Automated greenhouse with a retractable solar roof for households
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Elevator Pitch & Problem Statement

Households that grow plants often face a challenge in keeping up with the required groundwork for a greenhouse. So, for households who want monitoring and automation, our greenhouse with retractable solar roof provides an efficient way to grow plants. Unlike traditional greenhouses, our product does not require significant energy costs, continuous monitoring, and manual adjustment.

Objectives

1. **Zero emissions energy source:** utilizing solar PV's on the greenhouse to minimize GHGs and reduce reliance on non-renewable energy for sustainable plant growth.
2. **Automated Greenhouse Control:** Create an automated control system that monitors and regulates environmental factors, including temperature, humidity, and ventilation.
3. **Self-sufficiency for householders:** promotes food security, reduces dependence on imported produce, and encourages sustainable agricultural practices within the community.

Constraints

1. **Sunlight Exposure:** In Saudi Arabia, where the effective sunlight duration ranges from 5 to 8 hours, placing solar panels on greenhouse roofs is crucial to ensure energy efficiency and optimal plant growth.
2. **Space Limitations:** Adhere to a maximum greenhouse size of 3m x 4m x 2m to efficiently use space for solar energy and plant growth, minimizing shading.
3. **Temperature Control:** Implement cooling measures like fans to maintain ideal greenhouse temperatures (15-30℃) and optimizing conditions for both solar panels and plant health.
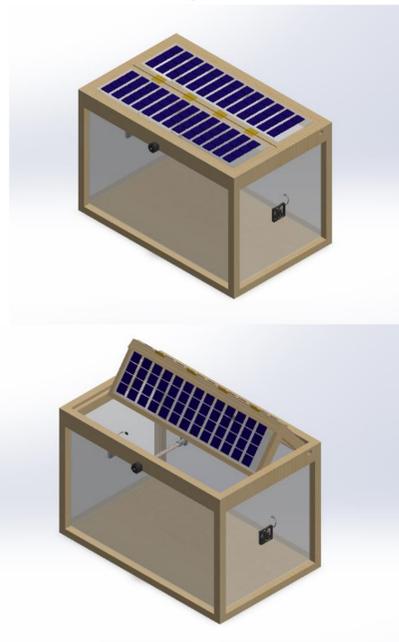
Target Specifications

1. Greenhouse dimensions of 100 cm x 60 cm x 60 cm
2. Maintain carbon dioxide levels within the range of 400-1500 ppm
3. The temperature sensor, ranging from 15 – 30℃ with an accuracy of 0.5℃
4. The system delivers a precise water flow rate adjustable between 100 and 300 ml/min.
5. Include a retractable roof mechanism capable of fully opening within a maximum time of 1 minute
6. Solar PV with a total power generation capacity of 38.4 Wh
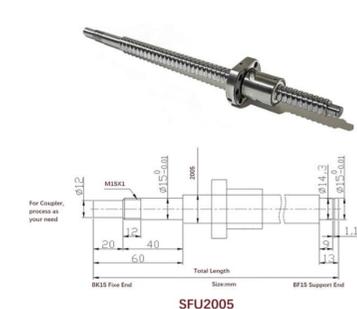
Prototype Design

The system utilizes sensors to measure CO2 levels, temperature, and humidity within the greenhouse, providing real-time monitoring of critical parameters. The control system dynamically adjusts ventilation, heating, and cooling to sustain optimal growing conditions for the plants. Furthermore, it incorporates a motorized ball screw mechanism to manage the solar roof, opening it to admit essential sunlight during the day and closing it to protect against excessive heat. Additionally, the system features a user-friendly dashboard that acts as the central hub for the greenhouse, enabling users to configure settings and monitor environmental conditions effectively.
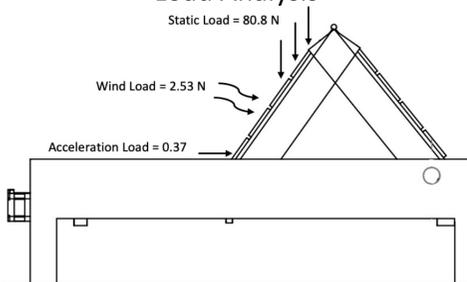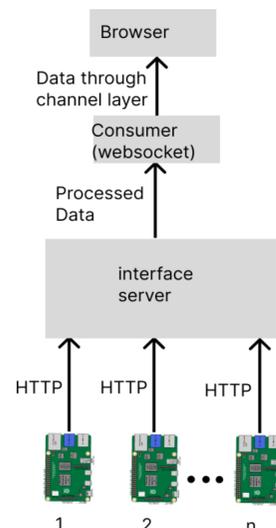
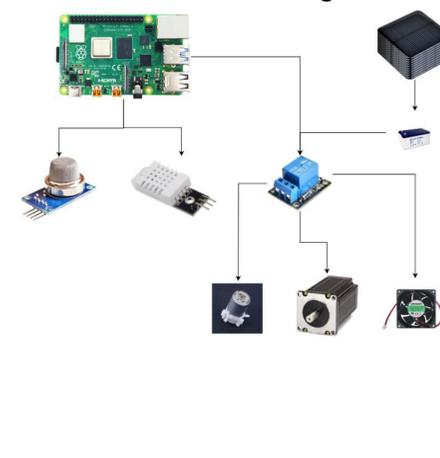**CAD**

Roof Design
Ball Screw Selection

SFU2005

Load Analysis

Static Load = 80.8 N
Wind Load = 2.53 N
Acceleration Load = 0.37

Networking Design

Browser

Data through channel layer

Consumer (websocket)

Processed Data

interface server

HTTP   HTTP   HTTP

1   2   ...   n

Electrical Design

Testing & Validation

Roof Timing: The stepper motor successfully rotates the ball screw of the solar roof, completing both folding and expansion in under 50 seconds.

Power Consumption: The total power consumption of all components is 29.76Wh, which is less than the generation capacity of 38.4Wh.

User-Friendly Interface: The dashboard and screens have been enhanced through usability studies to ensure an optimized user experience.

Greenhouse Environmental Controls: The system has been successfully validated to maintain carbon dioxide levels using the MQ2 sensor, and temperature using the DHT22 sensor.

Motor shaft safety validation:

$$d = (\frac{32n}{\pi\, S_y}(M^2 + T^2)^{\frac{1}{2}})^{\frac{1}{3}}$$

Factor of Safety (FOS), n = **3.22**
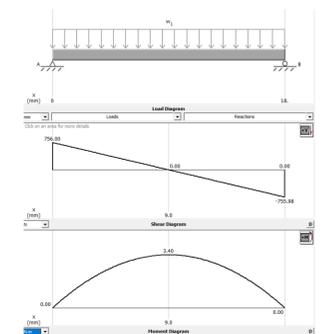
Project Impact

1. **Environmental:** Utilizes solar energy and efficient technologies to reduce greenhouse gas emissions, enhancing air quality and resource conservation.
2. **Health:** Supports nutritional health through local, organic food production, minimizing exposure to harmful chemicals.
3. **Welfare:** Enhances welfare by engaging users in gardening activities, promoting physical and mental well-being.

Conclusion

Our automated greenhouse with a retractable solar roof integrates advanced monitoring, climate control, and energy-efficient solar power, offering a sustainable and intelligent solution for home gardening. This project not only enhances plant growth and yield but also empowers users with a user-friendly dashboard for active cultivation management, fostering sustainability and a deeper connection to nature.