TeamDesign-044

Designing a Desalination System and an Automated Greenhouse That Works by Solar Energy.

KFUPM Design Expo

Elevator Pitch

For farmers dealing with freshwater scarcity and seeking sustainable agriculture solutions, AG-D offers an eco-friendly and efficient integrated desalination and greenhouse system. It optimizes energy usage, minimizes environmental impact, and provides a reliable source of fresh water for irrigation. The unique closed-loop water management efficiently captures, treats, and reuses excess irrigation water, making AG-D the ideal choice for environmentally conscious farmers.

Objective

Our project aims to design an innovative, sustainable solution for freshwater scarcity and agricultural efficiency through the integration of a solar-powered desalination system and an automated greenhouse. This approach addresses critical global challenges, including water scarcity, renewable energy use, and environmental sustainability. Our system's closed-loop water management enhances water use efficiency, contributing to sustainable agriculture practices. This project aligns with the 2050 vision for zero carbon emissions, representing a step forward in green technology and sustainable development.

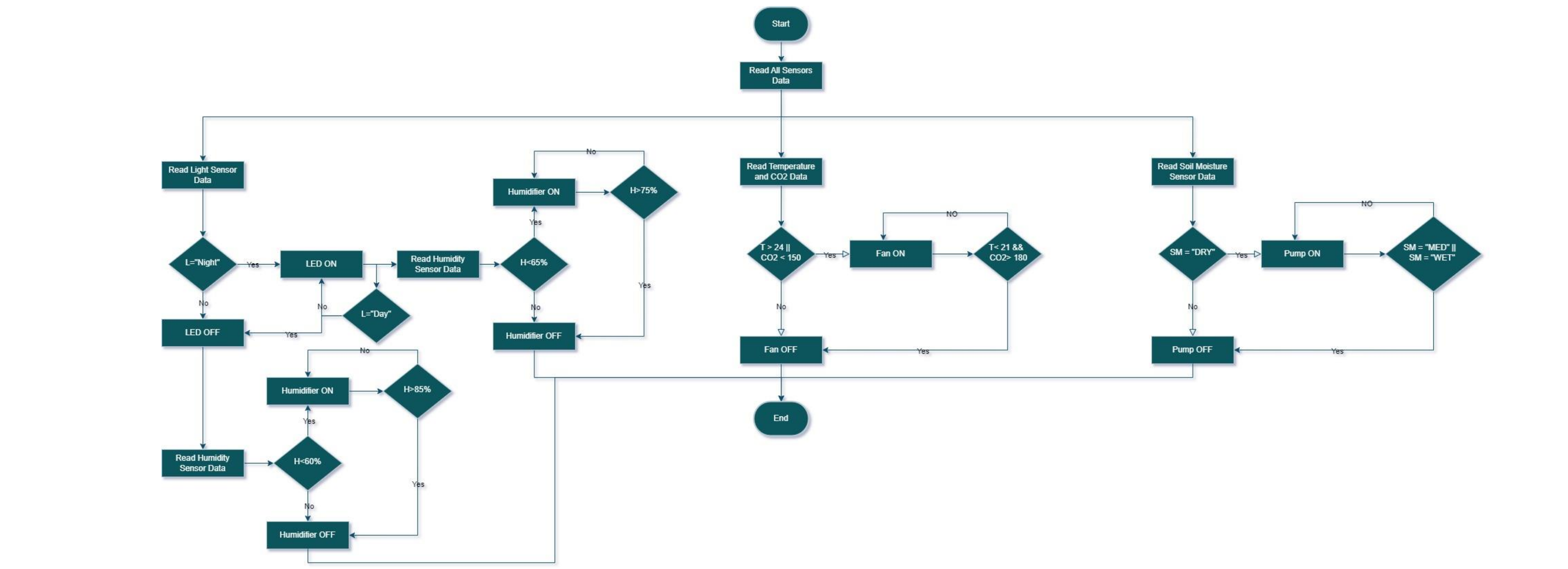
Constraints

1. Energy: Balance between efficiency & sustainability.
2. Water: Critical management due to scarcity.
3. Desalination: Environmental impact of brine discharge.
4. Environmental Control: Optimal greenhouse conditions.

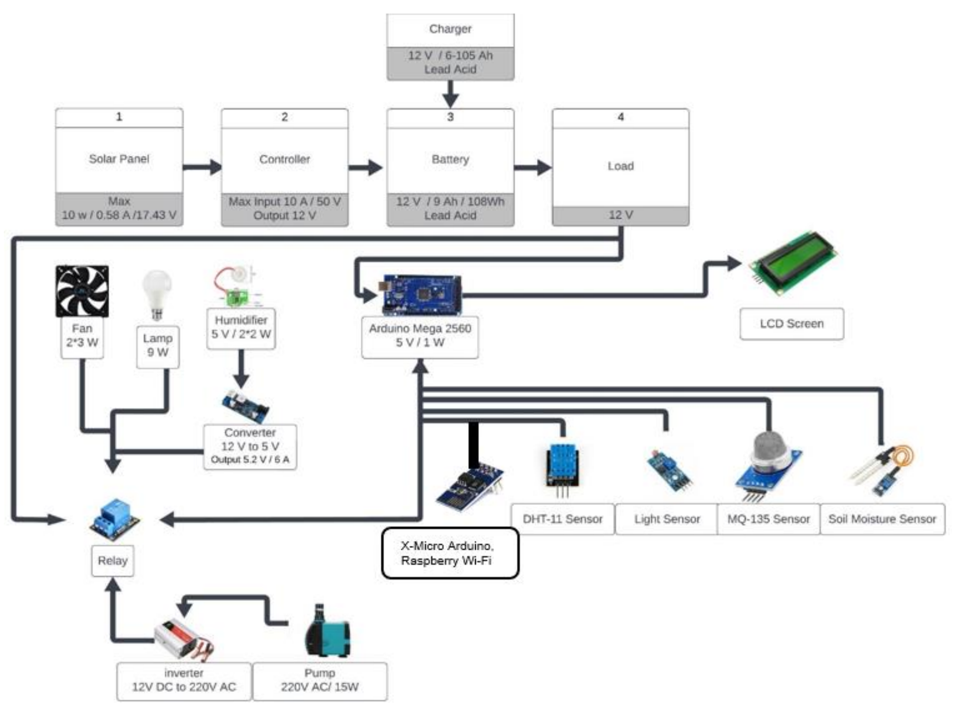
Specifications

1. Controlling the temperature degree between (21º-24ºC (70ºF – 75ºF))
2. Keep the humidity level around 65-75% in the night and 60%-85% during the day
3. For the soil, pH must be adjusted on the range of 6-6.8
4. Produce 1 m^3 of fresh water the energy required is 2.51 kWh with an overall efficiency of 60.8%
5. Provide the tomato plants with 0.6L of water when the soil moisture is less than 40%

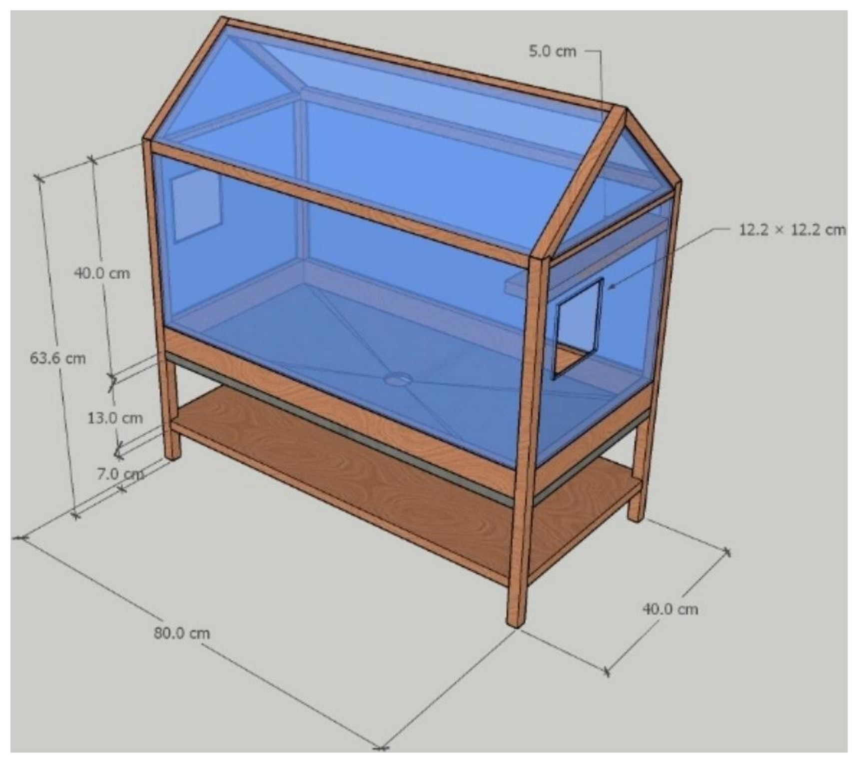
Design



Control System Flowchart



Electrical System Components



3D Module of The Prototype

```
import math

# Constants
N = 600                 # Number of tomato plants
W = 600                 # Water required per plant (in mL)
C = 0.18                # Electricity rate (in SAR per kWh)
E = 11.04               # Energy consumption (in kWh per minute)
F = 9369.25               # Flow rate of the irrigation system (in mL/minute)
E_rate = 0.24           # Evaporation rate (24% per day)
FC = 600 * 600          # Field capacity in mL (convert liters to mL)
stages = [0.60, 0.70, 0.75]  # Desired soil moisture content at each stage
watering_threshold = 0.40

# Variables
T = math.ceil((N * W) / F)   # Watering time for all plants (in minutes)
P = math.ceil(T * E * C)     # Cost of one watering event (in SAR)
operating_days = 0           # Total number of days the system operated
total_cost_sar = 0           # Total cost of operation (in SAR)

# Generate a watering schedule for the next 360 days
schedule = []
day = 0
soil_moisture = stages[0] * FC        # Start with desired moisture content for first stage
while day < 360:
    # Calculate water loss due to evapotranspiration
    loss = E_rate * soil_moisture
    soil_moisture -= loss

    # Determine the current growth stage and repeat the cycle if exceeded
    stage = (day // 30) % len(stages)

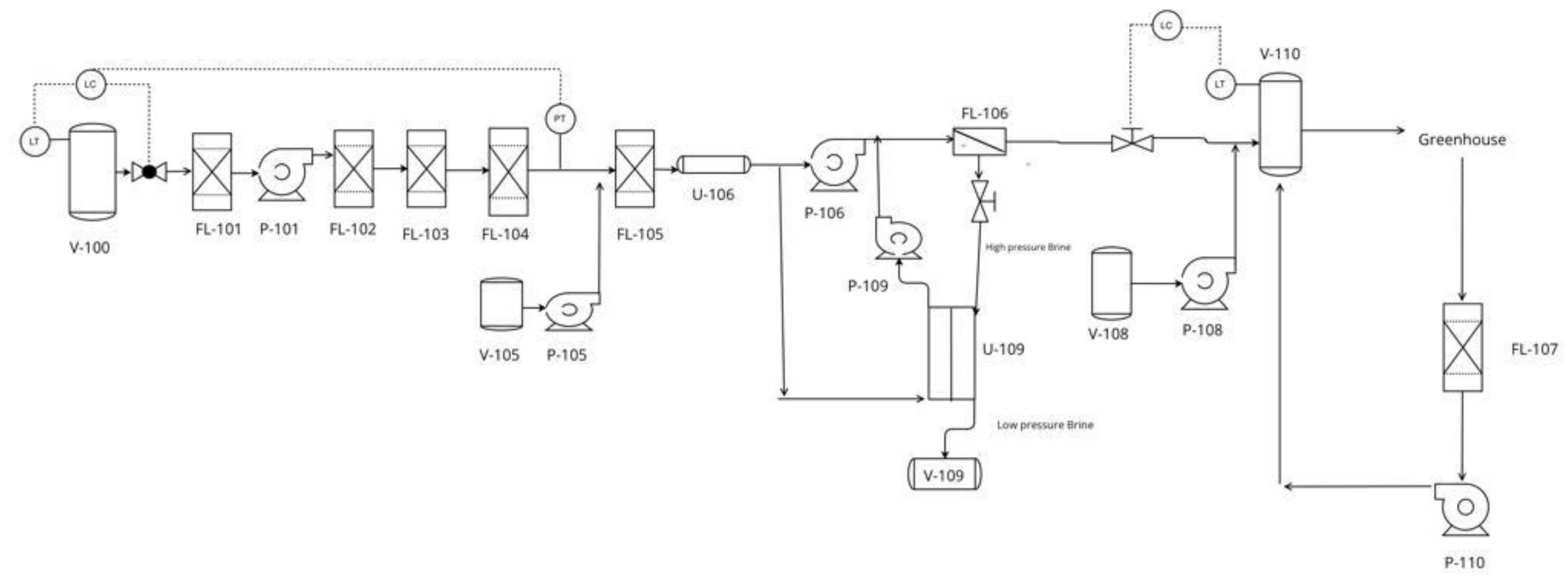
    # Check if watering is needed
    if soil_moisture / FC < watering_threshold:
        # Schedule a watering event
        schedule.append(day)
        soil_moisture = stages[stage] * FC  # Reset soil moisture to desired level for current stage
        operating_days += 1
        total_cost_sar += P

    day += 1

# Results
print(f"The watering time for all plants is {T} minutes.")
print(f"The cost per watering event is {P} SAR.")
print(f"Total cost for all watering events is {total_cost_sar:.2f} SAR.")
print("Watering schedule for the next 360 days (day numbers):")
print(schedule)
print(f"Total number of days the system operated: {operating_days}")
```

A model for water scheduling

Design



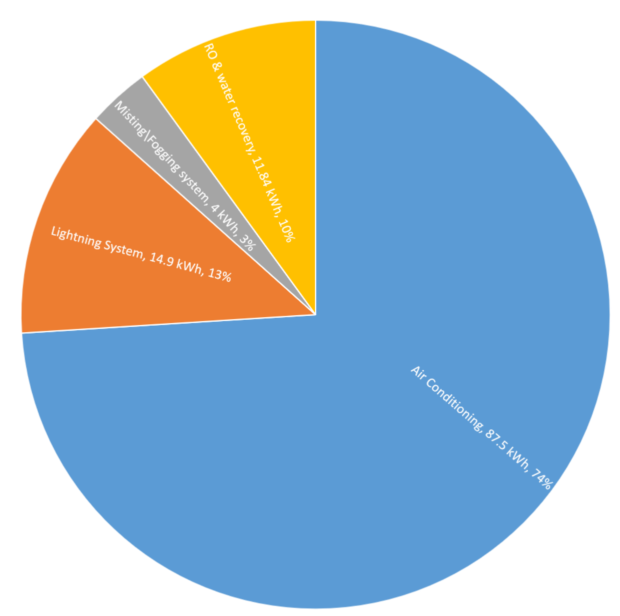
Process Flow Diagram of The RO system

Validation

Power Calculation

		Pass 1	ERD boost
Pump / Boost pressure	bar	60.8	1.8
Product flow	m3/h	0.6	
Pump flow	m3/h	0.6	0.7
Pump efficiency	%	85.0	87.0
Motor efficiency	%	90.0	95.0
VFD Efficiency	%	97.0	97.0
Power/Stage/Pass	kw	1.4	0.0
	BHP	1.8	0.1
Total pumping power	**kw**	1.4	
Pumping specific energy	**kwh/m3**	2.33	

RO System Power Requirement



Power Consumption

	1	2	3	4	5	6	7	8	9	10	11
Flow (m3/h)	1.33	0.596	0.596	1.33	1.33	0.734	0.730	0.734	0.734	0.600	0.600
Pressure (bar)	0	0	60.8	60.8	60.8	60.2	0	0	60.8	1.00	1.00
TDS (mg/l)	43612	43609	43609	43609	43609	78681	78681	43609	43609	701	701
pH	7.00	8.21	8.21	8.21	8.21	8.32	8.32	8.21	8.21	7.17	6.46
Econd (µs/cm)	67243	67241	67241	67241	67241	117599	117599	67241	67241	1499	1500

RO system simulation output

```
The watering time for all plants is 39 minutes.
The cost per watering event is 78 SAR.
Total cost for all watering events is 10920.00 SAR.
Watering schedule for the next 360 days (day numbers):
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 34, 37, 40, 43, 46, 49, 52, 55, 58,
61, 64, 67, 70, 73, 76, 79, 82, 85, 88, 91, 93, 95, 97, 99, 101, 103, 105, 107, 109, 111, 113,
115, 117, 119, 121, 124, 127, 130, 133, 136, 139, 142, 145, 148, 151, 154, 157, 160, 163, 166,
169, 172, 175, 178, 181, 183, 185, 187, 189, 191, 193, 195, 197, 199, 201, 203, 205, 207, 209,
211, 214, 217, 220, 223, 226, 229, 232, 235, 238, 241, 244, 247, 250, 253, 256, 259, 262, 265,
268, 271, 273, 275, 277, 279, 281, 283, 285, 287, 289, 291, 293, 295, 297, 299, 301, 304, 307,
310, 313, 316, 319, 322, 325, 328, 331, 334, 337, 340, 343, 346, 349, 352, 355, 358]
Total number of days the system operated: 140
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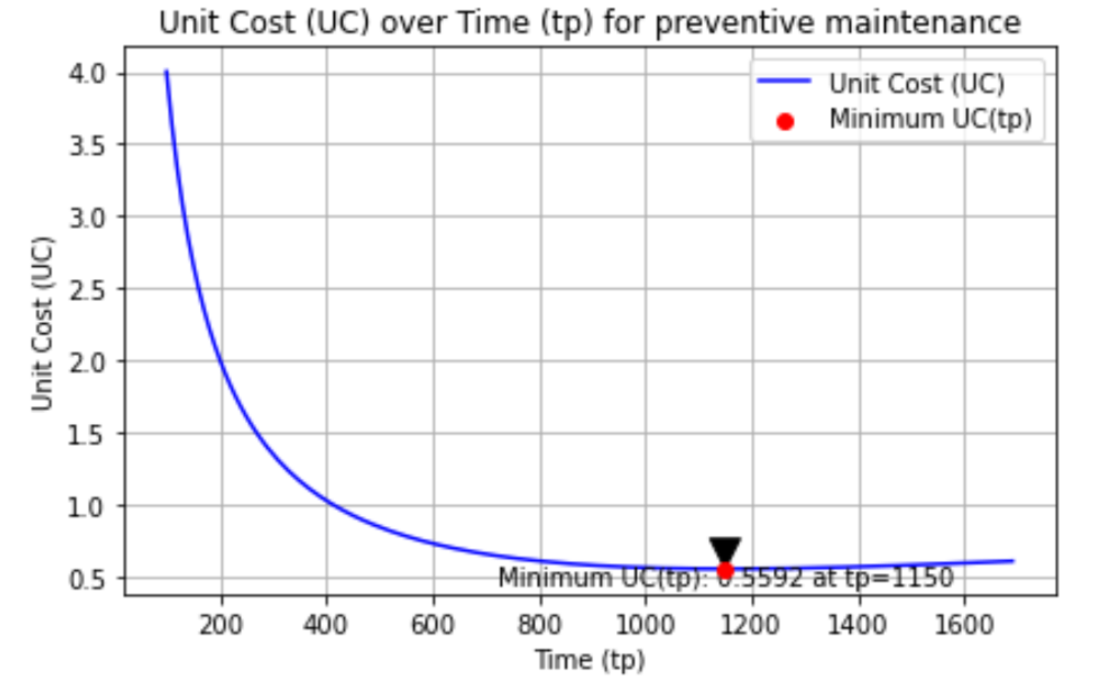
Schedule That Satisfies The Water Need for Tomatoes



Age-Based Preventive Maintenance Model for RO Membranes

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