Climate Smart Agricultural Greenhouse Employing Solar and Energy Efficiency Technologies at Low Cost for Tomato Production in ASEAN

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Collaborative Research Project

GREEN ENERGY SMART FARM

Collaborative Research on Green Energy Smart Farm

Issues

- Inappropriate Design of Greenhouses for Tomato Production
- High Greenhouse Temperature
- Low Efficiency in Energy Utilization in Greenhouses
- Inadequate information on Irrigation Rate and Media type for Greenhouse Tomato Production

- Low Productivity
- High Energy Cost

Output

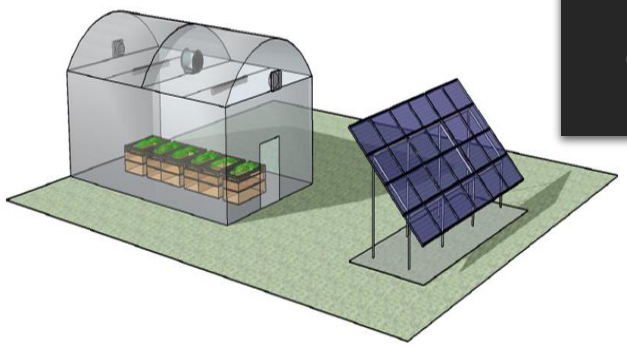
- Optimal Tomato Greenhouse Model
- Smart Solar Energy Efficient Greenhouse
- Recommendations for Optimum Shading, Irrigation Rate and Media types for Greenhouse Tomato Production

R&D Intervention

Modelling Optimal Tomato Greenhouse with Incorporation of Solar Energy and Energy Efficient Technologies – Luong Duc Nguyen

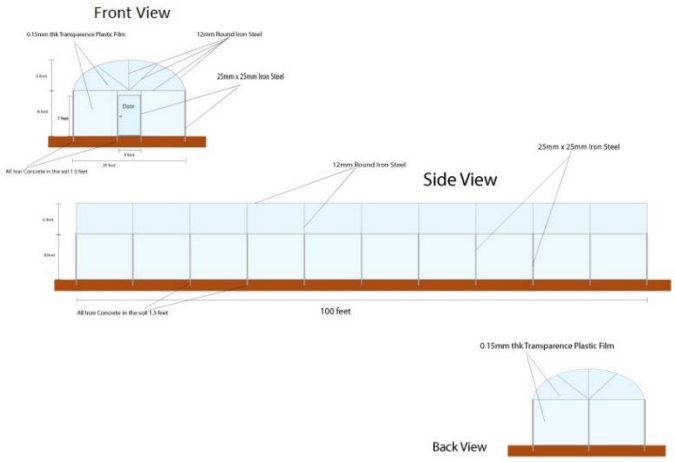
Quantifying Energy Savings, Cost and Environmental Impact of a Prototype Smart Solar Energy Efficient Greenhouse for Tomato Production in ASEAN – Nofri Yenita Dahlan

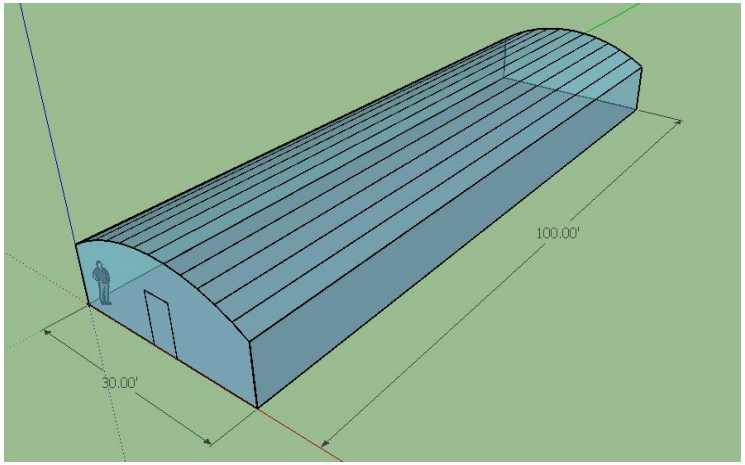
Efficient Energy Supply for Enhancement of Tomato Growth, Physiology, Yield and Quality in Relation to Light Transmission Level, Irrigation Rate and Media Types Grown under Smart Solar Greenhouse System – Siti Zaharah Sakimin

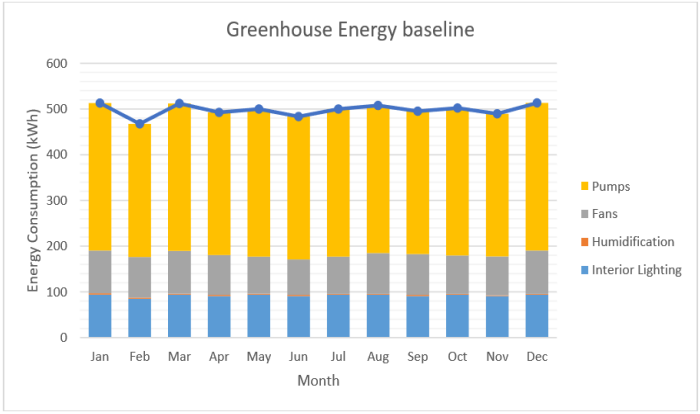


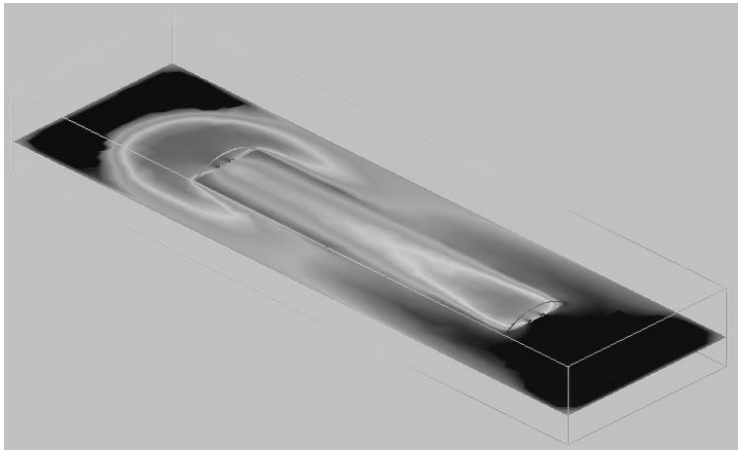
SMART GREENHOUSE SYSTEM FOR TOMATO GREENHOUSE AT UPM, SERDANG

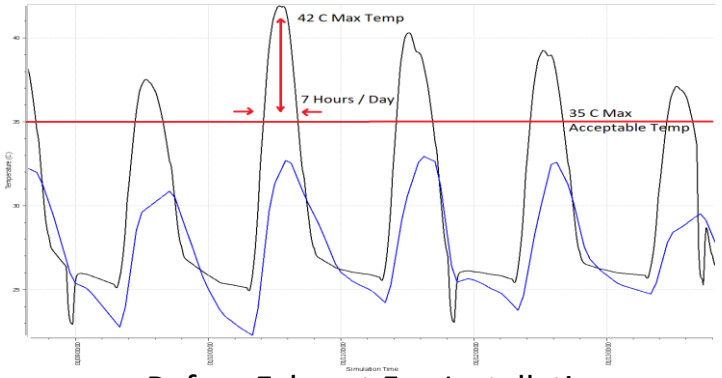
Modelling Optimal Tomato Greenhouse with Incorporation of Solar Energy and Energy Efficient Technologies using CFD and OpenStudio EnergyPlus Software



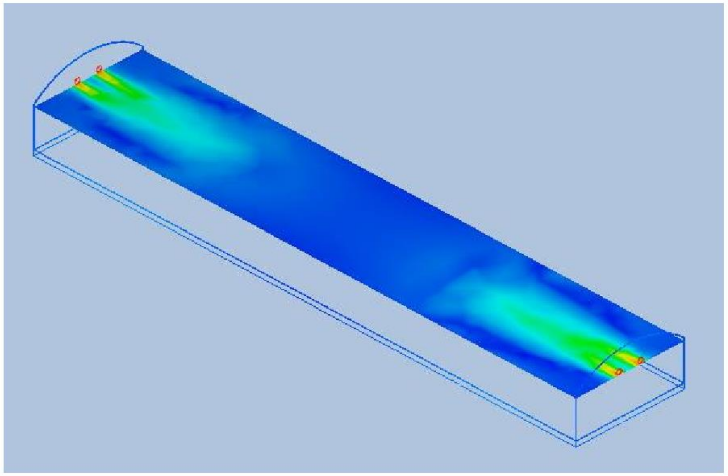


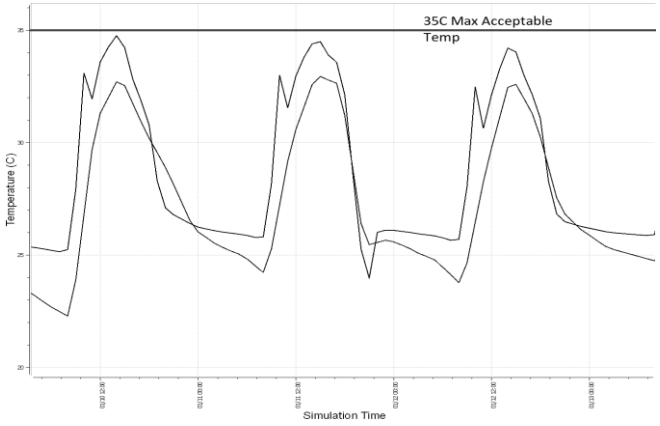




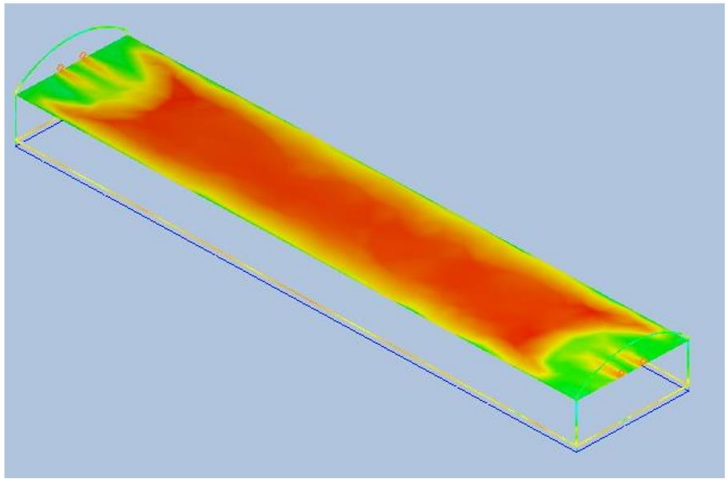


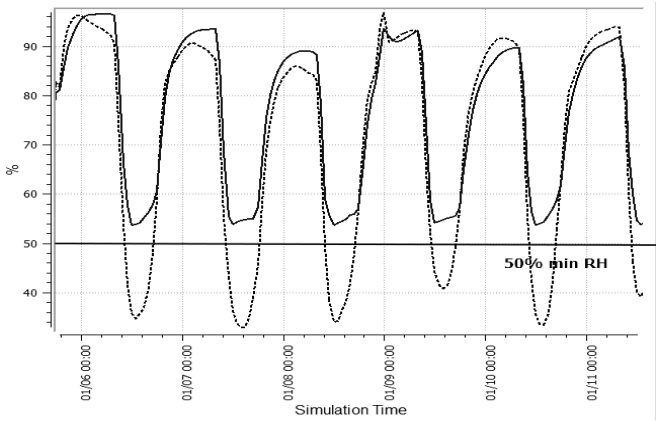
Before Exhaust Fan Installation



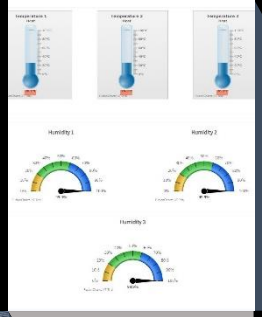


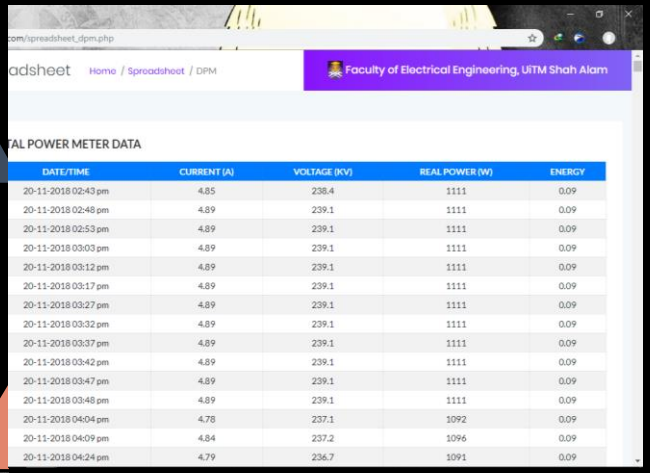
After Exhaust Fan Installation

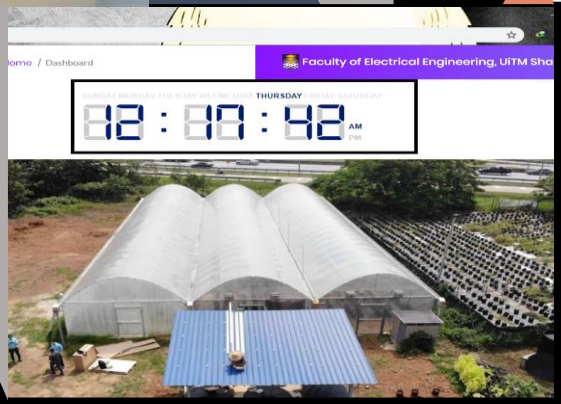




After Exhaust Humidifier Installation







- **Quantifying Energy Savings, Cost And Environmental Impact Of a Prototype Smart Solar Energy Efficient Greenhouse For Tomato Production In ASEAN**

Scope 1: Energy and Climate Monitoring System

- Five sensors and a digital power meter are installed to measure parameters such as temperature, soil moisture level, lux level, voltage, current and energy in the greenhouse.
- All the sensors and digital power meter (DPM380), are connected to a Nodemcu as the microcontroller
- All the data collected by the sensors are transmitted in real-time to a database in MySQL and display in a website.

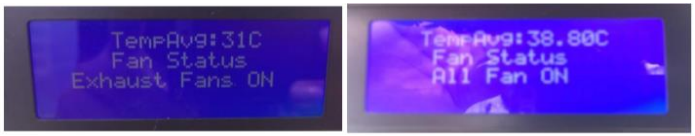
Scope 2: Temperature Based Control Of Ventilation System

Control panel of the relays

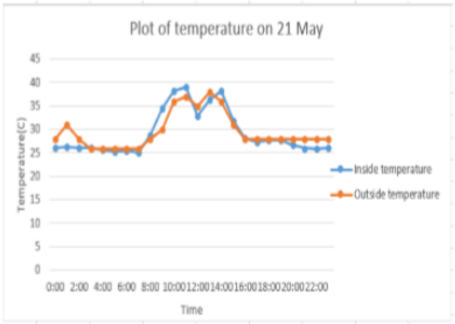
Axial fan (left) and exhaust fan (right) arrangement in the greenhouse

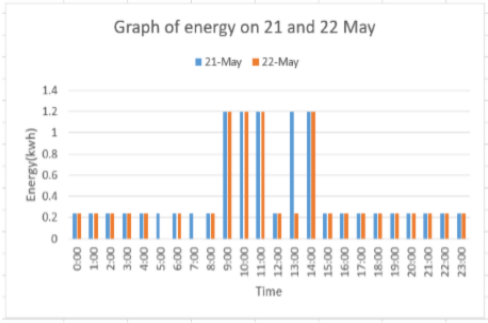
- The ventilation system in the greenhouse comprises of 6 exhaust fans and 2 axial fans.
- The control system will first receive signal from temperature sensors located in three different zones in the greenhouse i.e., left end, middle and right end. Average temperature is calculated from the three temperature readings.
- The signal will be interpreted and processed by the Nodemcu which performs as microcontroller to control the exhaust fans and axial fans.
- Three control conditions are set:
  1. average temperature is below 25°C all the fans are set to turn OFF by the relay,
  2. average temperature is between 25°C and 33°C, only the exhaust fans are turn ON,
  3. average temperature is higher than 33°C, all the fans are turn ON.
- The LCD will display the average temperature and the fans condition.

- Able to maintain the desired temperature for lowland tomato at lower energy consumption
- An average of 65.8% of energy was saved from the greenhouse as compared to baseline energy without the control system



Fan status when average temperature between 25°C and 33°C (left) and higher than 33°C (right)





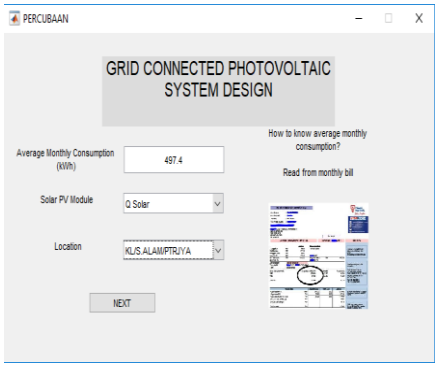
Inside and outside temperature and graph of energy consumption

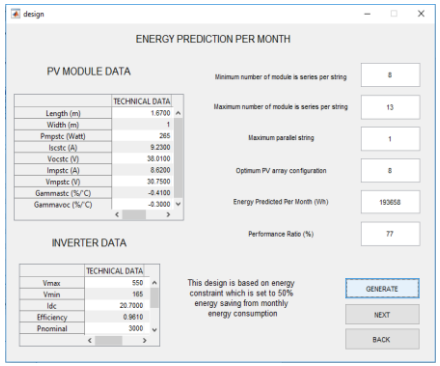
Scope 3: Solar PV Greenhouse

3kW Grid Connected Photovoltaic (GCPV) System:

1. 12 x 250W PV modules
2. 1 x Inverter
3. 1 x AC grid box
4. 1 x mounting structure
5. Online monitoring system

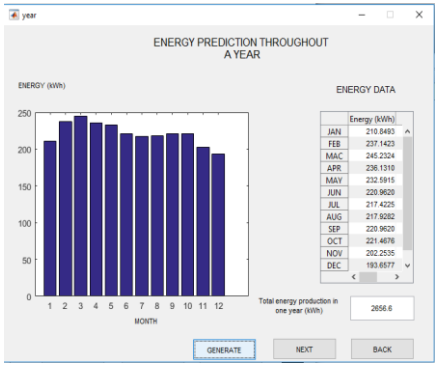
Software development for PV system design

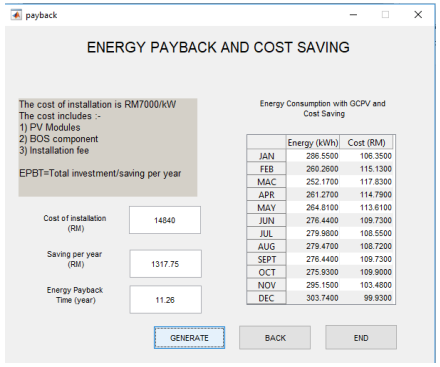




Load profile for tomato greenhouse

Equipment	No	Watt	Operation hour	Total (Wh)
2hp Motor	1	1.5kW	0.33	495
Lamp	5	36W	12	2,160
Axial Fan	2	400W	12	9,600
Exhaust Fan	6	60W	12	4,320
Total Energy Consumption per day (kWh/day)				16.58
Total Energy Consumption per month (kWh/month)				497.4





Thank You