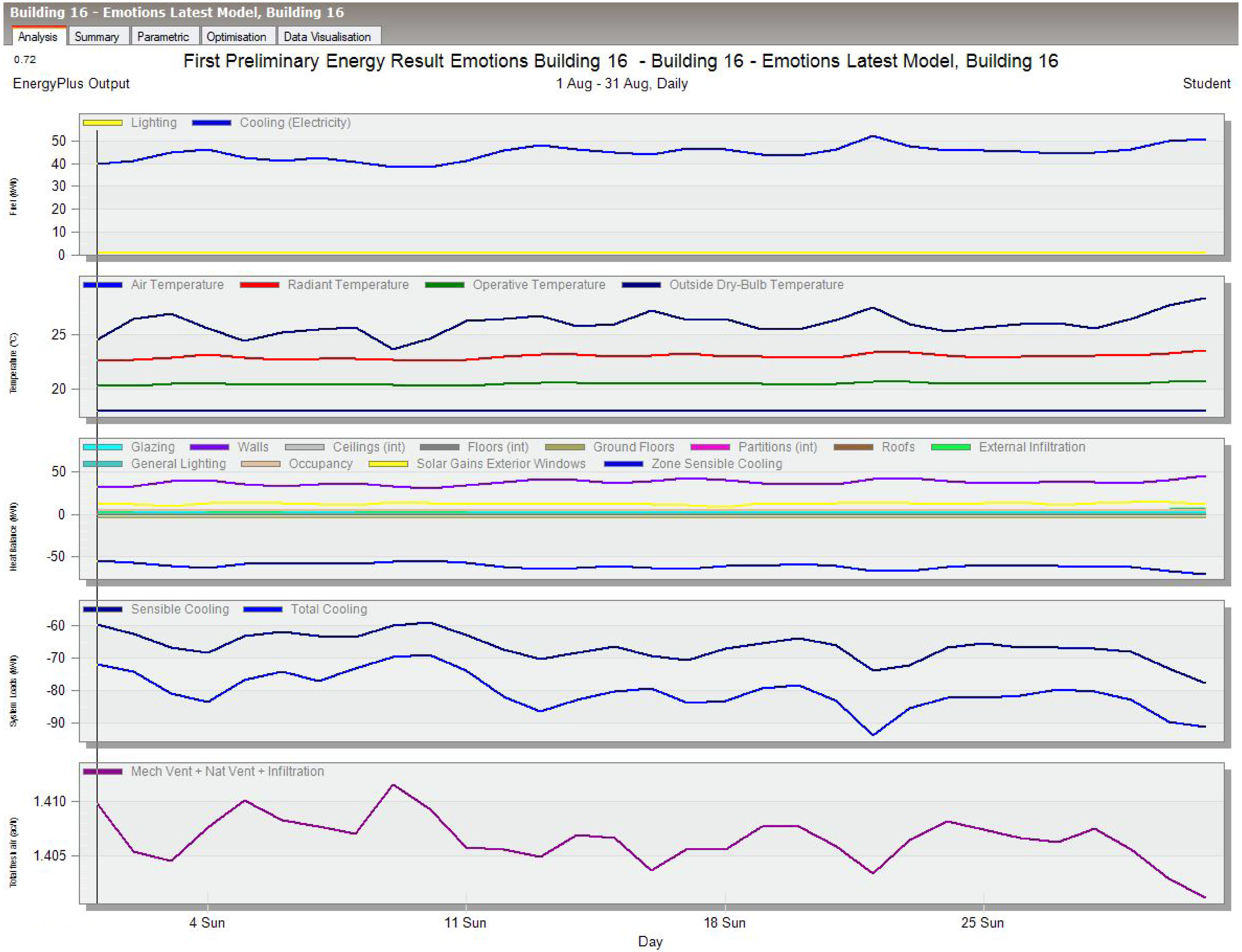


Figure 75: Virtual simulation of cooling energy consumption data collected from rooms 9, 23 and 38 of Guest Block 16 for the month of August, 2019. Source: Design Builder 2021.

Key Observations and Discussions from the energy simulation

The energy simulation of the most critical rooms (9, 23 and 38) of Guest Block 16, visible from Figure 75, brought to attention the amount of fuel used for cooling the rooms of Guest Block 16. Throughout the month in which the simulation was performed (August, 2019), the levels of fuel consumed in kWh for electricity destined for cooling reached high peaks of 50 kWh under the pre renovated (actual) state of the building. The lowest values are seen rounding the 40 kWh during the month-long simulation.

The heat balance of the construction components reflect a major absorption of solar heat gains on the walls, ranging from 31 kWh to 45.6 kWh. The solar heating energy absorption on the exterior windows reflect a lower stable consumption range from 7.5 kWh to 17.9 kWh. The rest of the construction elements are beneath these consumption levels, meaning that the main construction elements to have the attention for the calculation are exterior facade walls for their direct exposition to the sun and the exterior windows on these walls, which also are directly afected by the solar radiation, compared to the rest of the construction elements in their heat balance values.

The values of the HVAC system loads (in kWh) present also higher deficits in their loads of sensible cooling and total cooling levels, probably due to the constant transition of thermal energy between the outside and the inside spaces. This would translate into the HVAC units being constantly trying to maintain the cooling set point temperature inside the room while there are constant fluctuations of temperature through the construction components.

A valid observation made to test the quality of the insulating envelope, considering also the blockage of thermal bridging between the outside and the inside to avoid these thermal fluctuations. The great benefactor of a better insulated space could be the HVAC system itself from this perspective, where its cooling performance would increase if the internal temperature is more stable to control.

6.5 Most Critical Rooms Selection

These 3 critical rooms represent the highest cooling energy consumption per area over the month of August of 2019, as previously described as the hottest month of that touristic active year in the Dominican Republic.

Coincidentially, these 3 rooms are positioned one above each other, located on the East end of the building. Therefore, solar radiation impacts directly on the east and south facade of these identical rooms over the course of the morning and afternoon.

Throughout the cooling energy calculations of each of the phases of the sustainable facade renovation strategies, these rooms will be the reference point to the performance of each intervention. At the end of the calculations, conclusions will be drawn from the results and comparisons between each strategy on each of these critical rooms.

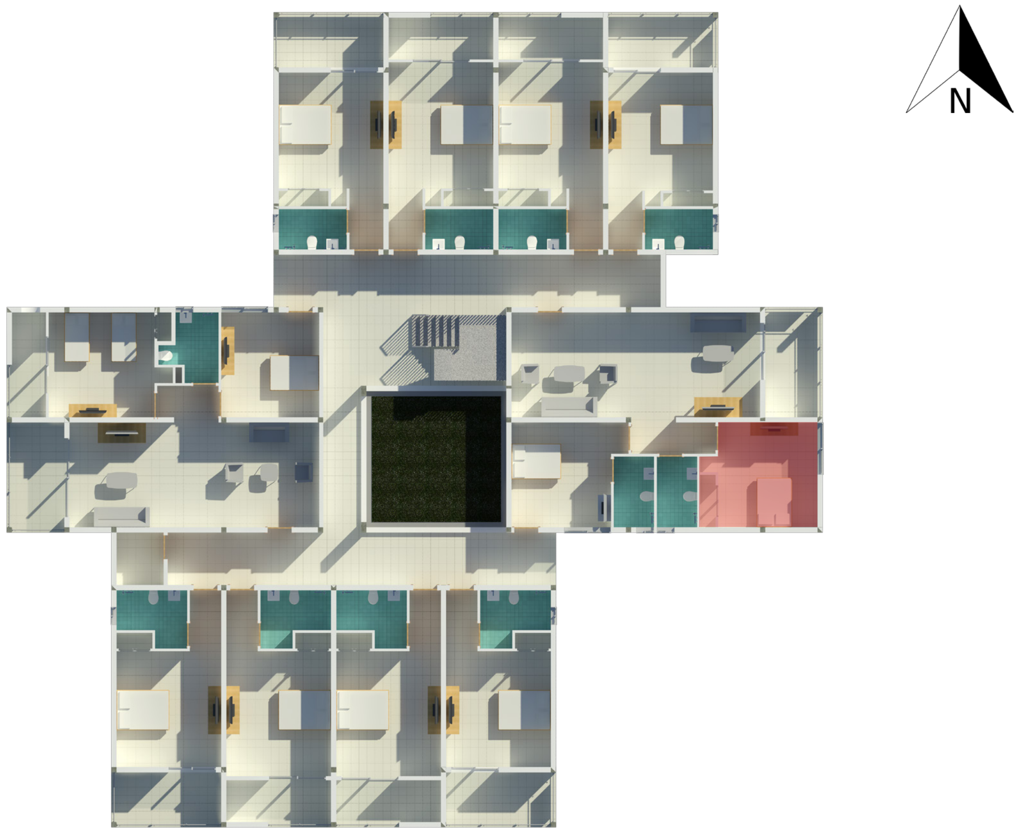


Figure 76: Floor plan location of rooms 9, 23 and 38. Source: Own

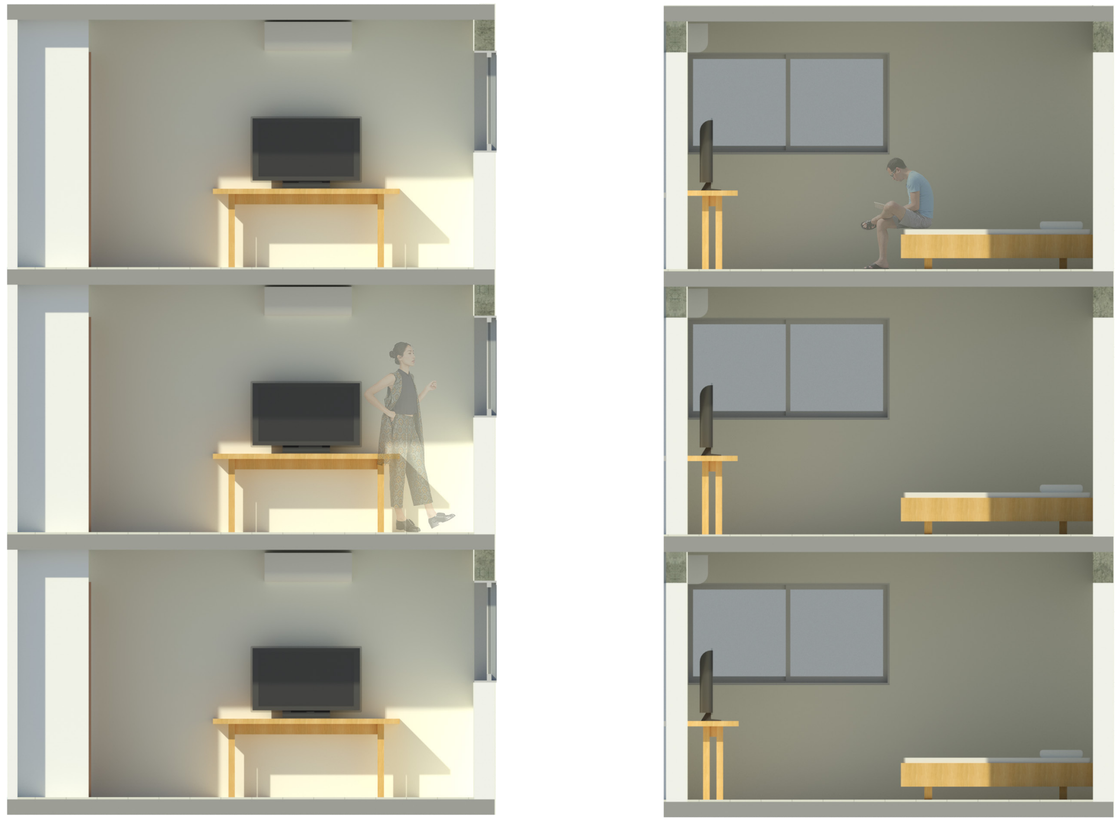


Figure 77: East and south facade section views of rooms 9, 23 and 38. Source: Own

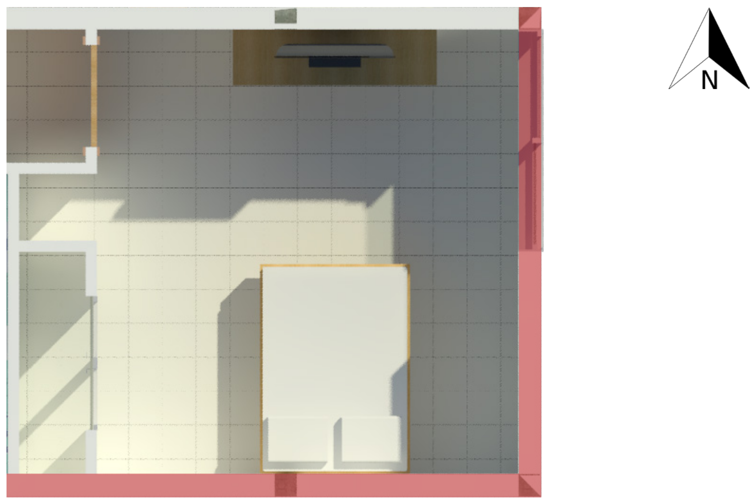


Figure 78: Indication of walls with higher exposure to solar radiation of rooms 9, 23 and 38. Source: Own

6.5.1 Most Critical Rooms Selection - Dynamic Simulation of Room 9

To identify the thermal properties of the selected critical rooms, a dynamic simulation of room 9 is contemplated. The following considerations were assumed for room 9 as the model room for this building physics calculations:

The room has a window size of 2.00 m^2 with an U-value of 5.48 W/m^2.K and a total area sum of exterior facade walls exposed to the sun of 18.30 m^2 with an U-value of 2.14 W/m^2.K. The ventilation considered is 1 air change per hour, with an air density of 1.2 Kg/ m^3, a specific air heat of 1,000 J/kg.K over an air volume of 36 m^2.

The assumed outside temperature, obtained from the average dry-bulb temperature registered by Design Builder over the month of August, 2019 is 31ºC, while the inside temperature is considered as the average cooling of 18 ºC by the HVAC split system (value given by the user experience of Emotions by Hodelpa). The solar load on the window (g= 0.81, obtained from Design Builder) is 520 W/m^2 (obtained from the graphical values of normal solar radiation for the Dominican Republic from Solargis, World Bank Group and ESMAP, 2017).

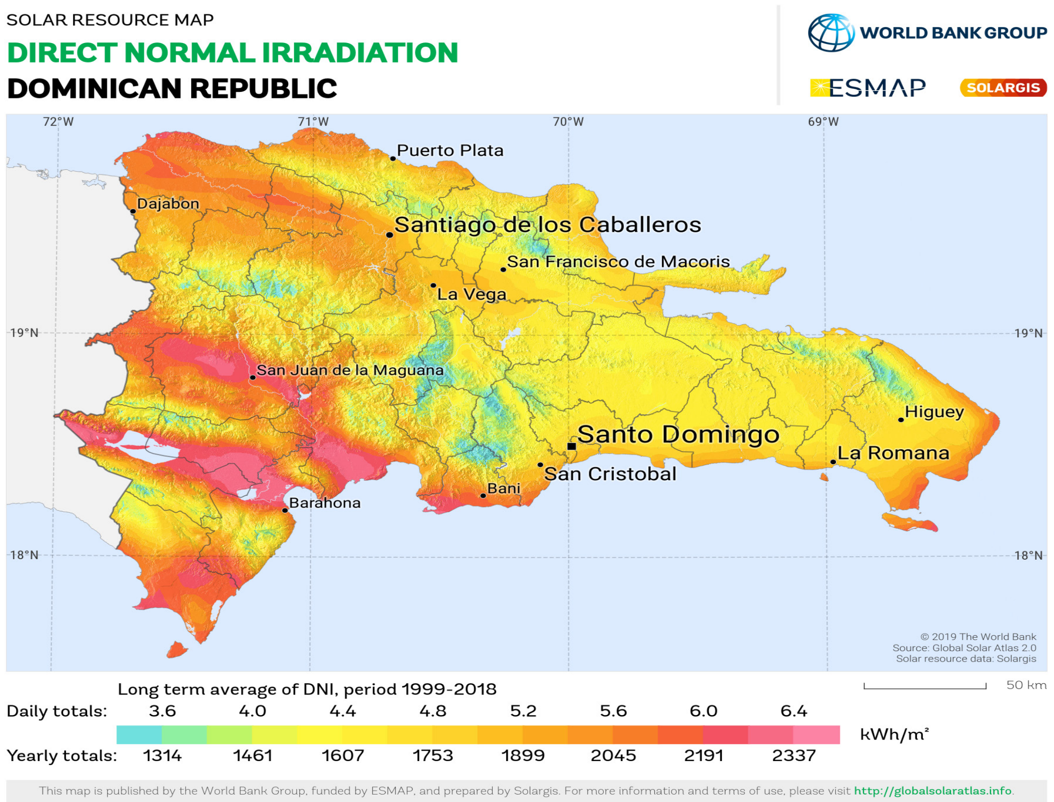
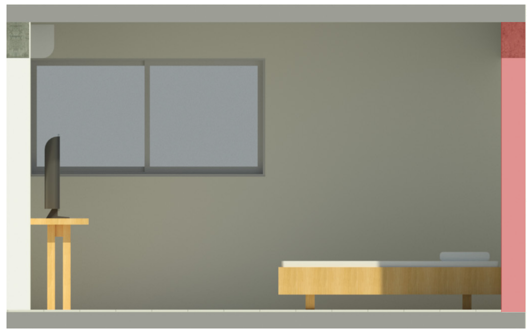


Figure 79: Direct Normal Irradiation of the sun on the Dominican Republic. Source: Solargis.com

The value obtained for Puerto Plata was 5.2 kWh/m^2/day, which translated to W/m^2 using the conversion of 1 W/m^2 is 0.01 kWh/m^2/day, then the converted value obtained is 520 W/m^2.

The heat production for the interior is assumed by 2 persons sitting calmly reading with a 105 W thermal energy metabolic production each (from Building Physiscs book by A.C. van der Linden, 2013). It is assumed that the relevant energy loss of this room is from the directly affected facades to solar exposure (East and West).

This values will be considered on a stationary situation, where people are always inside and the sun is always shinning. The selection of this situation is due to evaluate a critical performance scenario for the HVAC system, which will reveal the Qcooling value under these circumstances. Furthermore, other conclusions will be drawn from this calculations about which surfaces (wall or window) have the highest thermal gains.



Wall A

Position: South
Exposed surface: 10.75 m^2
U Value: 2.14 W/m^{2}K

Wall B

Position: East
Exposed surface: 7.55 m^2
U Value: 2.14 W/m^{2}K

Figure 80: Indication, dimension and u-value of exterior walls with higher exposure to solar radiation of rooms 9. Source: Own

$Q_{transmission} + Q_{ventilation} + Q_{sun} + Q_{intern} - Q_{cooling} = 0$

$\mathbf{Q_{cooling} = Q_{transmission} + Q_{ventilation} + Q_{sun} + Q_{intern}}$

$Q_{transmission} = (A_{window} \times U_{window} + A_{wall} \times U_{wall}) \times (T_{out} - T_{in})$

$Q_{transmission} = (2.00 \times 5.48 + 18.30 \times 2.14) \times (31\ ^oC - 18\ ^oC)$

$Q_{transmission} = (10.96 + 39.16) \times (13)$

$\mathbf{Q_{transmission} = 651.6\ W}$

$Q_{ventilation} = (p_{air} \times c_{air} \times n \times V_{air}) \times (T_{out} - T_{in})$

$Q_{ventilation} = (1.2 \times 1000 \times 36 \times 1/3600) \times (31\ ^oC - 18\ ^oC)$

$\mathbf{Q_{ventilation} = 156\ W}$

$Q_{sun} = qSun \times A_{window} \times g\text{-}value_{window}$

$Q_{sun} = 520 \times 2.00 \times 0.81$

$\mathbf{Q_{sun} = 842.4\ W}$

$Q_{intern} = 2 \times persons$

$Q_{intern} = 2 \times 105\ W$

$\mathbf{Q_{intern} = 210\ W}$

Therefore, the total cooling energy ($Q_{cooling}$) is obtained by the sum of the thermal values of each Q:

$\mathbf{Q_{cooling}} = Q_{transmission} + Q_{ventilation} + Q_{sun} + Q_{intern}$

$\mathbf{Q_{cooling}} = 651.6\ W + 156\ W + 842.4\ W + 210\ W$

$\mathbf{Q_{cooling} = 1,860\ W}$

The thermal transmittance ($Q_{transmission}$) difference between the surface areas of the walls and the window are obtained from the following calculations:

A) For the window:

$Q_{transmission} = (A_{window} \times U_{window}) \times (T_{out} - T_{in})$

$Q_{transmission} = (2.00 \times 5.48) \times (31\ ^oC - 18\ ^oC)$

$\mathbf{Q_{transmission} = 142.5\ W}$

B) For the walls:

$Q_{transmission} = (A_{wall} \times U_{wall}) \times (T_{out} - T_{in})$

$Q_{transmission} = (18.30 \times 2.14) \times (31\ ^oC - 18\ ^oC)$

$\mathbf{Q_{transmission} = 509.1\ W}$

C) Difference:

$Q_{transmission} = Wall\ Q_{transmission} - Window\ Q_{transmission}$

$Q_{transmission} = 509.1\ W - 142.5\ W$

$\mathbf{Q_{transmission} = 366.6\ W}$

The total cooling energy that result from the calculations of this situation is 1,724.8 W. This value defines the amount of energy that is consumed to cool down the thermal energy generated from solar transmission on all surfaces, ventilation of the air volume, the solar incidence on the windows and the metabolic energy generated by human activity.

For the next section of calculations, the formula to discover which is the inside temperature (T_{in}) of Room 9 will be applied under the previous calculated circumstances considering its thermal mass. The following data will be included about the concrete floor:

Room 9 has a concrete (p= 2,500 Kg/m^3, c= 840 J/KgK, obtained from the Building Physics book by A.C. van der Linden, 2013) floor area of 15 m^2 and a height of 2.4 m. The outside temperature, the Q intern, Q Sun, ventilation and transmission data will remain the same for this dynamic calculation. The purpose is to understand how much heating energy absorbs the inside space to modify its temperature considering that the room is heated by the solar radiation in a span of 11 hours (peak solar exposition from 7 am to 6 pm). This value was obtained from the cooling design graph of the day of August 1st, 2019 of energy evaluation performance, where is visible the fluctuations on the margins of the solar gains of the exterior windows between 7:00 am and 6:00 pm (11 hours).

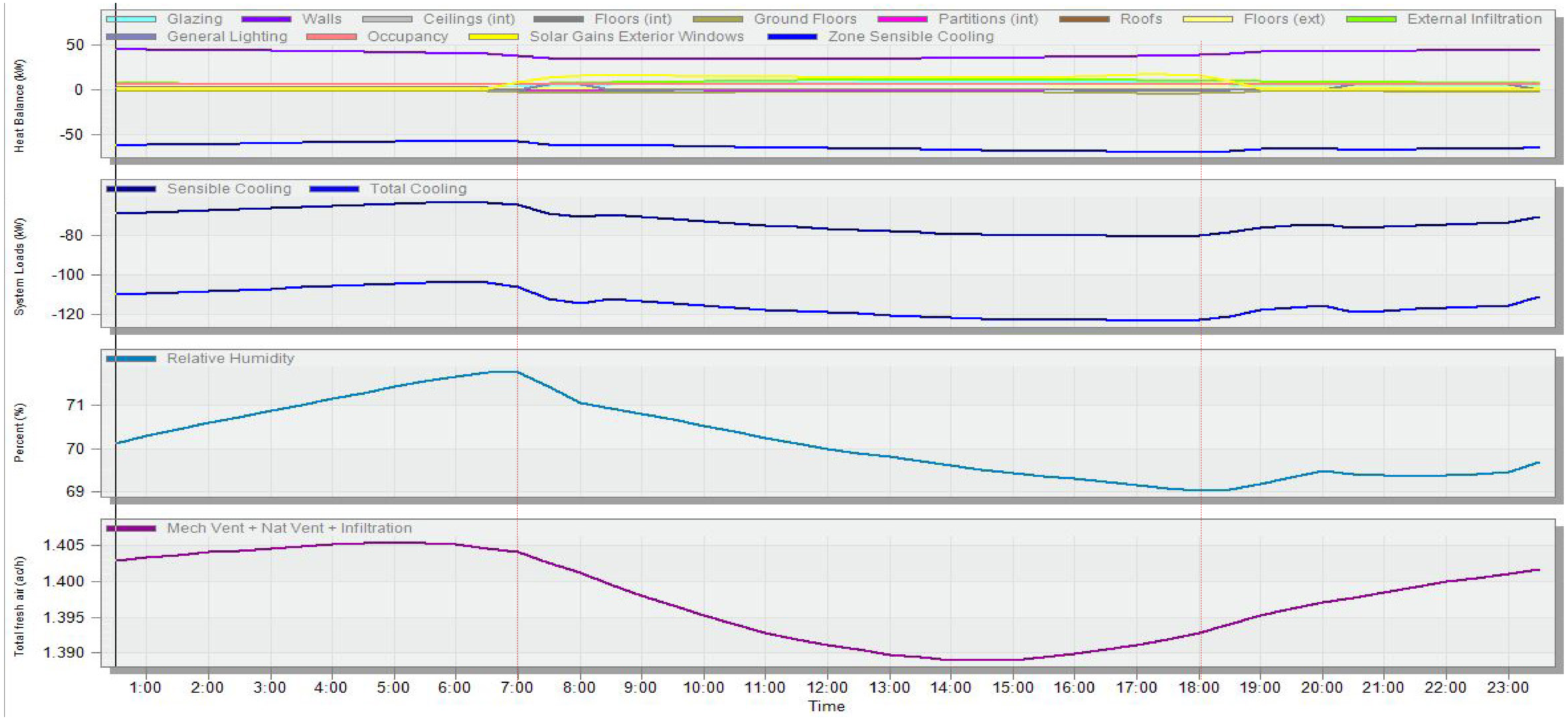


Figure 81: Indication of significant solar energy influence on Guest Block 16 under the cooling design performance simulation of August 1st, 2019. Source: Design Builder

$T_{in} = T_{out} + W/H\ (1 - e^{-H/M \times t})$

$\mathbf{T_{out} = 31\ ^oC}$

t = 11 hours x 3600 seconds = **39,600 seconds**

$W = Q_{intern} + Q_{sun}$

W = 160 W + 707.2 W

W = 867.2 W

$H = H_{transmittance} + H_{ventilation}$

$H = (A_{window} \times U_{window} + A_{wall} \times U_{wall}) + (p_{air} \times c_{air} \times n \times V_{air})$

H = (10.96 + 39.16) + 12

H = 62.12

$M = M_{material} + M_{air}$

$M = \text{floor area} \times \text{thickness} \times P_{material} \times C_{material} + P_{air} \times C_{air} \times V_{air}$

M = (15 x 0.15 x 2,500 x 840) + (1.2 x 1,000 x 36)

M = 4,725,000 + 43,200

M = 4,768,200 J/K

$T_{in} = T_{out} + W/H\ (1 - e^{-H/M \times t})$

$T_{in} = 31 + 867.2/62.12\ (1 - e^{-62.12/4,768,200 \times 39,600})$

$T_{in} = 31 + 867.2/62.12\ (1 - e^{-0.516})$

$T_{in} = 31 + 867.2/62.12\ (0.40)$

$T_{in} = 31 + 5.58$

$\mathbf{T_{in} = 36.58\ ^oC}$

Now, considering the temperature difference when evaluating the H value walls and the windows separately, its obtained:

$H = H_{transmittance} + H_{ventilation}$

$H = (A_{window} \times U_{window}) + (p_{air} \times c_{air} \times n \times V_{air})$

H = 10.96 + 12

H = 22.96

$H = H_{transmittance} + H_{ventilation}$

$H = (A_{wall} \times U_{wall}) + (p_{air} \times c_{air} \times n \times V_{air})$

H = 39.16 + 12

H = 51.16

T_{in} considering only the window:

$T_{in} = T_{out} + W/H\ (1 - e^{-H/M \times t})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (1 - e^{-22.96/4,768,200 \times 39,600})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (1 - e^{-0.191})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (0.17)$

$T_{in} = 31 + 6.42$

$\mathbf{T_{in} = 37.4\ ^oC}$

T_{in} considering only the walls:

$$T_{in} = T_{out} + W/H\,(1 - e^{-H/M \times t})$$

$$T_{in} = 31 + 867.2/\mathbf{51.16}\,(1 - e^{-51.16/4{,}768{,}200 \times 39{,}600})$$

$$T_{in} = 31 + 867.2/\mathbf{51.16}\,(1 - e^{-0.425})$$

$$T_{in} = 31 + 867.2/\mathbf{51.16}\,(0.35)$$

$$T_{in} = 31 + 5.93$$

$$\mathbf{T_{in} = 36.9\ ^{o}C}$$

From the results of the difference of transmission between the walls and the window, is evident to remark that the highest thermal energy absorbtion of Room 9 is obtained through the opaque surface (walls). The difference in thermal energy value is 366.6 W of the total added value of 651.6 W.

Therefore, is important to signal out that the interventions on the facade renovations on the walls might provide higher cooling energy savings than the interventions made on the windows. The same observation can be made by the resulting inside temperatures on both cases of transparent and opaque surfaces considering the thermal masses, where the absorption of thermal energy on the walls allow for a slightly cooler difference in relation to the smaller thermal mass of the glass.

This latter one allows the transference of more thermal energy through its body, which result in a poor thermall energy storage and therefore allowing the room to heat faster in the hour span indicated. Because the walls have a higher thermal mass, this results in the opposite, where a major amount of heat is stored in its own mass and further released after the sun is no longer heating the surface at night (precast.org, 2011).

Parting from these last remarks, the facade renovation strategies will have a priority focus on the external wall interventions. Therefore, the plan for the sustainable facade renovations strategies will be organized on phases, where each phase will determine which were the most effective strategy or strategies after the calculations in the end of each phase and then will refocus the next objectives from these conclusions on the next phase.

In consequence, the first phase will consist of the application of the passive design strategies explained in chapter 3, which are the improvement of the existing single glazing windows to an upgraded and more efficient double glazed windows, the addition of external shading on the window using sustainable wood for the device structure and reducing the window to wall ratio even further from its current size proportion to 50% its size.

After these simulations on Design Builder, conclusions will be drawn to determine which strategy provided the most cooling energy savings for the facade renovation and from that point, the next phase will focus on applying this strategy on different variants on the opaque surface (walls), which were the areas that reflected the highest thermal energy gains on the previous calculations. These variants could be the following:

If the improvement of the window glazing provides the most cooling energy savings, then other types of glazing will be tested in the simulation on phase 2, such as triple glazing and quadruple glazing.

If the improvement of the shading provides the most cooling energy savings, then other sizes of external shading on the external opaque areas (walls) will be tested in the simulation on phase 2, such as 0.5 m overhang, 1.0 m overhang, 1.5 m overhang and 2.0 m overhang. This approach will answer the question whether why these atypical rooms were the most cooling energy consuming per m^2 when compared to the rest of the rooms of the building, which most have overhangs over the directly conected balconies.

For the third phase is planned to consider the assembly of sustainable material layers over the existing external facade walls. The evaluation on the simulation will consider three scenarios for the cooling energy saved if the composed layers are added on the external side of the existing wall and if the existing walls are replaced by these panels. In the last strategy, the experiment of the ventilated facade in these layers will be tested as well.

6.6 Sustainable Facade Renovation Strategies

6.6.1 Phase 1: Application of Individual Passive Design Strategies

STRATEGY: IMPROVEMENT FROM SINGLE TO MORE EFFICIENT DOUBLE GLAZED WINDOWS

To begin the cooling energy performance evaluation, the application of individual passive design strategies is performed through the renovation of the poor performing single glaze windows to a more efficient double glazed window.
Therefore the first strategy of phase 1 will consist of replacing the single glazed 12.7 mm windows with a double glazed with LoE coating and tint laminated layer. The thickness of the glasses are 6 mm with a 13 mm cavity filled with argon gas. This model was retrieved from the library of Design Builder in order to provide a desirable category of double glazed with the lowest U-value possible among the other options available. The referenced efficiency is based on these solar performance qualities mentioned before.

Current Glazing Type: Single Clear Glazing 12.7 mm
U-Value(W/m2K): 5.479
g-Value: 0.81

New Glazing Type: **Double LoE (e2=1) Tint 6mm/13mm Arg**
U-Value(W/m2K): **1.499**
g-Value: **0.36**

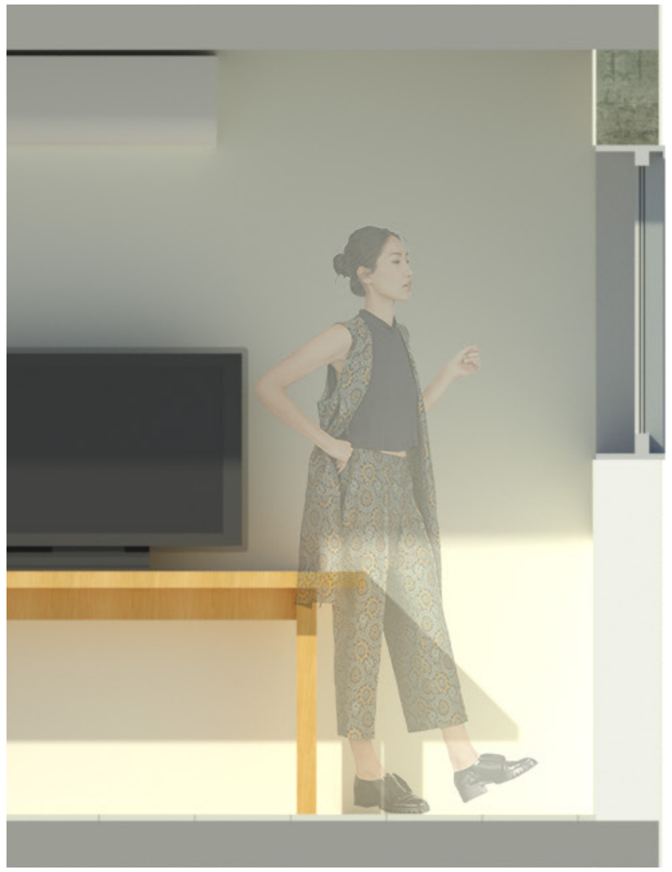


Figure 82: East Facade Opening of Rooms 9, 23 and 38 replaced by Double Glazing. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 1: APPLICATION OF INDIVIDUAL PASSIVE DESIGN STRATEGIES									
Improvement from single glazed to more efficient double glazed windows									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	510.1	34.0	**8.7**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	605.8	40.4	**7.9**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	614.8	41.0	**7.9**

Table 19: Cooling energy performance results from improving single glazed windows to more efficient double glazed windows of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: ADDITION OF EXTERIOR SHADING ON THE WINDOWS

The second independent strategy is to apply an external shadding to the windows. The exterior structure is based on glulam boards of 5 cm thick and adjusted to the 1.00 per 2.00 m dimensions of the window opening. The protrusion of the perimeter frame outwards is of 20 cm from the wall surface.

On Design Builder, the input data for shading were the following:

Type: **High reflectance - low transmittance shade**

Position: **Outside**

Control type: **Always on**

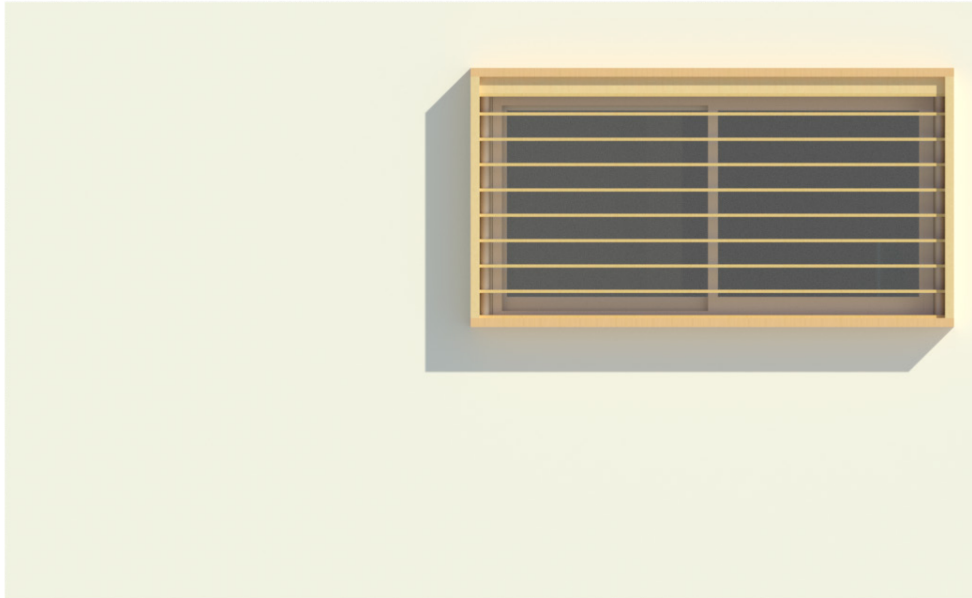


Figure 83: East elevation view of the shading strategy on Room 9. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 1: APPLICATION OF INDIVIDUAL PASSIVE DESIGN STRATEGIES									
Addition of exterior shading on the windows									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	434.8	29.0	**22.2**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	512.7	34.2	**22.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	535.6	35.7	**19.7**

Table 20: Cooling energy performance results from adding an exterior shading device on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: REDUCTION OF THE WINDOW-TO-WALL (WWR) RATIO BY 50%

The third independent strategy is to reduce the window to wall ratio from its current value by 50%. Therefore, the current value was halved from 30% to 15%. This resulted in a reduction from the original 1.0 m x 2.0 m window to the new window dimension of 0.5 m x 2.0 m.

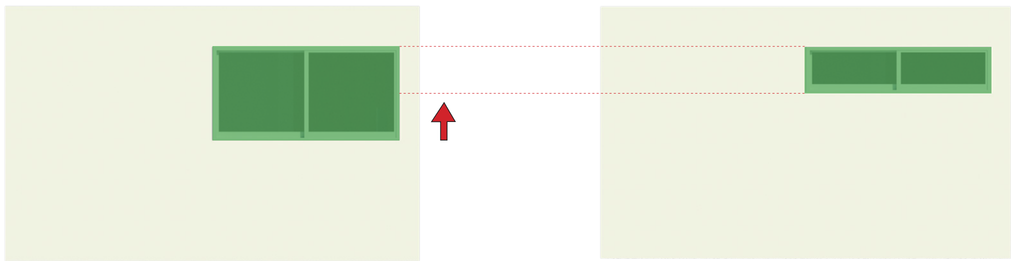


Figure 84: East elevation view of the WWR strategy on Room 23. Source: Own

Figure 85: East elevation view of the WWR strategy placed on Room 23. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Zone Air Sensible Cooling Energy (KWh)	Cooling Load per Area (Kwh/m^2)	Zone Air Cooling After Strategy (KWh)	New Cooling Load per Area (Kwh/m^2)	Savings (%)
PHASE 1: APPLICATION OF INDIVIDUAL PASSIVE DESIGN STRATEGIES									
Reduction of the Window-to-Wall ratio % (WWR)									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	452.4	30.2	**19.0**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	588.0	39.2	**10.6**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	614.2	40.9	**7.9**

Table 21: Cooling energy performance results from reducing the WWR by 50% on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

CONCLUSIONS OF THE RESULTS FROM THE STRATEGIES OF PHASE 1

The results present a variation of savings depending on the strategy. The least savings in cooling energy consumption were observed on the strategy of improvement towards double glazing, which remained under 10%.

A raise in savings from the first mentioned strategy are visible on the WWR, where the highest saving numbers were recorded on Room 9 by almost reaching a 20% difference. However, the results were inconsistent for rooms 23 and 38 in relation to room 9 in this strategy.

On the other hand, the highest savings in cooling energy demand were observed consistently between the three rooms on the strategy of the addition of external shading. In this intervention, the savings reached as far as 22% in savings, while the least of this rooms achieved saving numbers of 19.7%, adding a consistency value on the results, compared with the other two passive design strategies.

On Figure 86 , which represents the energy analysis of the simulation on the strategy of external shading, is visible to notice that the cooling energy consumption decreased significantly when compared to the values given of the general simulation of the building visible on Figure 75. The electricity fuel used for cooling energy presented a significant decrease in the energy consumption, presenting values ranging from 30 to 40 kWh. This is an improvement if the previous values presented on Figure 75 display ranges from 40 to 50 kWh.

Therefore, the most effective strategy of the Phase 1 energy simulation proved to be the addition of external shading on the windows. This means that the path to follow for Phase 2 of the sustainable facade renovation strategies will be based on the shading strategy, a decision fundamented on its energy savings potential in this particular climate and construction conditions.

Furthermore, as planned from the dynamic calculations section, Phase 2 will simulate the performance of four different shading strategies based on the overhang length over the opaque surfaces of the rooms. This parts from the results obtained that revealed that the opaque surfaces have a significant influence on the thermal absorption of the rooms when compared with the glazing surfaces. The lengths of the overhangs over the opaque surfaces to evaluate will be 0.5 meters, 1.0 meters, 1.5 meters and 2.0 meters. These dimensions were chosen in relation to provide a simple shading overhang in the 0.5 m option, where for my experience in typical dominican housing construction consider overhangs parting from 0.4, 0.5 and 0.6 meters of length, given the structural capability of reinforced concrete overhangs. These values were widely used in both during the architectural design studies and in the practice of construction in the Dominican Republic and Jamaica.

Therefore, from this basic parameter for overhangs in Dominican construction, which is also the base value for overhangs over opaque surfaces in Design Builder, the evaluation will be based on the simulation of the segments of 0.5 meter length plus other segment of 0.5 meter in the next strategy. Resulting in the addition of 0.5 meter afters each strategy until it reaches 2.0 meters of overhang, which is the average value of the lenght of balconies that provide shading on the sliding single glazed doors and which also provided better cooling energy performances per meters square when compared to the most critical room values of Guest Block 16. This approach is made to observe if the lenght of the overhang add an important difference in the cooling energy savings value.

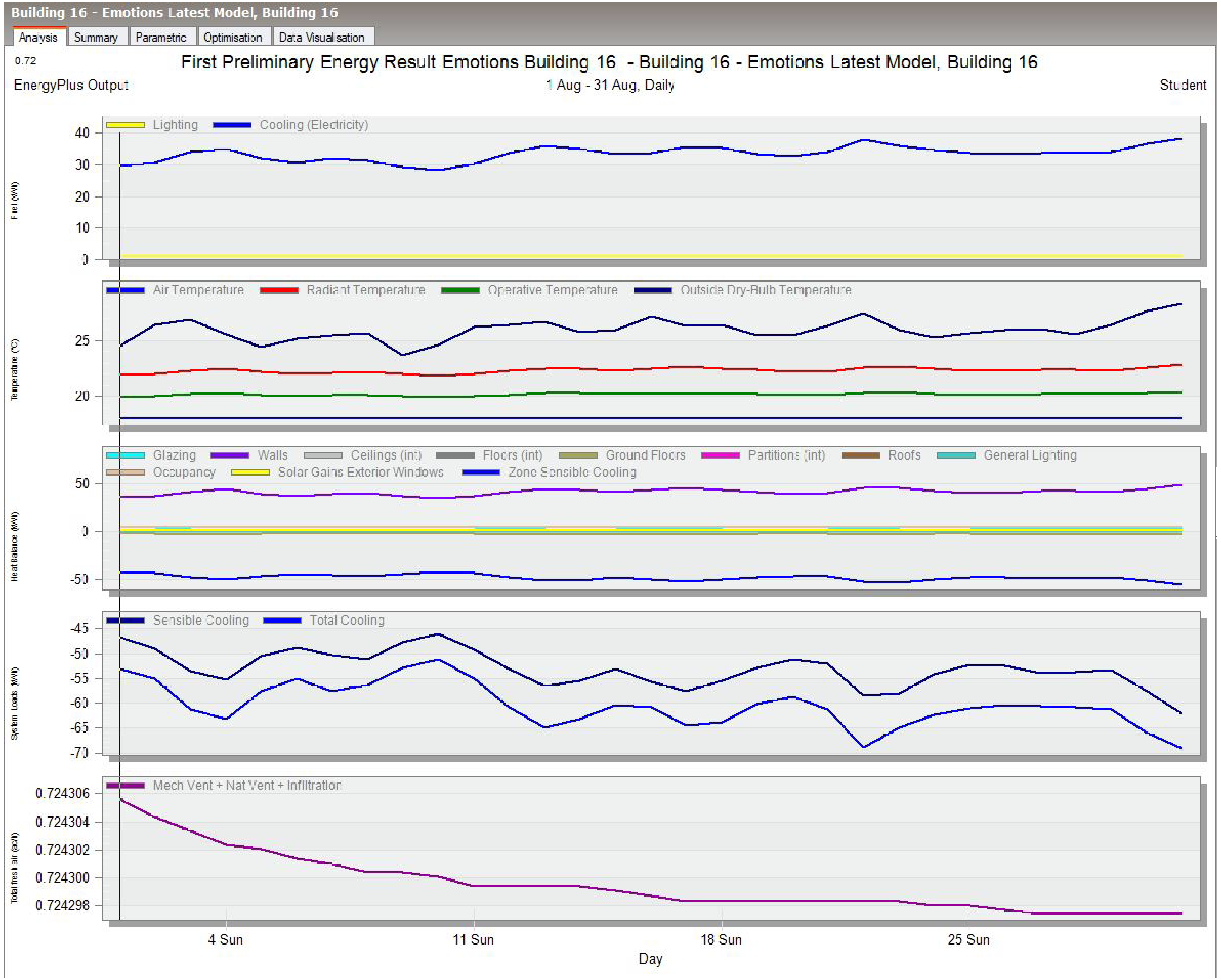


Figure 86: Cooling Energy Analisys of rooms 9, 23 and 38 under Strategy 2 (Shading) of Phase 1. Source: Design Builder 2021

6.6.2 Phase 2: Application of External Shading to Opaque Surfaces

STRATEGY: APPLICATION OF SHADING OVERHANGS OF 0.5 METERS LONG

This first strategy of the combined approach of Phase 2 is the addition of external overhangs of 0.5 meters long to shade the opaque surfaces, this strategy consider the external shading on the windows as well for the calculations. The vertical placement of these overhangs are organized to cover all the direct sun light given the lowest inclination of the sun from east to west. According to the data presented in the climate of the Dominican Replublic section, this angle of the sun path for the month of August has an inclination of 42.7 º, resulting in the placement of each horizontal shading after 0.5 meters throughout the lenght of the opaque surface for this strategy. The material intended for the overhang structure is glulam, from the sustainable materials table.

Shading type: **High reflectance - low transmittance shade**

Position: **Outside**

Control type: **Always on**

Figure 87: Section view of the exterior shading strategies on both window and walls. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 2: APPLICATION OF EXTERNAL SHADING TO OPAQUE SURFACES									
Application of shading overhangs of 0.5 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	384.9	25.7	**31.1**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	457.6	30.5	**30.5**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	473.8	31.6	**29.0**

Table 22: Cooling energy performance results from the combinations of double glazing and shading on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: APPLICATION OF SHADING OVERHANGS OF 1.0 METER LONG

This second strategy of the combined approach of Phase 2 is the addition of external overhangs of 1.0 meter long to shade the opaque surfaces. The vertical placement of these overhangs are organized to cover all the direct sun light given the lowest inclination of the sun from east to west. According to the data presented in the climate of the Dominican Replublic section, this angle of the sun path for the month of August has an inclination of 42.7 º. The placement of the horizontal shading overhangs structures on this strategy considered the position of the windows, placing a structure on both top and bottom ends of the window as a starting point and then the rest of the overgang structures where placed to cover the sunlight in the interval positioning of aproximated 1.0 meters in respect of each overhang vertically throught the opaque surface. The material intended for the overhang structure is glulam, from the sustainable materials table.

Shading type: **High reflectance - low transmittance shade**

Position: **Outside**

Control type: **Always on**

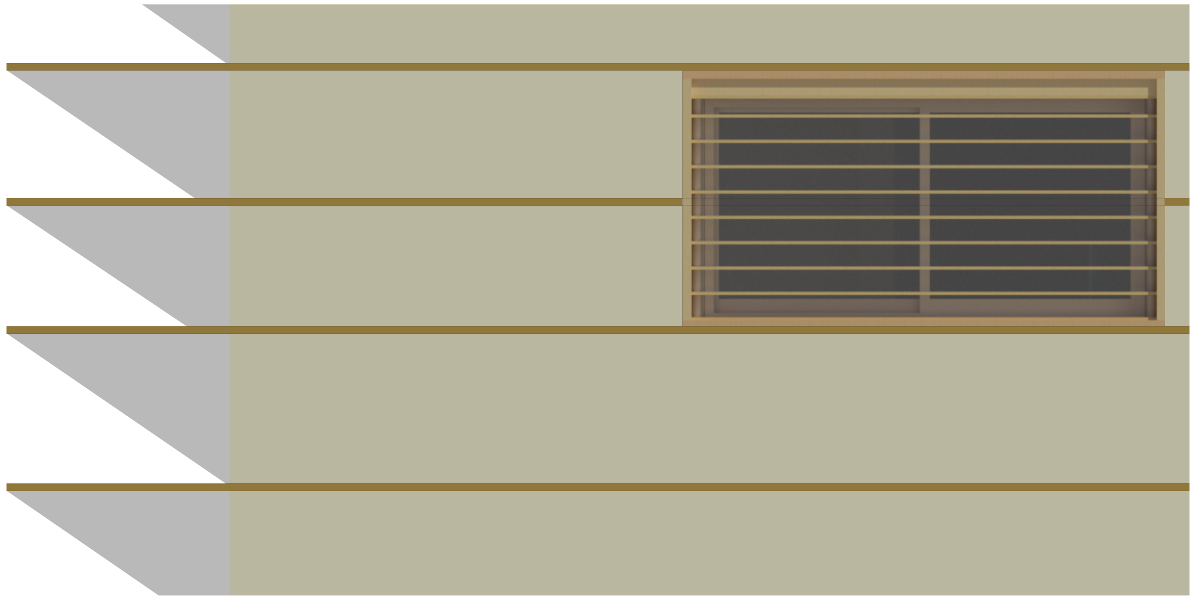


Figure 88: East Facade elevation of Rooms 9, 23 and 38 renovated with the addition of shading on window and a shading overhang of 1.0 m. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Zone Air Sensible Cooling Energy (KWh)	Cooling Load per Area (Kwh/m^2)	Zone Air Cooling After Strategy (KWh)	New Cooling Load per Area (Kwh/m^2)	Savings (%)
PHASE 2: APPLICATION OF EXTERNAL SHADING TO OPAQUE SURFACES									
Application of shading overhangs of 1.0 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	384.7	25.6	**31.2**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	455.3	30.4	**30.8**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	472.4	31.5	**29.2**

Table 23: Cooling energy performance results from the combinations of double glazing and WWR on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: APPLICATION OF SHADING OVERHANGS OF 1.5 METERS LONG

This third strategy of the combined approach of Phase 2 is the addition of external overhangs of 1.5 meter long to shade the opaque surfaces. The vertical placement of these overhangs are organized to cover all the direct sun light given the lowest inclination of the sun from east to west. According to the data presented in the climate of the Dominican Replublic section, this angle of the sun path for the month of August has an inclination of 42.7 °. The length of 1.5 m of the overhang was designed to include an external structure to support self weight, wind and earthquake forces. The material intended for the overhang structure is glulam, from the sustainable materials table. Furthermore, the external shading directly considered for the windows in previous cases were removed because the covering of the overhang is sufficient to cover the height of the window in its entirety.

Figure 89: Section view of the exterior shading strategies over both window and walls (1.5 m overhang) of Room 38, considering an external support (green). Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 2: APPLICATION OF EXTERNAL SHADING TO OPAQUE SURFACES									
Application of shading overhangs of 1.5 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	374.9	25.0	**32.9**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	439.9	29.3	**33.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	458.6	30.6	**31.3**

Table 24: Cooling energy performance results from the combinations of shading and WWR on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: APPLICATION OF SHADING OVERHANGS OF 2.0 METERS LONG

This third strategy of the combined approach of Phase 2 is the addition of external overhangs of 2.0 meters long to shade the opaque surfaces. The vertical placement of these overhangs are organized to cover all the direct sun light given the lowest inclination of the sun from east to west. According to the data presented in the climate of the Dominican Replublic section, this angle of the sun path for the month of August has an inclination of 42.7 °. The length of 2.0 m of the overhang was designed to include an external structure to support self weight, wind and earthquake forces. The material intended for the overhang structure is glulam, from the sustainable materials table. Furthermore, the external shading directly considered for the windows in previous cases were removed because the covering of the overhang is sufficient to cover the height of the window in its entirety.

Figure 90: Section view of the exterior shading strategies over both window and walls (2.0 m overhang) of Room 38, considering an external support (green). Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Zone Air Sensible Cooling Energy (KWh)	Cooling Load per Area (Kwh/m^2)	Zone Air Cooling After Strategy (KWh)	New Cooling Load per Area (Kwh/m^2)	Savings (%)
PHASE 2: APPLICATION OF EXTERNAL SHADING TO OPAQUE SURFACES									
Application of shading overhangs of 2.0 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	372.1	24.8	**33.4**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	446.5	29.8	**32.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	462.3	30.8	**30.7**

Table 25: Cooling energy performance results from the combinations of shading and WWR on the windows of rooms 9, 23 and 38. Source: Design Builder 2021.

CONCLUSIONS OF THE RESULTS FROM THE STRATEGIES OF PHASE 2

The results of the evaluation were slightly discouraging, given that since the expected results considering the dynamic calculations of Room 9 could suggest that covering the external surface of the facade walls would reflect into a higher amount of energy savings, compared to the shading strategy alone on the windows.

However, the results were positive from the perspective of increasing the cooling energy savings from the previous shading strategy, displaying a boost from the previous ranges from around 19 to 22 % towards ranges from 29 to 33 % for the strategies of Phase 2. This translates into an increase of about 10% in cooling energy savings from the most efficient strategy of Phase 1 to the most efficient strategy of Phase 2.

The main discussion about the influence of the lenght of the overhangs in the calculations is that is of minimum impact between them. This is visible in the strategy of the least overall cooling energy savings of phase 2, where the results of the strategy of adding overhangs of 0.5 m of lenght presented the lowest savings on Room 38 with 29 % and a highest value of 31 %. When compared to the strategy that provides the most cooling energy savings overall, the results of the strategy of adding overhangs of 1.5 m of lenght presented savings ranging from 31.3 to 33.1 %. This means that between the strategies, there is around 4% cooling energy savings percent of difference. Not significant enough to draw a definitive best among the group of strategies of Phase 2.

Is relevant to consider that the different lenghts of the overhangs might affect the functionality of the building, given if its directly adjacent or near to a circulation path or other exterior elements, such as vegetation, furniture or equipments. These consideration are site depending and specific to each project. In the situation of Guest Block 16, using overhangs longer than 0.5 meters of lenght can affect the circulation entrances to the building. Therefore, given the comparable numbers in cooling energy strategies among the other longer overhangs, it would be a fitter choice for this specific renovation project.

The cooling energy analysis of the strategy of adding a shading overhang of 1.5 m of lenght is presented on Figure 91. Here, is possible to observe that in comparison with the cooling energy analysis of the strategy of shading of the windows on Phase 1 visible on Figure 86, the fuel destined for cooling energy remains in the same ranges between 30 and 40 kWh. Meaning that the overall variations on between Phase 1 and Phase 2 are not of significant discrepancy.

Furthermore, the heat balance in kWh of the exterior walls remained similar as well, rounding near the 50 kWh mark. Its also of significance that the system loads of the HVAC for sensible cooling and total cooling of Phase 2 remained similar as well with the values of Phase 1. Indicating as well that there hasn't been significant variations in the cooling energy performance of the split units in regard of the strategies applied.

Therefore, it has been observed two phases involving first, the strategies to improve the cooling energy demands through redesigning with passive design approaches on the windows, then after observing these results it was concluded that the shading strategy provided the highest amount of cooling energy savings. In consequence, this served as the focal point for the next phase based on the shading on the walls. This approach was derived from the dynamic calculations made on chapter 6.5.1 on Room 9 as the room model. The results of phase 2 provided improvements of around 10 % in comparison from the first phase, an observation that can prove that intervening on the walls might get better chances of reaching the goal of the main research question goal if its possible to reach 50% cooling energy savings from sustainable facade renovation strategies.

Moreover, the next phase 3 will focus on the improvements of the walls by sustainable facade layers. The first intend is to observe how much cooling energy can be saved from removing the external facade walls exposed directly to the sun with a sustainable facade wall panel system, already presented on chapter 5 from a evaluation by layers to use in this phase. Afterwads, three strategies will be evaluated by preserving the existing walls to avoid demolition costs and test if the addition of only the structure, insulation and external layers are enough to obtain comparable values with the sustainable sandwich panel system. In addition to this two strategies, two more strategies will be tested to observe if the addition of a ventilated facade can make a difference in this tropical climate. One strategy will still consider the insulation in it and the other will remove the insulation from the layering, leaving only the external sustainable structure to support the exterior layer with the air space for ventilation included.

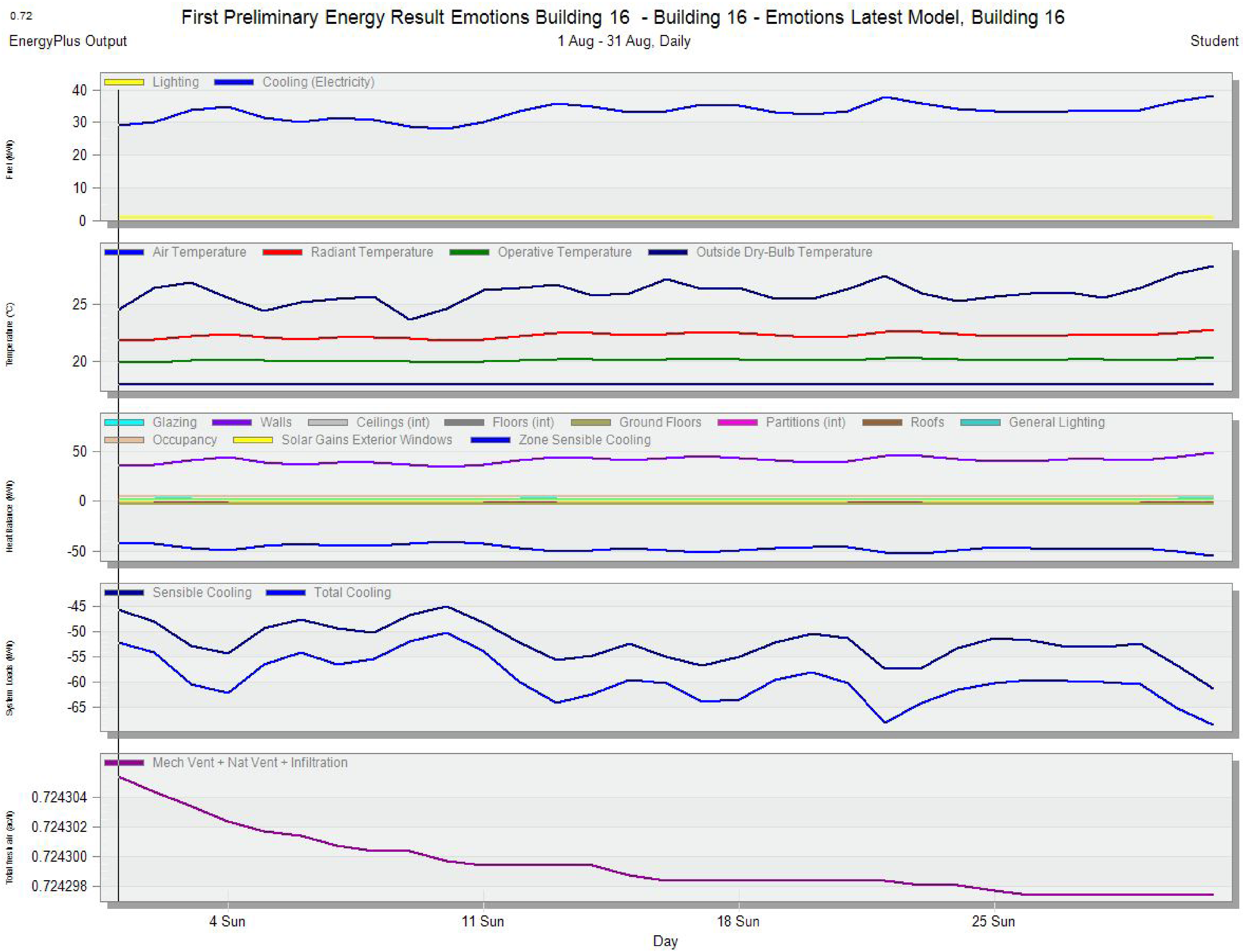


Figure 91: Cooling Energy Analisys of rooms 9, 23 and 38 under Strategy 3 (Shading overhangs of 1.5 m) of Phase 2. Source: Design Builder 2021

6.6.3 Phase 3: Sustainable Facade Layers

STRATEGY: REPLACEMENT OF EXISTING EXTERIOR CEMENT BLOCK WALLS WITH SELECTED SUSTAINABLE SANDWICH PANEL WALL (SPW)

The fist strategy of Phase 3 consist on the tactical renovation of the existing perimetral walls that are exposed to the direct weather interaction, such as solar radiation, rain, wind and humidity. The product that will replace this perimetral walls is the sandwich panel wall system, composed by an interior layer of OSB, attached to a bamboo structure that is supporting the insulation layer of cork and the exterior finishing layer of rockpanel. The sustainable and thermal properties of this sandwich panel wall can be reviewed on chapter 5.

This replacement strategy is intends to diminish the impact of taking extra space of the facade and to remove an inneficient old product (cement block walls) with a new sealed, efficiently insulated and sustainable wall product. The implications to the sustainable process could be the demolition costs and the purpose of the demolished waste from it. It was already explained in the previous conclusions of the general calculations of the cooling energy of the rooms that this waste can be used to create newer blocks cement without losing its material strenght for operability (Soutsos et al., 2011), an oportunity for local concrete businesses in recycling concrete products. The total width of the Sustainable Sandwich Wall Panel is 0.12 m, which would mean a gain of 0.20 cm of space for the interior rooms.

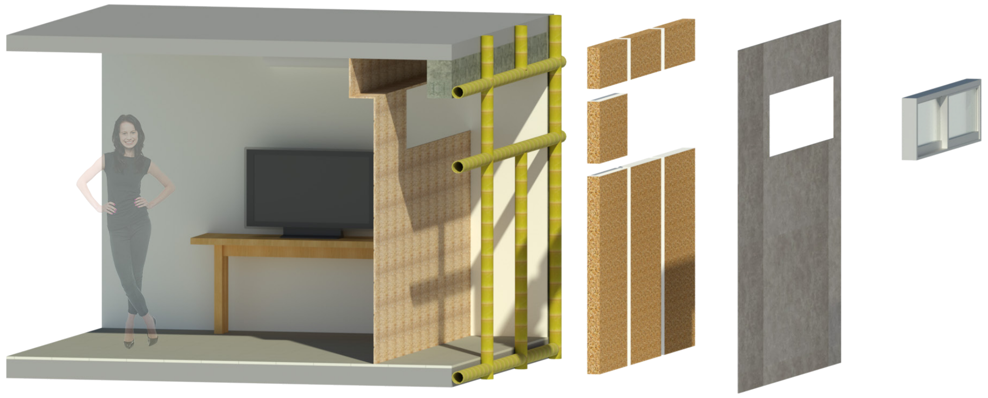


Figure 92: Section view of the exploded layer assembly of the sustainable sandwich panel wall in replacement of the exterior existing facade walls of Room 9. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 3: REPLACEMENT OF EXISTING EXTERIOR WALLS WITH SELECTED SUSTAINABLE SANDWICH PANEL WALL									
Replacement of existing exterior cement block-concrete plaster wall with previously evaluated Sandwich Panel Wall (SPW) assembled with Sustainable Materials									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	211.9	14.1	**62.1**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	262.4	17.5	**60.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	273.3	18.2	**59.0**

Table 26: Cooling energy performance results from Phase 3 Strategy 1 renovation of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: ADDITION OF EXTERNAL SUSTAINABLE WALL LAYERS TO EXISTING EXTERIOR CEMENT BLOCK-CONCRETE PLASTER WALLS

The second strategy consist in adding the layers selected for the sustainable sandwich panel but instead of having the OSB as the interior layer, the existing walls will serve as this interior finishing layer. Furthermore, the new sustainable layer product would serve as an airtight barrier as well, which can consequently improve the insulation between the existing exterior wall and the external environment. The additional with beyond the wall line of the layers are the 10 cm layer of cork plus the 8 mm layer of rockpanel. The bamboo structure is inserted along the cork layer with also 10 cm of diameter. The total addition of perimetral wall to the external wall surface is 0.108 m. This would make a total wall thickness of 0.308 m. These values are obtained from chapter 5.

Figure 93: Section view of the sustainable facade layers added to the existing walls on Room 9. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Zone Air Sensible Cooling Energy (KWh)	Cooling Load per Area (Kwh/m^2)	Zone Air Cooling After Strategy (KWh)	New Cooling Load per Area (Kwh/m^2)	Savings (%)
PHASE 3: SUSTAINABLE WALL LAYERS									
Addition of external Sustainable Wall Layers to existing exterior cement block-concrete plaster walls									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	192.9	12.9	**65.5**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	236.9	15.8	**64.0**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	240.2	16.0	**64.0**

Table 27: Cooling energy performance results from Phase 3 Strategy 2 renovation of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: ADDITION OF EXTERNAL VENTILATED SUSTAINABLE WALL LAYERS TO EXISTING EXTERIOR CEMENT BLOCK-CONCRETE PLASTER WALLS

This third strategy of Phase 3 consist in adding a ventilation air space of 10 cm, according to the proper functionality of air cavities for ventilation in tropical climates made by Barbosa et al., (2015) that a narrow cavity depth for ventilated facades of air conditioned buildings is preferred as it demands less energy consumption due to accentuated stack effect occurring in the cavity, which reduces the heat transmission to inside the occupied space. It also added that a taller cavity produces a stronger buoyancy force, creating a greater airflow rate to be extracted on the top. This can be preferable for a building of 4 levels such as Guest Block 16. Potentialy, further air cavity spaces can be studied to identify the most efficient dimension to ventilate air and firther reduce the cooling energy demands of the building.

Figure 94: Section view of the ventilated sustainable facade layers added to the existing walls on Room 9. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m²)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m²)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m²)**	**Savings (%)**
PHASE 3: SUSTAINABLE WALL LAYERS									
Addition of Ventilated external Sustainable Wall Layers with Insulation to existing exterior cement block-concrete plaster walls									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	176.7	11.8	**68.4**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	215.5	14.4	**67.2**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	214.4	14.3	**67.9**

Table 28: Cooling energy performance results from Phase 3 Strategy 3 renovation of rooms 9, 23 and 38. Source: Design Builder 2021.

STRATEGY: ADDITION OF EXTERNAL VENTILATED SUSTAINABLE WALL LAYERS TO EXISTING EXTERIOR CEMENT BLOCK-CONCRETE PLASTER WALLS WITHOUT INSULATION

The last strategy of Phase 3 will test the ventilated sustainable facade layers without insulation to evaluate if the factor of having an insulating layer on the exterior of a the ventilated facade in a tropical climate establish a considerable difference in cooling energy savings. Therefore, the assembly is similar to the previous strategy but the main operating factor will be the ventilation of air through the rockpanel (exterior layer) to remove the heat contained in the air cavity from the bottom to the top of the stacked space.

Figure 95: Section view of the ventilated sustainable facade layers without insulation added to the existing walls on Room 9. Source: Own

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 3: SUSTAINABLE WALL LAYERS									
Addition of Ventilated external Sustainable Wall Layers without Insulation to existing exterior cement block-concrete plaster walls									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	219.7	14.6	**60.7**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	267.8	17.9	**59.3**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	270.5	18.0	**59.5**

Table 29: Cooling energy performance results from Phase 3 Strategy 4 renovation of rooms 9, 23 and 38. Source: Design Builder 2021.

CONCLUSIONS OF THE RESULTS FROM THE STRATEGIES OF PHASE 3

In this phase, the direct interventions on the walls with sustainable materials provided much better results. The cooling energy savings boosted from the 30% of Phase 2 towards highly efficient numbers from 59% towards 68%.

The direct replacement of the existing exterior facade walls and the addition of ventilated sustainable facade layers without insulation on the same exisitng walls, strategies 1 and 4 of this phase respectively, showed similar cooling energy savings. These numbers were the lowest of phase 3, displaying ranges from 59% to 62%.

On the other hand, the improvements were higher when the addition of the same layer composition of the selected sandwich panel, excluding the internal layer of OSB, were added to the exterior face of the existing walls. The cooling energy savings ranged from 64% on the rooms 23 and 38 towards 65.5 % on room 9.

However, the highest cooling energy savings of phase 3 were seen on the third strategy, which consisted of adding an extra 10 cm cavity of air behind the external layer of Rockpanel to create a ventilated facade. This composition of layers, that includes the insulation of cork in difference from the last strategy, provided the best cooling energy savings values of all the phases. The ranges started from 67.2 % to 68.4 %.

The cooling energy analysis of strategy 3, the ventilated sustainable facade layers added to the existing walls is presented on Figure 96. Here, is possible to observe that in comparison with the cooling energy analysis of the strategy of adding a shading overhang of 1.5 m of lenght in Phase 2, visible on Figure 91, the fuel destined for cooling energy decreased significantly from the ranges of 30 and 40 kWh towards ranges of 15 and 18 kWh. Meaning that the overall variations on between Phase 2 and Phase 3 basically halved compared to the differences between Phase 1 and Phase 2.

Furthermore, the heat balance in kWh of the exterior walls remained reduce d significantly to a tenth of the previous values of Phase 2. The indicators simulated a decrease from 50 kWh to 5 kWh. This leaves only the effects of the exterior glazing rounding the 10 kWh, which can now be of knowledge to be reduced if the windows also use external shading in this situation. This can possibly provide further cooling energy savings if its applied.

The HVAC system loads for sensible cooling and total cooling of Phase 3 also decreased significantly from the numbers of Phase 2 almost by half. This indicates that there's been significant improvements for the cooling energy performance of the split units in regard of the strategies applied.

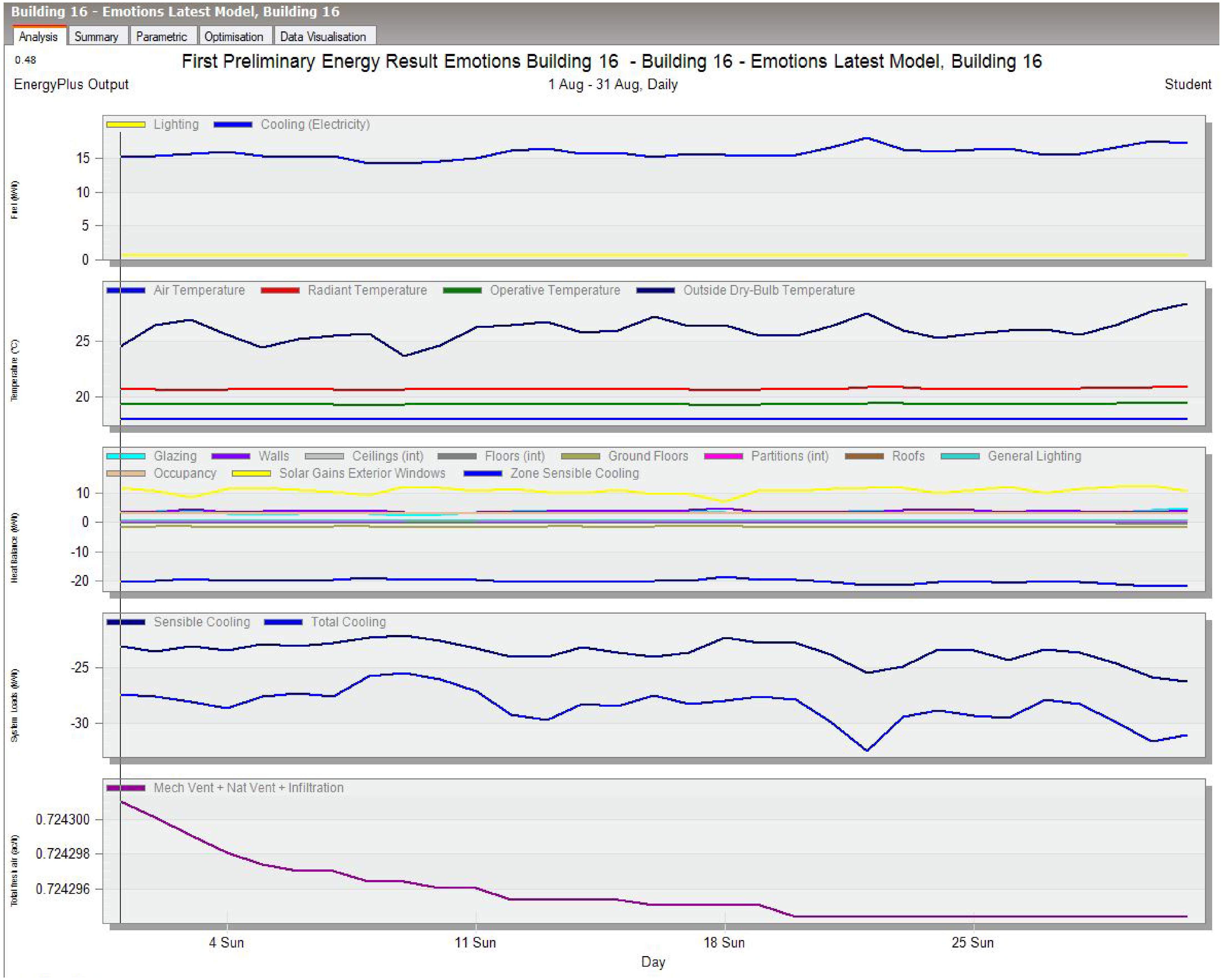


Figure 96: Cooling Energy Analisys of rooms 9, 23 and 38 under the strategy 3 of Phase 3. Source: Design Builder 2021

7.0 Post-Calculation: Applications and Observations

7.1 Practical evaluation of the economical challenge of the sustainable renovation strategies applied.

The results of the calculations provided considerable proof that there are alternative advantages for cooling energy savings through the proper use of passive design strategies. A practical question to the challenge that the application of these strategies could bring for renovation interests is how much is possible to save by comparing each renovation strategy in economic terms.

Therefore, an estimate of the cost of materials, their availability in the Dominican market and the labor costs related to the application of the 3 phases of the renovation strategies will be performed. The estimates will be evaluated in base of cost per lineal meter, meter square or cubic meter, depending on the category of the strategy. This apporach is intended for providing a practical guide to apply to several renovation projects while also make visible the price differences between each renovation strategy. Therefore, making more factible to determine which decision is more affordable and effective at the same time, since the cooling energy savings are already defined for each passive design renovation phase.

Firstly, is fundamental to introduce the database of “ConstruCosto.do”, which is an online service of updated database for price of materials, labor costs, equipment and costs-analysis for the construction sector of the Dominican Republic. The database version that will be used for the indicated renovation strategies in this chapter is from April 2021. The local prices of the Dominican peso (DOP) will be presented in Euros (EUR) in order to relate to the aforementioned list of sustainable materials of chapter 5.1. The currency conversion used at the date of August 2021 from euro to Dominican peso (DOP) is 67.67 DOP = 1 EUR (westernunion, 2021).

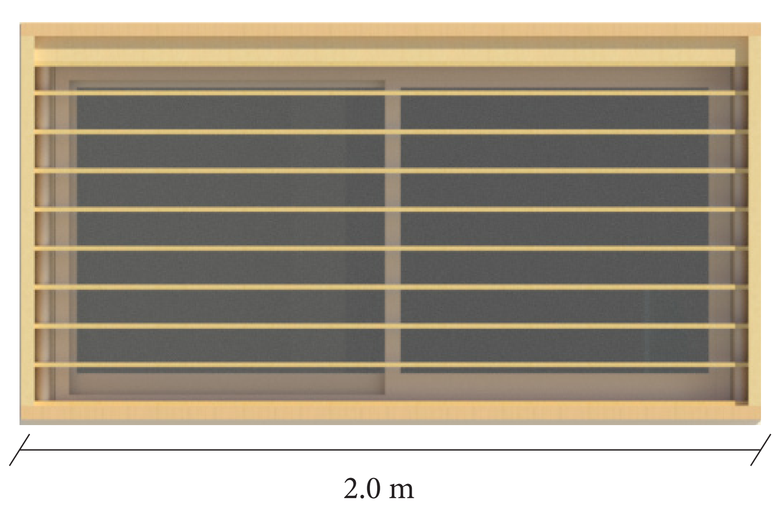
Phase 1: Application of individual passive design strategies
Strategy 1: Improvement from single to more efficient double glazed windows.

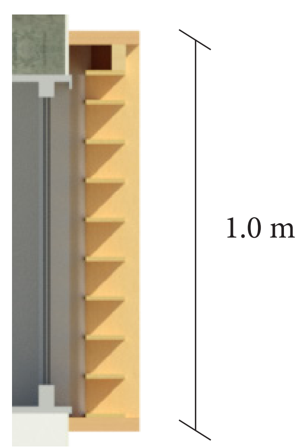
Product	Double Glazed Window
Dimensions (mm)	2000 x 1000
Costs per m2 (EUR)	190
Instalation costs	Included
Total Cost of Renovation per m2 (EUR)	190

The relative price of the double glazed window with LoE coating was based on the market rate of a local window company in the city of Puerto Plata, named Ternalum (2021). The addition of the Argon gas is excluded in the costs since they do not apply it for lack of demand. The price for a single glazing sliding window is EUR 105.6 m2, meaning that investing into a LoE coated double glazing window (excl. Argon gas) is 55.6 % more expensive.

Phase 1: Application of individual passive design strategies
Strategy 2: Addition of shading to the windows.

Material	Glulam boards (5cm)
Dimensions (lenght, width, thickness)	1000x100x50 mm
Cost per M1 (EUR)	7.9
Costs per m2 (EUR)	110.6
Instalation costs	7.6
Total Cost of Renovation per m2 (EUR)	118.2



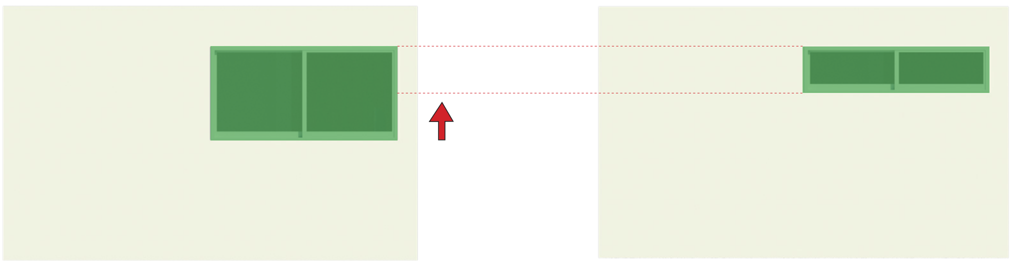


The assembly of the shading system consist on glulam boards of 5 cm thick cutted in modular board pieces of 10 cm width. The frame is assembled first and then the intermidate boards are added and nailed in. The boards sizes and prices are determined from the cost review of materials of chapter 5 and information provided by ConstruCosto (2021).

Phase 1: Application of individual passive design strategies
Strategy 3: Reduction of current size of WWR to 50%.

Product	Single Glazed Window
Dimensions (mm)	2000 x 500
Costs per m2 (EUR)	105.6
Instalation costs	Included
Addition of block layers per m2 (EUR)	5.90
Labor costs per m2(EUR)	2.90
Material finishes (mortar + paint) per m2	26.8
Labor costs of finishes per m2 (EUR)	3.7
Total Cost of Renovation per m2 (EUR)	144.9

The prices of the products used were considered from the quotation from a single glazed sliding window from Ternalum (2021) and the material and labor costs of the database of ConstruCosto (2021). In this strategy the placement of 15cm thick concrete blocks were considered to fill the gap of the reduced dimension of the WWR. An amount of 10 blocks of 6" (15cm), the mortar flashing, finishing and two layers of paint were considered with their respective material and labor costs.



Phase 2: Application of external shading to opaque surfaces
Strategy 1: Application of Shading Overhangs of 0.5 m in length

Material 1	Glulam boards (5cm)
Dimensions (lenght, width, thickness)	1000x1000x50 mm
Amount	0.5
Cost per M2 (EUR)	79.2
Material 2	Glualm beams (10cm)
Dimensions (lenght, width, thickness)	1000x50x100 mm
Amount	5
Cost per M2 (EUR)	31.7
Instalation costs	17
Total Cost of Renovation per m1 of perimeter (EUR)	88.3

Figure 97: Application of Shading Overhangs of 0.5m in length. Source: Own.

Phase 2: Application of external shading to opaque surfaces
Strategy 2: Application of Shading Overhangs of 1.0 m in length

Material 1	Glulam boards (5cm)
Dimensions (lenght, width, thickness)	1000x1000x50 mm
Amount	1
Cost per M2 (EUR)	79.2
Material 2	Glualm beams (10cm)
Dimensions (lenght, width, thickness)	1000x50x100 mm
Amount	6
Cost per M2 (EUR)	31.7
Instalation costs	37.2
Total Cost of Renovation per m1 of perimeter (EUR)	148.1

Figure 99: Application of Shading Overhangs of 1.0m in length. Source: Own.

Phase 2: Application of external shading to opaque surfaces
Strategy 3: Application of Shading Overhangs of 1.5 m in length

Material 1	Glulam boards (5cm)
Dimensions (lenght, width, thickness)	1000x1000x50 mm
Amount	1.5
Cost per M2 (EUR)	79.2
Material 2	Glualm beams (10cm)
Dimensions (lenght, width, thickness)	1000x50x100 mm
Amount	10
Cost per M2 (EUR)	31.7
Instalation costs	57.5
Total Cost of Renovation per m1 of perimeter (EUR)	223.9

Figure 100: Application of Shading Overhangs of 1.5m in length. Source: Own.

Phase 2: Application of external shading to opaque surfaces
Strategy 3: Application of Shading Overhangs of 2.0 m in length

Material 1	Glulam boards (5cm)
Dimensions (lenght, width, thickness)	1000x1000x50 mm
Amount	2
Cost per M2 (EUR)	79.2
Material 2	Glualm beams (10cm)
Dimensions (lenght, width, thickness)	1000x50x100 mm
Amount	12
Cost per M2 (EUR)	31.7
Instalation costs	77.7
Total Cost of Renovation per m1 of perimeter (EUR)	299.5

Figure 101: Application of Shading Overhangs of 2.0m in length. Source: Own.

The application of the overhangs are based on a glulam beam frame supported by knee braces to the existing exterior wall. Inside the frame, the 5cm thick glulam board is cutted into several pieces of 5 centimeters to create the louver effects over the opaque surfaces and the windows. After the 1.0 meter long overhang strategy, the next two (1.5m and 2.0m) are considered to be supported by a glulam column at the outside edge to provide extra support. The labos costs increase by every 10cm of height, according to the labor costs sheets of ConstruCosto (2021).

Phase 3: Sustainable Wall Layers
Strategy 1: Replacement of Existing exterior facade walls with Sustainable Facade Wall Panel (SFWP)

Demolition Costs per (m2)	3.2
Material 1	OSB (0.0127m)
Cost per M2 (EUR)	7.8
Material 2	Bamboo (10 cm)
Cost per M2 (EUR)	13.9
Material 3	Cork (10cm)
Cost per M2 (EUR)	158.9
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	291.5

In this strategy the first action to consider is the demolition of the existing exterior concrete block walls. Since the waste of the demolished blocks can be recycled, the transportation costs out of the construction site is not considered due to the compensation to be considered for the blocks to be recycled. The rest of the information is still found on chapter 5 and ConstruCosto (2021).

Phase 3: Sustainable Wall Layers
Strategy 1 (part B): Replacement of Existing exterior facade walls with Sustainable Facade Wall Panel (SFWP) using 5cm Cork instead of 10cm Cork.

Demolition Costs per (m2)	3.2
Material 1	OSB (0.0127m)
Cost per M2 (EUR)	7.8
Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 3	Cork (5cm)
Cost per M2 (EUR)	79.4
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	212

Since the thickness of the 2 commercial sizes of cork considered for these interventions, an extra evaluation was made by just varying the thickness of the cork from 10cm to 5cm to observe if the cooling energy savings were affected significantly. By good satisfaction of the results, there was only a 3% decrease in the cooling energy savings, giving an interesting edge for the costs of this intervention. From this strategy forward, an option with the two sizes of cork will be displayed.

Figure 102: Application of Sustainable Wall Layers A. Source: Own.

Figure 103: Application of Sustainable Wall Layers B. Source: Own.

Phase 3: Sustainable Wall Layers
Strategy 2: Addition of Sustainable Wall Layers on the existing facade wall

Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 3	Cork (10cm)
Cost per M2 (EUR)	158.9
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	280.5

Phase 3: Sustainable Wall Layers
Strategy 2 (part B): Addition of Sustainable Wall Layers on the existing facade wall using 5cm Cork instead of 10cm Cork.

Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 3	Cork (5cm)
Cost per M2 (EUR)	79.4
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	201

Phase 3: Sustainable Wall Layers
Strategy 3: Addition of Ventilated Sustainable Wall Layers on the existing facade wall (with Insulation)

Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 3	Cork (10cm)
Cost per M2 (EUR)	158.9
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	280.5

Phase 3: Sustainable Wall Layers
Strategy 3 (part B): Addition of Ventilated Sustainable Wall Layers on the existing facade wall (with Insulation) using 5cm Cork instead of 10cm Cork.

Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 3	Cork (5cm)
Cost per M2 (EUR)	79.4
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	201

Phase 3: Sustainable Wall Layers
Strategy 4: Addition of Ventilated Sustainable Wall Layers on the existing facade wall (without Insulation)

Material 2	Bamboo (0.10m)
Cost per M2 (EUR)	13.9
Material 4	Rockpanel (0.008m)
Cost per M2 (EUR)	102.5
Instalation costs	5.17
Total Cost of Renovation per m2 (EUR)	121.6

As a conclusion of this chapter, is possible to affirm that the strategy with the highest cooling energy savings and the cheapest in relation to the other strategies and their energy performance is the strategy of adding a ventilated sustainable facade layer without insulation. The cooling energy savings of this strategy is around 8% less effcicient than the best strategy in terms of this category, which is the same addition of a ventilated sustainable wall layers but with insulation. The price difference between these two strategies is almost 80 euros per meter square. In terms of cooling energy savings, it doubles all the overhang strategies on the opaque surfaces and triples the shading strategy on the windows, which was the most cooling energy efficient of the Phase 1.

Therefore, in terms of investment and efficiency, the around 60% of cooling energy savings in combination of a 121.6 euro cost per panel for a renovation seems to be the right choice.

On the other hand, this chapter can serve as an input data refrence to add other materials from chapter 5 to verify how much it would cost per m2 for their own renovation projects.

Figure 104: Application of Sustainable Wall Layers C. Source: Own.

Figure 105: Application of Sustainable Wall Layers D. Source: Own.

7.2 Cooling Energy Savings based on modification of cooling set point temperature of AC units

A question that is raised beyond the results of the calculations and the costs is how much cooling energy savings can be made by simply raising the cooling set point temperature of the air-conditioning units under the same conditions. The following information was calculated to understand the possible combinations between design strategies, material selection and adjustable temperature setpoints.

The previous calculations were based on the experience of the hotel management were the users, on average, placed the cooling set point temperature on 18 °C. This number was selected in order to respond to the average thermal comfort of the users on the critical aspect of the high energy consumption that is generated from the guest blocks. Which according to the manager, is the highest overall on the hotel because aside its operation during the day, it additionally operates during the whole night while the other areas of the hotel have more intermitent uses during the day and stay off during the night time.

Therefore, the following additional set of calculations are based on the observations of the cooling energy generation and savings on the degrees of 19 °C, 20 °C, 21 °C, and 22 °C, which is the cooling set point temperature used by default by the hotel when the customers arrive to their rooms. The comparisons from the referenced calculated values at 18 °C will also be presented, first in the pre-intervention phase and then on all the intervention phases.

Standard Cooling Energy Demand without interventions					
Cooling Energy Demand (in Kwh)					
Critical Rooms	18 °C	19 °C	20 °C	21 °C	22 °C
Room 9	559	496	430	365	302
Room 23	658	595	532	470	408
Room 38	667	607	544	481	419
Average	**628**	**566**	**502**	**439**	**376**
Savings Percentage	-	**10%**	**20%**	**30%**	**40%**

Table 30: Cooling energy performance by only varying the temperature of rooms 9, 23 and 38. Source: Design Builder 2021.

Cooling Energy Demand (in Kwh)					
Room 9					
Strategies	18 °C	19 °C	20 °C	21 °C	22 °C
Phase 1					
Double Glazing	510	440	456	463	471
Savings Percentage	**9%**	**21%**	**18%**	**17%**	**16%**
Shading	435	376	318	263	211
Savings Percentage	**22%**	**33%**	**43%**	**53%**	**62%**
WWR 50%	452	393	336	280	226
Savings Percentage	**19%**	**30%**	**40%**	**50%**	**60%**
Phase 2					
Overhang 0.5m	385	327	271	217	167
Savings Percentage	**31%**	**42%**	**52%**	**61%**	**70%**
Overhang 1.0m	385	326	269	214	163
Savings Percentage	**31%**	**42%**	**52%**	**62%**	**71%**
Overhang 1.5m	375	316	259	205	155
Savings Percentage	**33%**	**43%**	**54%**	**63%**	**72%**
Overhang 2.0m	372	314	257	202	153
Savings Percentage	**33%**	**44%**	**54%**	**64%**	**73%**
Phase 3					
Replacement of Walls with SFWP*	212	184	157	131	107
Savings Percentage	**62%**	**67%**	**72%**	**77%**	**81%**
Addition of SWL**	193	169	145	122	100
Savings Percentage	**66%**	**70%**	**74%**	**78%**	**82%**
Addition of Ventilated SWL with insulation	182	155	134	114	94
Savings Percentage	**68%**	**72%**	**76%**	**80%**	**83%**
Addition of Ventilated SWL without insulation	220	192	165	139	114
Savings Percentage	**61%**	**66%**	**70%**	**75%**	**80%**

*Sustainable Façade Wall Panel

**Sustainable Wall Layers

Table 31: Cooling energy performance by strategies varying the temperature of room 9. Source: Design Builder 2021.

Cooling Energy Demand (in Kwh)					
Room 23					
Strategies	18 °C	19 °C	20 °C	21 °C	22 °C
Phase 1					
Double Glazing	606	613	489	428	368
Savings Percentage	**8%**	**7%**	**26%**	**35%**	**44%**
Shading	513	458	405	352	299
Savings Percentage	**22%**	**30%**	**38%**	**47%**	**55%**
WWR 50%	588	532	477	421	367
Savings Percentage	**11%**	**19%**	**28%**	**36%**	**44%**
Phase 2					
Overhang 0.5m	458	404	350	298	245
Savings Percentage	**31%**	**39%**	**47%**	**55%**	**63%**
Overhang 1.0m	455	403	350	299	248
Savings Percentage	**31%**	**39%**	**47%**	**55%**	**62%**
Overhang 1.5m	440	387	336	284	234
Savings Percentage	**33%**	**41%**	**49%**	**57%**	**64%**
Overhang 2.0m	446	394	342	290	234
Savings Percentage	**32%**	**40%**	**48%**	**56%**	**64%**
Phase 3					
Replacement of Walls with SFWP*	262	248	233	218	203
Savings Percentage	**60%**	**62%**	**65%**	**67%**	**69%**
Addition of SWL**	237	224	210	197	183
Savings Percentage	**64%**	**66%**	**68%**	**70%**	**72%**
Addition of Ventilated SWL with insulation	221	204	193	181	169
Savings Percentage	**67%**	**69%**	**71%**	**72%**	**74%**
Addition of Ventilated SWL without insulation	268	251	233	216	198
Savings Percentage	**59%**	**62%**	**65%**	**67%**	**70%**

*Sustainable Façade Wall Panel

**Sustainable Wall Layers

Table 33: Cooling energy performance by strategies varying the temperature of room 23. Source: Design Builder 2021.

Cooling Energy Demand (in Kwh)					
Room 38					
Strategies	18 °C	19 °C	20 °C	21 °C	22 °C
Phase 1					
Double Glazing	615	615	501	445	389
Savings Percentage	**8%**	**8%**	**25%**	**33%**	**42%**
Shading	533	477	422	368	314
Savings Percentage	**20%**	**28%**	**37%**	**45%**	**53%**
WWR 50%	614	557	500	443	388
Savings Percentage	**8%**	**16%**	**25%**	**34%**	**42%**
Phase 2					
Overhang 0.5m	474	419	366	313	261
Savings Percentage	**29%**	**37%**	**45%**	**53%**	**61%**
Overhang 1.0m	472	418	365	312	260
Savings Percentage	**29%**	**37%**	**45%**	**53%**	**61%**
Overhang 1.5m	459	405	351	299	247
Savings Percentage	**31%**	**39%**	**47%**	**55%**	**63%**
Overhang 2.0m	462	408	355	302	250
Savings Percentage	**31%**	**39%**	**47%**	**55%**	**63%**
Phase 3					
Replacement of Walls with SFWP*	273	258	242	227	211
Savings Percentage	**59%**	**61%**	**64%**	**66%**	**68%**
Addition of SWL**	240	226	212	198	184
Savings Percentage	**64%**	**66%**	**68%**	**70%**	**72%**
Addition of Ventilated SWL with insulation	220	202	190	178	166
Savings Percentage	**68%**	**70%**	**72%**	**73%**	**75%**
Addition of Ventilated SWL without insulation	270	252	234	216	198
Savings Percentage	**60%**	**62%**	**65%**	**68%**	**70%**

*Sustainable Façade Wall Panel

**Sustainable Wall Layers

Table 34: Cooling energy performance by strategies varying the temperature of room 38. Source: Design Builder 2021.

In observation of the calculations of the cooling energy savings percentages, in higher cooling set point temperatures than 18 ^{o}C is possible to see relative increase by each degree Celsius the air conditioner is set to operate. For instance, it can be observed that only by adjusting the cooling set point temperature from 18 ^{o}C to 19 ^{o}C, without applying any strategy, an increase of 10% is calculated. The same circumstance happens by the subsequent addition of degrees until the cooling set point by the hotel is reached at 22 ^{o}C. Hypothetically, if the temperature is maintained at 22 ^{o}C as the cooling set point temperature for the operation of the AC in the most critical rooms, the cooling energy savings can escalate all the way to 40%.

On the other hand, when the same method of setting higher cooling set point temperatures than 18 ^{o}C is applied while also performing the strategies, the results are also interesting. The key observations per strategy on the most critical rooms evaluated are:

Phase 1 - Double Glazing

The improvements on Room 9 (Level 1) were lower than the improvements seen on Room 23 and 38. The variations for room 9 oscilated between 9% and 21%, not necessarily displaying an escalating improvement in the savings while the cooling set point temperatures were set higher by each degree Celsius. The situation for Room 23 and 38 was different. The savings improvement was visible by each degree higher than 19 ^{o}C, displaying an escalating improvement of 10% of cooling energy savings by each degree hotter. The case for setting a cooling set point temperature of 19 ^{o}C showed not considerable changes from the calculations at 18 ^{o}C. The overall increase on the cooling energy savings for Room 23 and 38 showed an increase from 8% to 42%.

By the observations it can be concluded that on the ground floor level (Level 1), the renovation of the windows to improved double glazing on critical room wall facades with single glazed windows have less impact on the cooling energy savings than a possible level 2 and 3 above under the same conditions.

Phase 1 - Shading of the windows

The improvements on the critical rooms were more consistent and more significant as well when compared to the improvements of the Double Glazing strategy. The improvements ranged from 28% to 62%, showing the highest values on Room 9, therefore the ground floor level (Level 1). The highest energy savings for Room 23 and 38 were observed between 53% and 55%.

By the observations it can be concluded that opposite to the double glazing strategy, shading the windows of the ground floor showed slightly higher cooling energy savings than Level 2 and Level 3.

Phase 1 - WWR size reduced by 50%

In a similar way, the improvements on the critical rooms were more consistent and more significant as well when compared to the improvements of the Double Glazing strategy in the same levels as the Shading strategy. The improvements ranged from 16% to 60%, showing the highest values on Room 9 as well. The highest energy savings for Room 23 and 38 were observed between 16% and 44%.

By the observations it can be concluded that opposite to the double glazing strategy and similar to the shading the windows, the ground floor showed slightly higher cooling energy savings than Level 2 and Level 3.

Phase 2 - Shading Overhangs of 0.5m, 1.0m, 1.5m and 2.0m on Opaque Surfaces

The strategy of shading the opaque surfaces, using the different overhangs lenghts of 0.5, 1.0, 1.5 and 2.0 meters to cover the facade wall surfaces exposed by the sun displayed higher improvements in relation to the temperature variations on the cooling set point of Phase 1. The cooling energy savings by variation of overhang lenghts had a savings percentage range from 29% to 73%. The display of higher savings were seen on the overhang of 2 meters, but with lower differences between the minimal lenght of 0.5 meters and the longest lenght in 2.0 meters. The variation between these 2 boundaries of lenght were between 1% and 3% on each degree of temperature that was set. On the other hand, the cooling energy savings were higher when the application of these strategies were applied on the ground floor as well, following a similar pattern to the savings of shading and WWR size reduction by 50% strategies.

Phase 3 - Replacement of existing exterior walls with SFWP

The highest improvements of all phases are seen on this last Phase 3, where all cooling energy savings percentages start around 59% and improve as much as 83%. In regard of the replacement of the existing exterior walls with the Sustainable Facade Wall Panels (SFWP), the savings percentages are more significant also on the ground floor (Room 9), where the savings range starts from 62% to 81%.

The variations are different for Rooms 23 and 38 (Level 2 and 3), were the maximum range between the lowest cooling set point temperature (18 ^{o}C) and the highest (22 ^{o}C) is only a mere difference of 9%.

Therefore, by the observations it can be concluded that the higher cooling energy savings benefits fit better on the ground floor level, than the second and third levels on these critical rooms. Furthermore, while observing the 62% of the cooling energy savings on the calculated worst scenario of 18 ^{o}C, managing to incease the cooling set point temperature would hypotetically improve all the way to 81% if the 22 ^{o}C mark is reached and maintained.

Phase 3 - Addition of Sustainable Wall Layers (SWL)

Leaving the existing exterior concrete walls on their place while adding sustainable wall layers proved to be slighlty better than the replacement strategy, considering the important factor that the demolitions costs would bring to a renovation investment. Therefore, the ranges displayed under the temperature variations of the rooms on the strategy of adding SWL on the exting exterior walls start from 64% at 18 ^{o}C to 82% at 22 ^{o}C.

These ranges display an improvement of 16% on each per room level, meaning a 4% cooling energy savings per degree increased from the basal 18 ^{o}C.

By the observations it can be concluded that the addition of SWL is not only more energy efficient than replacing the walls, but also cheaper in terms of construction costs in demolition and more sustainable in terms of reusing and avoiding CO2 production in the transportation of that waste, even if its going to be recycled afterwards.

Phase 3 - Addition of Ventilated SWL with Insulation

The addition of an air chamber in the SWL layering composition to allow ventilation through the facade was the strategy with the higest cooling energy savings of all the Phases. The physical assumption is that the accumulated heat gets dissipated away with the help of the wind and the natural inclination of the hot air to go upwards and leave the structure through an exhaust opening at the top of the facade wall by the strong buoyancy force that is generated in the cavity in respect to the outside air.

The cooling energy savings in this phase ranged from 68% to 83%, having a around 2 to 3% savings increase by each additional degree Celsius. As seen in previous strategies, the highest cooling energy savings were seen on the ground floor. Since all this patterns align an indication that the cooling energy performance is better on this level, its possible to assume that since the ground floor has a thicker layer of floor insulation that involves the constant temperature of the ground, the probabilities of loss of energy might be more persistent on the upper levels since their floor material is a 12 cm concrete slab. Therefore the amount of energy to maintain the temperature should be slightly higher than the amount of cooling energy needed to cool a room on the ground floor.

Furthermore, the insulation on the facade seems to perform an importan role as an insulating barrier for the heat contained in the air chamber that eventualy gets flushed away by the aforementioned effects on the ventilated facade.

Phase 3 - Addition of Ventilated SWL without Insulation

The last strategy just proves that the insulation is an important factor to be considered on the Sustainable Facade Layers. The reason can be seen on the cooling energy savings of the addition of the ventilated facade but without the presence of insulation. The savings ranged from 59% to 80%, showing similarities in the cooling energy savings while operating at 22 ^{o}C with differences of 3% in relation to the insulated strategy. However, on the most critical level (18 ^{o}C) the cooling energy savings percentages displayed a ranges difference of 7% and 8%. Therefore, under lower cooling temperature set points, the insulated SWL with a ventilation chamber performs better, therefore have the best cooling energy performance between the two.

8.0 Final Conclusions

The recollection of climatological data, together with the construction typologies and hotel typology in coastal hotels, allowed to frame an ideal background to be able to understand how a more accurate evaluation of the current situation of the demand for cooling energy in this type of human space.

Therefore, the first general baseline evaluation of the cooling energy demand on Design Builder was able to determine its effectiveness when compared with the data obtained from the maintenance management of the Emotions hotel in Puerto Plata, Dominican Republic. As previously described, these evaluations were made using the values of the hottest month of the busiest year of coastal hotel operation before the covid-19 pandemic. The comparative results remained under the 10% margin of error, indicating that these calculations are reliable to serve as a parameter of reference in this research.

The approach of introducing the sustainable materials provided a valuable tool to use along side the passive design strategies. This strategy of assembling this materials by layers provided a logical guide to follow when the time of selecting the best materials for each circumstance in a particular setting is presented. It also represented a different approach from the traditional and inneficient way of construction in the Dominican Republic.

To engage the basal structure of the calculations, a dynamic simulation was made to identify the most important factors of the thermal physics of the rooms of the hotel. It was identified that the external facade walls and the windows were the most important contributors to the thermal transmittances that included the effects on a room of the sun, the human activity, the ventilation and the direct transmittion of the opaque and transparent surfaces.

It was also concluded that the walls had a higher effect on the thermal absorption (thermal mass) which translated into a cooler inside than the window but also resulted in the the exodus of thermal energy during the abscence of the sun. It was also identified that the walls were responsible of the highest thermal energy transmittances to the room, which immediatly revealed that in this particular situation, an intervention on the walls would have a major effect on the cooling energy savings than an intervention on a window.

The results of the calculations have revealed that the differences in cooling energy saving improvements have significant variations depending on the renovation phase.

These differences were more accentuated on phase 3, where the strategies of sustainable facade layers over the existing concrete plastered-cement block walls provided cooling energy savings from 59% to 68% on the three selected critical rooms that were evaluated.

In this phase, the cooling energy savings boosted significantly compared to the previous 2 phases. The expectatives of the main research question of this thesis to reach a tentative goal of 50% were exceeded by almost 20 %.

Furthermore, based on the conclusions of each phase about the cooling energy analysis, it was possible to observe that the HVAC systems perform better when the walls are better insulated. Plus, the heat balance in kWh was reduced significantly when phase 3 of the renovations was applied.

In the post-calculation stage on chapter 7, it was possible to observe the investment side of the strategies. A careful economical analysis of each strategy was made, considering the local market of the Dominican Republic with updated data and the application of the cost analysis per material and panel prices was also included. The price of the materials, labor costs and instalation costs were all analysed and reported. In the conclusions segment, it was possible to affirm that the most cost-effective and energy efficient strategy of the renovation plan was the addition of ventilated sustainable wall layers without insulation. The variation between the loss of efficiency is minimal compared to the higher advantages of not using insulation in the costs estimations. This means that the cooling energy savings deficit is only 3% versus the around 80 Euro savings in investment per panel that can be saved in the renovation.

The other post-calculation analisys and observation made was performing a new set of calculations but only considering the variation of the cooling set point temperature from 18 ^{o}C to 22 ^{o}C, degree by degree. The 22 ^{o}C temperature mark is the current cooling set point temperature that the hotel management set on the AC units in the rooms before the users arrive and modify it. Given that itwould be possible to decide which temperature every user should use, without them being able to modify it, it would also provide great cooling energy savings alone without applying any renovation strategy. However, the calculations on each degree for all the strategies provided even better results. This can indicate that a clever combination of higher cooling set-point temperatures than 18 ^{o}C with the right strategy can provide the ideal cooling energy saving.

Therefore, after observing the results of the total calculations, its valid to conclude that using passive design strategies combined with sustainable materials previously evaluated in its most important sustainability aspects, is possible to improve in great amounts the cooling energy savings of a coastal hotel under tropical climate conditions.

These results, moreover, answered the main research question succesfully, which was “*Can the cooling energy demand of coastal hotels under tropical climate conditions be reduced by 50% by applying sustainable facade renovation strategies?”*, to which the answer would be yes, beyond 50% towards a potential 68% in cooling energy savings and by varying the cooling set point temperature, it can even reach 83% operating at 22 ºC.

8.1 Recomendations

Some recomendations that could improve the cooling energy performance before having to perform any of these sustainable renovation strategies are possible. Of course, they would need their own independent evaluation and a full report on these to confirm the exact savings percentages. These are the possible pre-interventions that could be recommend:

- Replacing the older cooling units with modern and more effcient models.
- Improving the size (capacity) in KWh of the HVAC unit that is underpreforming for a bigger and powerful unit that could manage the area and volume of the cooling area.
- Adding vegetation on the perimeter of the exterior facades to block the direct solar radiation and therefore reduce thermal energy absorbed by either the walls and/or the windows.
- Adding shutters on the outside of the windows to keep the apartments cool when they’re not in use. Once they have visitors, they can start the HVAC units and the cooling of the spaces should be faster because of the already coller temperature inside from the outside.
- Adding curtains with low energy transmittance on the inside.
- Maintain a higher temperature room than the 18 ºC that was set up for the calculations, based on the average set point temperature recorded from the user experience of the hotel maintenance records. Even if it affects directly the freedom of the user to manage the temperature comfort directly, establishing a higher range than the evaluated performance as the lowest cooling set point (tentatively 20 ºC for instance) to the maximum established temperature by the hotel before visitors come to use the apartments (24 ºC) can result in a lower consumtion by the simple logical fact that less cooling energy is used to reach and maintain a higher temperature than a lower temperature.
- Verify possible thermal bridging (thermal infiltration between the interior and exterior of a space). Providing a better insulation and sealing of the openings (windows or doors) and verifying any construction gaps as well can help to maintain better a regulated temperature in a closed environment or space.
- Provide alternative mechanical ventilation. This can stimulate the use of natural ventilation as well. Adding more options to the already existing HVAC system could provide a better management of energy usage depending on the thermal comfort of each user. Versatily is always helpful.
- Install dehumidifiers. As stated before on the chapter of thermal comfort, the amount humidity in a space in addition to a high temperature can influence negatively on the thermal comfort of the user. Usually when the humidity is high, the thermal perception is higher than the dry-bulb temperature acting in that moment. Therefore, reducing the amount of humidity in a space with low-consumption humidifiers and combine this with mechanical ventilation can also be a method to improve thermal comfort.
- Install solar panels to compensate the energy consumption from the grid.

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7.2 APENDIX

A) Cooling Energy Base Calculations Results of All Rooms in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK1:1ROOM**

Timestamp: **2021-04-29 12:03:45**

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Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	549.88	1035.47	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	549.88					3.65				
Minimum of Months	549.88	1035.47		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	549.88	1035.47		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 1

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK1:2ROOM**

Timestamp: **2021-04-29 12:03:45**

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Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	403.24	798.57	31-AUG-14:53	34.40	25.84	3.93	5.28	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	403.24					3.93				
Minimum of Months	403.24	798.57		34.40	25.84	3.93	5.28		21.95	21.95
Maximum of Months	403.24	798.57		34.40	25.84	3.93	5.28		21.95	21.95

ROOM 2

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK2:3ROOM**

Timestamp: **2021-04-29 12:03:45**

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Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	499.67	954.28	31-AUG-14:53	34.40	25.84	3.91	5.26	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	499.67					3.91				
Minimum of Months	499.67	954.28		34.40	25.84	3.91	5.26		21.95	21.95
Maximum of Months	499.67	954.28		34.40	25.84	3.91	5.26		21.95	21.95

ROOM 3

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK2:4ROOM**

Timestamp: **2021-04-29 12:03:45**

Table of Contents

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	705.86	1247.04	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	705.86					3.65				
Minimum of Months	705.86	1247.04		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	705.86	1247.04		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 4

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK5:5ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	506.35	1002.90	31-AUG-16:53	32.20	24.20	2.35	3.16	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	506.35					2.35				
Minimum of Months	506.35	1002.90		32.20	24.20	2.35	3.16		21.95	21.95
Maximum of Months	506.35	1002.90		32.20	24.20	2.35	3.16		21.95	21.95

ROOM 5

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK5:7ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	799.22	1684.31	31-AUG-17:25	31.35	23.96	5.13	6.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	799.22					5.13				
Minimum of Months	799.22	1684.31		31.35	23.96	5.13	6.91		21.95	21.95
Maximum of Months	799.22	1684.31		31.35	23.96	5.13	6.91		21.95	21.95

ROOM 7

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK5:6ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	433.52	779.42	31-AUG-14:53	34.40	25.84	2.29	3.08	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	433.52					2.29				
Minimum of Months	433.52	779.42		34.40	25.84	2.29	3.08		21.95	21.95
Maximum of Months	433.52	779.42		34.40	25.84	2.29	3.08		21.95	21.95

ROOM 6

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK3:8ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	831.06	1496.26	31-AUG-14:53	34.40	25.84	5.09	6.86	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	831.06					5.09				
Minimum of Months	831.06	1496.26		34.40	25.84	5.09	6.86		21.95	21.95
Maximum of Months	831.06	1496.26		34.40	25.84	5.09	6.86		21.95	21.95

ROOM 8

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK3:9ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	558.79	943.60	31-AUG-10:25	30.55	25.15	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	558.79					2.00				
Minimum of Months	558.79	943.60		30.55	25.15	2.00	2.69		21.95	21.95
Maximum of Months	558.79	943.60		30.55	25.15	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK6:11ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	665.97	1234.89	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	665.97					3.65				
Minimum of Months	665.97	1234.89		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	665.97	1234.89		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 11

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK3:10ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	420.66	749.09	31-AUG-14:53	34.40	25.84	2.18	2.93	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	420.66					2.18				
Minimum of Months	420.66	749.09		34.40	25.84	2.18	2.93		21.95	21.95
Maximum of Months	420.66	749.09		34.40	25.84	2.18	2.93		21.95	21.95

ROOM 10

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK6:12ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	473.64	926.92	31-AUG-14:53	34.40	25.84	3.91	5.27	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	473.64					3.91				
Minimum of Months	473.64	926.92		34.40	25.84	3.91	5.27		21.95	21.95
Maximum of Months	473.64	926.92		34.40	25.84	3.91	5.27		21.95	21.95

ROOM 12

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK4:13ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	474.94	925.64	31-AUG-14:53	34.40	25.84	3.91	5.26	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	474.94					3.91				
Minimum of Months	474.94	925.64		34.40	25.84	3.91	5.26		21.95	21.95
Maximum of Months	474.94	925.64		34.40	25.84	3.91	5.26		21.95	21.95

ROOM 13

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK4:14ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	691.37	1240.71	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	691.37					3.65				
Minimum of Months	691.37	1240.71		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	691.37	1240.71		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 14

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK7:15ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	905.65	1727.58	31-AUG-16:53	32.20	24.20	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	905.65					3.65				
Minimum of Months	905.65	1727.58		32.20	24.20	3.65	4.91		21.95	21.95
Maximum of Months	905.65	1727.58		32.20	24.20	3.65	4.91		21.95	21.95

ROOM 15

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK7:16ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	737.00	1419.51	31-AUG-16:53	32.20	24.20	3.93	5.29	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	737.00					3.93				
Minimum of Months	737.00	1419.51		32.20	24.20	3.93	5.29		21.95	21.95
Maximum of Months	737.00	1419.51		32.20	24.20	3.93	5.29		21.95	21.95

ROOM 16

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK10:17ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	377.47	805.02	10-AUG-09:00	27.70	23.25	10.64	24.10	13-AUG-16:45	30.20	26.73
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	377.47					10.64				
Minimum of Months	377.47	805.02		27.70	23.25	10.64	24.10		30.20	26.73
Maximum of Months	377.47	805.02		27.70	23.25	10.64	24.10		30.20	26.73

ROOM 17

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK8:19ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	555.47	1148.98	31-AUG-16:53	32.20	24.20	2.35	3.17	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	555.47					2.35				
Minimum of Months	555.47	1148.98		32.20	24.20	2.35	3.17		21.95	21.95
Maximum of Months	555.47	1148.98		32.20	24.20	2.35	3.17		21.95	21.95

ROOM 19

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK10:18ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	902.78	1580.09	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	902.78					3.65				
Minimum of Months	902.78	1580.09		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	902.78	1580.09		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 18

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK8:20ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	474.85	849.11	31-AUG-14:53	34.40	25.84	2.29	3.08	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	474.85					2.29				
Minimum of Months	474.85	849.11		34.40	25.84	2.29	3.08		21.95	21.95
Maximum of Months	474.85	849.11		34.40	25.84	2.29	3.08		21.95	21.95

ROOM 20

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK8:21ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	953.40	2100.03	31-AUG-17:25	31.35	23.96	5.13	6.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	953.40					5.13				
Minimum of Months	953.40	2100.03		31.35	23.96	5.13	6.91		21.95	21.95
Maximum of Months	953.40	2100.03		31.35	23.96	5.13	6.91		21.95	21.95

ROOM 21

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK11:22ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1010.43	1812.86	23-AUG-08:25	26.90	24.59	5.09	6.86	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1010.43					5.09				
Minimum of Months	1010.43	1812.86		26.90	24.59	5.09	6.86		21.95	21.95
Maximum of Months	1010.43	1812.86		26.90	24.59	5.09	6.86		21.95	21.95

ROOM 22

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	657.96	1144.01	31-AUG-09:55	30.00	25.00	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	657.96					2.00				
Minimum of Months	657.96	1144.01		30.00	25.00	2.00	2.69		21.95	21.95
Maximum of Months	657.96	1144.01		30.00	25.00	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK11:24ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	505.97	893.97	31-AUG-14:53	34.40	25.84	2.18	2.93	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	505.97					2.18				
Minimum of Months	505.97	893.97		34.40	25.84	2.18	2.93		21.95	21.95
Maximum of Months	505.97	893.97		34.40	25.84	2.18	2.93		21.95	21.95

ROOM 24

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK9:25ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	735.14	1359.45	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	735.14					3.65				
Minimum of Months	735.14	1359.45		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	735.14	1359.45		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 25

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK12:27ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	356.50	767.59	16-AUG-09:00	28.30	23.15	9.72	23.12	13-AUG-16:45	30.20	26.73
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	356.50					9.72				
Minimum of Months	356.50	767.59		28.30	23.15	9.72	23.12		30.20	26.73
Maximum of Months	356.50	767.59		28.30	23.15	9.72	23.12		30.20	26.73

ROOM 27

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK9:26ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	540.56	1039.66	31-AUG-14:53	34.40	25.84	3.91	5.27	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	540.56					3.91				
Minimum of Months	540.56	1039.66		34.40	25.84	3.91	5.27		21.95	21.95
Maximum of Months	540.56	1039.66		34.40	25.84	3.91	5.27		21.95	21.95

ROOM 26

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK12:28ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	833.46	1478.62	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	833.46					3.65				
Minimum of Months	833.46	1478.62		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	833.46	1478.62		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 28

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK13:29ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	431.64	828.60	10-AUG-09:00	27.70	23.25	14.08	28.35	13-AUG-16:45	30.20	26.73
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	431.64					14.08				
Minimum of Months	431.64	828.60		27.70	23.25	14.08	28.35		30.20	26.73
Maximum of Months	431.64	828.60		27.70	23.25	14.08	28.35		30.20	26.73

ROOM 29

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK13:30ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	398.26	864.91	10-AUG-09:00	27.70	23.25	11.43	25.10	22-AUG-15:30	31.60	26.26
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	398.26					11.43				
Minimum of Months	398.26	864.91		27.70	23.25	11.43	25.10		31.60	26.26
Maximum of Months	398.26	864.91		27.70	23.25	11.43	25.10		31.60	26.26

ROOM 30

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK13:31ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	402.58	869.35	10-AUG-09:00	27.70	23.25	11.89	25.85	22-AUG-15:30	31.60	26.26
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	402.58					11.89				
Minimum of Months	402.58	869.35		27.70	23.25	11.89	25.85		31.60	26.26
Maximum of Months	402.58	869.35		27.70	23.25	11.89	25.85		31.60	26.26

ROOM 31

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK13:32ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	449.14	849.31	09-AUG-08:15	23.58	21.30	15.36	30.06	22-AUG-17:30	29.45	26.26
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	449.14					15.36				
Minimum of Months	449.14	849.31		23.58	21.30	15.36	30.06		29.45	26.26
Maximum of Months	449.14	849.31		23.58	21.30	15.36	30.06		29.45	26.26

ROOM 32

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK15:33ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	610.80	1210.93	31-AUG-16:53	32.20	24.20	2.35	3.17	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	610.80					2.35				
Minimum of Months	610.80	1210.93		32.20	24.20	2.35	3.17		21.95	21.95
Maximum of Months	610.80	1210.93		32.20	24.20	2.35	3.17		21.95	21.95

ROOM 33

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK15:34ROOM**

Timestamp: **2021-04-29 12:03:45**

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	540.20	953.96	31-AUG-14:53	34.40	25.84	2.29	3.08	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	540.20					2.29				
Minimum of Months	540.20	953.96		34.40	25.84	2.29	3.08		21.95	21.95
Maximum of Months	540.20	953.96		34.40	25.84	2.29	3.08		21.95	21.95

ROOM 34

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK15:35ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	578.51	1180.03	10-AUG-09:00	27.70	23.25	17.73	38.88	22-AUG-17:00	28.90	25.90
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	578.51					17.73				
Minimum of Months	578.51	1180.03		27.70	23.25	17.73	38.88		28.90	25.90
Maximum of Months	578.51	1180.03		27.70	23.25	17.73	38.88		28.90	25.90

ROOM 35

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:36ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1053.68	1863.32	23-AUG-08:25	26.90	24.59	5.09	6.86	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1053.68					5.09				
Minimum of Months	1053.68	1863.32		26.90	24.59	5.09	6.86		21.95	21.95
Maximum of Months	1053.68	1863.32		26.90	24.59	5.09	6.86		21.95	21.95

ROOM 36

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK14:37ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	528.41	927.45	31-AUG-23:10	26.30	23.13	2.18	2.93	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	528.41					2.18				
Minimum of Months	528.41	927.45		26.30	23.13	2.18	2.93		21.95	21.95
Maximum of Months	528.41	927.45		26.30	23.13	2.18	2.93		21.95	21.95

ROOM 37

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK14:38ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	667.17	1150.89	31-AUG-09:55	30.00	25.00	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	667.17					2.00				
Minimum of Months	667.17	1150.89		30.00	25.00	2.00	2.69		21.95	21.95
Maximum of Months	667.17	1150.89		30.00	25.00	2.00	2.69		21.95	21.95

ROOM 38

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK16:39ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	781.16	1431.83	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	781.16					3.65				
Minimum of Months	781.16	1431.83		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	781.16	1431.83		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 39

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK16:40ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	594.49	1161.97	31-AUG-14:53	34.40	25.84	3.91	5.27	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	594.49					3.91				
Minimum of Months	594.49	1161.97		34.40	25.84	3.91	5.27		21.95	21.95
Maximum of Months	594.49	1161.97		34.40	25.84	3.91	5.27		21.95	21.95

ROOM 40

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK16:41ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	619.33	1204.59	31-AUG-14:53	34.40	25.84	3.91	5.27	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	619.33					3.91				
Minimum of Months	619.33	1204.59		34.40	25.84	3.91	5.27		21.95	21.95
Maximum of Months	619.33	1204.59		34.40	25.84	3.91	5.27		21.95	21.95

ROOM 41

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK16:42ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	832.35	1471.18	31-AUG-14:53	34.40	25.84	3.65	4.91	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	832.35					3.65				
Minimum of Months	832.35	1471.18		34.40	25.84	3.65	4.91		21.95	21.95
Maximum of Months	832.35	1471.18		34.40	25.84	3.65	4.91		21.95	21.95

ROOM 42

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **43ROOM:43ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1189.48	2154.86	31-AUG-23:40	26.10	23.16	4.99	6.72	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1189.48					4.99				
Minimum of Months	1189.48	2154.86		26.10	23.16	4.99	6.72		21.95	21.95
Maximum of Months	1189.48	2154.86		26.10	23.16	4.99	6.72		21.95	21.95

ROOM 43

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **44ROOM:44ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1256.90	2161.81	31-AUG-22:40	26.50	23.14	4.99	6.71	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1256.90					4.99				
Minimum of Months	1256.90	2161.81		26.50	23.14	4.99	6.71		21.95	21.95
Maximum of Months	1256.90	2161.81		26.50	23.14	4.99	6.71		21.95	21.95

ROOM 44

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **45ROOM:45ROOM**

Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1132.40	2046.77	31-AUG-23:25	26.20	23.15	4.81	6.48	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1132.40					4.81				
Minimum of Months	1132.40	2046.77		26.20	23.15	4.81	6.48		21.95	21.95
Maximum of Months	1132.40	2046.77		26.20	23.15	4.81	6.48		21.95	21.95

ROOM 45

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **46ROOM:46ROOM**

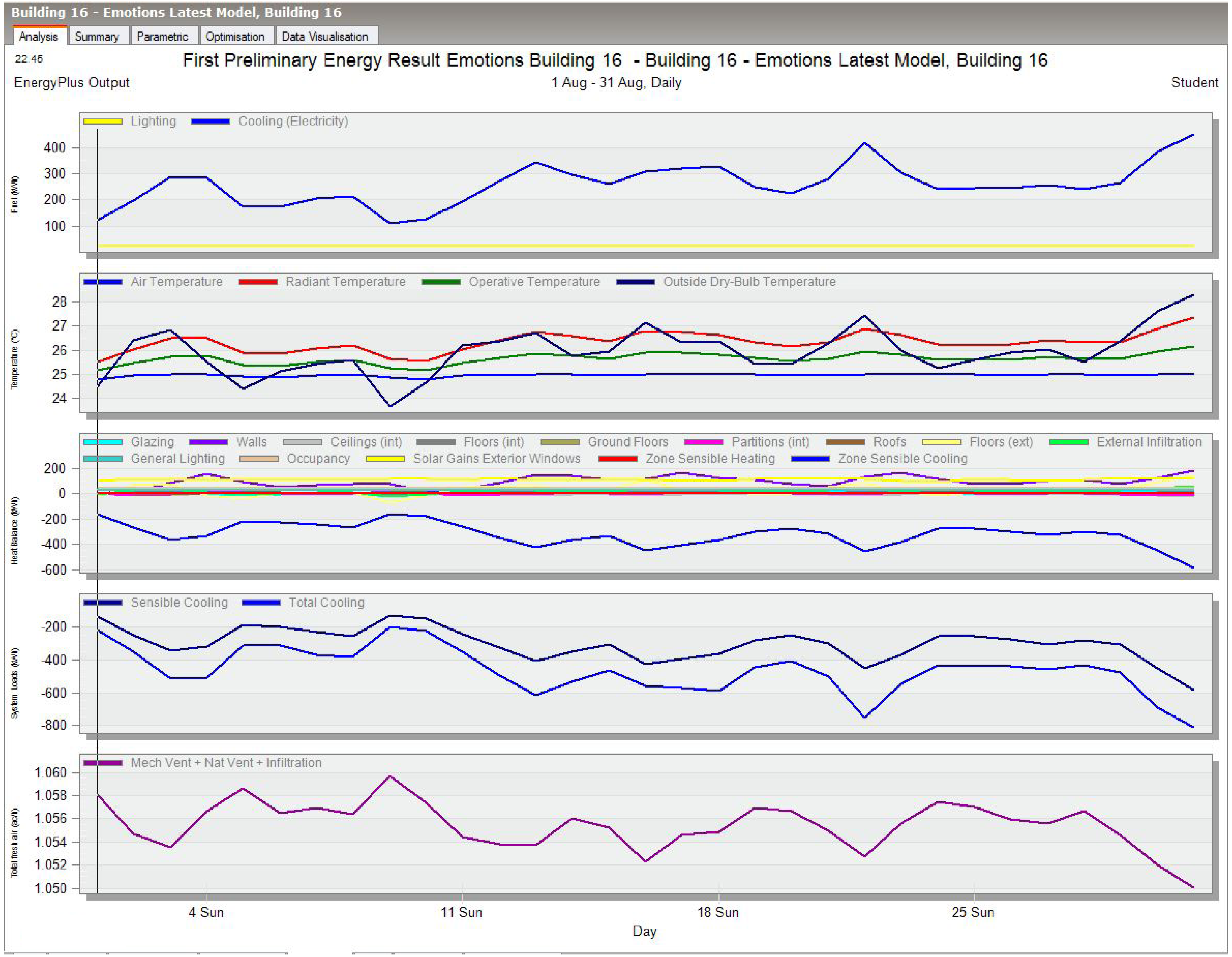
Timestamp: **2021-04-29 12:03:45**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	1068.03	1823.89	31-AUG-22:25	26.60	23.15	4.81	6.48	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	1068.03					4.81				
Minimum of Months	1068.03	1823.89		26.60	23.15	4.81	6.48		21.95	21.95
Maximum of Months	1068.03	1823.89		26.60	23.15	4.81	6.48		21.95	21.95

ROOM 46

B) Cooling Energy Base Calculations Analysis Chart of All Rooms in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



C) Individual Passive Design Calculations - Phase 1 - Double Glazing - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK3:9ROOM**

Timestamp: **2021-05-03 17:14:44**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	510.12	845.11	31-AUG-09:00	28.00	24.60	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	510.12					2.00				
Minimum of Months	510.12	845.11		28.00	24.60	2.00	2.69		21.95	21.95
Maximum of Months	510.12	845.11		28.00	24.60	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK11:23ROOM**

Timestamp: **2021-05-03 17:14:44**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	605.80	1046.89	23-AUG-09:00	27.70	24.77	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	605.80					2.00				
Minimum of Months	605.80	1046.89		27.70	24.77	2.00	2.69		21.95	21.95
Maximum of Months	605.80	1046.89		27.70	24.77	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:38ROOM**

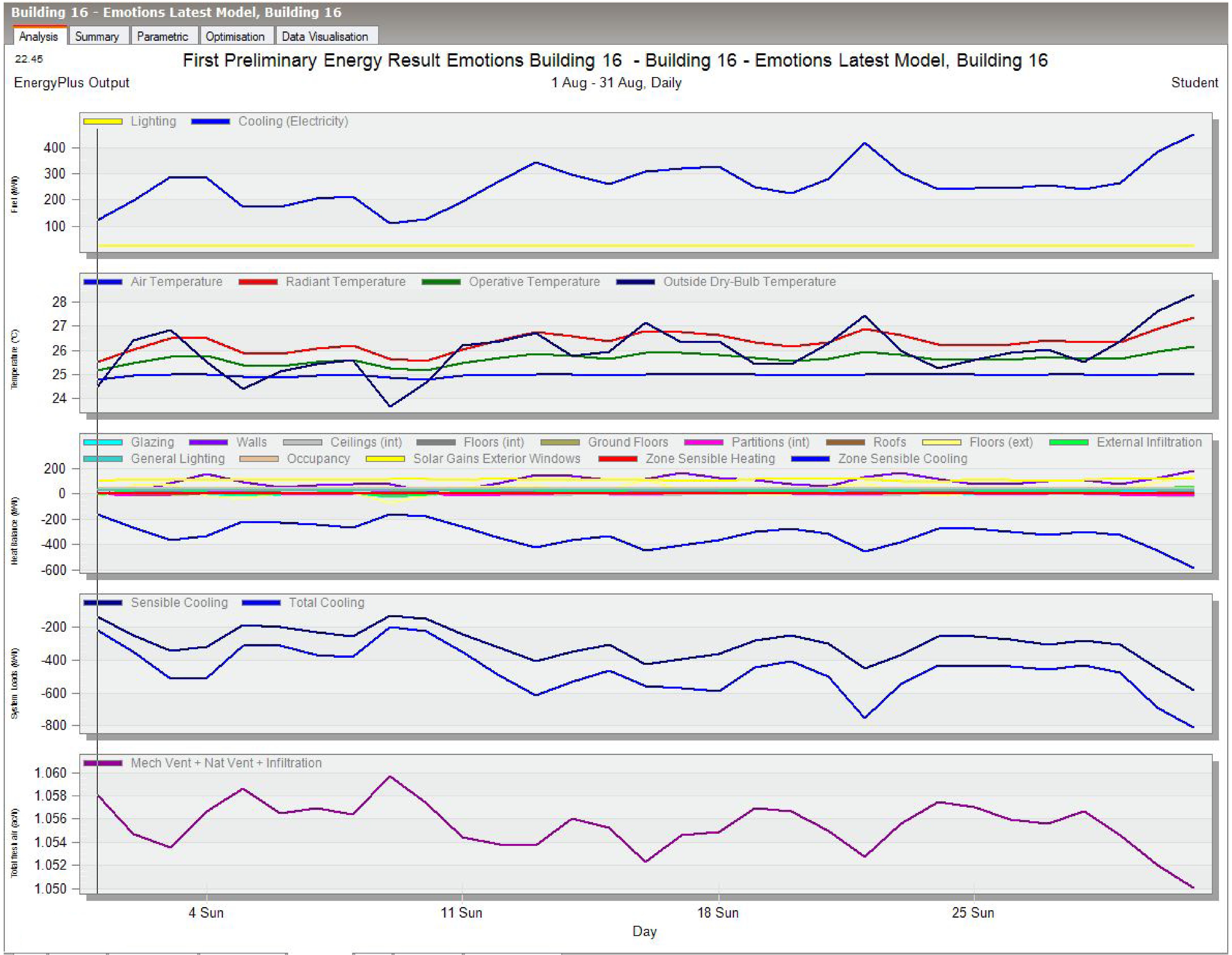
Timestamp: **2021-05-03 17:14:44**

Custom Monthly Report

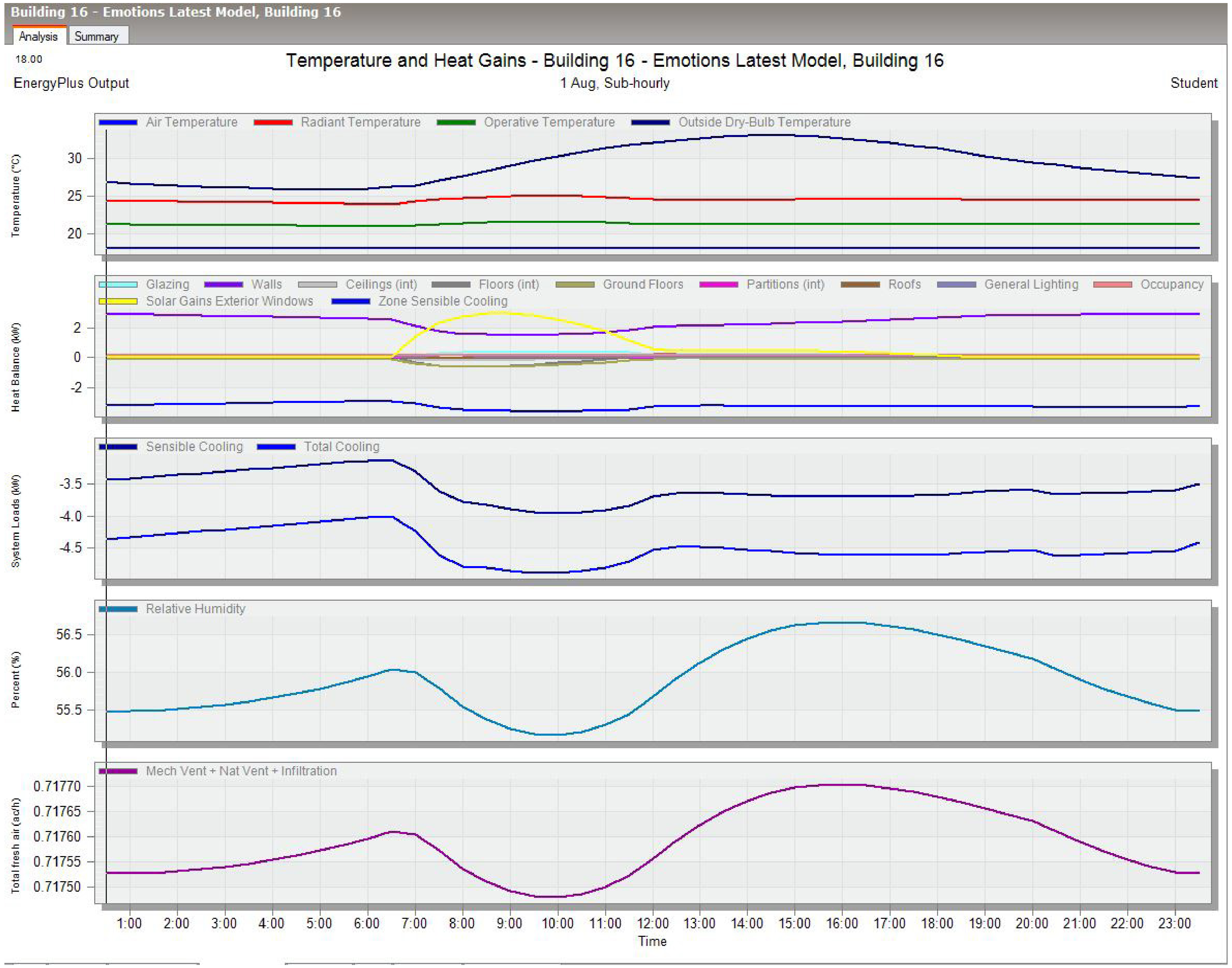
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	614.78	1053.87	23-AUG-09:00	27.70	24.77	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	614.78					2.00				
Minimum of Months	614.78	1053.87		27.70	24.77	2.00	2.69		21.95	21.95
Maximum of Months	614.78	1053.87		27.70	24.77	2.00	2.69		21.95	21.95

ROOM 38

C.1) Individual Passive Design Calculations - Phase 1 - Double Glazing - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



C.2) Individual Passive Design Calculations - Phase 1 - Double Glazing - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)
Building 16						
Block3:9Room	1.72	-1.3685	1.49	1.17	0.32	18.0
Block11:23Room	2.02	-1.0164	1.76	1.42	0.34	18.0
Block14:38Room	2.04	-0.9928	1.77	1.44	0.34	18.0
Totals	**5.78**	**-3.3777**	**5.03**	**4.03**	**0.99**	**18.0**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Humidity (%)	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per...	Outside Temperature at Peak Load (°C)
Building 16								
Block3:9Room	56.8	Sep 10:00	21.2	15.0	36.3	-91.21	114.4	30.3
Block11:23Room	54.9	Sep 09:30	21.7	15.0	38.6	-67.74	134.8	29.7
Block14:38Room	54.7	Sep 09:30	21.7	15.0	38.6	-66.17	135.9	29.7
Totals	**55.4**	**N/A**	**21.7**	**45.0**	**113.4**	**-75.04**	**128.4**	**N/A**

D) Individual Passive Design Calculations - Phase 1 - Shading - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK3:9ROOM**

Timestamp: **2021-05-04 00:25:25**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	434.84	759.29	31-AUG-23:30	26.20	23.15	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	434.84					2.00				
Minimum of Months	434.84	759.29		26.20	23.15	2.00	2.69		21.95	21.95
Maximum of Months	434.84	759.29		26.20	23.15	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-05-04 00:25:25**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	512.72	894.75	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	512.72					2.00				
Minimum of Months	512.72	894.75		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	512.72	894.75		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK14:38ROOM**

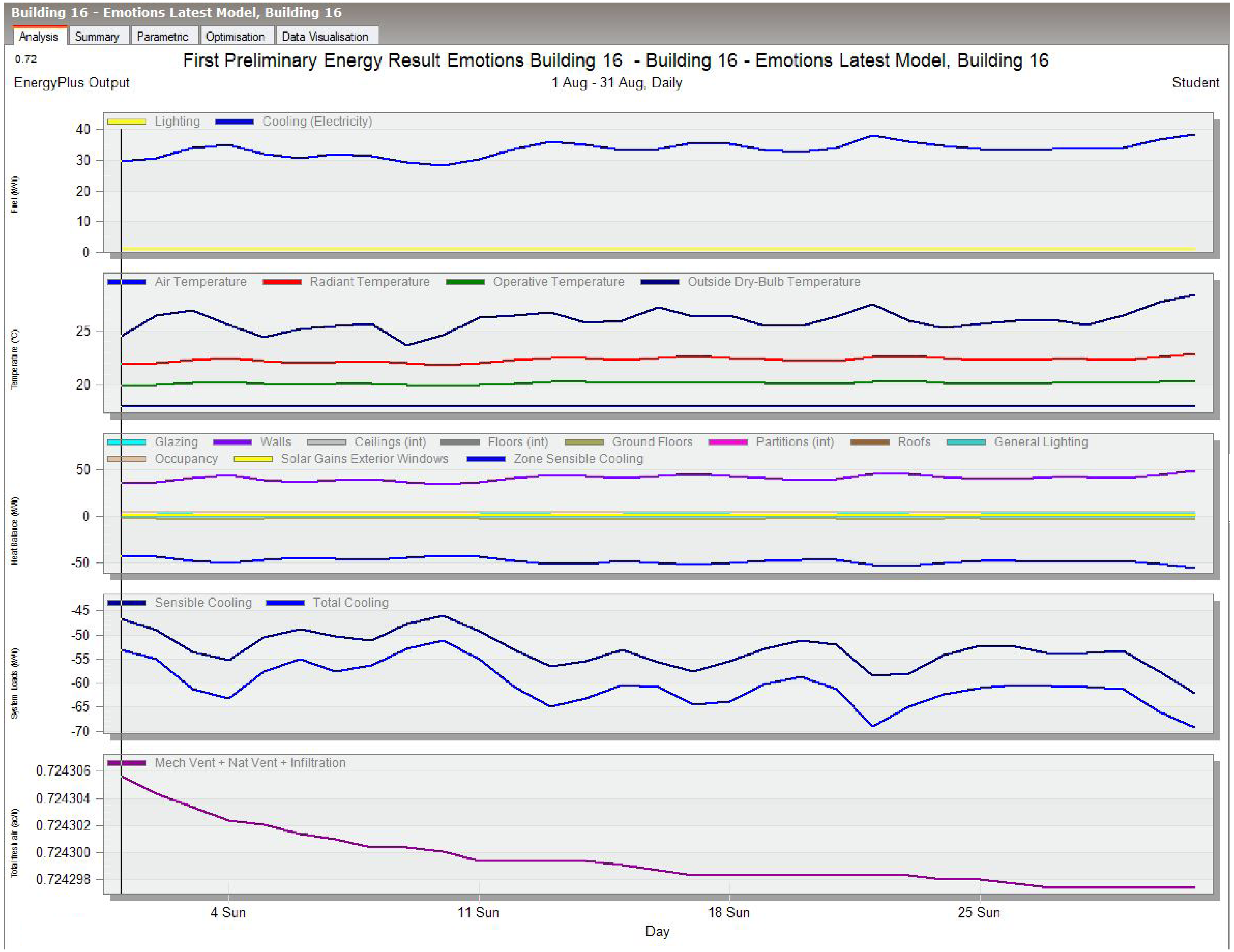
Timestamp: **2021-05-04 00:25:25**

Custom Monthly Report

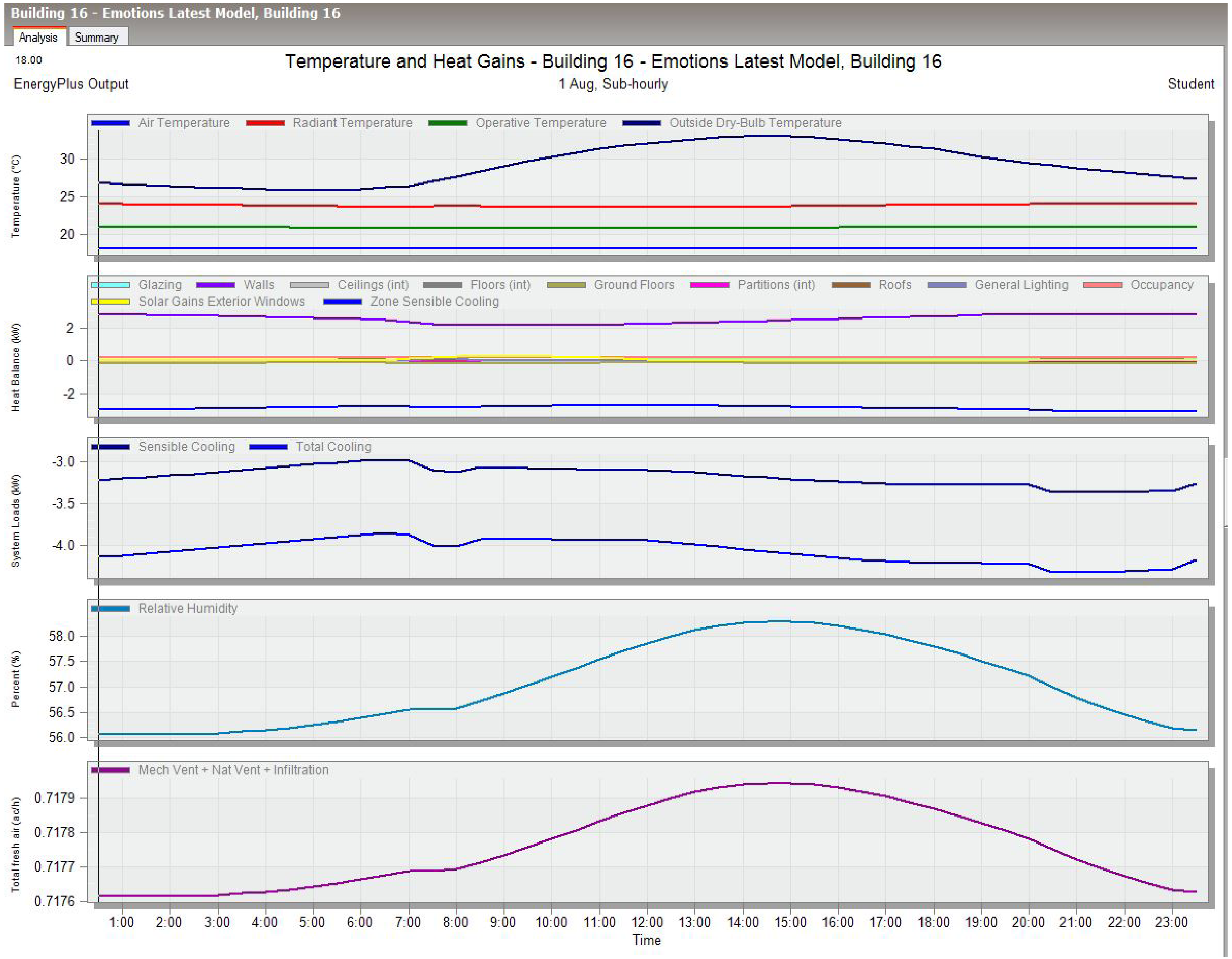
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	532.57	922.31	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	532.57					2.00				
Minimum of Months	532.57	922.31		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	532.57	922.31		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 38

D.1) Individual Passive Design Calculations - Phase 1 - Shading - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



D.2) Individual Passive Design Calculations - Phase 1 - Shading - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)
Building 16						
Block3:9Room	1.57	-2.7089	1.36	1.02	0.34	18.0
Block11:23Room	1.76	-1.3835	1.53	1.19	0.34	18.0
Block14:38Room	1.81	-1.2866	1.57	1.23	0.34	18.0
Totals	**5.13**	**-5.3791**	**4.46**	**3.44**	**1.03**	**18.0**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Humidity (%)	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16								
Block3:9Room	58.5	Sep 20:30	20.8	15.0	36.3	-180.54	104.5	29.1
Block11:23Room	56.7	Sep 21:00	21.1	15.0	38.6	-92.21	117.4	28.7
Block14:38Room	56.4	Sep 21:00	21.3	15.0	38.6	-85.75	120.4	28.7
Totals	**57.2**	**N/A**	**21.3**	**45.0**	**113.4**	**-119.50**	**114.1**	**N/A**

E) Individual Passive Design Calculations - Phase 1 - WWR - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

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For: **BLOCK3:9ROOM**

Timestamp: **2021-05-04 00:43:46**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	452.38	778.10	31-AUG-23:15	26.30	23.13	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	452.38					2.00				
Minimum of Months	452.38	778.10		26.30	23.13	2.00	2.69		21.95	21.95
Maximum of Months	452.38	778.10		26.30	23.13	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-05-04 00:43:46**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	588.00	982.42	31-AUG-10:30	30.55	25.15	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	588.00					2.00				
Minimum of Months	588.00	982.42		30.55	25.15	2.00	2.69		21.95	21.95
Maximum of Months	588.00	982.42		30.55	25.15	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

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For: **BLOCK14:38ROOM**

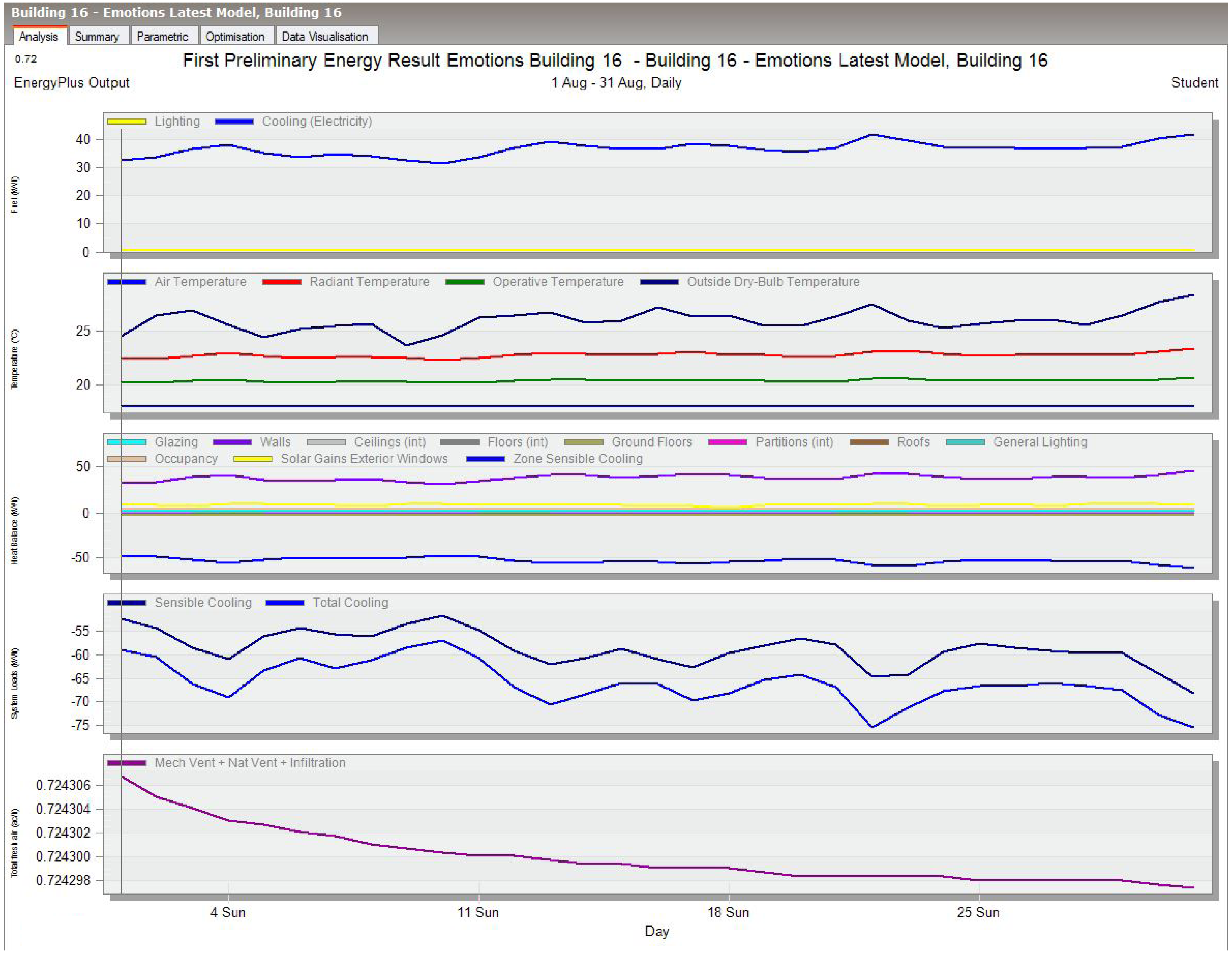
Timestamp: **2021-05-04 00:43:46**

Custom Monthly Report

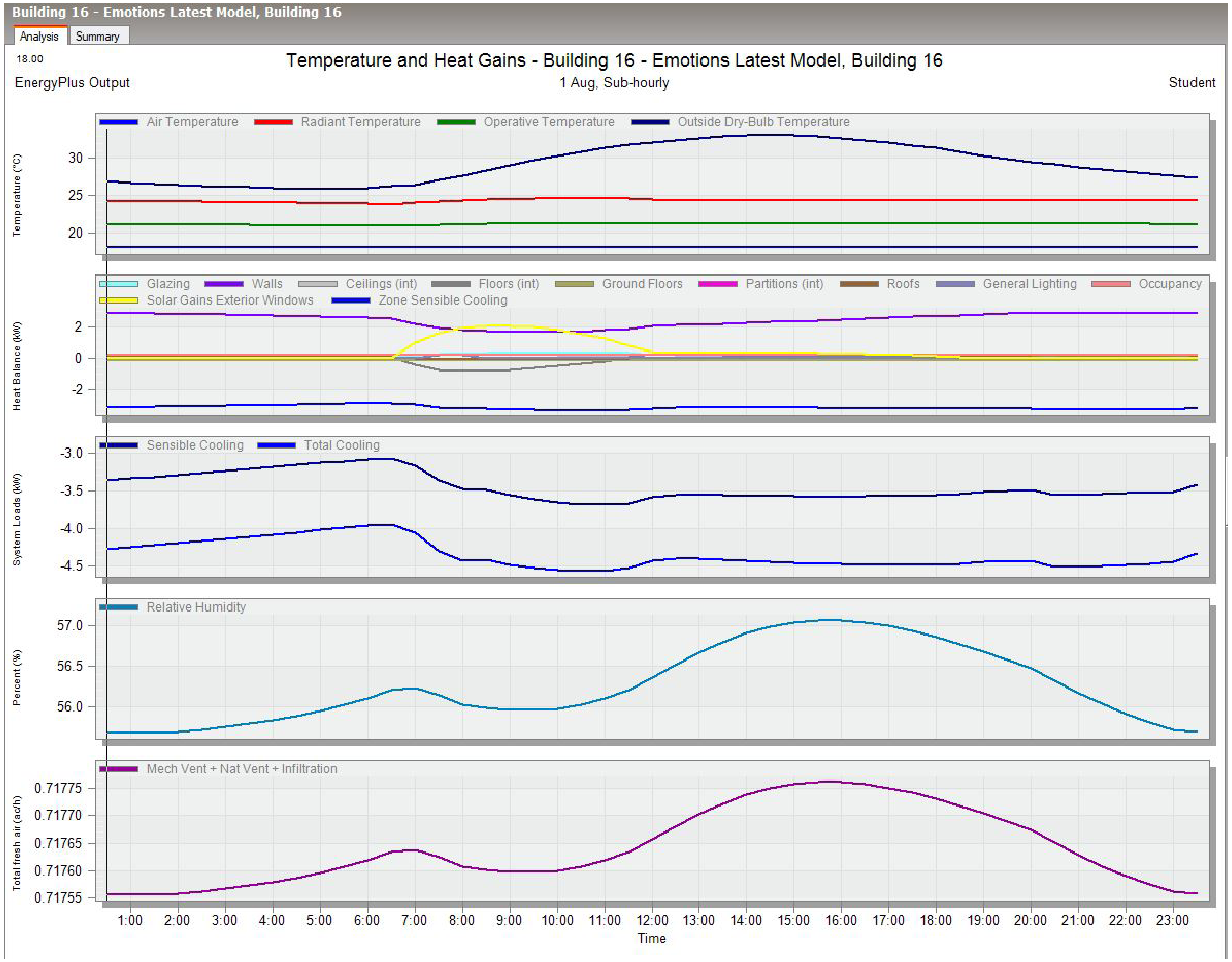
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	614.24	1008.63	31-AUG-10:15	30.27	25.08	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	614.24					2.00				
Minimum of Months	614.24	1008.63		30.27	25.08	2.00	2.69		21.95	21.95
Maximum of Months	614.24	1008.63		30.27	25.08	2.00	2.69		21.95	21.95

ROOM 38

E.1) Individual Passive Design Calculations - Phase 1 - WWR - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



E.2) Individual Passive Design Calculations - Phase 1 - WWR - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)
Building 16						
Block3:9Room	1.60	-2.2058	1.39	1.05	0.34	18.0
Block11:23Room	1.95	-1.0845	1.69	1.37	0.32	18.0
Block14:38Room	1.98	-1.0210	1.72	1.40	0.33	18.0
Totals	**5.52**	**-4.3113**	**4.80**	**3.82**	**0.99**	**18.0**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Humidity (%)	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16								
Block3:9Room	58.1	Sep 20:30	20.9	15.0	36.3	-147.01	106.6	29.1
Block11:23Room	55.4	Sep 10:30	21.6	15.0	38.6	-72.28	129.7	30.9
Block14:38Room	55.0	Sep 10:00	21.6	15.0	38.6	-68.04	131.9	30.3
Totals	**56.1**	**N/A**	**21.6**	**45.0**	**113.4**	**-95.78**	**122.7**	**N/A**

F) Shading of Opaque Surfaces - Phase 2 - Overhangs of 0.5 m - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-08 20:57:49**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	384.89	692.06	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	384.89					2.00				
Minimum of Months	384.89	692.06		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	384.89	692.06		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-08 20:57:49**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	457.61	823.59	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	457.61					2.00				
Minimum of Months	457.61	823.59		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	457.61	823.59		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:38ROOM**

Timestamp: **2021-06-08 20:57:49**

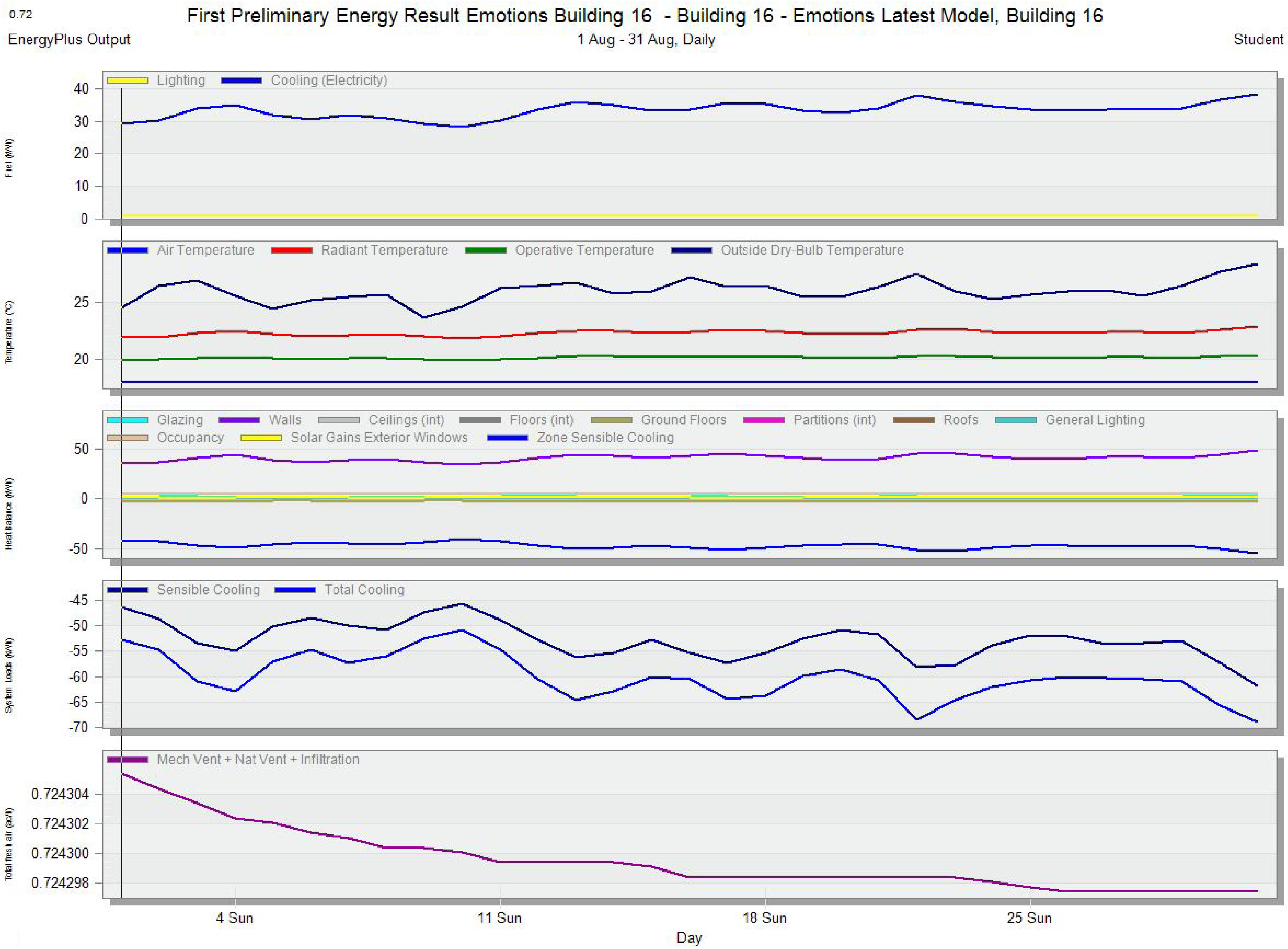
Custom Monthly Report

Table of Contents

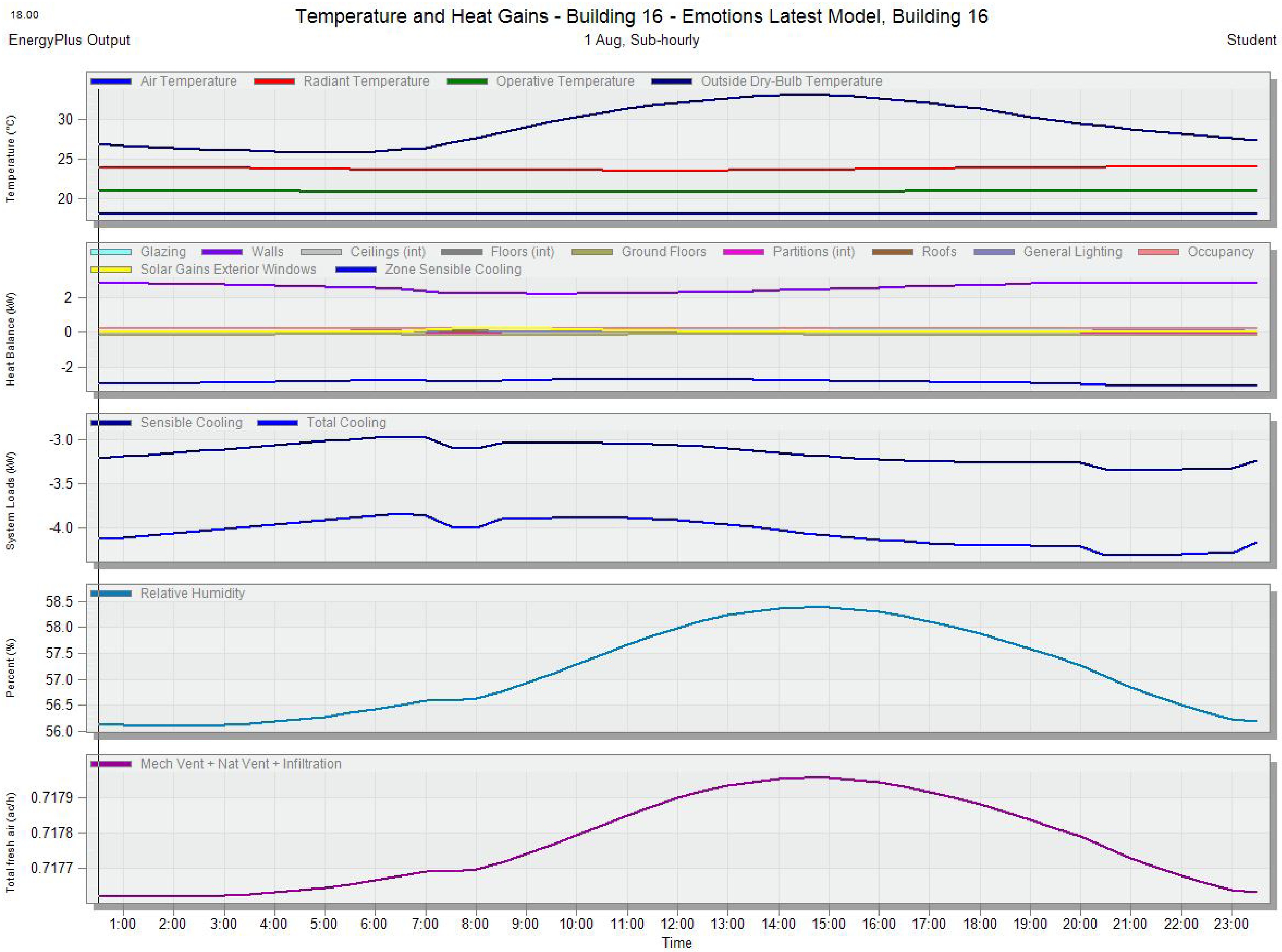
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	473.79	847.02	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	473.79					2.00				
Minimum of Months	473.79	847.02		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	473.79	847.02		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 38

F.1) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 0.5 m - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



F.2) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 0.5 m - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	1.57	-2.7340	1.36	1.02	0.34	18.0	58.5
Block11:23Room	1.75	-1.4035	1.53	1.18	0.34	18.0	56.8
Block14:38Room	1.80	-1.3040	1.56	1.22	0.34	18.0	56.4
Totals	**5.12**	**-5.4415**	**4.45**	**3.43**	**1.03**	**18.0**	**57.2**

Analysis | Summary

Zone	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16							
Block3:9Room	Sep 20:30	20.8	15.0	36.3	-182.21	104.4	29.1
Block11:23Room	Sep 21:00	21.1	15.0	38.6	-93.54	116.9	28.7
Block14:38Room	Sep 21:00	21.2	15.0	38.6	-86.90	119.8	28.7
Totals	**N/A**	**21.2**	**45.0**	**113.4**	**-120.89**	**113.7**	**N/A**

G) Shading of Opaque Surfaces - Phase 2 - Overhangs of 1.0 m - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 12:51:21**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	384.72	691.28	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	384.72					2.00				
Minimum of Months	384.72	691.28		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	384.72	691.28		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:38ROOM**

Timestamp: **2021-06-09 12:51:21**

Custom Monthly Report

Table of Contents

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	472.42	844.58	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	472.42					2.00				
Minimum of Months	472.42	844.58		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	472.42	844.58		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 38

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 12:51:21**

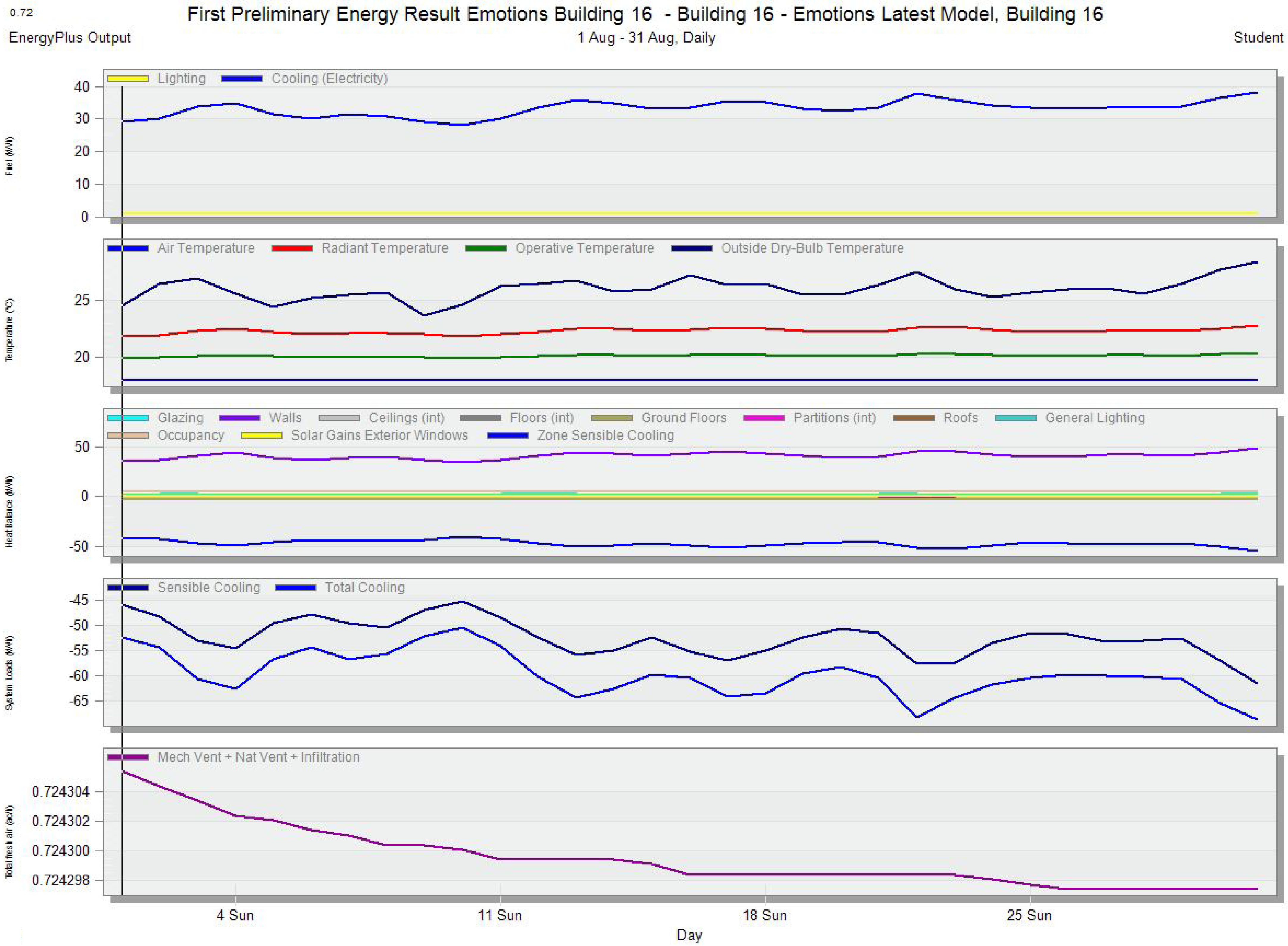
Custom Monthly Report

Table of Contents

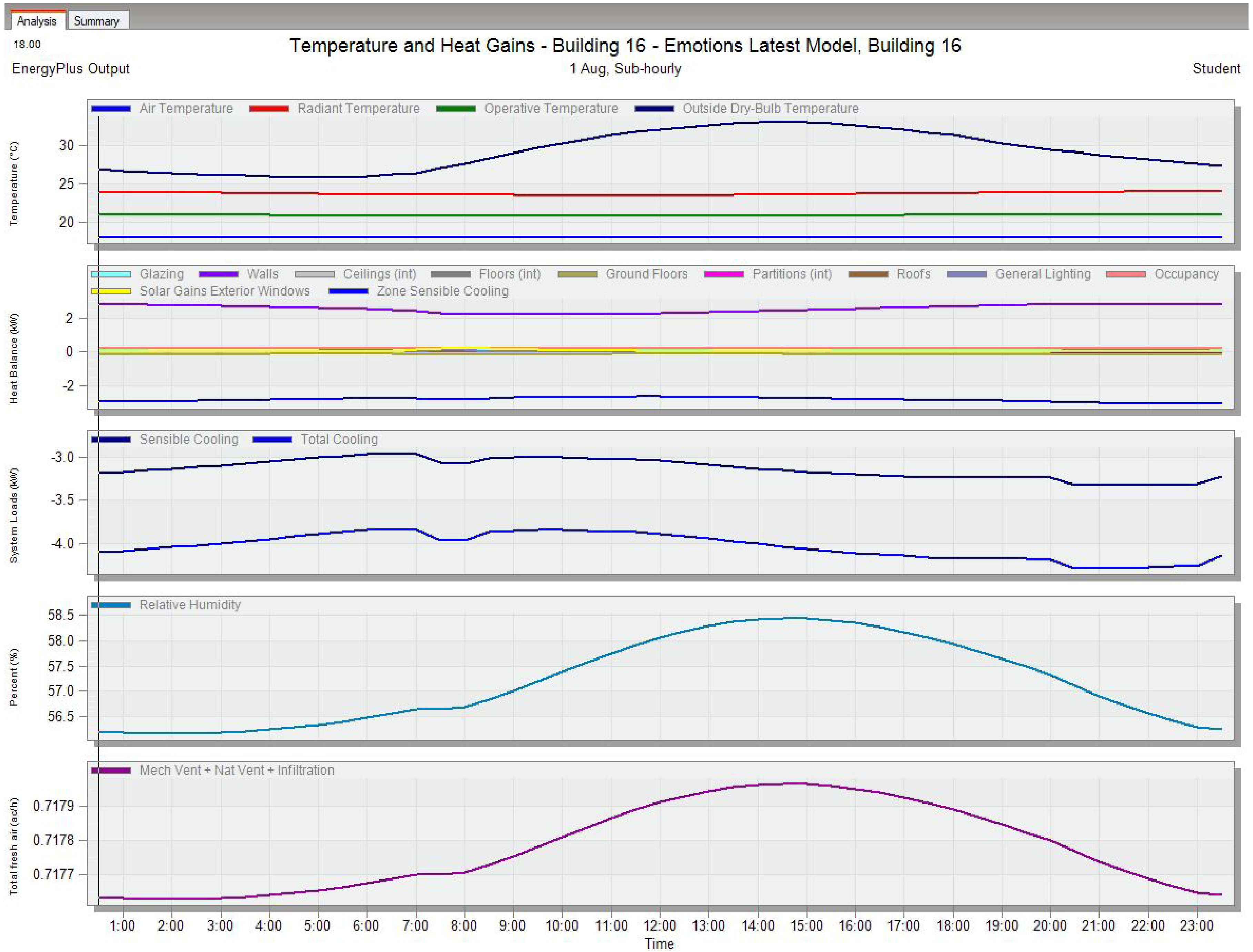
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	455.29	818.45	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	455.29					2.00				
Minimum of Months	455.29	818.45		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	455.29	818.45		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 23

G.1) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 1.0 m - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



G.2) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 1.0 m - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	1.56	-2.7709	1.36	1.02	0.34	18.0	58.5
Block11:23Room	1.75	-1.4261	1.52	1.18	0.34	18.0	56.8
Block14:38Room	1.79	-1.3232	1.56	1.21	0.34	18.0	56.5
Totals	**5.10**	**-5.5202**	**4.43**	**3.41**	**1.03**	**18.0**	**57.3**

Zone	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16							
Block3:9Room	Sep 20:30	20.8	15.0	36.3	-184.67	104.2	29.1
Block11:23Room	Sep 21:00	21.1	15.0	38.6	-95.05	116.4	28.7
Block14:38Room	Sep 21:00	21.2	15.0	38.6	-88.19	119.2	28.7
Totals	**N/A**	**21.2**	**45.0**	**113.4**	**-122.63**	**113.3**	**N/A**

H) Shading of Opaque Surfaces - Phase 2 - Overhangs of 1.5 m - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 13:08:41**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	374.91	678.20	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	374.91					2.00				
Minimum of Months	374.91	678.20		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	374.91	678.20		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 13:08:41**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	439.95	799.05	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	439.95					2.00				
Minimum of Months	439.95	799.05		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	439.95	799.05		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly** Table of Contents

For: **BLOCK14:38ROOM**

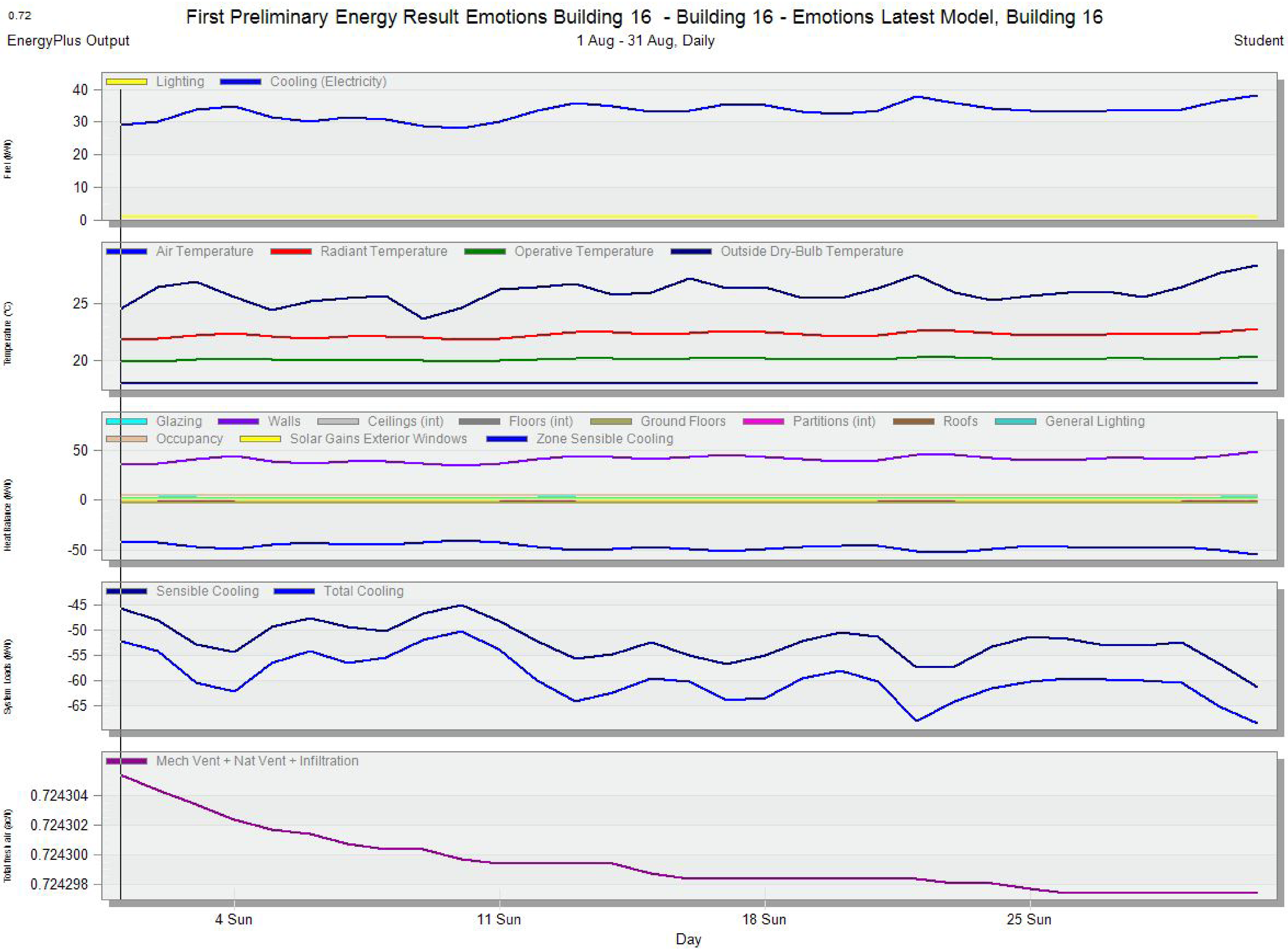
Timestamp: **2021-06-09 13:08:41**

Custom Monthly Report

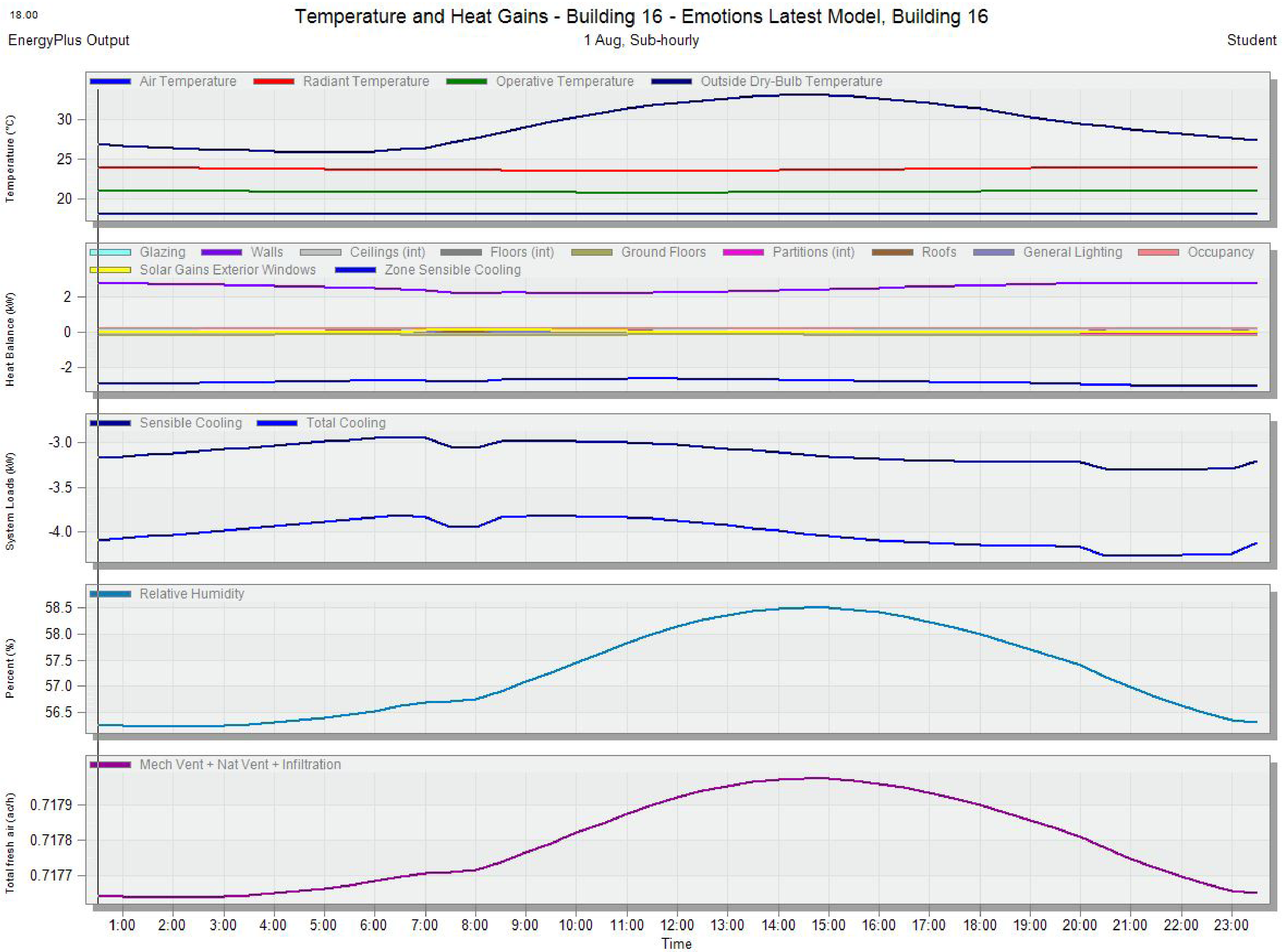
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	458.60	825.88	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	458.60					2.00				
Minimum of Months	458.60	825.88		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	458.60	825.88		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 38

H.1) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 1.5 m - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



H.2) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 1.5 m - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	1.56	-2.8184	1.36	1.02	0.34	18.0	58.5
Block11:23Room	1.74	-1.4484	1.51	1.17	0.34	18.0	56.9
Block14:38Room	1.78	-1.3416	1.55	1.20	0.34	18.0	56.6
Totals	**5.08**	**-5.6083**	**4.42**	**3.39**	**1.03**	**18.0**	**57.3**

Analysis | Summary

Zone	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16						
Block3:9Room	20.8	15.0	36.3	-187.83	104.0	29.1
Block11:23Room	21.1	15.0	38.6	-96.53	115.9	28.7
Block14:38Room	21.2	15.0	38.6	-89.41	118.7	28.7
Totals	**21.2**	**45.0**	**113.4**	**-124.59**	**112.9**	**N/A**

I) Shading of Opaque Surfaces - Phase 2 - Overhangs of 2.0 m - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 14:09:59**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	372.05	674.92	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	372.05					2.00				
Minimum of Months	372.05	674.92		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	372.05	674.92		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 14:09:59**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	446.49	809.43	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	446.49					2.00				
Minimum of Months	446.49	809.43		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	446.49	809.43		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK14:38ROOM**

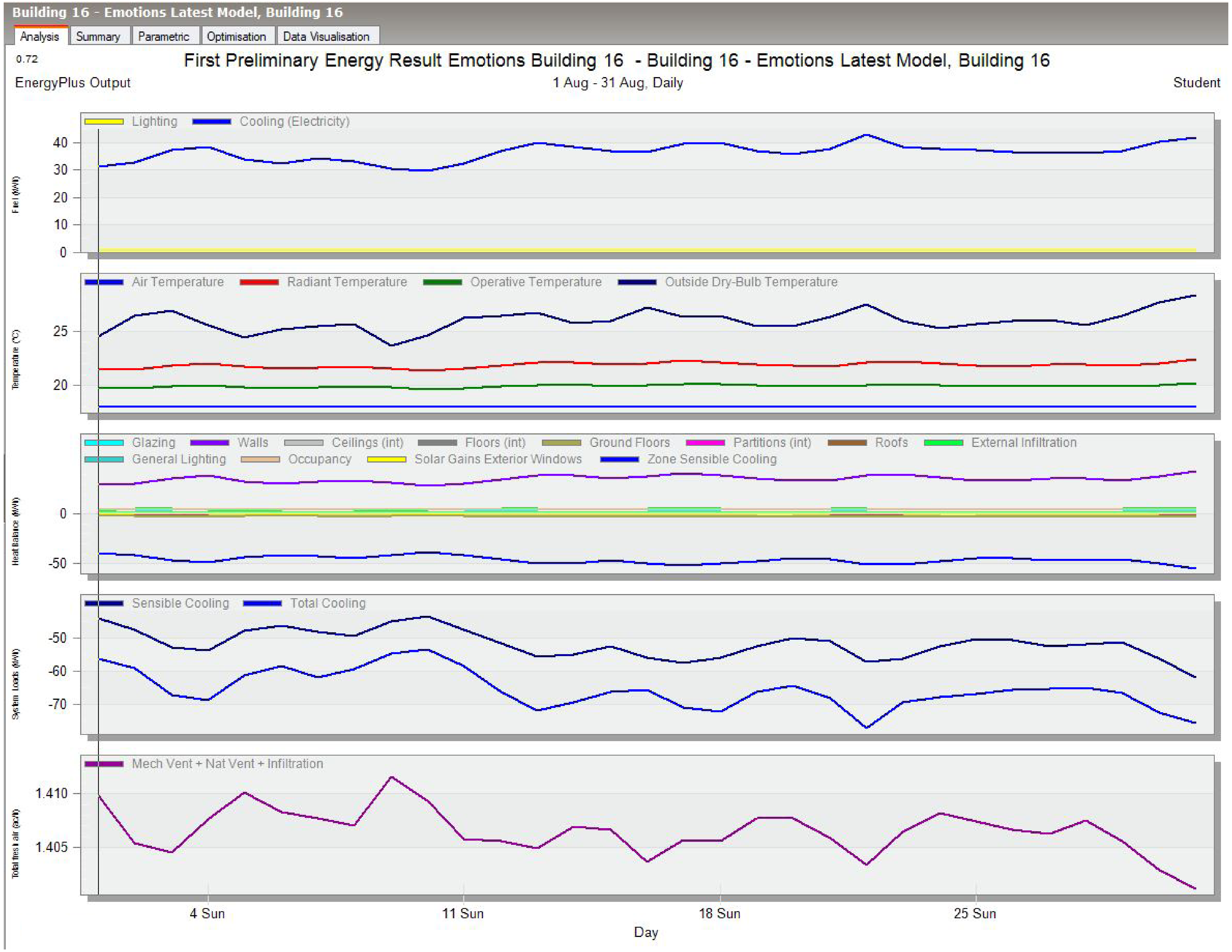
Timestamp: **2021-06-09 14:09:59**

Custom Monthly Report

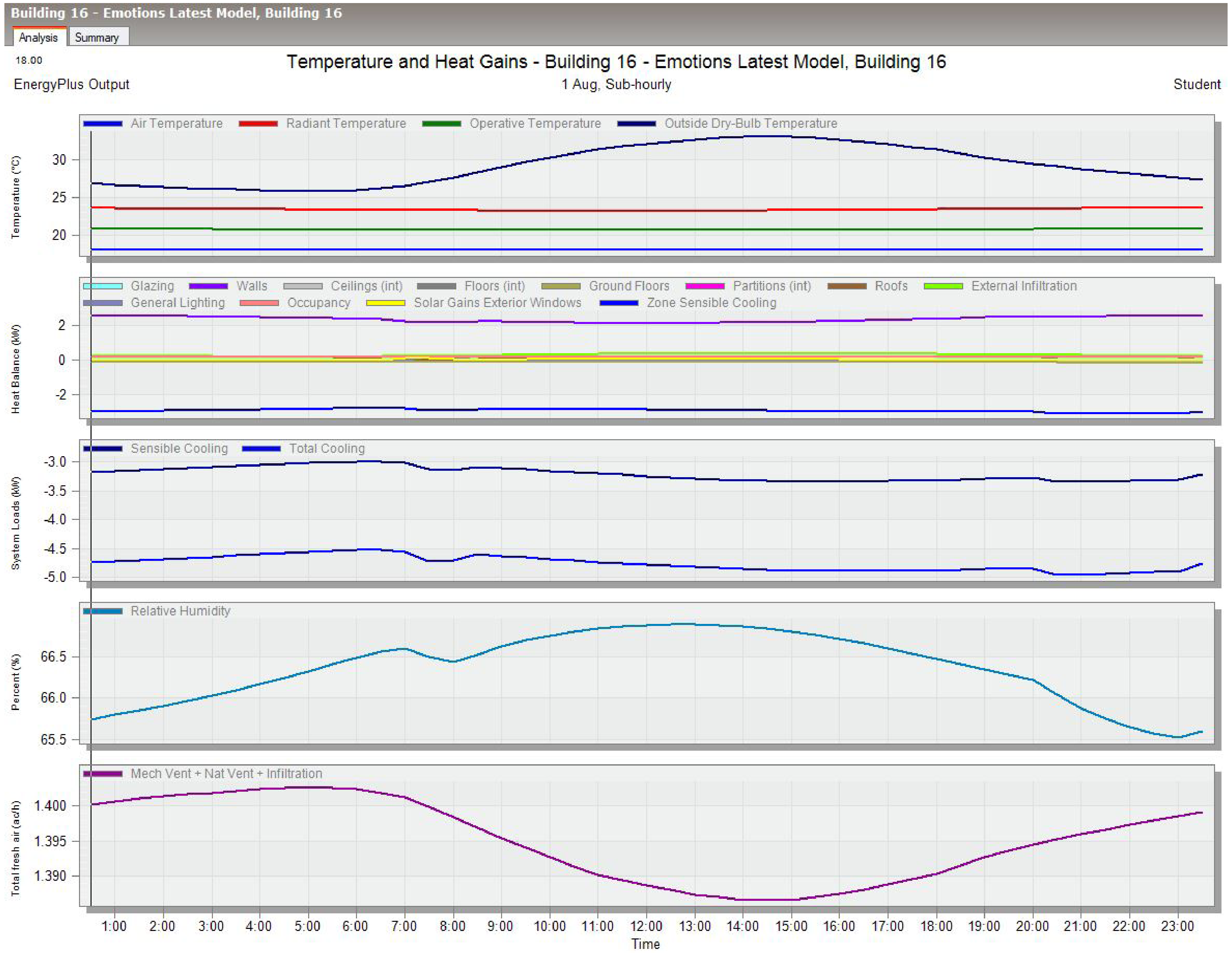
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	462.25	833.04	31-AUG-24:00	26.00	23.17	2.00	2.69	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	462.25					2.00				
Minimum of Months	462.25	833.04		26.00	23.17	2.00	2.69		21.95	21.95
Maximum of Months	462.25	833.04		26.00	23.17	2.00	2.69		21.95	21.95

ROOM 38

I.1) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 2.0 m - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



I.2) Shading of Opaque Surfaces Calculations - Phase 2 - Overhangs of 2.0 m - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
- Building 16							
Block3:9Room	**1.77**	**0.5208**	1.54	0.99	0.55	18.0	68.5
Block11:23Room	**1.98**	**0.7245**	1.72	1.14	0.58	18.0	66.8
Block14:38Room	**2.02**	**0.7851**	1.75	1.17	0.58	18.0	66.4
Totals	**5.76**	**2.0304**	**5.01**	**3.30**	**1.72**	**18.0**	**67.2**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
- Building 16						
Block3:9Room	20.5	15.0	36.3	34.71	118.1	29.1
Block11:23Room	20.8	15.0	38.6	48.29	131.8	29.1
Block14:38Room	20.9	15.0	38.6	52.32	134.3	29.1
Totals	**20.9**	**45.0**	**113.4**	**45.11**	**128.1**	**N/A**

J) Sustainable Facade Layers - Phase 3 - Replacement of Exterior Facade Walls with Sustainable Facade Sandwich Panel Walls (SPW) Calculations - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK3:9ROOM**

Timestamp: **2021-05-04 22:41:59**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	211.87	476.10	30-AUG-10:00	30.00	25.00	1.78	2.39	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	211.87					1.78				
Minimum of Months	211.87	476.10		30.00	25.00	1.78	2.39		21.95	21.95
Maximum of Months	211.87	476.10		30.00	25.00	1.78	2.39		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK11:23ROOM**

Timestamp: **2021-05-04 22:41:59**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	262.40	638.59	30-AUG-09:00	28.30	23.95	1.78	2.39	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	262.40					1.78				
Minimum of Months	262.40	638.59		28.30	23.95	1.78	2.39		21.95	21.95
Maximum of Months	262.40	638.59		28.30	23.95	1.78	2.39		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK14:38ROOM**

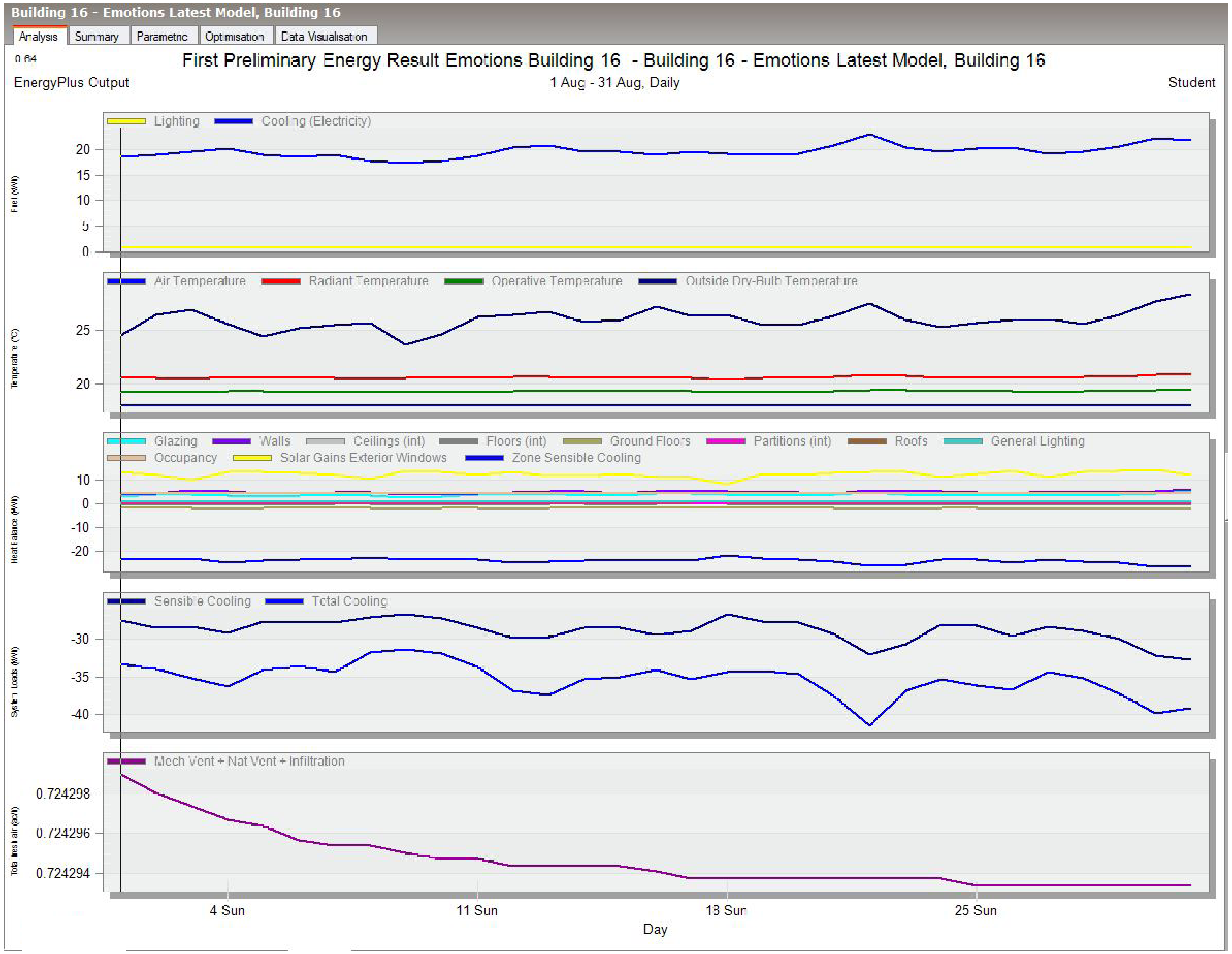
Timestamp: **2021-05-04 22:41:59**

Custom Monthly Report

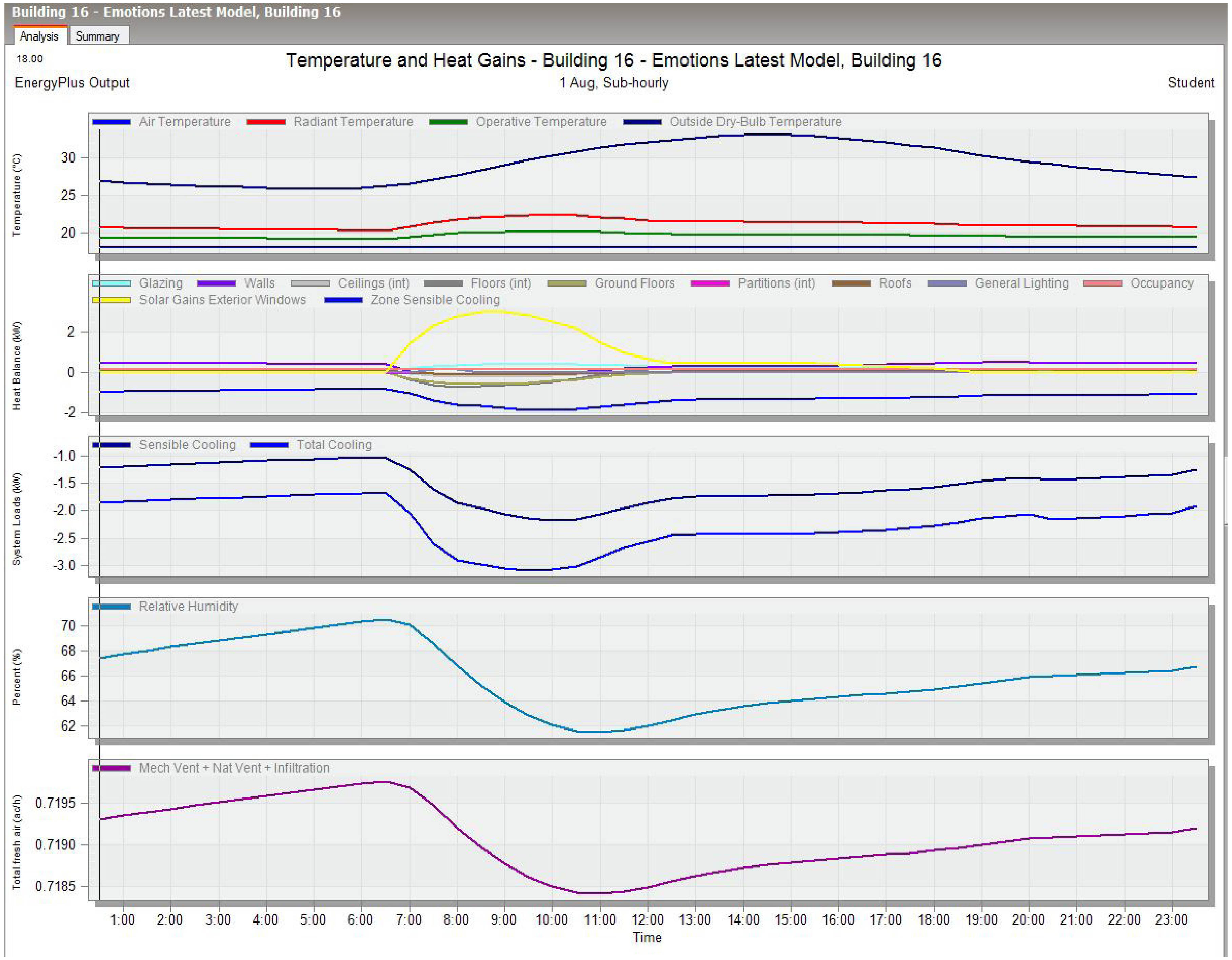
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	273.29	651.22	30-AUG-09:00	28.30	23.95	1.78	2.39	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	273.29					1.78				
Minimum of Months	273.29	651.22		28.30	23.95	1.78	2.39		21.95	21.95
Maximum of Months	273.29	651.22		28.30	23.95	1.78	2.39		21.95	21.95

ROOM 38

J.1) Sustainable Facade Layers - Phase 3 - Replacement of Exterior Facade Walls with Sustainable Facade Sandwich Panel Walls (SPW) Calculations - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



J.2) Sustainable Facade Layers - Phase 3 - Replacement of Exterior Facade Walls with Sustainable Facade Sandwich Panel Walls (SPW) Calculations - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)
Building 16						
Block3:9Room	**1.06**	**0.5759**	0.92	0.62	0.31	18.0
Block11:23Room	**1.30**	**1.1716**	1.13	0.78	0.35	18.0
Block14:38Room	**1.31**	**1.5456**	1.14	0.80	0.34	18.0
Totals	**3.67**	**3.2931**	**3.19**	**2.19**	**1.00**	**18.0**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Humidity (%)	Time of Max Cooling	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16								
Block3:9Room	64.6	Sep 10:00	19.9	13.4	32.3	43.12	79.5	30.3
Block11:23Room	62.7	Sep 09:30	20.3	13.4	34.3	87.71	97.1	29.7
Block14:38Room	62.1	Sep 09:30	20.4	13.4	34.3	115.72	98.3	29.7
Totals	**63.1**	**N/A**	**20.4**	**40.1**	**101.0**	**82.18**	**91.6**	**N/A**

K) Sustainable Facade Layers - Phase 3 - Addition of Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 14:56:38**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	192.95	402.62	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	192.95					1.48				
Minimum of Months	192.95	402.62		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	192.95	402.62		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 14:56:38**

Custom Monthly Report

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	236.85	537.42	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	236.85					1.48				
Minimum of Months	236.85	537.42		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	236.85	537.42		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:38ROOM**

Timestamp: **2021-06-09 14:56:38**

Custom Monthly Report

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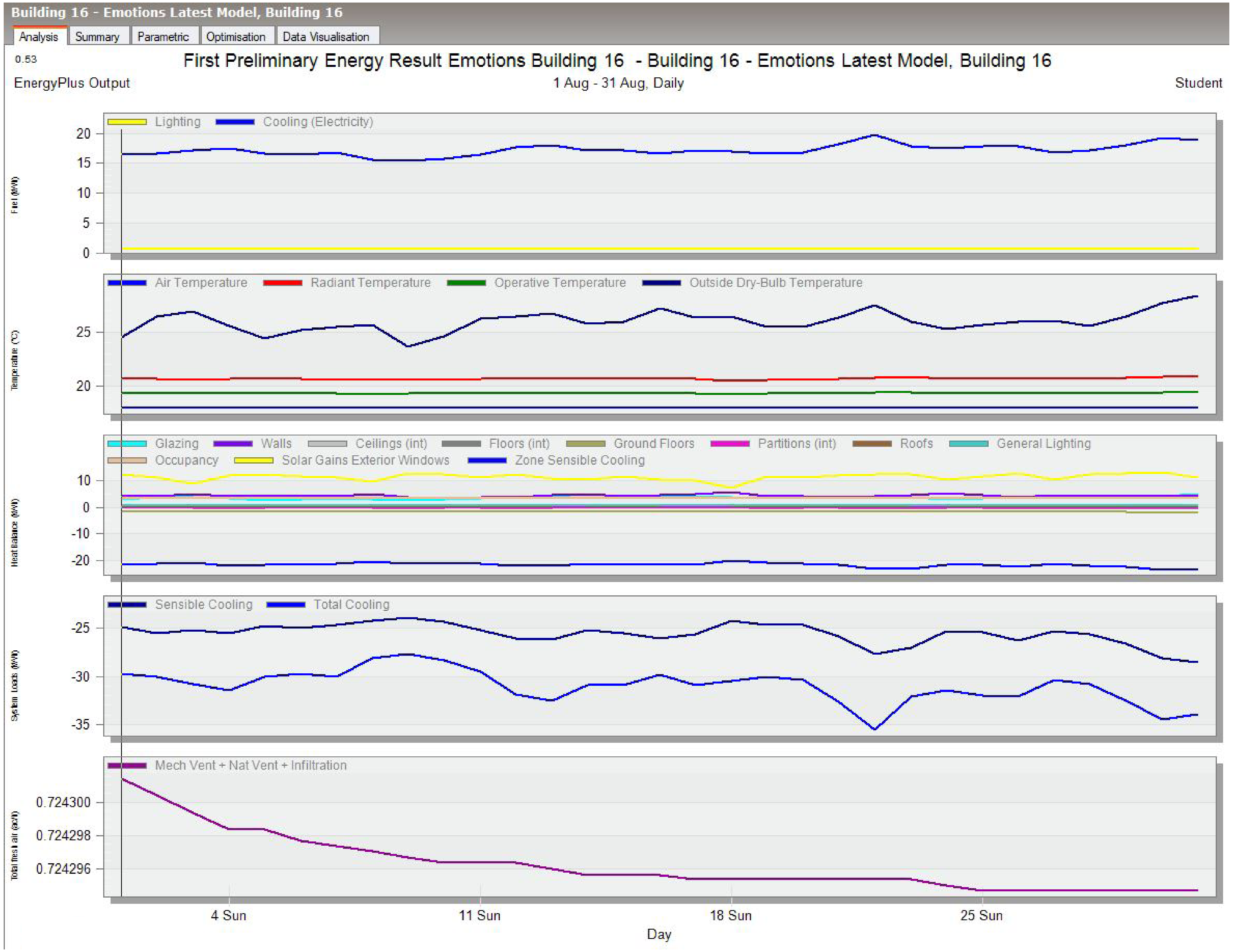
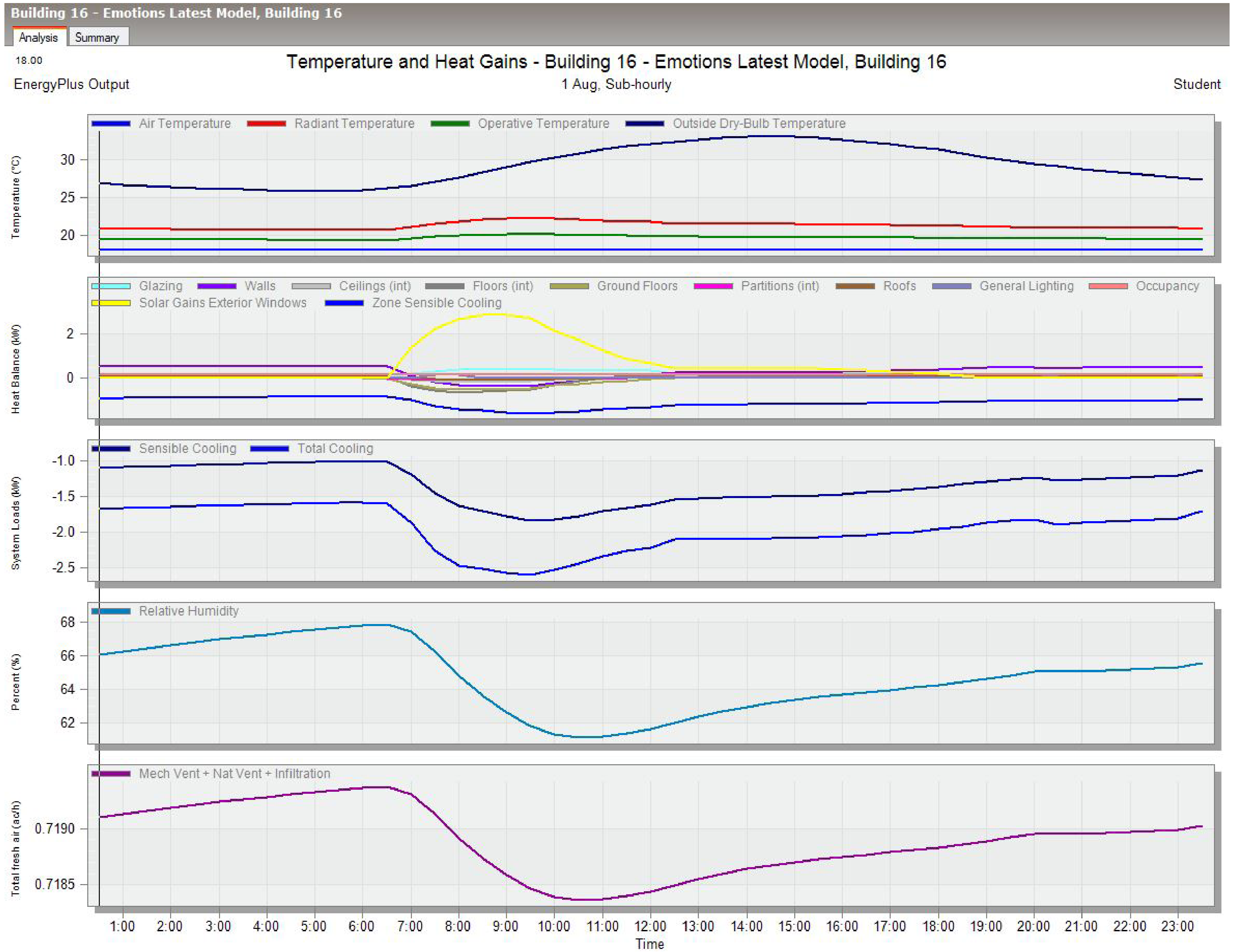
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	240.21	543.15	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	240.21					1.48				
Minimum of Months	240.21	543.15		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	240.21	543.15		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 38

K.1) Sustainable Facade Layers - Phase 3 - Addition of Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



K.2) Sustainable Facade Layers - Phase 3 - Addition of Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	**0.90**	**0.5244**	0.78	0.52	0.26	18.0	64.3
Block11:23Room	**1.09**	**1.6576**	0.95	0.67	0.28	18.0	61.6
Block14:38Room	**1.10**	**2.2008**	0.96	0.68	0.28	18.0	61.2
Totals	**3.09**	**4.3828**	**2.69**	**1.87**	**0.81**	**18.0**	**62.3**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16						
Block3:9Room	19.9	11.1	26.9	47.10	80.8	29.7
Block11:23Room	20.3	11.1	28.6	148.88	98.0	29.7
Block14:38Room	20.3	11.1	28.6	197.67	98.7	29.7
Totals	**20.3**	**33.4**	**84.2**	**131.22**	**92.5**	**N/A**

L) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

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For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 15:29:13**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	181.54	381.95	30-AUG-09:00	28.30	23.95	1.32	1.78	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	181.54					1.32				
Minimum of Months	181.54	381.95		28.30	23.95	1.32	1.78		21.95	21.95
Maximum of Months	181.54	381.95		28.30	23.95	1.32	1.78		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

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For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 15:29:13**

Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	221.03	508.16	30-AUG-09:00	28.30	23.95	1.32	1.78	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	221.03					1.32				
Minimum of Months	221.03	508.16		28.30	23.95	1.32	1.78		21.95	21.95
Maximum of Months	221.03	508.16		28.30	23.95	1.32	1.78		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

Table of Contents

For: **BLOCK14:38ROOM**

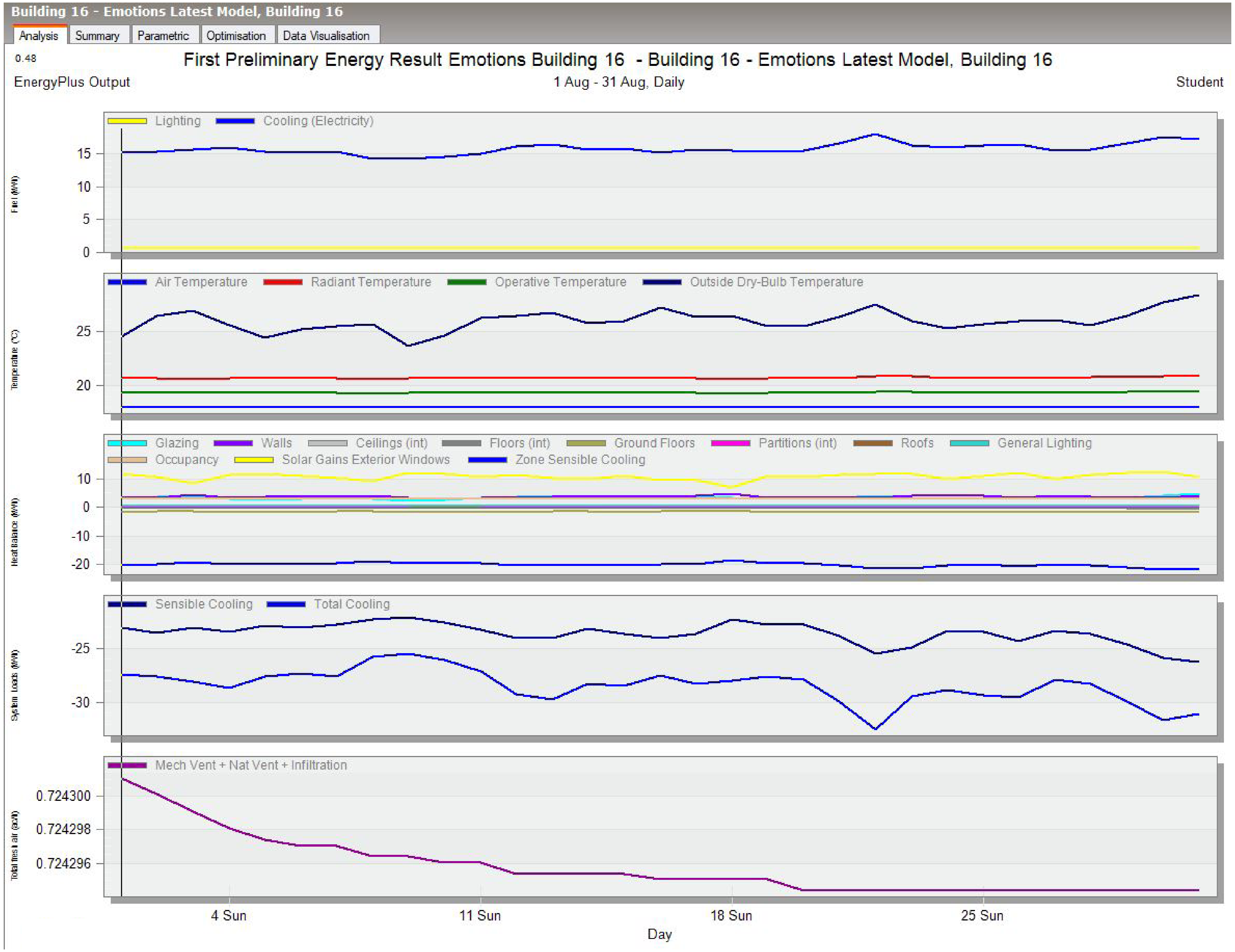
Timestamp: **2021-06-09 15:29:13**

Custom Monthly Report

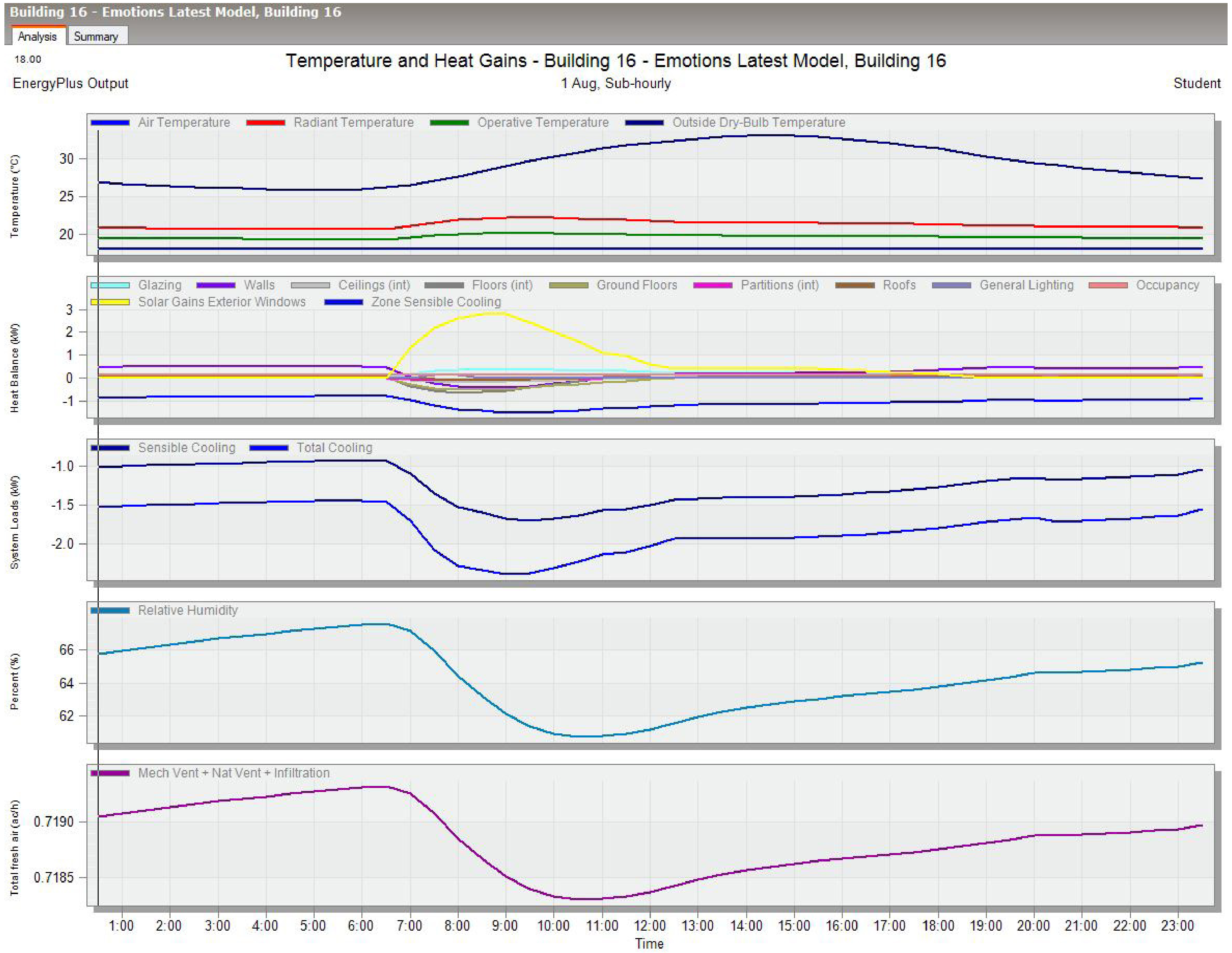
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	219.67	510.37	30-AUG-09:00	28.30	23.95	1.32	1.78	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	219.67					1.32				
Minimum of Months	219.67	510.37		28.30	23.95	1.32	1.78		21.95	21.95
Maximum of Months	219.67	510.37		28.30	23.95	1.32	1.78		21.95	21.95

ROOM 38

L.1) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



L.2) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers to Existing Exterior Facade Walls Calculations - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	**0.83**	**0.4467**	0.72	0.48	0.24	18.0	64.6
Block11:23Room	**1.01**	**1.2096**	0.88	0.61	0.27	18.0	62.0
Block14:38Room	**1.02**	**1.5483**	0.88	0.62	0.26	18.0	61.6
Totals	**2.86**	**3.2046**	**2.48**	**1.71**	**0.77**	**18.0**	**62.7**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16						
Totals	**20.3**	**29.8**	**75.2**	**107.38**	**95.7**	**N/A**
Block14:38Room	20.3	9.9	25.6	155.63	102.3	29.0
Block3:9Room	19.9	9.9	24.1	44.90	83.2	29.0
Block11:23Room	20.3	9.9	25.6	121.59	101.7	29.0

M) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers without Insulation to Existing Exterior Facade Walls Calculations - Rooms 9, 23 and 38.

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK3:9ROOM**

Timestamp: **2021-06-09 18:05:42**

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	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	219.68	441.47	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	219.68					1.48				
Minimum of Months	219.68	441.47		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	219.68	441.47		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 9

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK11:23ROOM**

Timestamp: **2021-06-09 18:05:42**

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Custom Monthly Report

	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	267.84	583.46	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	267.84					1.48				
Minimum of Months	267.84	583.46		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	267.84	583.46		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 23

Report: **ZoneCoolingSummaryMonthly**

For: **BLOCK14:38ROOM**

Timestamp: **2021-06-09 18:05:42**

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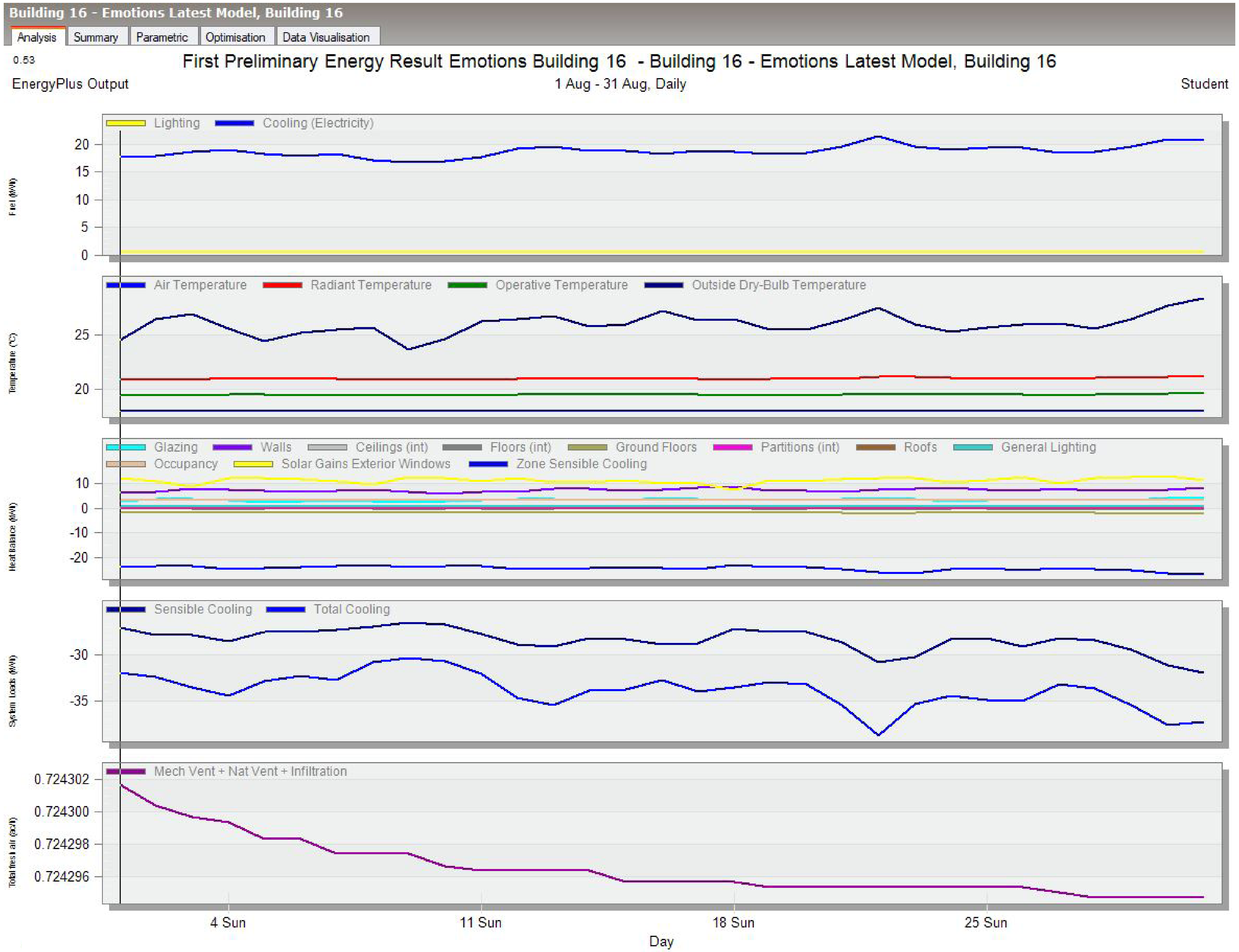
Custom Monthly Report

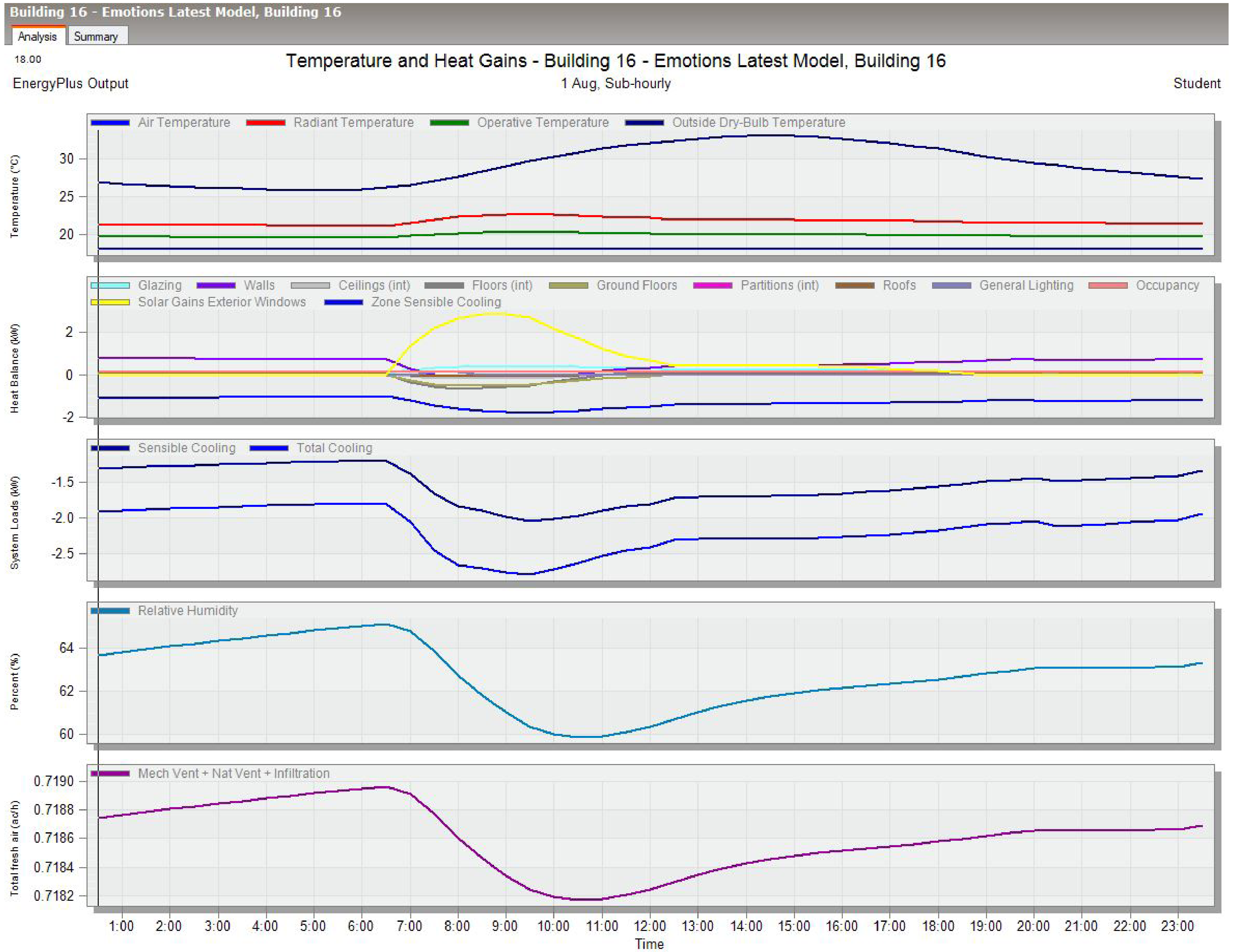
	ZONE AIR SYSTEM SENSIBLE COOLING ENERGY [kWh]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {Maximum} [W]	ZONE AIR SYSTEM SENSIBLE COOLING RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]	ZONE TOTAL INTERNAL LATENT GAIN ENERGY [kWh]	ZONE TOTAL INTERNAL LATENT GAIN RATE {Maximum} [W]	ZONE TOTAL INTERNAL LATENT GAIN RATE {TIMESTAMP}	SITE OUTDOOR AIR DRYBULB TEMPERATURE {AT MAX/MIN} [C]	SITE OUTDOOR AIR WETBULB TEMPERATURE {AT MAX/MIN} [C]
January	-	-	-	-	-	-	-	-	-	-
February	-	-	-	-	-	-	-	-	-	-
March	-	-	-	-	-	-	-	-	-	-
April	-	-	-	-	-	-	-	-	-	-
May	-	-	-	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-	-	-	-
July	-	-	-	-	-	-	-	-	-	-
August	270.49	587.88	30-AUG-09:00	28.30	23.95	1.48	2.00	01-AUG-00:15	21.95	21.95
September	-	-	-	-	-	-	-	-	-	-
October	-	-	-	-	-	-	-	-	-	-
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Annual Sum or Average	270.49					1.48				
Minimum of Months	270.49	587.88		28.30	23.95	1.48	2.00		21.95	21.95
Maximum of Months	270.49	587.88		28.30	23.95	1.48	2.00		21.95	21.95

ROOM 38

M.1) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers without Insulation to Existing Exterior Facade Walls Calculations - Cooling Energy Calculations Analysis Chart of Rooms 9, 23 and 38 in Guest Block 16 for the month of August, 2019. Performed on Design Builder, 2021.



M.2) Sustainable Facade Layers - Phase 3 - Addition of Ventilated Sustainable Facade Layers without Insulation to Existing Exterior Facade Walls Calculations - Cooling Design Analysis and Summary of a day of performance (August 1, 2019) on Rooms 9, 23 and 38.



Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Design Capacity (kW)	Design Flow Rate (m3/s)	Total Cooling Load (kW)	Sensible (kW)	Latent (kW)	Air Temperature (°C)	Humidity (%)
Building 16							
Block3:9Room	**0.97**	**0.8894**	0.84	0.58	0.26	18.0	62.7
Block11:23Room	**1.17**	**14.1859**	1.01	0.74	0.28	18.0	60.1
Block14:38Room	1.17	-33.5356	1.02	0.75	0.27	18.0	59.8
Totals	**3.30**	**-18.4604**	**2.87**	**2.07**	**0.81**	**18.0**	**60.8**

Building 16 - Emotions Latest Model, Building 16

Analysis | Summary

Zone	Max Op Temp in Day (°C)	Floor Area (m2)	Volume (m3)	Flow/Floor Area (l/s-m2)	Design Cooling Load Per Floor Area (W/m2)	Outside Temperature at Peak Load (°C)
Building 16						
Block3:9Room	20.1	11.1	26.9	79.88	86.7	29.7
Block11:23Room	20.5	11.1	28.6	1274.13	104.8	29.7
Block14:38Room	20.5	11.1	28.6	-3012.05	105.3	29.7
Totals	**20.5**	**33.4**	**84.2**	**-552.68**	**98.9**	**N/A**