

## BIOCLIMATIC ARCHITECTURE AS A DESIGN APPROACH WITH A MIDDLE APARTMENT IN SURABAYA AS A CASE STUDY

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### ABSTRACT

*Bioclimatic architecture as a design approach takes an advantage climate parameters to answer the problems of environment and energy. This approach is applied to optimize the quality of architectural design through the comfort and health of their environment. It was developed by simulating the design in the case of a middle apartment in Surabaya. To achieve its design goals is simulated: 1) transforming mass-form, 2) setting housing-unit plan, 3) making housing-unit facade, and 4) organizing overall lay-out. Simulation of this design is using several alternative designs to obtain an optimal design. Bioclimatic architecture is successfully implemented if it can optimize the potential of the existing climate. Bioclimatic quality is achieved when a middle apartment is designed to optimize penetration of natural light, cooling and air exchange building mass as well as minimize the acquisition of direct solar radiation. Bioclimatic architecture approach requires consideration of such architectural contexts: urban, economic and social aspects, because the technical nature.*

**Keywords:** *bioclimatic architecture, comfort and health, middle apartment.*

### ABSTRAK

*Arsitektur bioklimatik sebagai pendekatan perancangan memanfaatkan keuntungan dari parameter iklim untuk menjawab permasalahan lingkungan dan energi. Pendekatan ini diterapkan untuk mengoptimalkan kualitas perancangan arsitektur melalui kenyamanan dan kesehatan lingkungan sekitarnya. Apartemen menengah di Surabaya digunakan sebagai simulasi kasus perancangan dengan pendekatan ini. Simulasi perancangannya meliputi : 1) gunbahan bentuk massa, 2) denah unit hunian, 3) tampang hunian, dan 4) tata letak bangunan. Simulasi ini menggunakan beberapa alternatif desain untuk mendapatkan perancangan yang optimal.*

*Arsitektur bioklimatik dapat berhasil diimplementasikan jika mengoptimalkan potensi iklim yang ada. Kualitas bioklimatik dapat dicapai dengan optimalisasi pada penetrasi cahaya alami, pendinginan dan sirkulasi udara pada massa bangunan serta meminimalkan akuisisi radiasi matahari langsung. Karena bersifat teknis maka pendekatan arsitektur bioklimatik memerlukan pertimbangan konteks arsitektur seperti: kota, aspek ekonomi dan sosial.*

**Kata kunci :** *arsitektur bioklimatik, kenyamanan dan kesehatan, apartemen menengah*

## INTRODUCTION

Environment and energy is a global issue nowadays. Increasing use of energy to raise the living standards is not only in exploiting energy resources, but also could endanger the natural physical environment on a global scale. This has led the community to build a healthy and comfortable environment with responding to climate.

Development of the built environment can affect the climate and surrounding environment. Global warming is caused by emissions of carbon dioxide (CO<sub>2</sub>) are excessive in atmosphere. It happened with increasing the temperature average earth's surface, as a result of the greenhouse gas effect events.

Built environment or the architecture is the human response to its environment (Markus and Morris, 1980:33). This is manifested in the architectural design of both natural (passive), artificially (active) and a combination of both. Naturally the design is done by maximizing the potential architectural climate. Made in case of no attention to the potential for climate and comfort is achieved by using mechanical equipment. Mechanical equipment is used to solve the problem of inconvenience in space, but today evolved into the urban lifestyle. The use of AC that is used for daily needs resulting in the depletion of natural resources of the world due to increased energy consumption.

The impact of the use of air conditioning also affects the quality of health of its inhabitants. Spaces are always air conditioning and lack of natural lighting to be damp and dark. The rooms are damp and not exposed to sunlight become home to a bacterium, which can enter into the human respiratory tract and cause health problems. Symptoms may arise during their stay in a room, is lost when you've left the room, and felt again when returning to the room. The rooms are less than optimal or not according to its function to accommodate the needs and human activities can also cause psychological disorders. Improper architectural design can cause Sick Building Syndrome (SBS). The SBS term is generally used to describe diseases caused by poor condition of the room (Pudjiastuti, et al., 1999:44-45).

Based on this background, it would require a synergistic approach to architectural design with climate. Synergize means to optimize the potential for minimizing the impact on climate and natural surroundings. Synergize means doing design naturally (passive). This approach will automatically save energy of daily needs, especially for air conditioning (energy conservation). Automatic means comfort and health needs can be met so that energy is required only to artificial lighting at night and the application of electronic equipment by the inhabitants. Design approach is known as the Bioclimatic architectural approach (Olgay, 1963:10).

The case design of this paper is a middle apartment in Surabaya, was chosen because it is a solution to the problem of settlements in Surabaya and in fact the application of Bioclimatic architecture approach largely applies on vertical buildings that serves as an office (Yeang et.al, 1996:244). While the allocation for the middle class, due to its characteristics, is generally a group of independent, progressive, and critical. However, the standard limits of the social strata of society there are no absolutes. For general picture of the characteristics of this group is between 15-50 million annual income (PP No. 31 in 2007) and has a total family of 4 persons (RTRW city of Surabaya 2015).

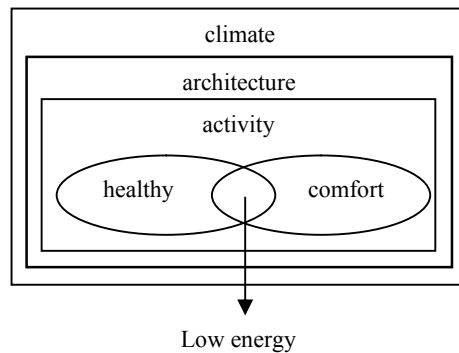


**Figure 1.** Site Location

Source: RTRW Surabaya 2015 and [www.earthgoggle.com](http://www.earthgoggle.com)

## Bioclimatic Architecture

Architecture bioclimatic is a synergistic approach to architectural design with climate, one that unites the discipline of human physiology, climatology and integrated building physics in regional architecture. Synergy between architecture and climate to take advantage or use of the potential from climate and minimize impact on the surrounding environment. Potential of climate include air temperature, solar, wind and humidity. Architecture accommodate activity human. For humans to activity and performing optimum then requires a comfortable and healthy condition, so avoid from Sick Building Syndrome (SBS).



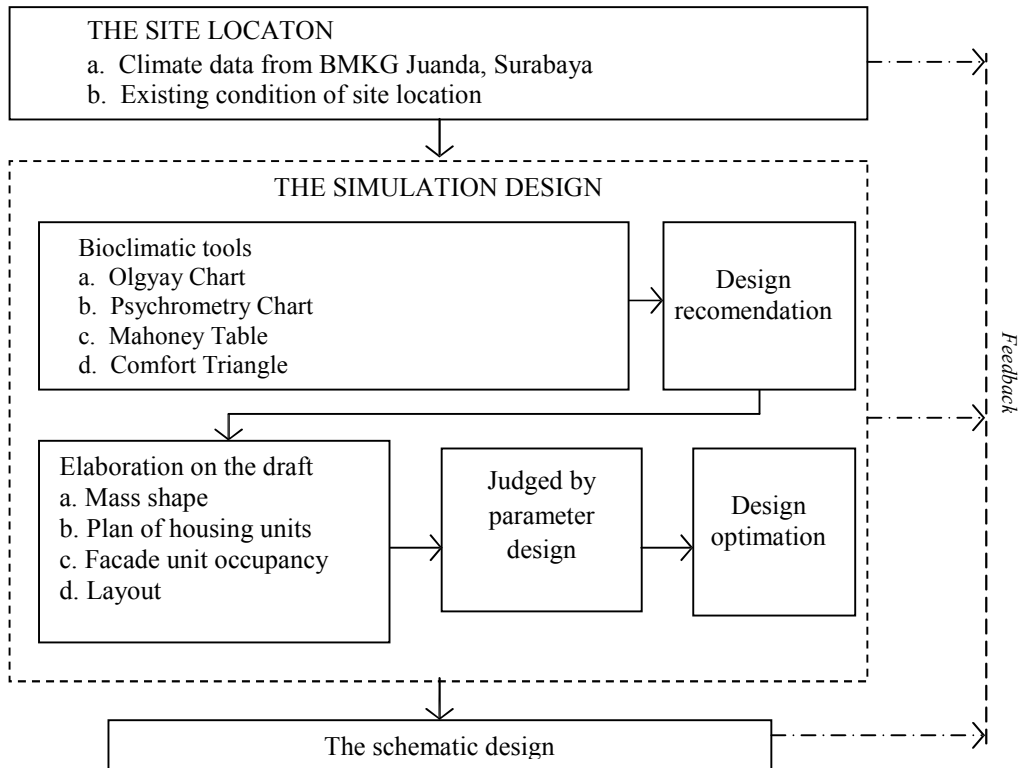
**Figure 2.** The Bioclimatic Architecture as a Design Approach  
Source: Krisdianto, 2010

Leisure is the desired condition and not difficult for humans. Health is human condition with parameters that humans can perform optimally or condition human welfare is an absolute. If this can be achieved with passive design, the need for energy will only take place at night day course is for artificial lighting and for equipment that are not residents used to say continuously (electronic equipment). This is what energy consumption that is automatically used can to operations to be low (energy conservation). Architecture approach bioclimatic can be described as shown in Figure 2.

### Simulation Method

The simulation method is designed base on the findings of Duerk (1993:47-58). To obtain a design concept with an approach whose objective is a measurable design the necessary performance requirements (performance requirements). Performance requirements are conditions that must be met or the parameters for the design goal can be achieved. These requirements form the parameters of comfort and health that have been mentioned in the previous chapter and apply the recommendations of the design obtained by using assistive devices bioclimatic. These tools consist of chart bioclimatic of Olgay, psychrometry charts, Mahoney tables and Comfort triangle.

Flow simulation of the design has a linear plot and vice versa. Linear process if the process is phased in accordance with the order and to force back and forth when each stage of recurrent or return to the previous process. Review the location of design in the form of climate data from BMKG and existing condition of site design case is used as a base to conduct the simulation. Simulation design of a form of mass forms, floor plans of housing units, the facade of housing units and apartment layout will be assessed by using the parameters and requirements to obtain optimum performance draft a schematic design of middle apartments in Surabaya.



**Figure 3.** The Flow of Simulation Design  
Source: Krisdianto, 2010

## RESULTS AND DISCUSSION

### Design Criteria

Design of a middle apartment with bioclimatic architecture approach aims to achieve optimal comfort and health and to avoid the SBS. The design able to reduce the impact of environment especially urban heat island effect, and global warming in general. The design criteria are include:

1. Draft minimum receive the sun's heat directly.
2. The design can optimize the entry of sunlight into the room for natural lighting (sunlight penetration).
3. The design can optimize the cooling of the building mass, especially at night and morning.
4. The design can optimize the exchange of air from the outside in building.

### Design Parameters

Bioclimatic architecture as design approach on middle apartment has the design parameters as shown in Table 1 below.

**Table 1.** The Design Parameters of Bioclimatic Architecture as a Design Approach on Middle Apartment

Design No	Parameter	Comfort		Healthy	
		Indicator	Information	Indicator	Information
1	Air temperature	25.5°C-28.7°C (Santosa, 1986)	Quantitative, evaluated with the program Ecotect v5.5	Air temperature of the body (normal) is around 37°C, while the body's skin surface air temperature ranges from 31°-34°C (Frick, 2006:40).	Qualitative
2	Daylight illumination	Glare and good views	Quantitative,	Corridor,Bathroom = 100 lux; Family, Bedroom=200 lux (Satwiko,2009:155 and Szokolay,2004:291)	Quantitative, evaluated with the program <i>Desktop Radiance</i>
3	Space	Accommodate enough activity, 9m <sup>2</sup> / person for occupancy, min 1.8m wide corridor, a room with min. every 30 unit (PERMENPU No. 05/PRT/M/2007, Chiara, 2001; Neufert, 1999)	Quantitatively at least schematic design based on standard	Living space in accordance with the number of occupants, activities, equipment and ergonomics	Qualitative
4	Air quality	Minimal pollution and ventilation, air change (Pudjiastuti,dkk., 1999:69)	Qualitative based on location, the existence of cross ventilation and chimney on the draft	Based on the Highest Levels Allowed (KTD) and Threshold Limit Value (NAV) (Pudjiastuti,dkk., 1999:8, Satwiko 2009: 104)	Qualitative

Source: Krisdianto, 2010

### Surabaya Climate Condition

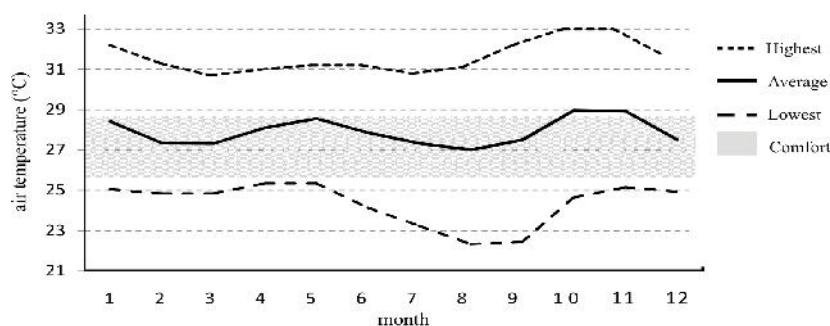
Surabaya climate data obtained from the Bureau of Meteorology, Climatology and Geophysics (BMKG) stations 2008. Surabaya climatic conditions during the year can be obtained by creating a climate profile Surabaya. Profil columned city where

each is located in parallel to see fluctuations in the climate of each element is quite influential in the area of humid tropical climate.

### 1. Air Temperature

The average air temperature in Surabaya between 27° C-29° C. From the data BMKG Juanda, obtained the lowest air temperature reaches 22°C at 5:00 a.m. to 06:00 pm while the highest temperature reached 33°C at 12:00 to 13:00 pm. Diurnal daily in the city of Surabaya between 5 –11°C.

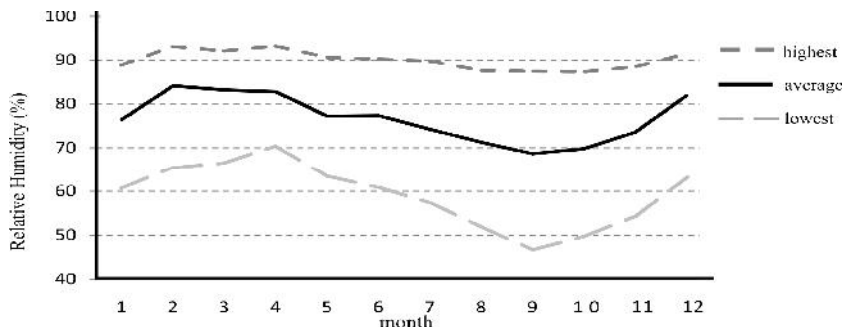
The average air temperature of about 83% of Surabaya is in comfort zone, only in October and November just outside the zone (Figure 4). We have the hottest month in November and highest air temperatures occurred at 1300. Coldest month fall in August and the lowest air temperature occurred in 06.00.



**Figure 4.** The Graph of Air Temperature in 2008  
 Source: adapted from data BMKG at Krisdianto, 2010

### 2. Air Humidity

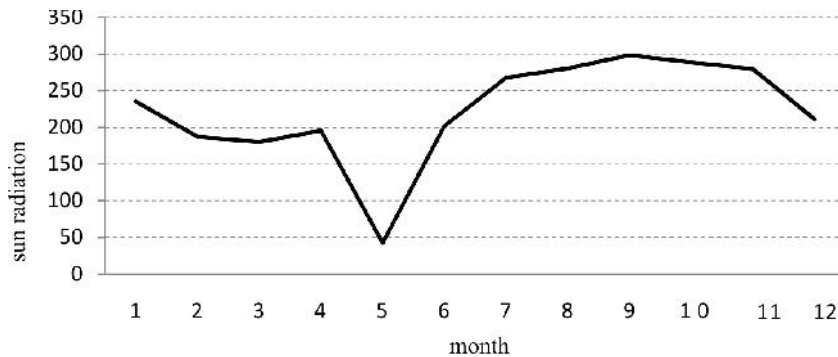
The average humidity in Surabaya is between 70% -85%. From the data BMKG Juanda, obtained the lowest air humidity reaches 46% at 12:00 to 14:00 pm while the highest air humidity reaches 94% at 05.00-06.00WIB (Figure 5). Rainfall in Surabaya is quite high, especially in December, January, February and March.



**Figure 5.** The Graph of Relative Humidity in 2008  
 Source: adapted from data BMKG at Krisdianto, 2010

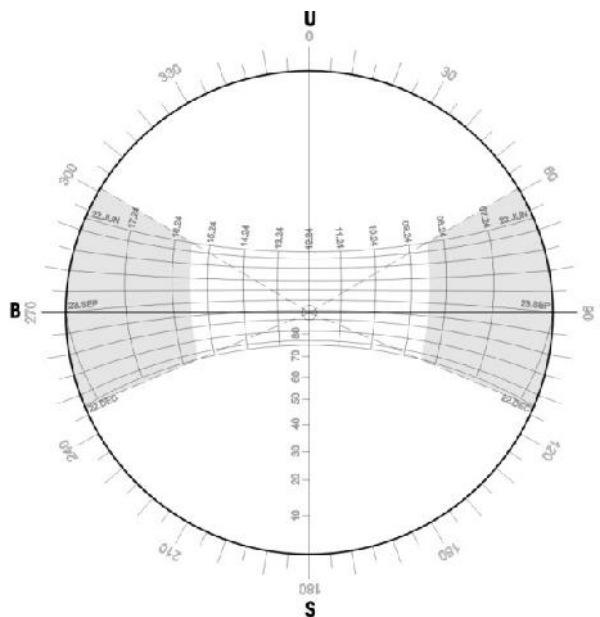
### 3. Sun

Duration of solar radiation between 11-12 hours (from 6:00 a.m. to 18:00 pm GMT). Based on data from BMKG, the greatest radiation occurred at 10.00-12.00WIB (Figure 6).



**Figure 6.** The Graph of Sun Radiation in 2008  
 Source: adapted from data BMKG at Krisdianto, 2010

The movement of the sun in one year can be seen through the solar sun-chart of Surabaya (Figure 7). The sun moves on the outer track on the North side on June 22 and in contrary on 22 December. In September the maximum solar radiation occurs because the sun right in line *khatulistiwa* outstanding. This happened at 11.00 am where the sun radiates heat to the max. The area is a grey area to direct daylight is healthy.

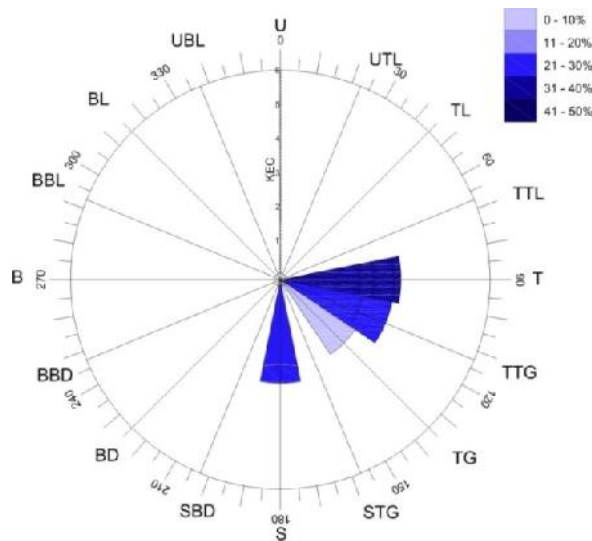


**Figure 7.** The Graph of Sun-Chart in Surabaya  
 Source: adapted from sun tool at Krisdianto, 2010



#### 4. Wind

The data includes wind speed and direction of the wind speed. There are divided into two types of breeze and wind. Data from BMKG indicates that the wind speed in the city of Surabaya only ranged from 2 to 3.6 m/s and the wind was blowing from the southeast direction toward the West-South-North Sea. This happened at month from December to May and usually marked by rain. Instead occurred around June-Nopember wind blowing from East to West direction. But the data in 2008 showed unpredictable rain, because it could have rained every month but only a few moments (Figure 8).



**Figure 8.** The Graph of the Direction and Wind Speed on Average in 2008

Source: adapted from sun tool at Krisdianto, 2010

Coldest and warmest month is determined based on climatic data obtained from Juanda BMKG 2008. Moon was taken from the moon which has an average air temperatures as low and tertinggi. Ini affect the design of buildings with bioclimatic architecture as a design approach:

August was the coldest month in the year 2008, with conditions:

- The average air temperature 27°C, the highest air temperature 31.1°C at 14.00 pm and the lowest at 22.3°C at 06.00 pm.
- Average humidity of 71.3%, 88.7% at the highest at 06.00 pm and the lowest 51.8% at 14.00WIB.
- The sun radiation level by an average of 280.5 W/m<sup>2</sup> with the highest point occurred at 12.00WIB with the amount of 521.4 W / m<sup>2</sup>.
- Average wind speed 3.2 m/s, with a top speed of 6.3 m/s at 15.00 and 16.00WIB and the lowest 0.8 m/s at 04.00WIB and wind tends from east.

November is the hottest month in 2008, with conditions:

- a. The average air temperature 28.9°C, the highest air temperature 33.1°C and the lowest 25.1°C at 13.00WIB at 06.00 pm.
- b. Average humidity of 73.6%, 89.6% at 05.00WIB highest and the lowest 54.3% at 14.00WIB.
- c. The level of solar radiation by an average of 279.6 W/m<sup>2</sup> with the highest value occurred at 13.00WIB with the amount of 462.6 W/m<sup>2</sup>.
- d. Average wind speed 2.3 m / s, with a top speed of 4.8 m/s at 14.00 pm and at the lowest 0.6m/det 06.00WIB, with wind direction tends from east.

Based on 2008 after the observed climate data and processed, it can be deduced that the sun radiates heat at a maximum of about 549.2 W/m<sup>2</sup> at jam11.00WIB on September 22<sup>th</sup>.

Based on climatic data mentioned above, the wind has the potential to be used to cool the structure, while for high enough radiation should be reduced by shade or shadowing as closely as possible, especially on the East and the West to protect the facade for no increase in air temperature in the room.

### **The Site Condition**

The climate on the site has some problem: air pollution and noise from the Urip Sumoharjo, density of buildings around and the lack of vegetation can cause the urban heat island and air temperature and wind speed can not be regulated. They have some potencies looks like creating a comfortable microclimate, the footprint that extends to the East-West direction to minimize the acquisition of the sun. The recommendation are raised tread life and make a fence from the plant so as to be noise pollution and air filters, greening of the site and buildings and the mass extends to follow the axis of the tread.

The problem of building regulation on the site is the minimal building coverage. It should be more effective of the site with maximizing outbreaks and utilizing the GSB as a green space and public areas. The condition around the location is untidiness, the lack of open space that the community that are difficult to carry out communal activities. They can be made aside from being a shelter also has other functions, recreational and commercial functions. The recommendations are provide public spaces and social facilities, provide open space and greening green: green wall, green roof, bioshader.

The building typology around the site is rapidly. They are residential density that is less optimal for daylight and natural air flow, fire danger, sanitation is poor, cause the building led to the lack of absorption space and green space and also the lack of vegetation led to increased air temperature when the irradiation optimal in the afternoon. But it has a potential value likes housing area with a maximum height of 12 m and socialization intimate because of the density of buildings. The recom-

mentation are designed the building is a low-rise buildings form shadowing to allow for lighting and natural air flow for existing residential surroundings.

The narrowness of access to the area around footprint and is only for pedestrians, absence of access for fire evacuation, absence of adequate parking and it should not be parked along the Urip Sumoharjo road. The location is in the downtown and on the edge of secondary arterial road and there is a bus stop and pedestrian bridge near the site. Depend on that situation, it must be design with widening the road to 5 m and 1.5 m pedestrian on the street next to the site by taking land tread design, creating access through the site and also make a pocket park for the area in the basement of the building.

## CONCLUSIONS

Bioclimatic architecture approach can be successfully applied in urban areas where the design can maximize the potential climate there. These potentials include air temperature, air humidity and hot sun and the winds. Design criteria to optimize the entry of sunlight (penetration) into the design to natural lighting, minimal design to receive the sun's heat directly, and the design can cool a structure or building mass, especially at night and morning and plan to optimize the exchange of air from outside into the building and vice versa.

Method design simulation using parameters that include convenience and health parameters both quantitatively and qualitatively in air temperatures, strong sunlight, space, and air quality. Strategy design includes building orientation, building configuration, use of materials on the building, opening in the building and use of vegetation. This strategy was elaborated with the simulated mass shape design, floor plan and facade of housing units, and spatial planning.

Bioclimatic architecture as a design approach contributes to sustainable development. Passive design that became the principle in this approach is able to minimize energy requirements and daily operational (energy conservation) because of the fulfilment of a comfortable air temperature throughout the day and strong sunlight is healthy and comfortable. Energy requirement is only required for artificial lighting at night and electronic equipment occupants. Minimize the occurrence of SBS, by optimizing the exchange of air, good air quality, air temperature a healthy and comfortable, and natural lighting. Bioclimatic more technical approach that is required in its application contexts such as the context of urban design, economic and social aspects.

Application the bioclimatic architecture as a design approach on middle apartment has a difference with the implementation of the office because the apartment consists of floor plans and a complex spatial and many barriers (wall). The rooms have privacy and different activities. The design also contributed to the city. Fulfilments

of open space for people to socialize and daily activity on place so people become more prosperous and global climate change impacts can be minimized.

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