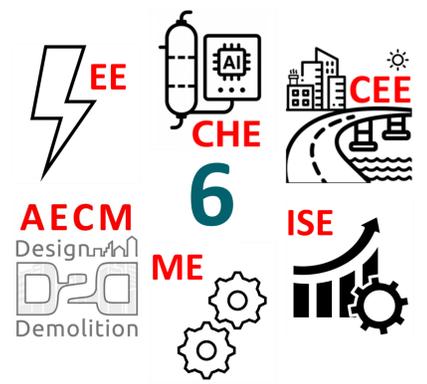


Sustainable Saudi Urban Living: Integrating Greywater Treatment and Renewable Energy into Vertical Farming

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Project Objective

To design and prototype a sustainable urban housing system that integrates greywater recycling, renewable energy sources (solar and wind), and small-scale vertical farming to improve environmental efficiency, reduce dependency on external resources, and align with Saudi Vision 2030 sustainability goals.

Constrains

- Backwashing and Media Replacement
- Water Pressure (<80 psi)
- Sensors Operate between 10 °C - 35 °C
- Fluctuated Flow Entering The System
- Compliance with The Saudi Building Code
- Adaptation to Local Climate Challenges

Specifications

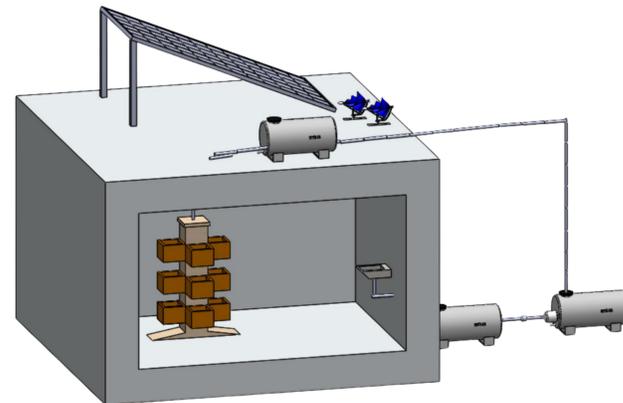
- Treatment Efficiency (> 70%)
- 6.5 > pH > 7.5
- U-values for walls 0.2 – 0.3 W/m²·K
- 60% Green Roof Coverage
- 1.5 - 4 kW generated per wind turbine
- Pump Horsepower ≤ 2 hp
- Micro controller with 8-16 I/O

- Predictive Models
- 4000L Storage Tank Size
- Load Capacity of 250 kg/m²
- Thermal Resistance Up to 50°C

Integrated Specifications

- Time of Greywater Collection to Watering the Plants <6 hours
- The Renewable Energy Penetration Percentage is 60%
- 5 Story Sustainable Building with Land Area of 700 m²

Prototype Development



Validation and Verification

For Graywater Treatment System:

- Greywater treatment efficiency: 80% removal of contaminants (exceeding 70% target).
- pH control: Maintained between 6.5–7.5 throughout the process.
- Mass balance on filter unit confirmed full silica removal and 83% MgSO₄ removal.
- Calcium hydroxide dosing: Optimal range determined at 7–17 mg/L to stabilize pH.

For Electric and Energy Systems:

- Sensor performance: Operated reliably between 10°C and 35°C, with optimal accuracy at approximately 22°C.
- Wind turbine output: Generated an average output of 2.7 kW, delivering ~2.7 kWh of energy per hour.

Time	GIVEN VALUES		Sun - kW choices		LOLE	0
	Demand (kW)	average PV output/day (kW)	output	surpl	stored	failure
1	70	6.798	73.3002	3.30	0	No
2	70	6.798	73.3002	3.30	1	No
3	70	6.798	73.3002	3.30	1	No
4	70	6.798	73.3002	3.30	1	No
5	70	6.798	73.3002	3.30	1	No
6	70	6.798	73.3002	3.30	1	No
7	70	6.798	73.3002	3.30	1	No
8	70	6.798	73.3002	3.30	1	No
9	70	6.798	73.3002	3.30	1	No
10	70	6.798	73.3002	3.30	1	No

Irrigation System:

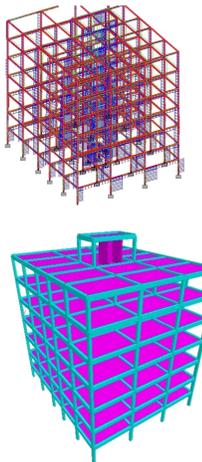
- Pipe design that meets the safety regulations of pressure <80 Psi

Grundfos CMBE
TWIN 3 51 - 52 GPM
1 HP



The structural design:

- satisfies carrying all building loads safely including dead, live, seismic, and wind loads with: Max horizontal displacement = 18.6 mm, Max axial stress for beams = 39.263 MPa



Conclusion

This project demonstrates a sustainable housing model that integrates greywater recycling, renewable energy, and vertical farming. It offers an innovative solution to reduce resource consumption, lower carbon emissions, and support Saudi Arabia's Vision 2030 for a greener future.