U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON

TEAM SHUNYA
Building a sustainable future

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ATTACHED HOUSING

Indian Institute of Technology Bombay
National Institute of Design, Ahmedabad.

PROJECT DAKSH

The Indian Institute of Technology, Bombay (IITB India), a premium institute of science and technology, along with the National Institute of Design (NID), Ahmedabad presents to you, Team SHUNYA. Team SHUNYA is a group of engineering and architecture students committed to expanding sustainable research for the betterment of humankind by coming up with innovative zero-energy housing solutions for a sustainable future.

Design Strategy

Uncontrolled urbanization in the very limited building spaces left is accelerating the construction of matchbox buildings at an alarming rate to meet the infrastructural demand of the growing urban population, This calls for a reconstruction of existing structures with sustainable building techniques a necessity. The harsh reality has paved the path for re-developed cluster housing, which includes 1-2-3BHK(**B**edroom-**H**all-**K**itchen) attached housing, thus ensuring users' core values and culture are in focus as well. Hence, with our mission towards building renewable housing solutions, the current project aims to re-develop the existing Artist village in Navi-Mumbai into sustainable attached housing using environment-friendly principles and giving this lost village, an identity again. This model could be used as a precedent for the implementation of sustainable housing solutions in countries with similar economic and climatic conditions like India, such as Santa Cruz de la Sierra city (Bolivia), Makati City (Philippines), etc.

The re-development of the attached-housing model focuses on using renewable energy for the whole cluster as a common utility, applying passive architectural techniques, at the same time utilizing the choicest innovative technologies developed in IIT Bombay. The design strategy includes– radiant cooling panels, spot ventilation, LED(Light Emitting Diodes) lights, solar photovoltaic(PV) and HVAC system utilization at cluster level, recycled building material, rainwater harvesting, and greywater recycling system, along with Glass Fibre Reinforced Plastic(GFRG) panels for walls and roofs to ensure efficient use of energy. Thus, the name Project "Daksh" which means efficient in Indian language, Hindi. The project also introduces a unique 'Design it yourself' concept to give users the freedom to choose house design elements like doors, windows, etc

Technical Specifications

- **U values**
  - Wall assembly: 0.161 Btu/hr/sqft/°F
  - Roof assembly: 0.063 Btu/hr/sqft/°F
  - Saint Gobain's Nano Silver Chroma Double Glazing Insulation, U-Value: 0.282 Btu/hr/sqft/°F
- **Solar PV capacity:** 50 kW (Cluster Level)
- **Battery capacity:** 100 kWh (Cluster Level)
- **Inverter Rating:** 50 kVA (Cluster Level)
- **Solar Energy generation:** 74,500 kWh/yr
- **Energy consumption:** 67,450kWh/yr
- **Centralized Heat Pump Cooling Capacity:** 60 kW (204.7 kBTU/hr)
- **Radiant panel chilled water temperature:** Inlet: 10 ℃ (50 °F); Outlet 18 ℃ (64.4 °F)
- **Hot water supply temperature:** 45℃ (113 °F)

Project Data

- Artists Village, Navi-Mumbai, India
- Warm and humid climate, 3A (ASHRAE, IGBC)
- **Dwelling unit:** 581 sqft(1 BHK), 786 sqft(2BHK) 999 ft2(3BHK)
- **Attached Housing lot size:** 16361 sqft
- **Number of Dwelling units in a cluster:** 10
- **Dwelling unit typologies:** 1 BHK(4 houses), 2 BHK (4 houses), 3 BHK (2 houses)
- 3-4 occupants – 1BHK, 4-5 occupants – 2BHK, 6-7 occupants – 3BHK
- **EUI target (Cluster Level):** 25.5 kBtu/ sqft.yr (23.2 kBtu/sqft.yr without Electric Vehicle charging)
- **HERS Index without Solar PV:**
  - 1BHK- 69; 2BHK- 70; 3BHK- 75
- **HERS index with 5kWp Solar PV:**
  - 1BHK-4; 2BHK- 13; 3BHK- 24
- **Estimated construction cost:** INR 2718 ($36)/sqft

Architecture
The passive architecture ensures proper ventilation and daylighting. The bamboo facade and stack effect reduces the house's heat, thus decreasing the load on the cooling system. The user is provided with a DIY (Design it Yourself) catalog along with future expansion provisions within the cluster. Parking lots and open spaces are provided at the cluster and community levels.

Engineering
Construction time is reduced by six times than that of a conventional building. Building controls integrated with the cluster level HVAC, appliances, lights, and security systems ensure safety and reduce energy wastage. Reused/recycled greywater along with efficient water fixtures result in 45% water savings. The solar rooftop generation will be collected centrally on the cluster level.

Market Analysis
The design caters well to the functional and psychological needs of the occupants. The estimated construction cost for a single-bedroom house is INR 1.58 million or ($21,054). Whereas for Belapur, a similar house, on average, costs roughly INR 2.9 million ($39,992). Considering the savings in utility costs due to on-site energy generation, the design's life cycle cost falls within the bounds of affordability.

Durability and Resilience
The building level is 1.5 feet above the ground to avoid water logging issues during rains. Seismic waves factor incorporated for earthquake effect. Better fire-resistant materials, fire alarms, alerts on a home automation app will ensure user safety in case of a fire emergency. Solar hybrid system (grid + battery) island itself in case of disasters and provides backup for running critical loads in the houses.

Embodied Environmental Impact
The wall materials reduce CO_2 emissions by 40% when compared to conventional brick walls. Centralized Solar PV saves nearly 160 tonnes of CO_2 per year per dwelling unit. And also locally available materials, insulation, vapor barrier, window glazing, water recycling, and rainwater harvesting have been considered to ensure low environmental impact from cradle to grave.

Integrated Performance
Passive architectural techniques ensure reduction in HVAC and lighting loads. Optimized performance of solar PV and HVAC is ensured by a common utility system used for electricity supply and HVAC. Heat pump systems running on direct supply from the utility generate cooling for the whole day and heat rejected in the condenser is recovered for domestic hot water. Customized automation app ensures efficient utilization of the common utility supply

Occupant Experience
Open planning helps in providing a lot of customization scope for the user, and also helps in better ventilation. The thermal and acoustic properties of the building materials ensure sufficient insulation of heat and noise from attached neighbourhood dwellings. The automation system of the house provides safety and comfort to the occupant.

Comfort and Environmental Quality
Radiant Cooling and Dehumidifying panels with better heat transfer coefficient developed at Heat Pump Laboratory IIT Bombay tackle the sensible and latent loads simultaneously. These panels ensure a comfortable temperature of 25 ℃ and relative humidity of 50% RH in the conditioned space. The slanted opening on the roof is connected to all spaces and provides sufficient passive ventilation. Active ventilation is ensured in all spaces with ceiling fans for circulation and exhaust fans for spot ventilation.

Energy Performance
The total 50kWp of rooftop solar PV for the whole cluster, managed by the common utility system meets the projected electrical demand and remains net positive in terms of energy exchange with the grid. A centralized 100kWh battery, and the thermal energy storage system ensure maximization of local consumption of generated electricity. Also, battery storage is capable of supplying critical loads during grid disruptions, at the same time. Grid interaction capabilities of the system in the form of demand response and feed-in tariffs, work in tandem to reduce grid stress, and maximize profit and/or minimize cost.