AUTOMATED TEMPERATURE AND HUMIDITY CONTROL SYSTEM FOR STRAWBERRY PLANTATION USING SOLAR PANEL

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Abstract- This paper presents the Automated Temperature and Humidity Control System for Strawberry Plantation using Solar Panel is aimed to facilitate the farmers or gardeners to involve in greenhouse system and improve agriculture technology. In Malaysia, the climatic conditions are favourable to the development of solar energy, with abundant sunshine throughout the year. The climate influences the types of plantation in an area. For example, the process of planting strawberry plants in Kedah needs suitable humidity and temperature. The maximum temperature specified for planting strawberries in this project is 20°C while the minimum soil moisture was 70%RH. This project is to encourage plantation of cold climate plants under normal temperature with the control of automated temperature and humidity control system. There are several parts which control the system such as temperature and humidity sensor is basically to control and maintain a sustainable temperature and humidity for the growth of cold climate plants. These sensors will detect the requirement and operate as the system designed. Photovoltaic (PV) solar panel is the power source for the project. The energy from the sun lights will be absorbed and converted to electrical energy. Led flash siren alarm will be activated to alert when error occurs in the system. The body and roof of the design is transparent for photosynthesis purpose. The organizer will be able to use the system manually and automatically. The program code for manual method is designed by using Programmable Integrated Circuit (PIC).

Keywords- Solar Panel, Strawberry Plant, Temperature, Humidity, PIC.

I.INTRODUCTION

In Malaysia, the climate is always hot, and humid throughout the year. The average temperature in Malaysia is 27°C while humidity is within the range of 60%-70%. The plants which grow in Malaysia are favourable to our climate. This project is about to encourage the growth of cold climate plants in Malaysia for example strawberry plantations. The plants which grow in cold climate differ from plants which grow under 27°C. The average temperature is 10-20°C.The humidity is 70-80% [6].

The concept of this project is based on the plantation in Cameron Highlands. This system can be built in any area in Malaysia because the temperature and humidity level inside the system unaffected by the surrounding temperature [6]. In local cafes and restaurants, it is a trend to incorporate strawberries in the menu, whether as ingredients for a dish or a choice of flavour in pies, cakes, ice cream, waffles, chocolate and drinks. As the fruit does not keep for long, stock that goes unsold at farms and markets is processed into jams, pickles, biscuits and other treats for sale as dry goods. As the strawberry plant grows ideally in cold but dry conditions, the best time to enjoy fresh strawberries is from May till August, months with the least rainfall. This project will boost up the number of strawberry plantation not only on the hill but using greenhouse system.

In Cameron Highlands, strawberries are grown by hydroponic method in greenhouses to allow for high volume and quick production rates. The plants are placed in soil bags or pots and stacked on racks, the greenhouses keeping them dry from excess moisture. The system inside the greenhouse will ensure the temperature and humidity are 20°C and 70%. The requirement of temperature and humidity are very important to maintain the size, colour of the fruit and taste of sweetness. The changes of the temperature or humidity inside the greenhouse will reduce the quality of the fruit. The demand for strawberries is very high in Malaysia. Automated system can reduce the cost of import strawberries from countries such as Turkey, USA, and Italy and just to list a few.

The system operates by using the electricity which generates by the photovoltaic (PV) solar panel. Solar energy is used when the sun shine, DC current will be used whereby solar power has stopped contributing the system to control the maintenance. DC supply will start to generate automatically when solar energy stopped producing solar power. The solar panel has a photovoltaic cell inside, which converts sunlight to an electrical current. A solar panel's effectiveness depends on the size and quality of the solar cell and the transparency of the protective cover. System can be operated in two ways; from solar energy and Direct Current (DC) supply voltage. Solar energy is used when the sun shine, but the DC supply voltage will be used when solar energy is no longer supplying power to the system.

Activities which being process in this system will be displayed on LCD. For example, when the system is

running automatically to flush water to the plants, "watering" will display. Moreover, PIC programming is the main software for this project. Buzzer or LED will represent for any failure in this system. The buzzer or siren will alert the operator that the system has error at that time. The temperature and humidity sensors will detect the heat and humid of the system. The LCD is used to display the process which going on the system. The DC fan is used as the cooling device in the system. For example if the temperature increased in sudden within the system this DC fan will operate and decrease the temperature of the system. DC motor is used to operate the roof of the system [1].DC motor rotate clockwise when the rain detector sense input and rotate anticlockwise when the rain detector once stop receiving input[2].

The organization of this paper is as follows:
Section 1 introduces the background of the project, the problem statement, and the purpose of developing the project. This section also mentions the importance's of the project. The background study and the related research have been discussed in section 2. The methods or approaches used in the project have been discussed in section 3. In section 4, operating principle, design details, and experimental results of magnetic current limiter has been presented. The analysis and simulation results have been discussed in section 4. The project has been concluded in section 5.

II. RESEARCH BACKGROUND

This section contains the literature review on theoretical concepts applied in this project. It contains the information gathering of the project in order to complete the whole project. There will be some discussion of the research background related to the project. The overall result in the concept literature framework shows that the link between research projects with the theory and concepts in the figure or an appropriate model. The research background for this section is about solar panel and strawberry plantations.

2.1 Research based on Solar Panel Applications

Solar power is the conversion of sunlight into electricity, either directly using photovoltaic (PV), or indirectly using concentrated solar power (CSP). Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Photovoltaic convert light into electric current using the photovoltaic effect. Photovoltaic were initially, and still are, used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. They are an important and relatively inexpensive source of electrical energy where grid power is inconvenient, unreasonably expensive to connect, or simply unavailable. However, as the cost of solar electricity is falling, solar power is also increasingly being used even in grid-connected situations as a way to feed low-carbon energy into the grid.
Remote buildings, such as schools, community halls, and clinics, can benefit from solar energy. In developing regions, central power plants can provide electricity to homes via a local wired network, or act as a battery charging station where members of the community can bring batteries to be recharged. PV systems can be used to pump water in remote areas as part of a portable water supply system. Specialized solar water pumps are designed for submersible use or to float on open water. Large-scale desalination plants can also be PV powered using an array of PV modules with battery storage. PV systems are sometimes best configured with a small diesel generator in order to meet heavy power requirements in off-grid locations. With a small diesel generator, the PV system does not have to be sized to cope with the worst sunlight conditions during the year. The diesel generator can provide back-up power that is minimized during the sunniest part of the year by the PV system. This keeps fuel and maintenance costs low. For many years, solar energy has been the power supply choice for industrial applications, especially where power is required at remote locations. Because solar systems are highly reliable and require little maintenance, they are ideal in distant or isolated places.
Solar energy is also frequently used for transportation signalling, such as offshore navigation buoys, lighthouses, aircraft warning light structures, and increasingly in road traffic warning signals. Solar is used to power environmental monitoring equipment and corrosion protection systems for pipelines, well-heads, bridges, and other structures. For larger electrical loads, it can be cost effective to configure a hybrid power system that links the PV with a small diesel generator.
The life-cycle for greenhouse emissions of solar power is in the range of 22 to 46 g/kWh depending on if solar thermal or solar PV is being analysed, respectively. The life cycle emission intensity of hydro, wind and nuclear power are lower than solar as of 2011 as published by the IPCC, and discussed in the article Life-cycle for greenhouse emissions of energy sources. Similar to all energy sources were their total life cycle emissions primarily lay in the construction and transportation phase, the switch to low carbon power in the manufacturing and transportation of solar devices would further reduce carbon emissions. A 1-kilowatt system eliminates the burning of approximately 170 pounds of coal, 300 pounds of
carbon dioxide from being released into the atmosphere, and saves up to 105 gallons of water consumption monthly.
Greenhouse system improves the growing of vegetables, fruits and flowers. Greenhouse coverage

protects plants from the effect of environment as in figure 1[3]. Sustainability of a greenhouse is a vital concept in order to run a greenhouse, especially one of the method used for is the growing of the plants. Besides that making a suitable sustainable greenhouse is very simple. In order to build a greenhouse building it uses the greenhouse effect as in the sense the by trapping needed temperature inside. Most of greenhouse is made of glass and plastics which allow the sunlight to go through the building and helps the building to keep hold of the heat more efficiently [5]. Using a greenhouse concept in Malaysia will allow a gardener or farmer to extend the growing of cold climate plants. The main challenge of sustainable greenhouse is to maintain with the issue of heat or in other words the temperature and humidity of the system. The temperature low indicates that the humidity is high whereby when the temperature high the humidity level is low. The sustainable greenhouse productivity produces a variety of plants such as grapes, strawberry, tomatoes, rose plants, vegetables and just to list a few. The greenhouse facilities range is from industrial to large commercial production. The greenhouse industry is quickly becoming a very high technology industry with embedded systems, robotics, and innovations of agriculture. The automated temperature and humidity control system for strawberry plantation using solar panel based on the concept of greenhouse.

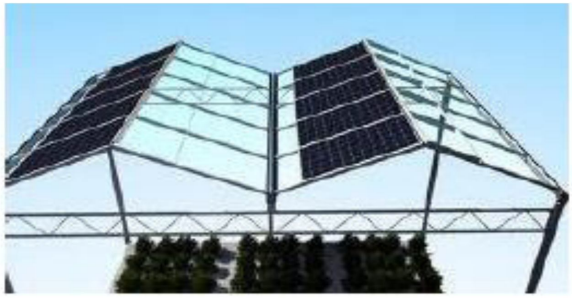

Figure 1: Greenhouse technology

2.2 Research on Important Factors to Maintain Top Quality of Strawberry Fruits

The correct use of drip irrigation provides an ideal soil moisture level for plant growth. The irrigation time interval depends on the rate of water evaporation, temperature, the stage of plant development and the flow rate of the drip tube. The irrigation interval starts out short and increases as the plant develops and the temperature rises. The demand for water is greatest during the fruit setting and fruit sizing stage. It is important for the soil to be at the ideal soil moisture level during this time to obtain high yields of high quality fruit. Growers who are using drip irrigation for the first time are encouraged to water by a set schedule. Within time, the growers will be able to fine tune the irrigation schedule to their fields. Growers should check their fields every 2 or 3 days to determine if the time intervals for irrigation need to be increased or decreased. The soil in the root zone (6- 8 inches deep) should be moist and form a loose ball when squeezed in your hand. The soil should never be saturated. Water should not run out from under the plastic into the middle of the row.

Side dressing can also be done by injecting the fertilizer through the drip lines by using an injection device. This method is known as fertigation. Growers apply some of the nitrogen fertilizer preplant (40-80 lb. of N/A) and inject the side dressing nitrogen in equal increments from bloom and fruit set and continue to harvest. The nitrogen fertilizer is injected into the system at a rate of 3/4 pound of N/A per day or 5 1/4 pounds of N/A per week.600- 700 lb of 8-24-24/A preplant. Start fertigation 3 to 4 weeks after transplanting and continue through harvest. Inject 16 pounds of AMNO3 or 32 lb of CaNO3 or 30 KNO3 per acre per week. The greenhouse grade of CaNO3 or KNO3 is easier to dissolve and inject [5].

Strawberry cultivars vary widely in size, colour, flavour, shape, and degree of fertility, season of ripening, liability to disease and constitution of plant. The automated temperature and humidity control system for strawberry plantation will emphasize the control of the temperature of the system and the moisture of the soli by using PIC 16F877A [4]. The reduction of the required temperature will adjust by the cooling system when the sensor detects any changes from the surrounding. The moisture of the soil control by humidity sensor whereby when the soil is dry automatically the water pump drips water to the soil. These two factors are very important to maintain the top quality of the strawberry fruits as in figure 2.

Figure 2: Strawberry fruits

III. METHODOLOGY

The project design involved software, hardware, and mechanical design part. The project was complete once the hardware development part is successfully done. Once the hardware part is done, then it will be integrated with the whole system of the project. In hardware process there is part whereby need to do troubleshooting and testing. The procedure will go on until reach yes part for the testing process. Lastly, the software and hardware will be integrated into mechanical design of the project.

The assembly language which is used in this project is specified for PIC16F877A. The program code controls the sensor and gives feedback to the system. The temperature sensor once detect the temperature above 21°C it the cooling system will be activated. The cooling system of the project is DC fan. The program code determines the moisture level of the soil to maintain the humidity level. The software part of this project controls the flow of the system. The temperature and humidity level in the system can be changed when numerical part of the program code is changed accordingly. CCS C compiler is used to produce the coding for the entire system. This means the functionality of each sensor and the system is completely dependent on the coding produced. This coding will then be incorporated into a component known as PIC16F877A which is available in Proteus software. Proteus is software that is used entirely for circuit design for the entire project. In addition, Proteus also has many advantages as well as circuit simulation and can directly design a Printed Circuit Board (PCB). The schematic diagram of the project circuit using Proteus software is shown in Figure 3, while Figure 4 shows the PCB design of the project circuit.

The biggest problem that can be seen during the implementation of this project is to synchronize the program code and hardware. Besides, the voltage regulators are used in this project is to lower down or regulate the voltage for PIC circuit and LCD display input. If seen, the output from the solar panel is 21V and the input required by the PIC circuit and the LCD display is only 5V. Thus, the voltage regulator is desirable to reduce and stabilize the 21V voltage to only 5V voltage.

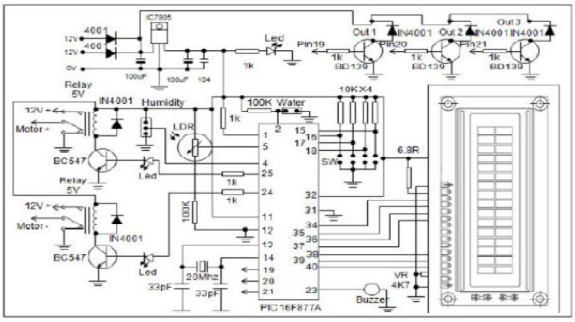

Figure 3: The schematic diagram of the project's circuit

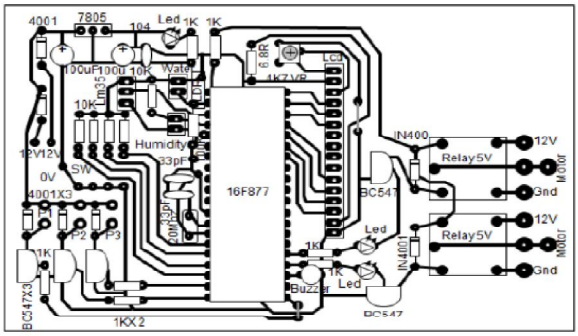

Figure 4: The PCB design of the project's circuit

The concept of this project will lead to the cultivation of strawberry plants in Cameron Highlands, Malaysia. This system can also be developed in any location in Malaysia because the temperature and humidity levels are not yet a major problem when using this system. Figure 5 shows the basic concept of the project.

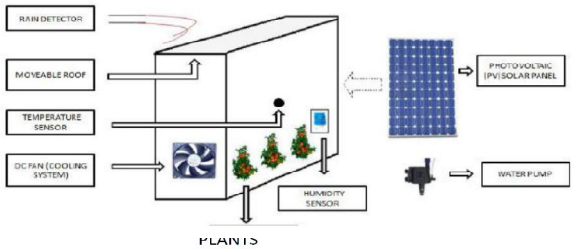

Figure 5: The basic concepts of the project

The temperature for strawberry plantation system is controlled by the cooling system using a DC fan. If the current temperature recorded in the greenhouse is less than 21°C, the cooling system will not run, the reverse occurs if the current temperature recorded was 21°C and above. Soil moisture rates play an important role for tomato cultivation. In this project, the rate of soil moisture is automatically controlled using a water pump that works to bring the water to the ground by the demand needed by the soil. In this project, the pump will bring the water to the ground when humidity is recorded below 25% and the pump will stop when the reading is above 25% and above. Strawberry cultivation system also has a display that is able to determine if the weather is sunny or dark (night). If it rains, the system will pull the transparent roof automatically. This will control the water level as well as to prevent rain from damaging the strawberry plants. Users also have the option either want the system works by using a solar panel or DC supply. Figure 6 shows the mechanical design (prototype) for the project.

The landscape of the real strawberry plantation for this system is adjustable according to the demand and the requirement of the vendor. The quantities of the strawberry plants are important because the size of the system need to be designed according to the requirements. 500 square feet can produce nearly 500 000 fruits throughout the year. 500 square feet landscape of the system randomly contain 20 000 strawberry plants.

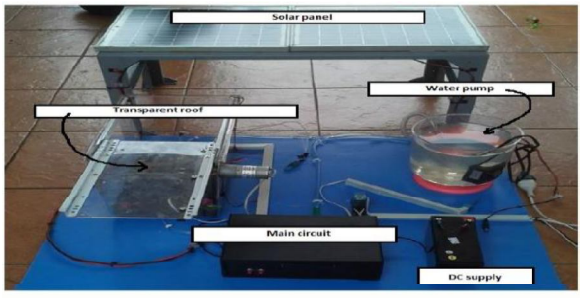

Figure 6: The mechanical design (prototype) for the project

IV. ANALYSIS AND RESULTS

Analysis of Sensors:

(A) Temperature Sensor

The temperature sensor is in this project to measure the current temperature in the greenhouse. Based on the observation, when the temperature decreases, the voltage goes up [4]. That is means the voltage is inversely proportional to the temperature inside the greenhouse. Recorded highest voltage is 5V and Figure 7 shows the analysis for temperature sensor for this project.

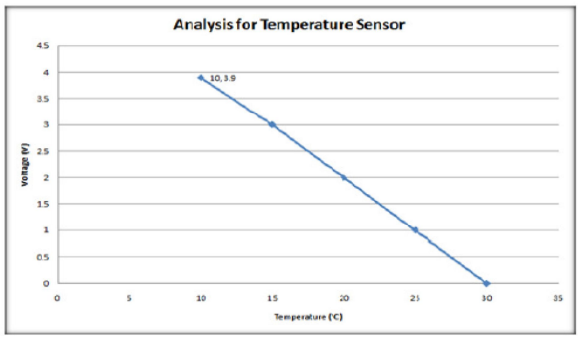

Figure 7: The analysis for temperature sensor

(B) Humidity Sensor

To measure the humidity of the soil in the greenhouse, the humidity sensor is used [4]. Based on the observation, the low humidity gives the highest voltage. Same as in previous case (temperature), the voltage is inversely proportional to the humidity of the soil inside the greenhouse. The recorded highest voltage is also 5V and Fig. 8 shows the analysis for humidity sensor for this project.

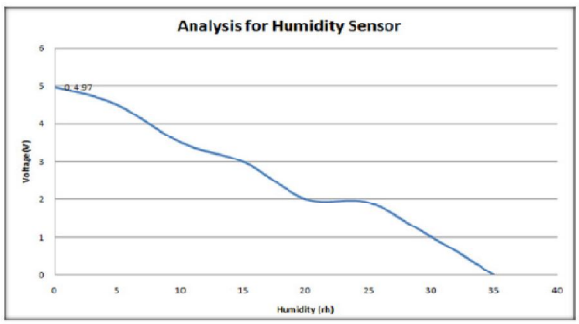

Figure 8: The analysis for humidity sensor

(C) Rain Sensor

Rain sensor plays an important part in this project. As mentioned before, rain sensor detects the presence of rain on tomato plants. If it rains, the rain detector will send a signal to the motor to pull the transparent roof so that it will cover the entire tomato plants in the greenhouse. The readings of rain detector are measured using digital multi meter and the analysis is shows in Table 1. Based on Table 1, the voltage is 0V when the rain is detected while it has the value of 4.87V when the rain is undetected.

Table 1: Rain detector voltage readings

Condition of the rain	Voltage drop at rain detector (V)
Detected	0
Undetected	4.87

(D) Photocell Sensor

Photocell sensor is used in this project to determine if the weather is sunny or dark (night). The analysis result of photocell sensor is shown in figure 9. The voltage is directly proportional to the percentage of output light.

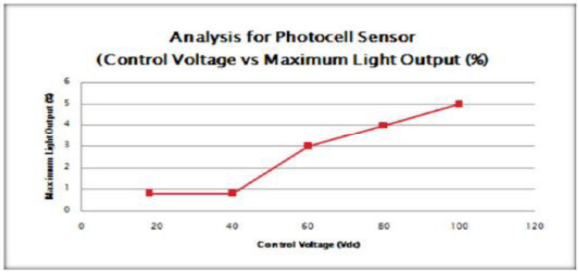

Figure 9: The analysis for photocell sensor

CONCLUSION

This paper presents the application of the project in strawberry plantation. The project designed should be developed in Malaysia because every year Malaysia has imported more than 22.1 million fruits, vegetables, flowers, and many more from other cold climate countries. Agricultural Research and Development Institute of Malaysia (MARDI) is one company that feels very appropriate to develop the project. The project is also seen will give a lot of benefits if commercialized in Malaysia because it can help improve the agriculture sector in Malaysia regardless of the hot climate in Malaysia.

As for the suggestion, the concept strawberry plantation can be replaced by grapes plantation. Grapes generally require a hot and dry climate during its growth and fruiting periods. It is successfully grown in areas where the temperature range is from 15°C-40°C. High temperatures above 40°C during the fruit growth and development reduce fruit set and consequently the berry size. Low temperatures below 15°C followed by forward pruning impair the bud break leading to crop failure. The temperature of the system need to be changed according to the graphs plants needs and growth. The control system of the automated control system needs to be set according to the period of growth to maintain the top quality of the strawberries [6].

The limitation of the project is greenhouse concept. The strawberry plantation is normally at hills or mountains. The reason is because of the naturally low temperature. The automated system does not suitable at mountains or hills because the system itself has the cooling system. The project should build at land whereby sunshine throughout the year has. Shortly,

the automated system can be built at variety places except Cameron Highlands, Genting Highlands and just to list a few [6].

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