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# A Novel Design of Transparent PV Integrated Automated Greenhouse

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**Abstract—***The greenhouse is basically used for cultivating plants at adverse climatic conditions. For this, suitable environment is created inside greenhouse for plants to grow. The parameters like light intensity, moisture, humidity etc. should be maintained accordingly. This paper deals with automation of the greenhouse so that the manpower should be reduced and better efficiency is obtained. The microcontroller and sensors are calibrated according to the plants requirement so that there should be suitable environment inside greenhouse even though the outside conditions are worse. The use of transparent PV make it more ecofriendly and grid independent.*

**Keywords:** *Photovoltaic, Kilogram, Phase Change Material, Feet*

## 1. INTRODUCTION

Green house is a building used for cultivation of plants. In it we shows one such means to utilize greenhouse with automated climate control. The greenhouse is usually of different sizes and designs. The greenhouse proposed in this paper is of odd span in which pitch of the roof is longer for one side as compared to another. The size of this greenhouse is 6’*6’*8’.The main objective of this greenhouse is to create a sustainable environment for the growth of plants. In it along with cultivation of plants and algae itsdaily evaluation is carried out with and without automation which leads to a comparative analysis in it.It is encorporated with 150 W Solar PV Panels which includes the concept of BIPV. Agricultural greenhouses offer one solution to our ever-increasing demand for higher crop production. We no longer rely solely on naturally existing soil and meteorological conditions – such locations are limited. Greenhouses provide better environments for on- and off-season cultivation. They allow the growth of many varieties which would not grow optimally otherwise. A heating and/or cooling system maintains the controlled climate inside and energy is derived from fossil fuels and/or electricity. The growing trend of ‘local is better’ also dictates using cleaner energy in greenhouses. Fresher produce as well as lower transport costs maintain sustainability[1]. Greenhouse is made up of double wall polycarbonate sheet having 6 mm thickness. After comparing it with other materials we have concluded that it has an insulation factor i.e. R factor of 1.54 along with the U factor i.e. heat factor of 0.65 which is best amongst all the other available and economic materials like single pan glass, double pan glass,8 mm tri wall polycarbonate sheet[4]. The plants to be cultivated in it are WithaniaSomnifera, BacopaMonnieri, Tulsi, EcliptaProstrata and TrianthemaProtulacastrum along with the blue and green algae. The weekly growth of algae is monitored in spectrophotometer.

In it phase change material is encapsulated in soil. It is a building product having thermal energy storage properties in the form of a cementitious hollow core building block having a hollow core or cores and having within the hollow core(s) a composite containing a phase change material[2]. Phase change materials may be repeatedly converted between solid and liquid phases and utilize their latent heat of fusion to absorb, store and release heat or cool during such phase conversions[3]. These latent heats of fusion are greater than the sensible heat capacities of materials. For example, in phase change materials, the amount of energy absorbed upon melting or released upon freezing is much greater than the amount of energy absorbed or released upon increasing or decreasing the temperature of a material over an increment of 10° C[1]. Upon melting and freezing, per unit weight, a phase change material absorbs and releases substantially more energy than a sensible heat storage material that is heated or cooled over the same temperature range. In contrast to a sensible heat storage material that absorbs and releases energy essentially uniformly over a broad temperature range, a phase change material absorbs and releases a large quantity of energy in the vicinity of its melting/freezing point[3]. However, due to its relatively high specific heat, the phase change material can supply a significant amount of sensible heat as well[2]. The phase change material to be encapsulated is paraffin wax 20 carbons which is an organic PCM with melting point as 36.7’c and heat of fusion is 246 KJ/Kg.This will absorb the extra heat which goes upto 47’C here and helps in sustainable growth of plants.

## 2. METHODOLOGY

The greenhouse was prepared for cultivation of various plants under the controlled environment. The main aim of controlling the inside environment of the greenhouse was to provide a climate suitable for the growth of various plants[17]. This will also help in cultivating plants in their non-seasoning time. There were various aspects involved in the greenhouse setup.

### 2.1 Construction setup

The key features of construction setup involves following points:-

- The greenhouse was of odd span.i.e.The roof having south side facing the sunis kept long.
- The greenhouse was made of polycarbonate sheet which has good transparency and impact strength[5].
- The soil bed was prepared with the help of FRP sheet of 2 ft. height. The soil is the mixture of sand, soil and manure suitable for plants in right proportion.
- Then there was LED lighting and fan setup involved in the greenhouse setup.
- There are cooling and exhaust fan for maintaining good climatic conditions for plant growth[8].
- The LED lighting was installed to provide PAR at night, which is suitable for plant growth[6].
- Microcontroller and various sensorswere also installed for automaticcontrolling the environment inside the greenhouse[15].
- The various sensors involved were temperature sensor, humidity sensor, LUX sensor and soil moisture sensor.
- The energy source to carry out the automation inside greenhouse was the sunlight. To harness the solar energy, transparent PV was used as BIPV.
- The transparent PV was installed on the rooftop of the greenhouse facing the south side.
- Cooling inside the greenhouse involves evaporative cooling. For this fan and pad cooling setup was installed inside the greenhouse.

### 2.2 Dimensions

The greenhouse was of dimension 6’ by 6’ by 8’. The flooring of the greenhouse is done by cement block of height 1 ft. The frame of the greenhouse is made of mild steel and the body is prepared by polycarbonate sheet having good transparency and strength. The soil bed inside greenhouse is of 2 ft. height and 6 ft. wide. The cooling fan was placed at plant height. There were three exhaust fan also provided at the top to have proper air circulation inside greenhouse.

### 2.3 Inside Architecture

The architecture inside greenhouse includes the microcontroller and sensors along with plants cultivated in the soil bed. The sensors were used for sensing the various parameters like LUX, temperature, relative humidity and soil moisture. The temperature and humidity inside greenhouse were maintained suitable for plant growth[7]. The LUX sensor identifies the need of artificial light when the daylight is not sufficient for photosynthesis process. The artificial light used was generally the LED light green in colour to allow the plant growth in best possible manner[16]. In addition to this, the phase change material (PCM) is also incorporated within the soil bed to maintain a proper soil temperature. Generally the soil temperature is maintained because of the low melting point of the PCM.

## 3. GREENHOUSE AUTOMATION AND CONTROL

The automation of the greenhouse is done to reduce the human effort for carrying out various works inside greenhouse[9]. The automation design of greenhouse includes hardware and software. The source of power was the rooftop transparent PV harnessing the solar energy[14].

### 3.1 Hardware Description

The hardware part of automation includes the microcontroller and sensors[18]. The microcontroller PIC16F877A, installed was the heart of the greenhouse control[10]. The programming of the microcontroller includes a programmer, development board and PICKIT2 software. The development board was used to obtain the desired application from the microcontroller. The programmer provide the programming in hex file.

**Fig. 1: Development Board**


**Fig. 2: PIC KIT 2**

There were parameters set for controlling different aspects of climatic conditions like light intensity, humidity, temperature and soil moisture[11]. The sensors involved were:-

- **LUX sensor**: - it checks the light intensity suitable for photosynthesis process.
- **Humidity sensor**: - it checks the humidity inside the greenhouse. Then accordingly the cooling and exhaust fan were run.

- **Temperature sensor**: - it checks the temperature inside the greenhouse suitable for plant growth.
- **Soil moisture sensor**: - the soil moisture is kept to a predetermined level so that the plant could have sufficient water supply for their growth[12]. There were proper irrigation provided when the buzzer connected to the sensor goes off indicating the need of irrigation.

**Fig. 3: Transparent PV**

### 3.2 Software Description

The programming of the microcontroller is done in C language and CCS compiler was used that generated a hex file in the system.The microcontroller used was PIC16F877A[19]. It is a low-power, high performance CMOS 8-bit microcomputer with 4K bytes of Flash programmable and erasable read only memory (PEROM)[21]. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set and pin out [1].The PICKIT2 software work as an interface between the programmer and the system containing the hex file[24]. The development board is used for execution of the desired operation by the microcontroller[20].

### 3.3 Steps followed to design the system[13]

**Fig. 4: Greenhouse design**

The following steps were taken to design the automated system:-

1. Determine the system variables to be controlled by the microcontroller system like temperature, humidity, etc.
2. Determine the size of the greenhouse and its design as well.
3. The programming and the installation of the microcontroller and sensors.
4. The LED lighting and fan installation inside greenhouse.
5. Installation of dripper for drip irrigation inside greenhouse near the roots of the plants to avoid wastage of water[22].

## 4. CONCLUSION

The proposed design has several advantages. There are various concepts incorporated inside greenhouse which will help in making it more ecofriendly and modern.

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