TEAM

087

Biophilic Saudi Housing

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Project Defenition

Introduction

- Sustainable smart villa design for Saudi climate
- Integrates solar, wind, kinetic, and greywater systems
- Aligned with Vision 2030 and Saudi Building Code

Problem Statement

In response to rising urbanization and climate challenges, sustainable housing that is energy-efficient, water-conscious, and carbon-neutral is urgently needed. This project proposes a smart villa that generates renewable energy, recycles water, and ensures thermal comfort using passive and smart systems

Project Impacts

- Reduces water consumption by 40%
- Covers 80% of energy demand from renewable energy resources
- Promotes sustainability awareness in communities
- Cuts energy usage by 30%

Final Target Specifications

1- ≥50% greywater recycled for reuse
2- Net zero carbon emmisions
3- WWR greater than 50%
4- R-value greater than 2
5- 80% of energy demand covered by sustainable resources

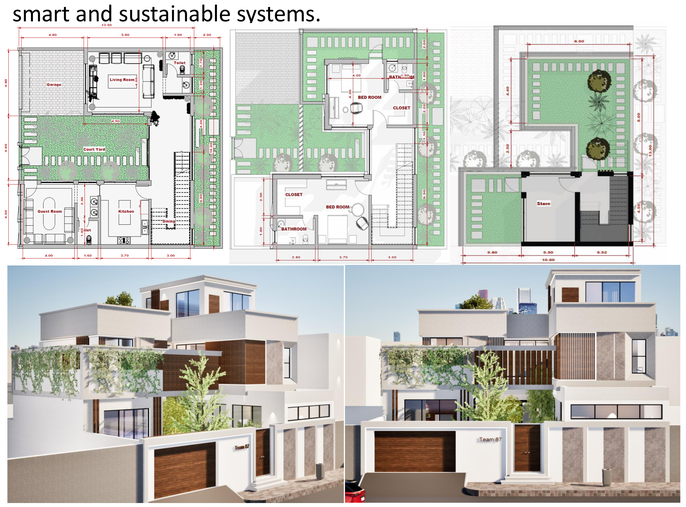
Constraints

1- Adhere to Saudi Building Code
2- Design must withstand 50°C external temperature
3- 90% of materials and technologies must be sourced locally.
4- Design should occupy no more than 200 m^2
5- Budget less than 10,000 SAR for the Prototype

Villa Design

Architectural design:

The design concept is a residential villa that conducted smart and sustainable systems.



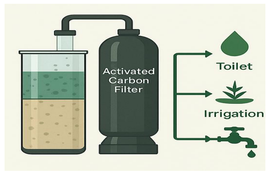
- Windows to wall ratio= %59 > %50 (project specifications)
- Windows on green areas= %98 > %50 (project specifications)
- Green spaces on lot area= %23.75 > %20 (project specifications)
- Recycled constructions materials= %70 > %50 (project specifications)
- Walls R-value= 2.42 m^2.K/W > 2 (project specifications)
- Green roof R-value= 3.85 m^2.K/W > 2 (project specifications)
- Cross ventilation in Summer= 0.78 > 6 (project specifications)
- Cross ventilation in Winter= 0.65 > 6 (project specifications)

HVAC:

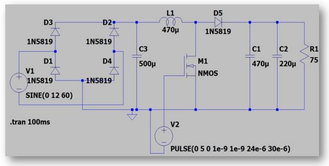
- Required cooling load= 30590 W
- 6 MTC 22000PTU units are selected, cooling load capacity= 38600 W
- Cooling COP= 4.25 > 3.5 (project specifications)

Grey Water Recycling System:

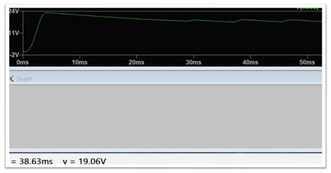
- Filtration layers: Bio-Sand, Activated Carbon, UV Sterilizer
- Grey water recycling= 62.5 > %50 (project specification)



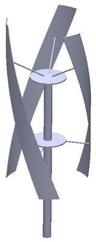
Energy Generating Pressure Tiles Circuit:

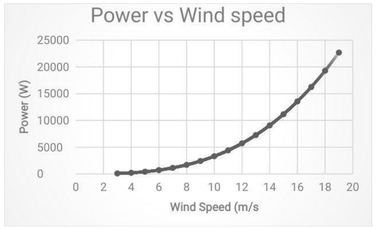


Validation:

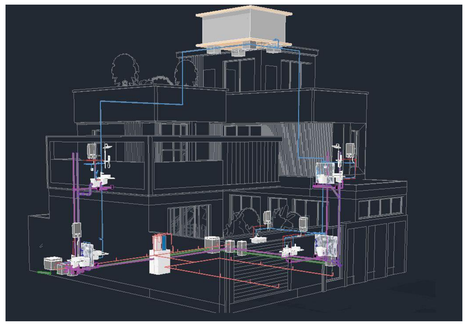


Wind Turbine:





Plumping:



Prototype & Conclusion

Energy Optimization Model

1. Parameters

- G: Set of energy generation sources
- C: Set of energy consumption sources
- D_jt: Energy demand for consumption sources at time t
- C_ij: Unit cost of energy from source i to consumption j
- C_solar: Capital cost per solar panel

2. Decision Variables

- x_ijt: Energy allocated from source i to consumption j at time t
- N_solar: Number of solar panels

3. Objective Function

Minimize total cost of energy:

$Z = \Sigma_{i \in G} \Sigma_{j \in C} C_{ij} * x_{ijt} + C_{solar} * N_{solar}$

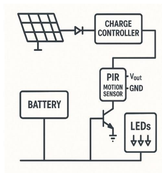
4. Constraints

1. Demand Satisfaction: $\Sigma_{i \in G} x_{ij} \geq D_j \; \forall j \in C$
2. Energy Supply Limits: $\Sigma_{j \in C} x_{ij} \leq E_i \; \forall i \in G$
3. Environmental Target: $\Sigma_{i \in \{Solar, Wind, Kinetic\}} \Sigma_{j \in C} x_{ij} \geq 0.8 * \Sigma_{j \in C} D_j$
4. Roof Area Limit: $N_{solar} * A_{panel} \leq 24$
5. Non-negativity and Integrality: $x_{ij} \geq 0$; $N_{solar}, N_{battery} \in \mathbb{Z} \geq 0$

Water recycling:

The prototype simulates one handwash basin, producing around 32 L/day of greywater. This represents 4.4% of the villa's total greywater and is filtered using a downsized system scaled from the full design, achieving the same 62.5% reuse efficiency.

Renewable energey:



Conclusion

The biophilic Saudi housing project present a Scalable model for sustainable living by Integrating sustainable systems.