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The Model of WWF Passive Cooling to Cope Global Warming in the Urban Settlements

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Abstract. This paper examines how to reduce GHG (Green House Gas) emissions at architecture level. The study focuses on efficiency energy, because it has become the most dominant of GHG emissions. The urban settlements are mostly using AC (Air Conditioning) to get thermal comfort. The accumulation of using AC, as a mechanical cooling model, is the biggest consumption of energy in urban settlements. However, it needs the new solution to get thermal comfort without using AC. The study uses experiment to answer the research objective. To get thermal comfort without AC (mechanical cooling model) or electric fan (active cooling model) is a passive cooling model. To create passive cooling in the urban settlements, it needs the new design. By using WWF (Water-Wind-Flora) in designing, the urban settlements can get the thermal comfort. Many tests of thermal comfort have been done to know the result of passive cooling effort. By using AZ-HT-02 and LM-81AM (the tools of thermal comfort), the urban settlements are actually still at the comfort zone. Having an efficiency of energy, the model of WWF passive cooling can reduce GHG emissions in urban settlements. In the other words, to cope the global warming in the urban settlements, people can use the model of WWF passive cooling. Afterwards, at the large scale of using WWF passive cooling, the effort of reduction of GHG emissions will have a significant result.

Keywords: emission, climate change, global warming, urban settlements, WWF passive cooling

I. INTRODUCTION

The background of this research is how to find a new solution for climate change and global warming in the scope of architecture. To minimize the climate change and global warming, Indonesia has created RAN-GRK and RAN-API since 2009. RAN-GRK (*Rencana Aksi Nasional-Gas Rumah Kaca*) means national action plan on mitigation from climate change and global warming by emission reduction, while RAN-API (*Rencana Aksi Nasional-Adaptasi Perubahan Iklim*) means national action plan on adaptation from climate change and global warming by adjusting its impact. This study focuses on RAN-GRK. It uses experiment to answer the research objective. Finally, by using WWF (Water-Wind-Flora) in designing, the urban settlements can get the thermal comfort without using AC (Air Conditioning). Having an efficiency of energy, the model of WWF passive cooling can reduce GHG emissions in urban settlements. Afterwards, at the large scale of using WWF passive cooling, the effort of reduction of GHG emissions will have a significant result. Indonesia has committed to reduce GHG (Green House Gas) emissions by 26 percent financed by its own resources and up to 41 percent with international support in 2020 (Bappenas, 2016). Latest, Indonesia has committed to reduce GHG emissions by 29 percent financed by its own resources (fair scenario) and up to 41 percent with international support (ambitious scenario) in 2030. Climate change will be affected around the globe, with Indonesia being one of the most severely affected countries due to its large number of islands (approximately 17,000), and the communities' great dependency on natural resources. There are 4 sectors of GHG emissions in Indonesia: (1) land based; (2) energy; (3) IPPU (Industrial Processes and Production Use); and (4) waste. Energy is the most dominant sector of GHG emissions (Bappenas, 2015). It has more than a half (1.44 GtCO2e) of all GHG emissions (2.88 GtCO2e) in 2030, as seen at the following diagrams:

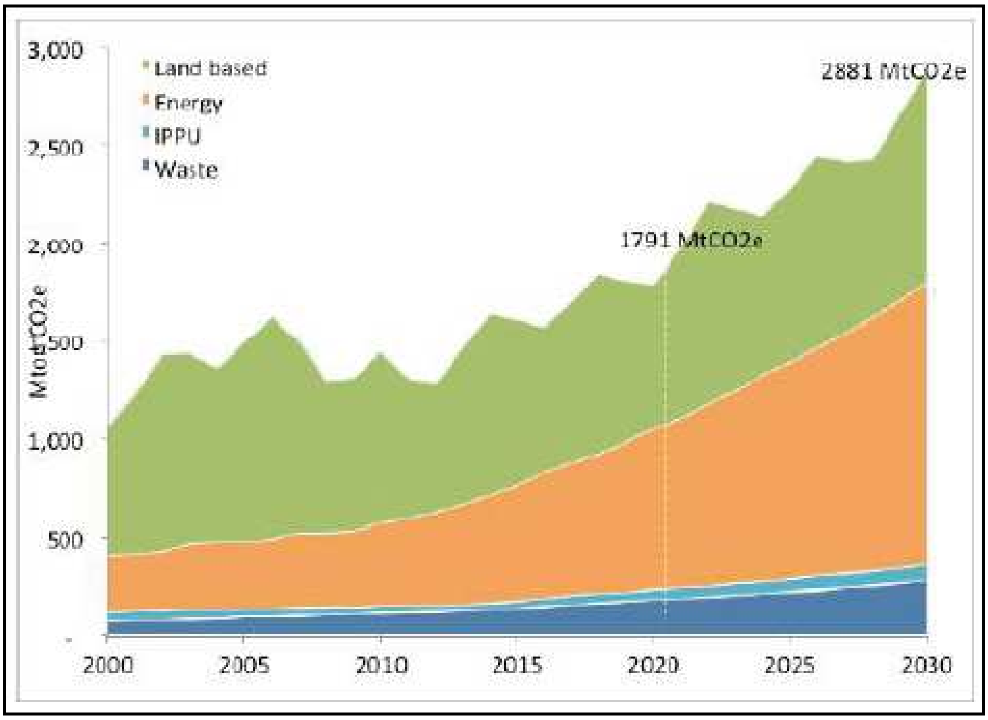

FIGURE 1. The 4 Sectors Projection of GHG Emissions in Indonesia in the Year 2030:
(1) Land Based; (2) Energy; (3) IPPU (Industrial Processes and Production Use); and (4) Waste
(Source: Bappenas, 2016)

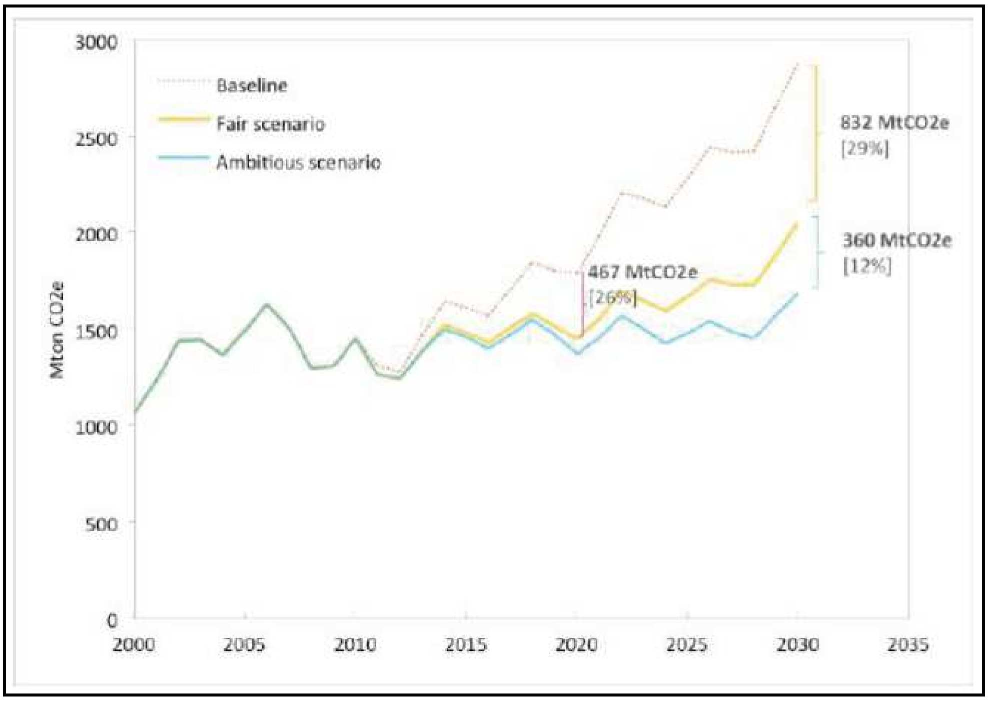

FIGURE 2. The 3 Types Projection of GHG Emissions in Indonesia in the Year 2030:
(1) Baseline Scenario; (2) Fair Scenario; and (3) Ambitious Scenario
(Source: Bappenas, 2016)

II. THEORITICAL FRAMEWORK

According to Frick (2007), thermal comfort depends on three things: (1) air temperature; (2) air humidity; and (3) air movement. Air temperature relates to solar radiation; air humidity relates to water vapor; while the air movement (wind) relates to pressure. Each of these factors ultimately forms a distinctive blend, which is often referred to as the Comfort Zone, as seen at the following diagram:

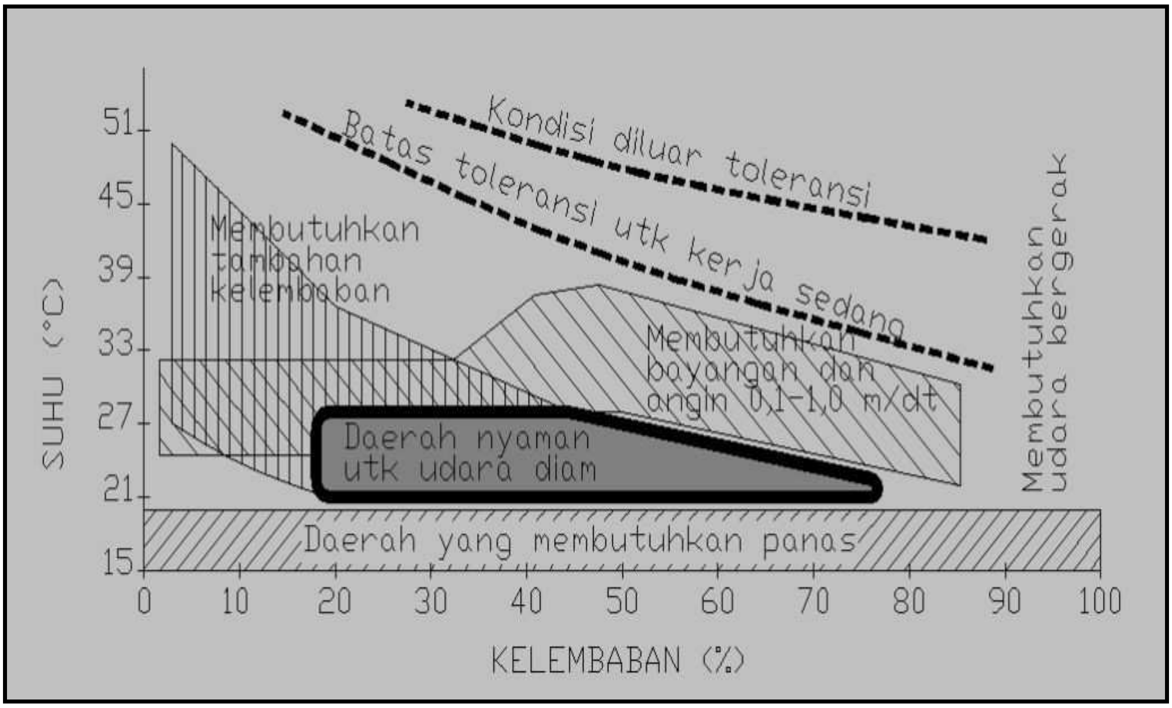

FIGURE 3. Thermal Comfort Zone Depends on Air Temperature, Air Humidity and Air Movement
(Source: Frick, 2007)

According to the diagram above, thermal comfort zone is divided in two categories, namely: without air movement and within air movement. Thermal comfort zone without air movement is divided into three things, namely: (1) cool comfortable, its effective temperature of 20.5 to 22.8 degrees Celsius; (2) optimal comfortable, its effective temperature of 22.8 to 25.8 degrees Celsius; and (3) warm cozy, its effective temperature of 25.8 to 27.1 degrees Celsius. Thus, this type shows that the area of human physical comfortable can be achieved on the condition of the room temperature of 21-27 degrees Celsius (within the humidity of 20-70%). Furthermore, thermal comfort zone of within air movement (wind speed range 0.1-1.0 m/s), the area can comfortably achieved on condition of room temperature of 25-35 degrees Celsius (within the humidity 5-85%). In other words, if there is happens air moves in the space, the temperature comfortable for humans could be 8 degrees higher than comfortable standard of silent air type (Givoni, 1998).

Air cooling can be divided into three types (Frick, 2008), namely: (1) passive cooling; (2) active cooling; and (3) mechanical cooling. Passive cooling refers to the result of building design, without any operational and equipment; active cooling requires operational measures and equipment; while mechanical cooling relies on refrigeration appliance and distribution of cold air. Passive air cooling needs 2 ways of air circulation: cross ventilation and vertical ventilation. Cross ventilation is an effort to design a building space that makes the direction of air movement occurs horizontally. Cross ventilation makes the intake air (inlet) comes through the ventilation holes at the bottom of the room and goes to the exhaust air (outlet) that lies at the opposite ventilation holes inlet and higher than inlet. Meanwhile, the vertical ventilation is an effort to design a building space that makes the direction of air movement upward due to the natural power, called the stack effect. This power is due to differences in air temperature, where the air with a higher temperature has a lighter weight so that it will move up. Thus, vertical ventilation system requires air holes out at the top of the chamber and air inlet holes at the bottom of the building.

III. RESEARCH METHOD

This study uses an experimental method. There are three main processes as follows: (1) the design stage; (2) the construction stage; and (3) the testing stage. The first stage was carried out in the year 2009-2010, while the second stage was carried out in the year 2010-2015, then the third stage was carried out in 2016. The first stage is the most important thing to do for coping global warming in the urban settlements, because it is the step of finding and creating solution. According to GBCI (Green Building Council Indonesia), there is a *Greenship Home V.0.1* to measure the sustainable design of urban settlement. Previous research (Qomarun, 2013) shows that this house is categorized as a gold score (48 points). Passive cooling model absolutely needs the natural environment, namely: sun, earth, plant, wind, air and water, to support the building. Besides, it needs a specific design of intake-outlet on the wall to create horizontally circulation. Afterwards, it also needs a specific design to build a Stack Effect at the top floor, to create vertically circulation. According to the previous research, there is no wind (air movement) in the site until 2 meters high. Otherwise, the air movement can only appear above 2 meters high. To design passive cooling, the first floor has pond to gain water (W); the second floor has cross ventilation to get wind (W); and the third floor has pergola to get flora (F). Afterwards, this passive cooling design is called as WWF (Water-Wind-Flora). The second step is construction stage. It needs 3 years for building construction (2010-2013) and 2 years for landscaping construction (2014-2015). Finally, the third stage is carried out some tests of thermal comfort. Tests are conducted on Thursday, September 22nd, 2016, from morning till night with 5 time ranges: (1) 07.00; (2) 12.00; (3) 15.00; (4) 17.00; and (5) 21.00. Thermal test was conducted by measuring air temperature, air humidity and wind speed at 30 point locations. The 30 points are placed across three locations: (1) at the front of the house; (2) on the exterior of the house; and (3) in the interior of the house. To measure air humidity and air temperature, the research uses Digital Thermo-Hygrometer (Model AZ-HT-02); while to measure wind speed, the research uses Digital Anemometer (Model LM-81AM). Data is collected from field survey and arranged into a digital worksheet. To analyze data, the research uses the diagram of thermal comfort zone. The result will be concluded properly as thermal comfort zone if the interior has a temperature range 25-35 degrees Celsius; a wind speed range 0.1-1.0 m/s; and the humidity range 5-85%. The building design and research process can be seen at the following diagrams:

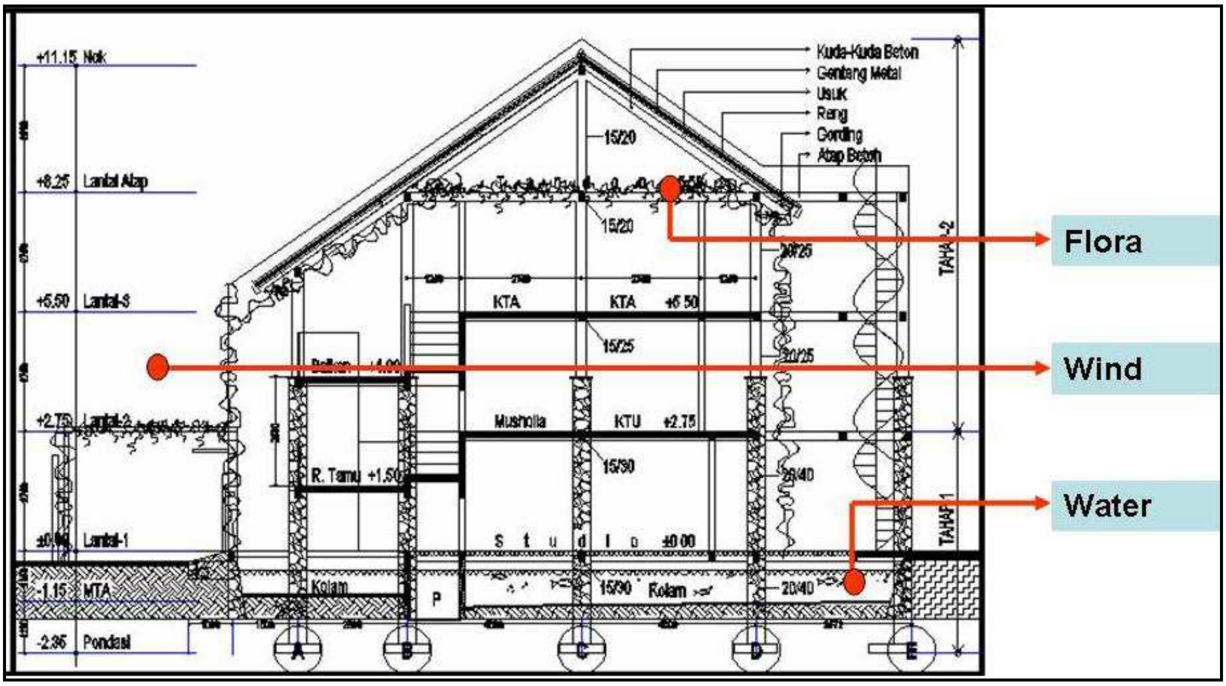

FIGURE 4. The Design Stage (2009-2010):
Designing WWF (Water-Wind-Flora) as Passive Cooling Model

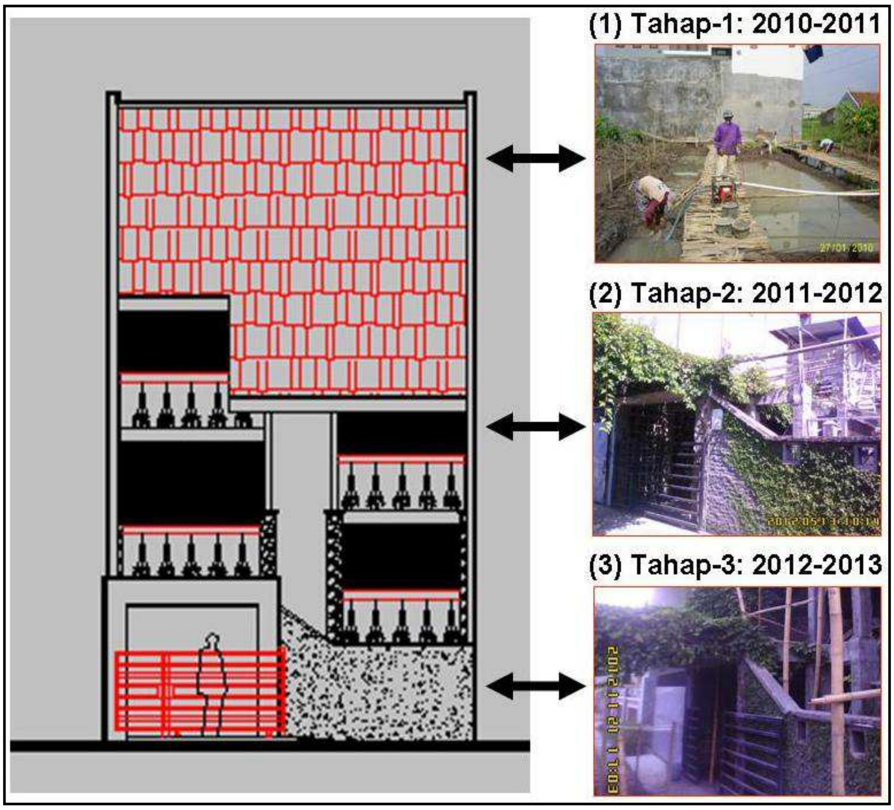

FIGURE 5. The Building Construction (2010-2013) and Landscaping Construction (2013-2015): Creating Element of Water, Wind and Flora at First, Second and Third Floor

FIGURE 6. The Test Stage (Thursday, September 22nd, 2016): Testing of Air Temperature, Air Humidity and Wind Speed at 30 Point Locations

IV. FINDING

Based on the results of measurements made by the research team on Thursday, September 22nd, 2016, with a range of 5 times from morning till night at 30 point locations as described above, then the resulting field conditions of air temperature, air humidity and air movement as follows:

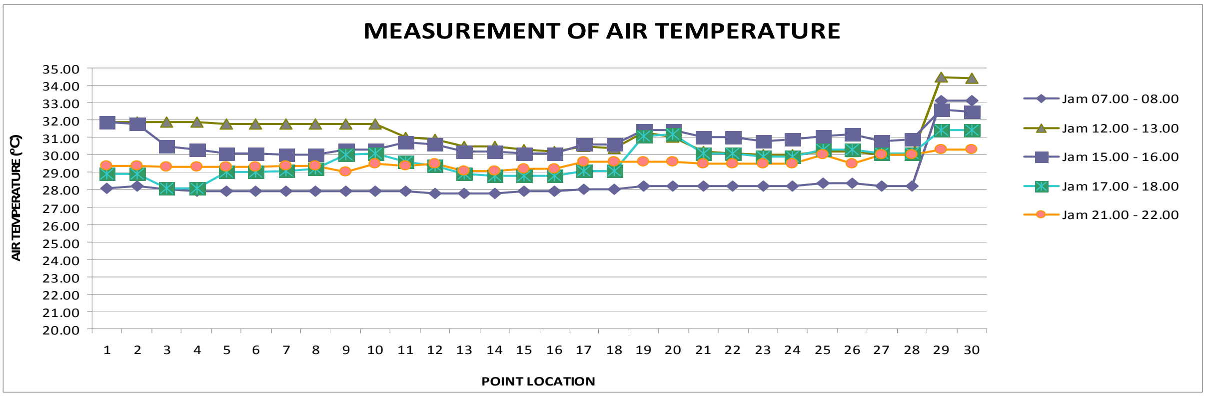

FIGURE 7. The Measurement of Air Temperature

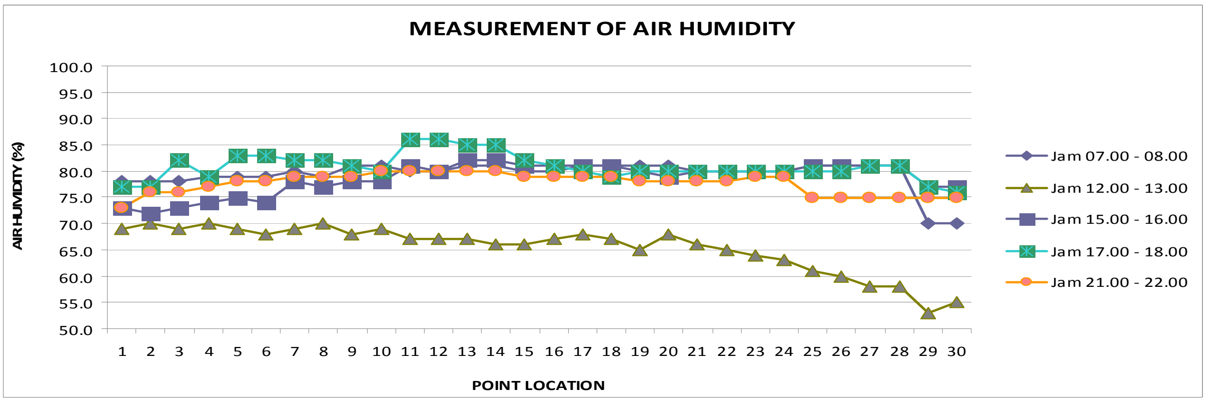

FIGURE 8. The Measurement of Air Humidity

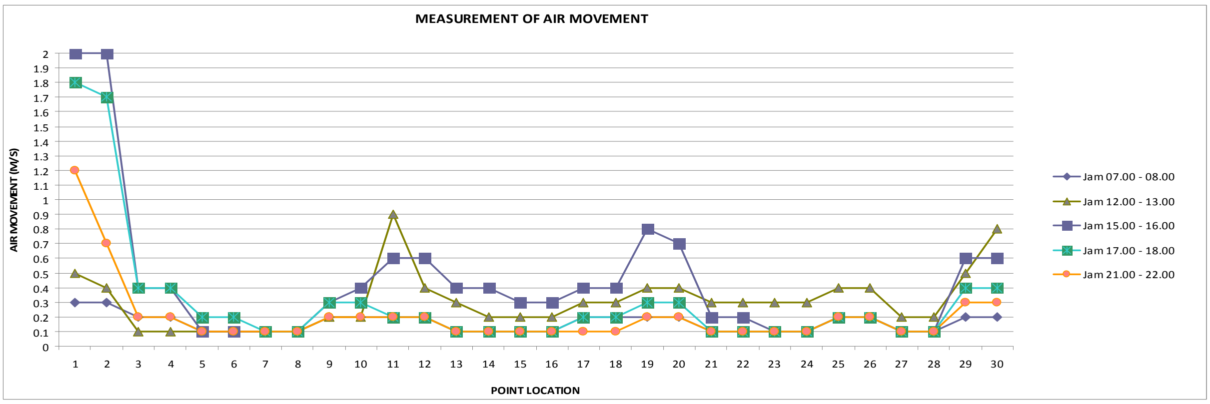

FIGURE 9. The Measurement of Air Movement

According to the result of measurement above, the interior of the house (point location: 5-8; 13-16; 21-24; 28-29) can reach the comfort zone. It lies on a temperature range 25-35 degrees Celsius; a wind speed range 0.1-1.0 m/s; and the humidity range 5-85%. Based on the temperature measurement chart above, when the exterior temperature reach a peak conditions (34.5 degrees Celsius), the interior temperature can drop to be 30.0 degrees Celsius. In other words, this WWF passive cooling model can lower the temperature by 4.5 degrees Celsius (34.5-30.0). The primary key of WWF passive cooling can achieve comfort zone is the presence of air movement. The wind (air movement) can move from one place to another place because of pressure. The pressure can be created by designing a different temperature. Different temperature can be created by chain reaction of natural environment, namely water, sun, wind, flora and earth. Finally, different temperature can be seen as evaporation (water), radiation (wind) and respiration (flora).

V. CONCLUSION

This paper examines how to reduce GHG (Green House Gas) emissions at architecture level. The study focuses on efficiency energy, because it has become the most dominant of GHG emissions. By using WWF (Water-Wind-Flora) in designing, the urban settlements can get the thermal comfort and efficiency energy. According to this experiment research, the interior of the house can reach the comfort zone. It lies on a temperature range 25-35 degrees Celsius; a wind speed range 0.1-1.0 m/s; and the humidity range 5-85%. Afterwards, when the exterior temperature reach a peak conditions (34.5 degrees Celsius), the interior temperature can drop to be 30.0 degrees Celsius. In other words, this WWF passive cooling model can lower the temperature by 4.5 degrees Celsius (34.5-30.0). The primary key of WWF passive cooling can achieve comfort zone is the presence of air movement. The wind (air movement) can move from one place to another place because of pressure. The pressure can be created by designing a different temperature. Different temperature can be created by chain reaction of natural environment, namely water, sun, wind, flora and earth. Finally, different temperature can be seen as evaporation (water), radiation (wind) and respiration (flora). Having an efficiency of energy, the model of WWF passive cooling can reduce GHG emissions in urban settlements. In the other words, to cope the global warming in the urban settlements, people can use the model of WWF passive cooling. Afterwards, at the large scale of using WWF passive cooling, the effort of reduction of GHG emissions will have a significant result. The author suggest that urban communities can reduce electrical energy, especially air conditioning with a variety of creative-innovative finding, such as the model of WWF's passive cooling. In addition, the author suggest to researchers and academics of Architecture to conduct various research about alternative energy-saving design for residential houses in urban areas, in line with the era of global warming and climate change leading to global decay.

VI. REFERENCES

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