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Original Research Paper

Solar Exhaust Fan with Temperature Sensor

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Abstract: Household nowadays need to face the global warming and also have to face increase in cost of living. In this era also, especially Malaysia is the one of developer country, so there so many developments. So this situation can lead to many crises to the household for example dust, high temperature, and the increasing in the electrical bill. This study was aimed to develop solar exhaust fan with temperature sensor that can help the household to overcome the issue. The project used the evolutionary prototyping model. Quantitative method approaches were used for this study where 33 participants were participating in the survey before design the system and 32 respondent respond to survey during the user acceptance testing.

Keywords: Arduino Uno, Solar Exhaust Fan, Temperature Sensor.

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1. Introduction

In this era, household cannot avoid from the fact that they have to face the global warming and also the increasing in cost living. Due the rapid of developing country, there are so many construction, factory and also vehicle that lead to greenhouse effect. The greenhouse gases for example Carbon Dioxide rate released with Carbon Dioxide rate absorb are big in different due to uncontrollable logging and open burning. The gases were absorbing the radiation from the sunlight that usually the radiation will bounce back out of atmosphere. Since it absorbs the radiation the heat also will be bounce back to the earth.

From worldometer website record that the increasing rate birth and death was more than three time different in number where birth rate are higher than death rate [1] [2] [3]. This shown that human populations are increase rapidly, so the request of resources was higher. This situation leads to a lot of construction and development in various sectors to accommodate the human needs. Nowadays there a plenty of houses was built in the city and near developing area that leads to the increasing number of vehicle that contribute to pollution and dusk. Mostly household in this area need to have air conditioner and some of them have to hire the maid to clean their house every day. They also need to pay the big amount for their electrical bill due to the large amount of energy needed by air conditioner to cool the temperature surrounded that already in high temperature. Solar exhaust fan was the created to overcome this issue.

The system is focusing on home's exhaust fan using a solar technology [4] [5] [6]. The economy of the system in term of saving the cost and increase of the performance of the system with reduced environmental impact. The free sources of energy by using a solar are paramount importance. Mostly house in the Malaysia used the air conditioner. The air conditioner used a lot electrical energy especially when the temperature in the surrounding was higher. With the present of the exhaust fan can decrease the air temperature, so it helps to minimize the energy needed for air conditioner to cool the temperature. The temperature sensor helps the user to estimate the temperature setting at the air conditioner. When the exhausted fan sucks the hot air in the house, the air pressure was low in the house, so the air pressure from outside will enter the house and cool the house.

The main function for exhausted fan is to suck the dust essentially for the house in urban area due to daily activity like industrial activity in particular on factory and increasing number of the vehicle on the road that triggered a lot of dust [5]. The system also sucks the unnecessary odor, for example the cooking odor and the unpleasant smell from toilet.

The existed exhaust fan for home literally consumes a lot of electricity energy due to large energy needed to activate the fan. The bigger wide area of the house the more energy needed for the fan to extract the dust and odor. The solar are used to solve the problem since solar is the free sources energy supply and also not harming the nature.

2. Literature Review

2.1. Solar

Solar is the heat and radiant from sun. People use sun as an energy supply for electronic machine and it can use without releasing the greenhouse effect. Basically solar had two main technologies, solar photovoltaic and solar thermal. Solar photovoltaic convert radiant from sunlight. Photovoltaic panel was used to absorb the radiant and heat from sun, the photon energy from sunlight hit the panel and make the electron free excite and causing a charge and supply the electricity [4] [6]. For solar thermal it turns the sunlight into heat. The heat will evaporate the water to steam and make the turbine start moving and supply the electrical energy.

2.2. Exhaust Fan

Exhaust fan is a fan created for ventilating an interior by drawing air from the interior and expelling it outside [7].

2.3. Home Automation using IOT

Home automation using IOT is smart home design to helping people manage the home appliances freely and build an autonomous environment in home [8] [9]. Wireless communication as Wi-Fi was used for this project to controlling the home appliances and with full security. The functions of this system are prevent from theft using vibration sensors that used to detect the motion and vibration, activates the exhaust fan monitored using temperature and humidity sensors an maintained at room temperature. For a house to have huge system like Home Automation using IOT, it will need a large

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amount of investment and not everyone can have it. To activate the exhaust fan using a sensor and maintain the temperature will need a large amount of electrical energy and can lead to wasted energy and higher electrical bill.

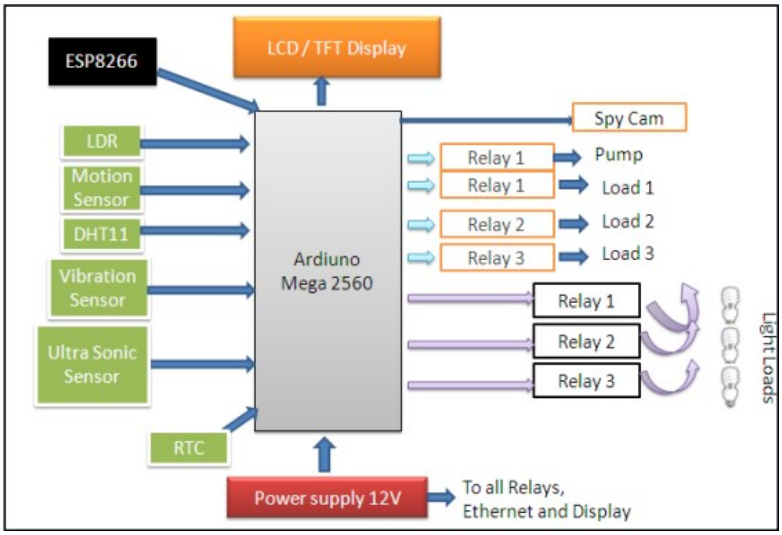

Figure 1. Home Automation using IOT

2.4. Liquid Flow Control Based Upon Energy Balance and Fan Speed for Controlling Exhaust Air Temperature

This system builds to control the speed for exhausted fan using temperature sensor and liquid as cooler agent. This system was complicated system that can cost large amount of money. Since this system was automatic, it is difficult to household to handle it manually [10] [11]. The room temperature is not fixed and was influenced by the environment temperature. If the fan switches the speed when the temperature is low, the room temperature can increase again, and to make a fan to increase the speed, it will take a large amount of electrical energy [12]. This system leads to wasted energy of electrical.

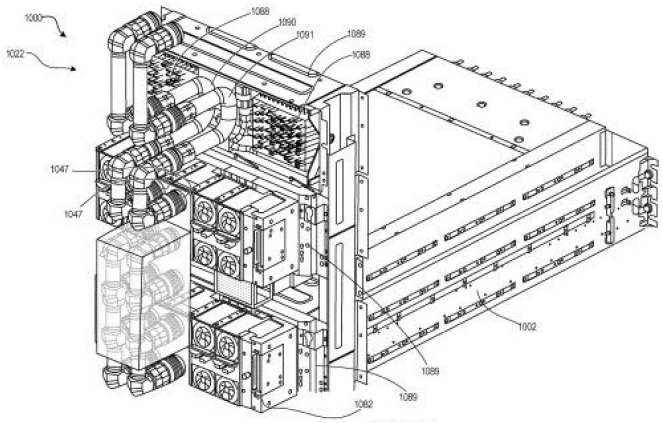

Figure 2. Liquid Flow Control for Controlling Exhaust Air Temperature

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2.5. Solar-Powered Ridge Vent Fan Unit

This system was simple system build to save the electrical energy and other function of exhaust fan. But this system only work when daylight or have a huge amount of solar energy since it not provide battery storage that can store the solar energy that accepted by solar panel [5] [13]. Other than that the user cannot check their room temperature.

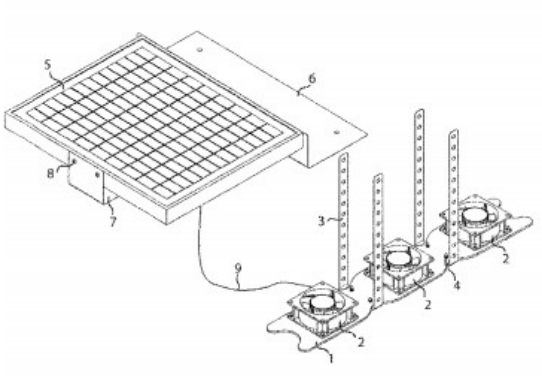

Figure 3. Solar-Powered Ridge Vent Fan Unit

2.6. Solar Powered Exhaust Fan

This system was simple system build to save the electrical energy and other function of exhaust fan [14]. This system also has automatic and manual switches. The user cannot check their room temperature.

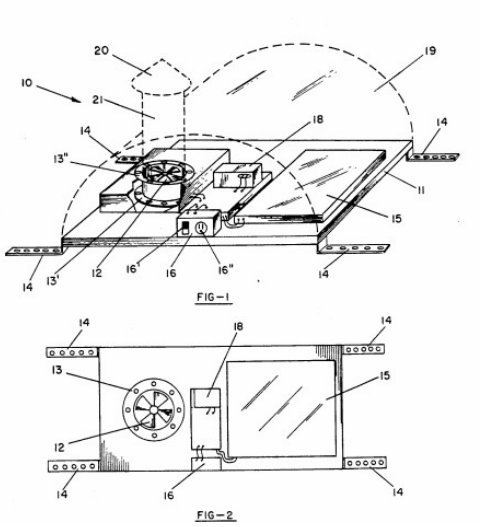

Figure 4. Solar Powered Exhaust Fan

2.7. Hardware for Solar Exhaust Fan with Temperature Sensor

There are few component used, namely:

2.7.1. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet) [4] [6] [9]. It consists of 14 digital input/output pins which is 6 can be used as pulse width modulation(PWM) outputs and 6

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analog inputs, it also consists of a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header and a reset button [14]. It contains everything needed to support the microcontroller. "Uno" was chosen to mark the release of Arduino Software (IDE) 1.0 that means one in Italian. For the research work digital pins is connected to LCD board and analog input is connected to breadboard to link with other component. USB connector use to link the Arduino with computer to programmed the Arduino UNO board. Arduino Uno shows in Figure 5 and it specification can be seen in Table 1.

Figure 5. Arduino UNO

Table 1. Specification for the Arduino UNO

Brand required.	Arduino
Series	Rev 3
Item model number	A000066
Item Weight	1.6 ounces
Product Dimensions	3.15 x 2.17 x 0.98 inches
Item Dimensions LxWxH	3.15 x 2.17 x 0.98 inches

2.7.2. TMP36 Temperature Sensor

The TMP36 are low voltage and precision centigrade temperature sensors suitable for the research work. The sensor read and provide a voltage output that is equal to the Celsius (centigrade) temperature and will be display to LCD board after export the information to Arduino UNO [9] [15]. The TMP36 is very accurate and do not require any external calibration to provide typical accuracies temperature range. The sensor are operate for a single-supply operation from 2.7 V to 5.5 V maximum. The TMP36 is specified from −40°C to +125°C, provides a 750 mV output at 25°C, and operates to 125°C from a single 2.7 V supply.

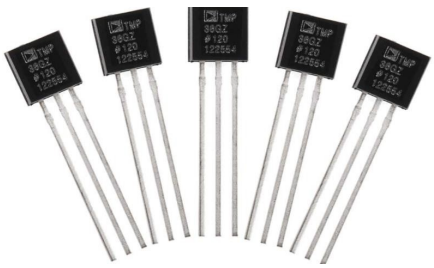

Figure 6. LM35 Analogue Precision Centigrade Temperature Sensor

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2.7.3. 12V Cooling Fan

12V Cooling Fan in Figure 7 and it specification can be seen in Table 2.

Figure 7. 12V Cooling Fan

Table 2. Specification for the 12V Cooling Fan [9]

Dimension	60*60*25mm
Current	0.25A
Speed	5600RPM+-10%
Connector	2P XH2.54
Dimension	60*60*25mm
Current	0.25A

2.7.4. LCD Display Module DC 5V

LCD Display Module DC 5V in Figure 8 and it specification can be seen in Table 3.

Table 3. Specification for the LCD Display Module DC 5V [7]

Voltage	5V DC
LCD display type	Characters
Module dimension	80mm x 35mm x 11mm

Figure 8. LCD Display Module DC 5V

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2.7.5. NPN Transistor 2N2222

NPN Transistor 2N2222 shows in Figure 9 and it specification can be seen in Table 4.

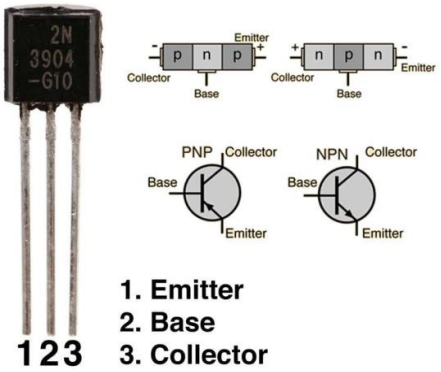

Figure 9. NPN Transistor 2N2222

Table 4. Specification for the NPN Transistor 2N2222 [8]

Transistor Type	NPN
Current	Collector (Ic) (Max)600mA
Voltage	Collector Emitter Breakdown (Max) 40V
Vce Saturation (Max) @ Ib, Ic	1V @ 50mA, 500mA
Current	Collector Cutoff (Max)10nA

2.7.6. Diode

A diode acts as a one-way switch for current known as semiconductor device. The diode works to allows current to flow easily in one direction, and block the current from flow back to opposite directions [13]. Diodes are change alternating current (AC) into pulsating direct current (DC) and known as rectifiers. Diodes works due to polarity, determined by an anode (positive) and cathode (negative). When positive voltage is applied to the anode, diodes allow current to flow in one direction. When a diode is reverse-biased, it acts as an insulator and does not permit current to flow and vice versa, it is forward-biased. Diode shows in Figure 10 and it specification can be seen in Table 5.

Figure 10. Diode

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Table 5. Diode

Diode Standard	1000V 1A
Through Hole	DO-41 1n4007 Rectifier Diode
Product Dimensions	3.94 x 3.15 x 1.97 inches; 1.76 Ounces

2.7.7. Capacitor

Capacitor shows in Figure11 and it specification can be seen in Table 6.

Figure 11. Capacitor

Table 6. Specification for the Capacitor [14]

Capacitor	10uf 50v electrolytic
Diameter	4mm, Height:7mm,Tolerance :±20%
Package Dimensions	3.7 x 3.5 x 0.7 inches; 0.81 Ounces

2.7.8. Solar Power Mini

Solar Power Mini shows in Figure 12.

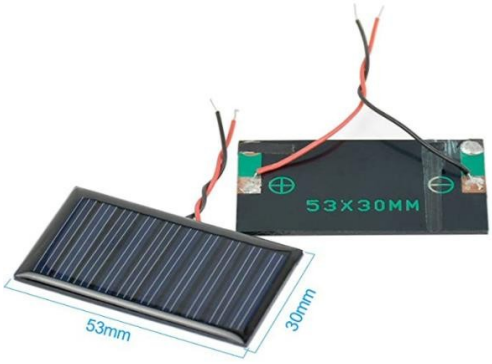

Figure 12. Solar Power Mini

Solar power is energy that extract and converted into thermal or electrical energy. Solar energy is the most abundant renewable energy source and cleanest, solar technologies can extract this energy

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for a different of uses, including supply the electricity, providing light and a comfortable interior environment, and uses for heating water for domestic, commercial, or industrial use. There are few ways to uses the solar energy [16], first is photovoltaics that can be used to power anything from small electronics by generate electricity directly from sunlight using an electronic process. Second is solar heating and cooling and third is concentrating solar power (CSP) applications both use to provide water heating in the case of SHC systems, or to run traditional electricity-generating turbines in the case of CSP power plants using heat and radiation produce by the sunlight.

For the research work, thermal mass theory was used. Thermal mass is used to store heat from the Sun in the term of solar energy that use any material that can extract the energy. Stone, cement, and water are the common thermal mass materials. In the past people are keep their buildings cool by absorbing solar energy during the day and radiating stored heat to the cooler atmosphere at night. Nowadays solar panel was created to extract the heat and radiation from the sunlight to supply the electrical energy. In this research work solar panel is connected to AC-DC converter to charge the battery.

3. Methodology

For this system, rapid prototyping was used [17] [18]. Rapid prototyping was implementing in design phase where the stakeholder can give their opinion about the prototyping. Rapid prototyping is the best compared to other method because it can deliver a high quality software system in a less time compared to other method [19] [20]. This is because Rapid prototyping is giving high priority to user participation from the very beginning of the development. This can have satisfied the user.

Analysis and requirement gathering phase is where the user was asking for the relevance of this system to develop and their opinion about the solar exhaust fan to implement to their house, second phase is where prototyping was creating and ask for feedback from every stakeholder. If any changes or improvement needed, the prototyping will rebuild until the prototyping was satisfied the user. After prototyping was finalized, the system will start to be built perfectly and will be testing in the next phase. The white box and black box was involved in the testing phase.

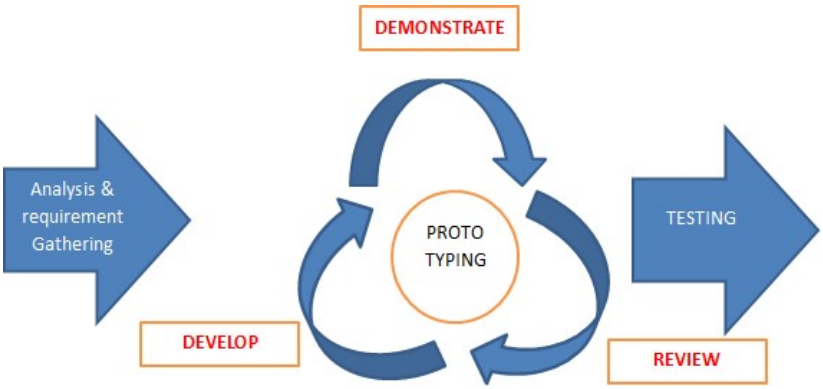

Figure 13. Rapid Prototyping

4. Result and Finding

4.1. Prototype

The building prototype phase is where illustrate the overall process of developing a product or system from the beginning till the product develop completely. In this stage, developer use a temperature sensor and programmed the system to detect the temperature surrounding and displaying on the LCD board. Solar was implement at the roof, while fan is implement between the wall so the air can flow through it. Solar used to extract the sunlight and change to DC power supply to activate the system. The fan only activates when the user turns on the switch. The figure shows the house design to implement the system.

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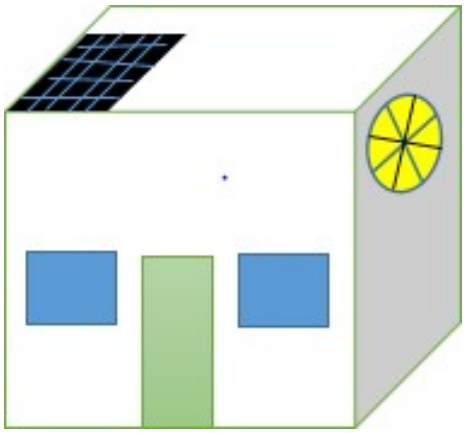

Figure 14. Prototype for the Solar Exhaust Fan with Temperature Sensor

Arduino UNO was used for the prototype. There are few step to assemble all part. Firstly, LCD board is connected first to checked whether it functionality in good condition. Wire all set up to the Arduino UNO as the figure. USB connecter connect to pc to give a power supply to the Arduino UNO. When the LCD board is activating, The LCD is in a good condition. Next step connects the TMP36 and capacitor to the breadboard and wiring up the component and connect to Arduino UNO. Then after connect the component, the Arduino UNO was programmed to checking the TMP36 is in good condition. Thermometer also use to check whether the sensor give an approximate reading. Next step is connecting the fan. Fan was connecting with diode to make sure it gives a direct power supply and connect to transistor to make sure the fan has enough power supply to activate. The USB was again connected to pc to justify the functionality of the fan. Next is setting up the rechargeable battery with solar using converter to change from AC to DC. Finally, connect the battery to the breadboard. And testing the whole system.

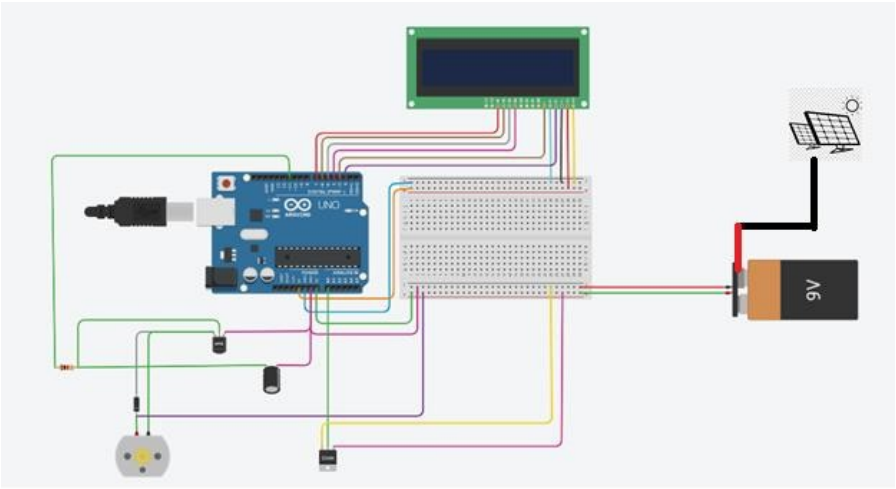

Figure 15. Wiring-Up for the Solar Exhaust Fan with Temperature Sensor

4.2. Testing

Testing findings are based on the TMP36 and the solar charger controller. For the temperature sensor, testing is done 3 time to get the efficiency value. And the solar charger controller is test for the solar charge the battery in 1 hour.

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Table 7. Result Findings for TMP36 Sensor

TMP36	First Reading (C)	Second Reading (C)	Third Reading (C)	Average (C)
	30.0	28.0	27.0	28.3
			Efficiency	**17.0**

Table 8. Result Findings for Solar Charger Controller

Solar Charger Controller	First Hour	Second hour	Third Hour	Average
Battery Percent	30%	45%	61%	17
Percentage	20%	15%	16%	
Efficiency (Highest Increasing Percentage-Average)				3

Based on the result we can conclude that if the users used the same size of solar and the same sensor, the result will approximately same as the result, but due to different size of the house, the user need to have powerful fan and larger solar panel to support the energy needed by the fan.

4.3. Feedback Given by Respondents

There were 36 people participating in this questionnaire. Feedback from respondents was recorded by distributing questionnaire form to respondent after they have watch a demo video.

Table 9. Feedback Given by Respondents

	Survey Question	Strongly Disagree	Disagree	Slightly Disagree	Agree	Strongly Agree
NO.	Solar ExhaustFan with Temperature Sensor	1	2	3	4	5
1.	do the solar working	0	0	6	8	18
2.	do the fan working	0	0	6	6	20
3.	do the temperature sensor working	3	1	7	7	14
4.	Do you need to implement this product to your house?	4	0	9	7	12
	Total	7	1	28	28	64

Table 9 shows the result of functionality of the solar exhaust fan with temperature sensor. Based on the table, the overall result of functionality shown that from 32 respondents 50 % strongly agree that the functionality of the solar exhaust fan with temperature sensor is excellent, respondent said agree while slightly disagree have same percentage with 21%, 0.1% disagree and 5% strongly disagree. So, it means the functionality of the solar exhaust fan with temperature sensor reaches its goal.

5. Conclusions

Solar exhaust fan with temperature sensor have a capability to reduce almost 20 percent of electrical bill and also help to clean the house from dust and bad odor. In the urban area, mostly household implement the air conditioner due the heat and have to face the dust due to mostly house near to main road. Due to different type of house, the different size and power needed for develop the solar exhaust fan with temperature sensor. The powerful fan will need to make sure it can extract the odor and dust. The bigger solar panel also need to supply more power to the fan. Solar exhaust fan with temperature sensor has wide potential due to increasing urban population and the rapid growth of development.

Due to global warming issue and the increasing of spent in living, this product can help a lot of people today to save a lot of money.

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