



Project Samsara

Project Summary

This proposal is an attempt at disruptive innovation in state-sponsored housing design and business models by Team SHUNYA, a multi-disciplinary group of 20 motivated students, guided by accomplished professors, pursuing the goal of affordable sustainable housing.

We present a retrofit strategy for a slum rehabilitation housing (SRH) building, as an example for 520,000 existing & new SRH units. We address the health & safety issues reported by the community as well as research articles by enhancing the quality of life using innovative active & passive measures.

Design Strategy

Our key focus has been on retrofitting to optimize safety, daylighting, natural ventilation, & thermal comfort; addressing the residents' previous concerns about inadequate access to these essential elements for a better lifestyle. Recognizing the need for social-cohesion, our approach ensures that community spaces are strategically distributed throughout the building, establishing a hierarchy of conviviality. This hierarchy ranges from individual dwelling units to floor plate common areas, culminating in a dedicated community kitchen for the entire building.

This arrangement not only fosters a sense of belongingness, but also addresses the specific needs of the marginalized & hardworking individuals of the society. These spaces serve as extensions of their households and avenues for small ventures and enterprises, empowering them to achieve financial independence. Moreover, the incorporation of these open spaces contributes not only to social well-being but also enhances the overall penetration of daylight and ventilation throughout the building.

Project Data

Location:	Mumbai, Maharashtra, India
Climate Zone:	0A (Coastal Warm-Humid)
Lot Size:	6,450 ft ² (600 m ²)
Dwelling Unit Size:	360 ft ² (33.5 m ²)
Building Size:	66,700 ft ² , 15 storeys (each building)
Occupancy:	450 people per building (148 ft ² /person)
Cost of New Building:	\$11/ft ²
Retrofit Cost:	\$4.5/ft ²
Average Utility Cost:	\$45/month (present), \$12
EUI:	16 kBtu/ft ² /yr (without renewables) -3.13 kBtu/ft ² /yr (with renewables)
Annual CO ₂ Emissions:	-1.53 kg CO ₂ e/ft ² /yr

Technical Specifications

R-Values (K-m²/W)

Walls:	2.22	Roof:	2.5
Foundation:	4.5	Windows:	2.1

HVAC:

Central membrane based Heat Pump (CoP = 7.42)

Target User Group

Low Income Households in Mumbai, India

Average Family Size:	5 people per household
Gross Annual Income:	< \$7,200 per household
Annual Housing Budget:	< \$2,000 (target)
Disposable Monthly Income:	5% - 20%
Mortgage to income ratio:	55% (present), 10% (aim)

Project Highlights

Architecture

Critical spatial analysis of the existing building revealed significant scope for improvement, where we reconfigured the floor, while **retaining 79% of existing walls**. This increased the habitable area per dwelling unit by 135 ft², & allowed us to provide operable windows to all dwelling units on any given floor. In order to enhance passive performance, we employed a 3-dimensional **Pareto void strategy**, removing poorly performing units, which creates multiple atriums & enables the penetration of light & fresh air deeper into the building. These atriums shall accommodate community spaces within the building mass. Further, we propose a 'free-plan' concept; where occupants get to choose the apartment layout as per their preference.

Health

Health issues stemming from deprivation of sunlight & fresh air are the biggest concerns for most affordable housing projects in India. Thus, our primary goal is to **enhance livability** using retrofit strategies that focus on **providing natural ventilation, daylight, & adequate thermal comfort**, improving acoustic insulation, uplifting the overall quality of life. We aim to ensure a healthy, safe, & comfortable lifestyle by maintaining adequate indoor environmental quality.

Community

Current redevelopment practices are leading to the gentrification of neighborhoods, resulting in the social, cultural and economic exclusion of lower-income households. The common spaces created using our void strategy offer a new way to support the residents, while our proposed community kitchen aims to build **economic resilience**. Our proposal aims to improve the state of affordable housing & create an **inclusive neighborhood**, achieved by providing access to shared amenities for cooking, eating, and laundry, as well as open spaces for all occupants within the building, encouraging **social interactions** & a vibrant mix of **dynamic land uses within a building**.

Envelope

We have developed a linear-programming based multi-criteria decision making tool which is helping us to select the most appropriate envelope. The best retrofit strategies which are optimizing the parameters of life-cycle costs, embodied energy, & thermal performance with locally available building materials are employed.. Simulations indicate **23.2% reduced cooling demand** by adding thermal insulation to the existing envelope; & increase of just 20% in existing wall-window ratio can improve Useful Daylight Intake (UDI) by **36%** for lower-level floors.

Engineering

We propose a chilled-water membrane based heat pump system, which hasn't been much explored. The expected efficiency of this system is **91.02% higher** than the existing system, with a **CoP of 7.42**. Moreover, we've carried out the structural integrity assessment of the existing building, & appropriate repairs have been identified to ensure **structural compliance with updated codes**.

Grid-Interactivity

After reducing energy demand via passive cooling, we've maximised on-site energy generation via **rooftop PV (79.2 kWp) & BIPV (47.5 kWp)**. Using smart energy management system, we aim to induce **demand shifting**, reducing grid load during peak hours. We've also developed resilience strategies to provide 3 days of backup power for all critical household loads & 7 days for shared building amenities. Furthermore, we propose smart automation for central systems using home assistant and making it user friendly making the building efficient in term of energy savings.

Efficiency

The implementation of the **void strategy** increased the UDI per average household by **40%**, along with increasing the ventilation rate from <1 to **4 ACH**. Moreover, the proposed solar powered community kitchen saves **75% of cooking fuel import**, while saving about \$12,000 annually. Greywater recycling and rainwater harvesting help save about 80% of annual freshwater demand and thus helps achieve the net zero water goal.

Life Cycle

We have conducted a comprehensive preliminary LCA, with **cradle-to-grave** system boundary, through material flow analysis & process-based carbon accounting. On integrating market-available second life building materials into the retrofit strategy, we were able to **reduce embodied CO₂ by 22%** as compared to the existing building.

Market

As the state desperately looks for land and feasible business models to house the urban poor, we propose a net-zero mixed-use deep retrofit as a holistically sustainable redevelopment strategy. Our industry partners are helping us with detailed cost calculations with present market rates, & as per early estimates, retrofit would cost 1/3rd of new construction. The retrofit cost per household can be covered in **10 years** with a **10% mortgage to income ratio**.