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# Rooftop Turbine Ventilator performance for Terrace House in Malaysia

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**ABSTRACT**

This study evaluates the effectiveness of a Rooftop Turbine Ventilator (RTV) in expelling hot air from the attic and reducing heat accumulation in a terraced house in Malaysia. By integrating the RTV with natural ventilation, the system improves indoor air quality and reduces dependency on air-conditioning, consequently lowering energy consumption. The RTV operates as a form of wind-assisted stack ventilation, relying on the pressure difference between indoor and outdoor air to generate airflow through the building's openings. While wind-driven ventilation may be less reliable in densely packed terraced house areas, the stack effect, which requires lower air intakes and taller building heights, is more effective. However, while this stack effect can aid natural ventilation, it can also introduce hot and humid tropical air into the building. Therefore, a balanced design is necessary to manage temperature and humidity effectively. This paper provides a preliminary investigation into the role of RTV in enhancing stack ventilation within a terraced housing unit.

**Keywords:** house, natural, RTV, terraced, ventilation

## 1. Introduction

Over the past four decades, Malaysia has undergone significant economic growth and social transformation, with rapid urbanization driven by a rising population. This has contributed to an increased demand for housing [1]. As a result, many residential developments were rushed into construction, often without adequate consideration for the local climate. Consequently, these houses frequently suffer from discomfort and excessive heat [2], leading to higher energy consumption for cooling purposes [3].

Air pollution has become a pressing environmental concern in Malaysia due to a variety of factors, such as the combustion of natural gas, petroleum, coal, and other materials like agricultural and animal waste [4]. In 2006, the country's CO2 emissions reached approximately 118 million tonnes, or about 7.2 tonnes per capita [5]. According to reports from the World Data Atlas, emissions have been climbing steadily, reaching 248.8 million tonnes by 2019. The International Energy Agency (IEA) reported in 2015 that most of Malaysia's CO2 emissions are linked to energy-related activities. Furthermore, a study by Zakaria et al. Zakaria et al., [6] showed that over 40% of the carbon gases in the country's environment are attributed to emissions from buildings. Between 2002 and 2005, energy consumption in Malaysia's residential sector rose from 17.5% to 21% [7], reflecting the growing middle class's adoption of energy-intensive lifestyles [8].

Terraced houses in Malaysia first emerged in the early 20th century during British colonial rule. Today, the country has constructed more than five million terraced housing units, along with various other types of residential buildings. These homes, based on British designs, typically feature only two external walls—front and back—with the main living spaces at the front and kitchen and additional bedrooms at the rear. Comfort in living spaces is influenced by more than just environmental factors. Cultural and social practices play a significant role in shaping design preferences. Designers must understand the needs of the occupants and their environment, ensuring that homes not only address environmental factors but also allow for flexibility in creating comfortable conditions. Comfort is therefore not only a physiological or technical consideration but also a social one, rooted in shared assumptions about ideal living environments.

In recent years, Malaysia's continued economic growth has provided further opportunities for public housing development. However, this raises questions about whether adequate attention has been given to optimizing comfort within mass-produced homes. Understanding the conditions of traditional Malaysian housing can offer valuable insights into how modern housing can be improved in terms of thermal comfort. With a wide array of housing options available to buyers, thermal comfort is often overlooked by developers. Historically, the low cost of electricity and the widespread use of air conditioning have made artificial cooling systems highly popular, contributing to the increasing energy consumption of buildings [9]. However, with rising electricity and fuel costs, there has been a growing awareness of environmental concerns.

Researchers have extensively studied the indoor temperatures of homes in Malaysia's tropical climate. In urban areas, the internal temperatures of houses can exceed 30°C throughout the day [10][11]. Most houses today are warmer inside than outdoors, so designs that help maintain an indoor temperature close to the outdoor climate are considered more favorable. Consequently, many designs incorporate extensive ventilation openings to promote air circulation and remove trapped heat. Some more radical designs even eliminate walls to create open-plan layouts. However, this often only helps balance indoor and outdoor temperatures without achieving significant cooling. The stack effect is a natural ventilation phenomenon where air moves from a high-density area to a lower-density one. The temperature difference between the interior and exterior of the building causes air to become either denser or less dense inside the building. Stack effect works most effectively when air intakes are placed at lower levels and the building height is maximized [12][13][14].

## 2. Method

This study adopts a field measurement approach to assess the thermal conditions within a typical single-story terraced house. The selected house is located at Taman Desa Ilmu in Kota Samarahan, Sarawak, with geographical coordinates at 1.5168234 latitude and 110.3180055 longitude. Built using conventional materials, the house consists of a concrete floor slab, plastered brick walls, and a metal pitched roof. With a total area of 65 m² (700 ft²), the house comprises three bedrooms and two bathrooms. Figures 1 and 2 illustrate the house's layout and sun path orientation, respectively. Figure 2 provides a rear view of the building, representing half of the unit.

**Figure 1** Side view of the tested house is a corner lot terraced house located at Taman Desa Ilmu, Kota Samarahan (before the installation of the vent).

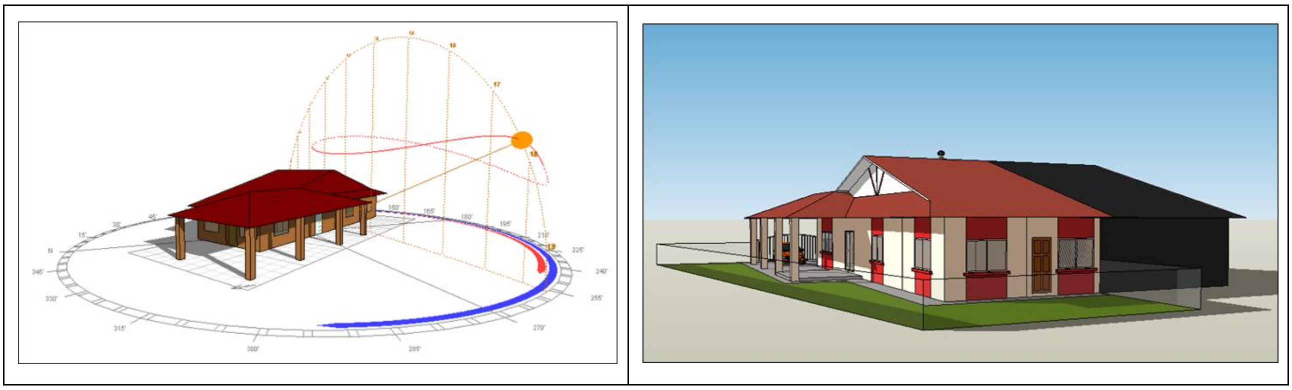

**Figure 2** Sun path orientation and rear view of the terrace house

Prior to any data collection, all measurement instruments were calibrated in a controlled indoor setting to check for sensitivity and accuracy. For temperature measurements, a Kyowa UCAM Data Logger 60B, shown in Figure 3, was employed. This device allows for easy operation and provides real-time data which can be printed instantly. The device is connected to a personal computer, where data is recorded every ten minutes and can be exported for further analysis using the HOBO Program [15] [16].


**Figure 3** Kyowa UCAM data logger 60B

The study's experimental period lasted from 8:00 AM to 8:00 PM. Temperature readings were taken using type K thermocouples (Figure 4), with aluminum foil shielding to prevent interference from solar radiation. The thermocouples were connected to the data logger (Figure 5), placed at various measurement points, both inside the house and in the attic (Figures 6 and 7). Node points for temperature readings inside the house (Figure 6) were positioned one meter above the floor, while measurements in the attic (Figure 7) were made at the midpoint of the space.

**Figure 4** A thermocouple wrapped with the aluminum foil to minimize solar radiation

**Figure 5** Thermocouples connected to the data logger

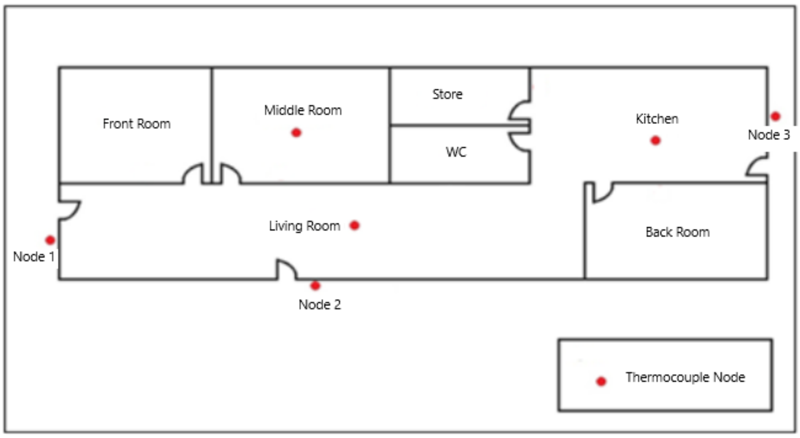


**Figure 6** Thermocouple node points for temperature measurement

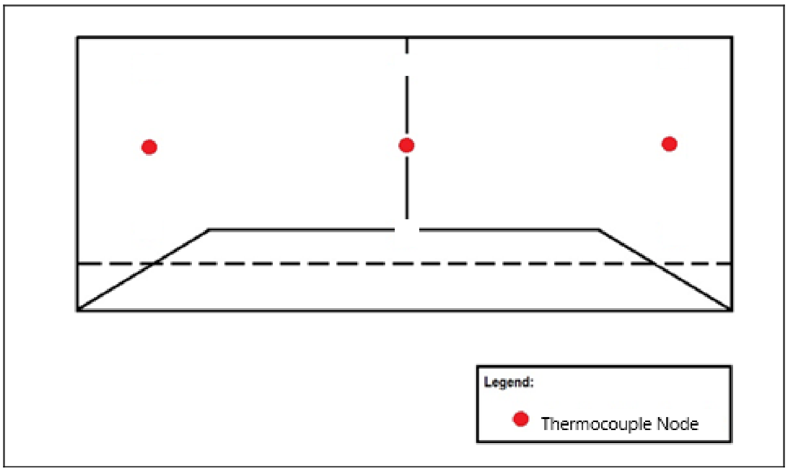


**Figure 7** Thermocouple node points at mid-point various areas in the attic

The data collection was carried out in two phases: before and after the installation of the rooftop turbine ventilator (RTV). Measurements were conducted for five consecutive days in each phase, ensuring consistent outdoor weather conditions (temperature, solar intensity, and wind conditions) to minimize external variability. The experiments were conducted during June, when the weather was predominantly hot with intermittent cloud cover. Figure 8 displays the RTV installation on the house's roof, and Figure 9 shows the house with the RTV during the second phase of the experiment.

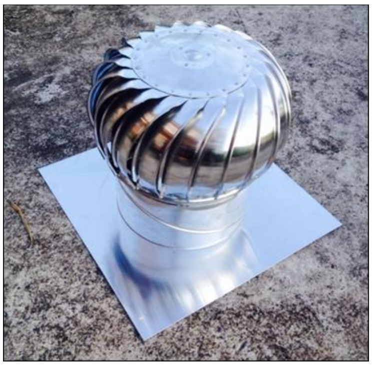

**Figure 8** Standard stainless RTV 24-blade fan ventilator sized 14 inches.

**Figure 9** Terraced house with RTV for the second stage of data collection

## 3. Results and Discussion

The comparison of air temperature before and after the installation of a unit of RTV was done based on the five days' hourly mean temperature from 8am until 8pm of the two different stages. The effect of RTV on the air temperature in the living room is as shown in Figure 10.

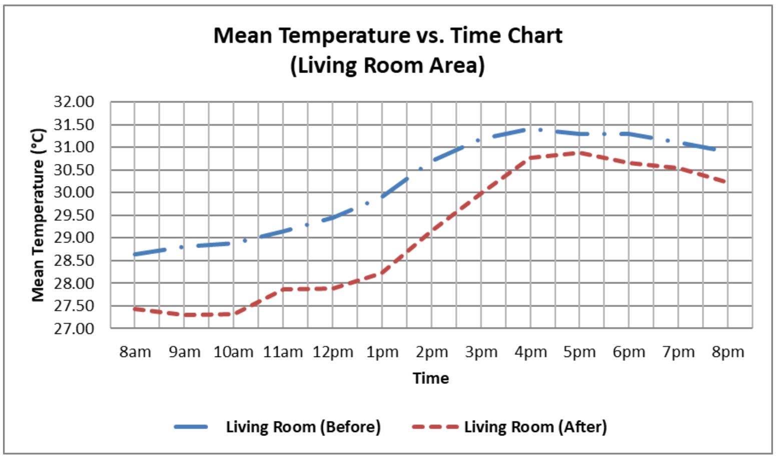


**Figure 10** Mean temperature difference (living room)

Figure 10 shows the mean temperatures for the living room area has been decreased after the installation of the RTV. The difference in the mean temperature was at the highest at 10.00 am with the mean temperature of

1.6°C lower as compared to the mean temperature before the installation of the RTV. The lowest difference in the mean temperature was at 5.00 pm with the mean temperature of 31.3°C before and 30.9°C after the RTV. The difference of 0.4°C was because of the living room exterior facing the west side which is exposed to the sun radiation.

Results of the comparison between the mean temperature at the kitchen area before and after the installation of the RTV was shown in Figure 11. The data shows, that the RTV unit manage to lower the temperature of the kitchen areas as high as 1.6°C in the afternoon. This is because that area was not exposed to direct sunlight (implicated in Figure 2) from the whole morning until afternoon.

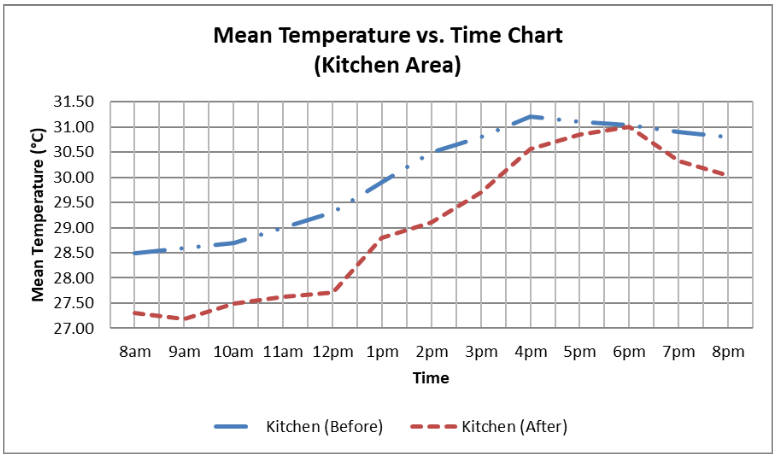


**Figure 11** Mean temperature difference (kitchen)

Figure 11 also shows, that the difference was only 0.04°C, because the location of the kitchen was blocked from cross ventilation passage way and the space does not get a good ventilation system which increased the indoor temperature.

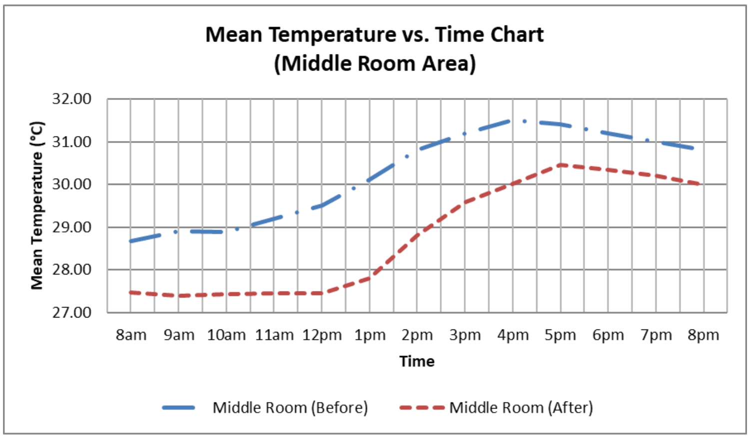


**Figure 12** Mean temperature difference (middle room)

Figure 12 shows the comparison of mean temperature differences in the middle room. The graph indicated of the indoor temperature decreases with the usage of RTV. The highest difference in the mean temperature is about 2°C between 1 pm and 2 pm. This shows that the RTV was very effective where cross ventilation was not feasible in the middle room of the terraced house.

Figure 13 shows the mean temperature difference during the experiment conducted in both the non-ventilated and ventilated attic of the house. The mean outdoor temperatures of the two stages experiment were almost similar. The temperature in the attic with RTV is lower compared to without RTV. The difference was about 3°C in the mid-day and contributed to a lower temperature to the indoor spaces below. The effect of the lower temperature on the attic space affecting the living area, kitchen area and middle room was shown clearly in Figures 10, 11, and 12.

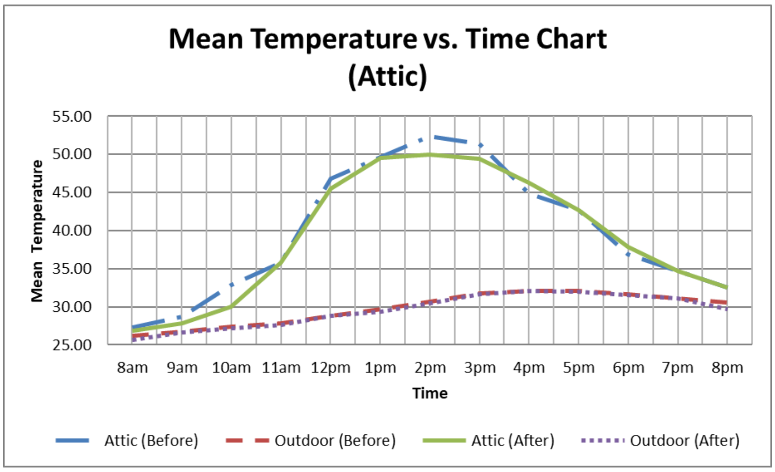


**Figure 13** Mean temperature difference (attic)

## 4. Conclusion

Experimental work has been successfully conducted on a standard terraced unit in Sarawak Malaysia. The study showed the effectiveness of the RTV unit in lowering the indoor temperature of the terraced house. The 10 days of data collection (5 days with RTV and 5 days without RTV) during the hotter month of Malaysia showed that the particular standard RTV units of 14 inches with 24 blades can reduce as much as 2°C for an indoor living space of 700ft$^2$ (65m$^2$). Perhaps with many different configurations of such devices – different shapes of vanes and ratios between the main dimensions, the efficiency would be increased. Nevertheless, although the value is insignificant, if the air-conditioning system was in place, the lower value of 1°C can reduce energy usage by 10%. This brief research helps to open a venue for further research at a similar nature with a different typology, larger sample size, and similar devices of scale RTV.

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## 6. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. The research was conducted with full academic integrity, and no financial, personal, or professional relationships that could have influenced the research were present.

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