Team Shunya

Building a sustainable future

Engineering

U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

Jury Documentation

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Introduction

Given the geographic location and climatic conditions of Mumbai, the engineering designs adhere to the best standards in safety and reliability for the occupants of the house. The house's energy needs were carefully modelled based on the hot and humid climate of Mumbai and the building is equipped with state-of-the-art HVAC system. The generation system makes sure that the house isn't fully dependent on the grid and consequently on fossil fuels for its energy needs. Water efficient fixtures and gray water recycling ensures uninterrupted water supply and also enables water savings. Furthermore, the in-house automation system ensures that the user can set their comfort parameters and also monitor all the appliances in the house. Finally, a centralized BIM model integrates the all the engineering aspects of the house which facilitates hassle-free information transfer that enables the house to function as a single entity. The sections that follow describe all the design elements and their implementation.

Envelope Design

The envelope design ensures it doesn't fail, not in regular functioning and the face of calamities.

Footing

Although the design works from top to bottom, the conditions on the site resulted in soft soil and a Safe Bearing Capacity of around 30 kN/m^2 was determined and confirmed from the data of soil SBC available for the nearby sites. This led to a foundation change from isolated to raft footing. Raft footing also prevents differential settlement and can sustain on soil with such low bearing capacities.

Structure Design

One of the biggest challenges was to design connections that were dismantlable. This decision ensured that the material would be reusable when dismantling the structure, increasing the scrap value and recyclability of the house. Steel was chosen for the structure since it has higher circularity, lower embodied energy and recycling value than Reinforced Cement Concrete (RCC) structures. It also has higher durability, low maintenance and allows rapid construction with less labour work.

Table 1 - Comparison of Steel and RCC

Material	Recycling Rate (%)	Embodied Energy (GJ/tonne)
Steel	88	18
RCC	5-10	90-120

Table 2 - The Structural Sections for Various Components

Component	Section Used
Columns	RHS 200x100x5
Beams	ISMB200
Solar Structure	RHS 100x50x3.2

The Rectangular Hollow Sections (RHS) were chosen to make the connections more straightforward, even if eccentric to the column. They do not cause any offsets in the envelope due to the structure. RHS also have better torsional capabilities than I sections or other sections commonly used for columns.

ISWB 150 was initially proposed for the design, but due to non-availability in the market, ISMB 200 was used for all the beams in the structure due to their market availability. To maintain enough flange width to rest the metal deck and the structural slab system, we preferred higher sections of the beams over the lower ones.

Designing a solar structure for a house with more than 20 panels was crucial to the integrated design. A part of the roof structure is integrated with solar panels, and the solar installation above the bedroom on the first floor also takes the ceiling loads. The solar structure of choice was critical under wind loads since the uplift forces increased due to less dead load. We used the most optimal section, RHS 100x50x3.2, since sections required a moment of inertia on a plane higher than the other. In some places, the section could be decreased, but having many sections would lead to difficulties in market availability and site execution. A single section that could satisfy all the criteria was searched to make it easier.

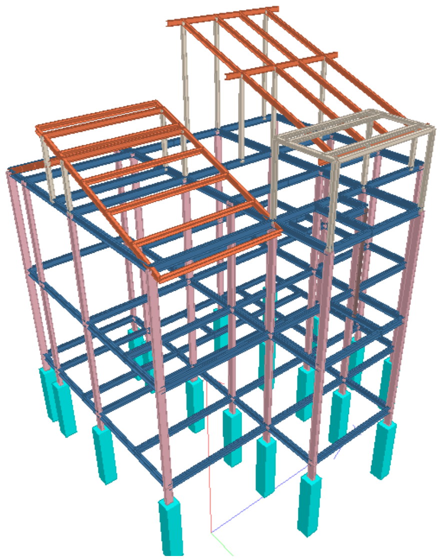

Figure 1 - Structure analyzed using STAAD Pro

On the first floor, the design of the spiral staircase needed a deeper understanding of the construction technique for the staircase than just the structure. It involved designing a stair step adjusted to the angle required with the ring connected to the central pole.

We've designed the house for handling the dead loads as per IS 875 (Part 1): 1987, live loads as per IS 875 (Part 2): 1987, wind loads as per IS 875 (Part 3): 2015, earthquake loads as per IS 1893(Part 1):2016 and a combination of all these loads as per IS 800:2007.

In summary, the structure is designed to last for the next 50 years. The challenges involved with designing the structure made the design process exciting, and the execution of the structure proved its constructability, for which the BIM of the structure played a significant role.

Slabs

Precast hollow core concrete, metal deck, and RCC slabs are popular materials for constructing building floors. Precast hollow core concrete is a prefabricated concrete element that provides excellent strength and durability but has an issue with the connections when connecting with a steel moment-resisting frame. RCC slabs are a popular choice for constructing floors in residential buildings but require much time for shuttering, binding reinforcement and curing. The metal deck is a prefabricated metal panel often used in commercial buildings but is now used for residential and other types of construction. It provides permanent shuttering, which reduces the RCC's shuttering time if the composite concrete and metal deck are used. The metal deck can be strong enough to sustain loads and can be fixed within short time spans.

Hollow concrete precast panels were initially proposed for the slab structure but had problems connecting to the steel beams. Hence, the structural metal deck and the metal decks finally used are TR50 and TR60+ profiles. Above the metal deck, Ecoboard is used where loads are low, and concreting is done at places with higher loads. The Reinforced Concrete Specifications are as per BS 4483, as the Indian Standards do not have any codes for composite metal decks.

Wall Assembly

Wall assembly is critical for ensuring an energy-efficient design and a comfortable indoor environment. We summarize the material selection process and decisions made for wall assembly design and their properties.

Table 3 - U Value Comparison of Candidate Materials/Material Assemblies for Walls

Wall Assembly	U Value (W/m²K)
Bricks (230 mm)	1.5
AAC Blocks (230 mm)	0.8
PUF Sandwich Panel	0.22
*** Ecoboard + Fiber Cement Board + Insulation**	0.243
Fiber Cement Board + Insulation + Hollow Core Concrete Blocks	0.37

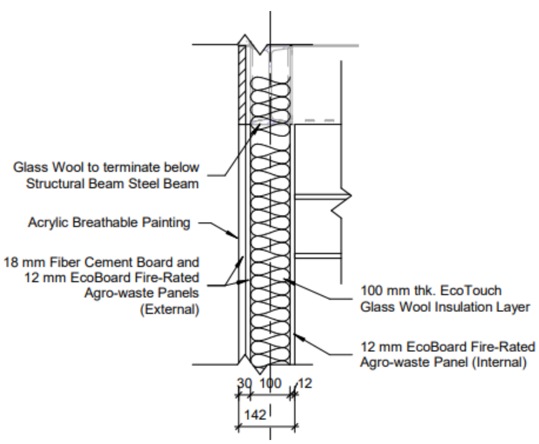

Figure 2 - Schematic of Wall Assembly consisting of Ecoboard panels, Fibre Cement Board and Insulation

Bricks are among the most commonly used building materials worldwide for their durability, fire resistance, and excellent thermal insulation. However, they have a high carbon footprint due to the energy required to manufacture them. The u-value of bricks is around 1.5 W/m²K.

Autoclaved Aerated Concrete (AAC) Blocks are the emerging popular choice for high rise construction in our country, with a U-value of 0.8 W/m2K for a 230 mm thick wall. They also have a relatively low carbon footprint. But Project Vivaan was aimed to be a dismantlable structure and hence we discarded the option. Similarly, even though PUF panels are better in terms of thermal performance, the polyurethane foam used for insulation contains toxins and hence was not chosen.

Therefore, we used Ecoboard wall panels made from agricultural waste materials, such as rice straw, wheat straws or bagasse, which would otherwise be burned or left to decompose, releasing greenhouse gases. Additionally, agro waste-based wall panels have a lower embodied energy than conventional building materials like concrete or brick, reducing CO_2 emissions. They are lightweight, fire-resistant, termite resistant, and recyclable at the end of their life.

Glass wool is an insulation made from recycled glass that has been melted and spun into thin fibres. It is used to create a barrier between the interior and exterior of a building, reducing heat transfer and maintaining the indoor temperatures. This assembly of materials used in Project Vivaan ensured a proper balance between thermal performance and environmental performance in terms of the carbon dioxide emissions.

HVAC

Being a coastal city, the relative humidity in Mumbai is soaring high around the year. The system is designed to handle the latent and sensible load separately to ensure controlled comfort conditions throughout the year. A desiccant-based system handles the latent load, improving the system's efficiency.

System Design

The critical design parameters for HVAC systems include demands of thermal comfort, energy conservation, reliability, simplicity, and cost.

The energy requirement is managed well throughout the day by using a thermal storage system to offset the peak demand loads of the house. A fan coil unit is operated with chilled water temperature of 12°C to handle the sensible load for the house. As compared to the conventional FCU which operates at 7°C of chilled water supply, our system performs better since the evaporator is operated at higher temperatures. The latent load is handled by the liquid desiccant-based dehumidification system that works on the natural process of absorption. This system has a higher COP than normal refrigeration dehumidifiers and is specially developed for residential purposes to have an efficient and quicker control of the relative humidity levels of the room.

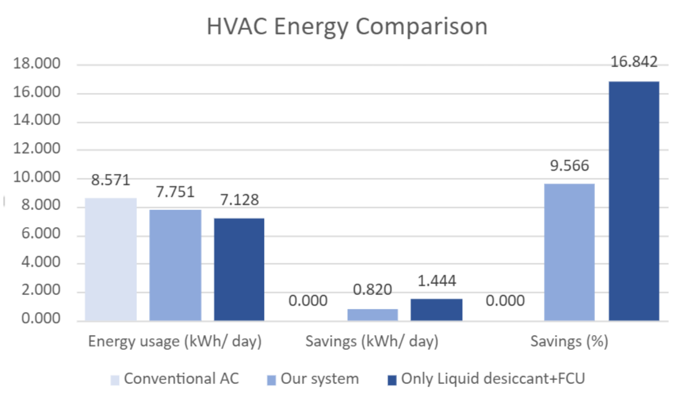

Figure 3 - Energy Efficiency Ratio Comparison

Energy Efficiency and Performance

In a typical 5-star rating AC, for our target design conditions, we would have a COP of 3.5 whereas our system serves a COP of 4.21, which translates to ~17% energy savings. In addition, occupants would face performance deterioration in a typical AC system due to frosting on the evaporator, increasing its energy consumption by up to ~15% over time.

The system would result in a 30% reduction in refrigerant needed, leading to a lowering of greenhouse gas emissions.

Electricity Consumption and Generation

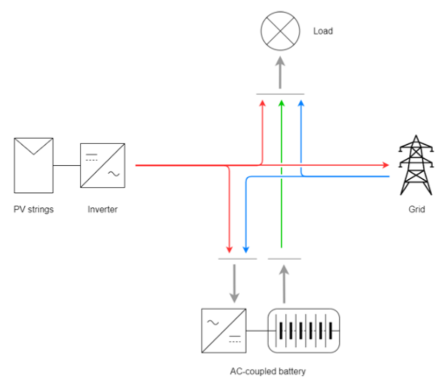

Figure 4 - Generation System Outline

To meet the electricity demands of the house, the generation system is designed with a 10.36 kWp capacity. It has a yearly generation of 13,893 kWh to ensure the house is net zero energy compliant. Mono-crystalline PERC panels with half-cuts were selected as the best technology for our application based on the market study. The inverter is rated at 13 kW and will come with two MPPTs to maximise the energy extraction from the PV strings.

Battery storage would also be part of the system to decrease the overall dependence on the grid by powering the appliances from the battery instead of the grid during the non-solar hours. It also helps make the home resilient against extreme weather events, which might result in both PV and grid unavailability. The battery system size is 28.8 kWh, which alone can power all the essential loads for 1.5 days. The battery technology selected is Lead Acid, an AC-coupled system to an inverter.

Automation

We've opted to design the automation system using Home Assistant: An open source automation system that can be controlled by single application or web interface. This choice provided us the following benefits in terms of design and deployment

- Ease of deployability
- Low Energy Consumption
- Integrated, interoperable, customisable
- Customisable and extensible UI
- Companion Mobile Application

An automation system enables users to control and monitor various utilities within the house. The integrated design allows users to monitor and control appliances like lighting, air conditioning, ventilation, and hot water supply. Users can track temperature, humidity levels, air quality, and lighting intensity within the various zones of the house. It displays the energy consumption of essential and non-essential loads, which is tracked by a custom energy monitoring system. A snapshot of the application's user interface is shown in the Figure 5 .

A room's comfort systems and lights only need to be active while the space is occupied. A PIR sensor detects when a person enters the room, and the ESP microcontroller activates the comfort systems/lights in the room. If the person stays in the room for an extended period, the ESP microcontroller senses a Bluetooth tracker on the person and keeps the lights on and maintains CO2 levels until the person leaves the room.

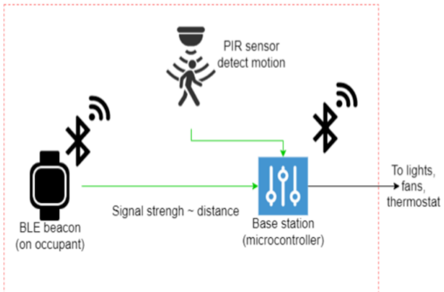

Figure 6 - Occupancy Based Automation of Utilities

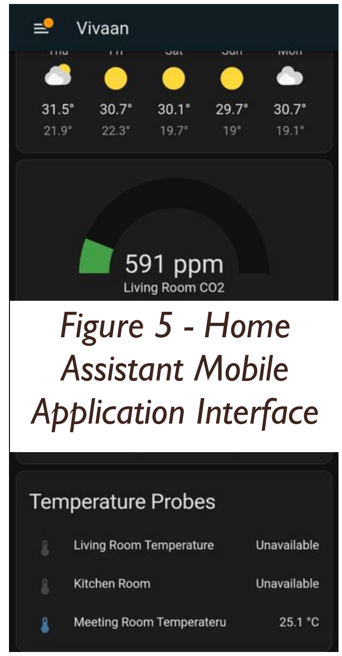

Figure 5 - Home Assistant Mobile Application Interface

We recycle the cooled-down water in hot water pipes to ensure no water is wasted. We use the DS18B20 temperature sensor to measure the water temperature, and an ESP microcontroller drains the cold water in the pipe and fills it with warmer water from the tank.

Plumbing

Annual rainfall of 2422 mm in Mumbai makes it an excellent location for rainwater harvesting. According to UPIC 2016 (Uniform Illustrated Plumbing code), the daily water requirement of a family of 4 is 668 litres. By implementing water-efficient fixtures, greywater recycling and rainwater harvesting in our project, we'll have more than 81% of water savings (130 litres/day), making our house IGBC Near net zero water house.

Water Efficient fixtures

Water-efficient fixtures at low-flow taps and shower heads, dual flush toilets, and toilet stops are improved fixtures that can satisfy our needs using less water than regular old-day fixtures. Using modern state-of-the-art fixtures, we will reduce our water requirement to 400 litres per day which is 41% water savings against our standard fixtures (UPIC codes).

Gray water recycling

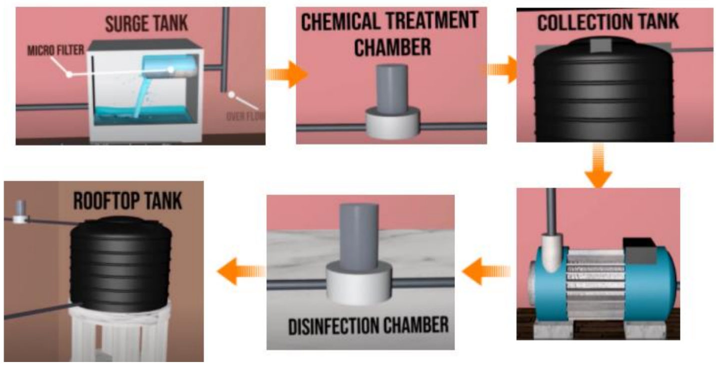

Figure 7 - Gray Water Recycling Process Flow

Grey water generated from showers, tubs, washing machines, and bathroom sinks is collected, filtered and used again for activities like flushing, gardening, and washing cars saving 60 litres per day, giving additional 9% savings.

Rainwater Harvesting

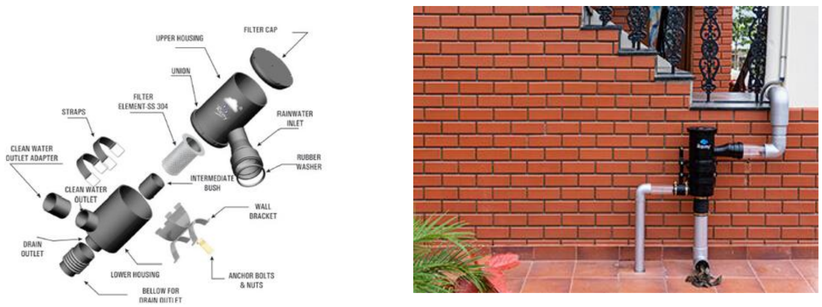

Figure 8 - Rainwater Recycling System Components

During monsoons, we will collect the excessive rainwater, filter it, store it and use it for the rest of the months by using leaders to direct the flow into the pipes(gutters) connected with filters to filter the rainwater.

With a more than 500 sq ft catchment area, we can store 10000 litres of water to fulfil our water requirements for about 1.5 months, accounting for 31% of water savings.

Building Information Modelling (BIM)

The Project Vivaan has been designed, planned, controlled, and monitored through Building Information Modelling (BIM) based Common Data Environment (CDE). A complete 7D BIM is planned to be implemented in the project. The applications of BIM include:

1. Centralized BIM models for different stakeholders such as mechanical, electrical, plumbing, architecture, structure, landscaping, and fire protection.
2. Energy and Lighting analysis from central 3D models created.
3. LCA integration with BIM for sustainability.
4. Project cost and timeline integration with BIM for visualization and dynamic BOQ generation for day-to-day activities.
5. Generation of good for construction (GFC) and as-built drawings from **Clash free** coordinated models.
6. Digital twin development based on as-built models for facilities management (FM) and continuous monitoring of thermal, automation, and safety performances of the house.
7. Interactable VR model for no accessible areas and especially abled visitors of the house.

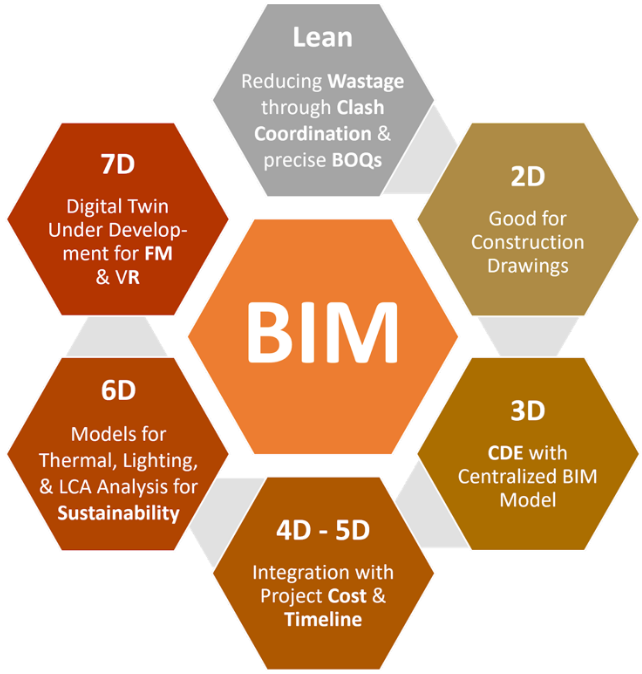

Figure 9 - Possibilities of BIM Modeling

BIM allowed hassle-free information management through Autodesk construction cloud as CDE during the project. Training and visualization of critical structural and MEP connections for students enabled a clash-free coordinated model resulting in lean construction through less material and time wastage.

We've done cash-flow forecasting and derived material procurement schedule from 5D BIM. It also helped with dynamic generation BOQs as per the requirement and timeline of the project. Material properties and sun path derived from the BIM model for Energy, Lighting, and Life Cycle Analysis helped the team remove duplication of work and resulted in integrated project delivery.

Appendix

Energy Analysis

Software used - PV*SOL Premium

Version Used - 2023 (R3)

Database version - 3.45

PV*SOL Premium: PV*SOL premium is a simulation program with 3D visualization and detailed shading analysis for the calculation of photovoltaic systems in combination with appliances, battery systems and electric vehicles.

This software was used for simulating a Grid connected PV System with Electrical appliances and Battery systems. It allows using the battery as an energy storage medium and also as a source, not just as a means for providing backup.

These are some of the parameters used for running the simulation.

Climate Data	Mumbai, IND (2007 -2020)
Values source	Solcast TMY
PV Generator Output	13.08 kWp
PV Generator surface area	61.3 m^2
Number of PV modules	24
Battery storage capacity	29.6 kWh

Shown below is the schematic SLD of the generation system together with battery storage. The battery system is AC-coupled to prevent heavy grid dependence in the monsoon months when the generation is low. This is reflected directly in the **Level of self-sufficiency** metric, which measures how much we are independent of the grid.

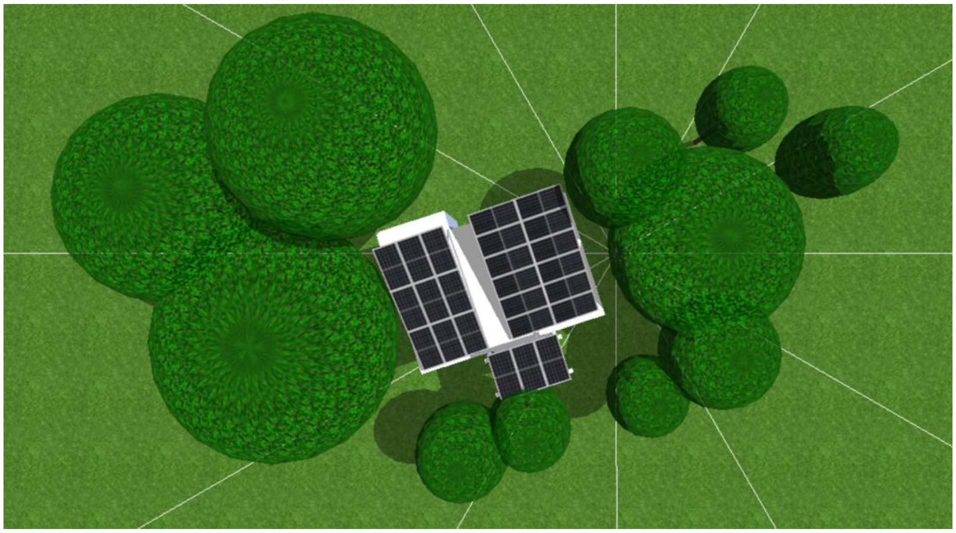

Figure 11 - 3D Model Used for Analysis incorporating shading

Consumption profile stats fed into the software (loads divided into hourly intervals for a typical year with changes - 8760 entries) and also includes the HVAC loads taken separately into account.

Floor	Room	Appliances	Tag	Power Rating (W)	No.	Total (W)	Time of Use 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Daily Usage Time (h)	Daily Energy Usage (kWh)
Plinth Floor	Kitchen	Oven	Non-essential	2000	1	2000													0.25								0.25				0.50	1.00
	Kitchen	Mixer	Non-essential	750	0	0								0.25																	0.25	0.00
	Kitchen	Induction stove	Essential	2000	2	4000								0.5					0.5								0.5				1.50	6.00
	Kitchen	Lights	Manageable	10	5	50							1	1	0.5	1			1	1				0.5	0.5		1	0.5	0.5		8.50	0.43
	Kitchen	Exhaust Fan	HVAC	15	1	15								1	0.5				1	0.5				0.5			1	0.5			5.00	0.08
	Kitchen	Refrigerator	Essential	150	1	150	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	3.12	0.47
	Kitchen	Chimney	HVAC	240	1	240								1					1					0.5			1				3.50	0.84
	Kitchen	Water Purifier	Essential	36	0	0									0.33					0.33								0.33			0.99	0.00
	Kitchen	Socket			4	0																									0.00	0.00
	Kitchen	Power Socket				0																									0.00	0.00
	Kitchen	HVAC Pumps				0																									0.00	0.00
	Kitchen	Toaster	Non-essential	700	1	700								0.25																	0.25	0.18
	Dining Room	Lights	Manageable	10	9	90							0.5	0.5	0.5						1			0.5	0.5			0.5	0.5		4.50	0.41
	Dining Room	Fan	HVAC	35	1	35							0.5	0.5	0.5						1			0.5	0.5			0.5	0.5		4.50	0.16
	Dining Room	Exhaust Fan	HVAC	15	1	15							0.5	0.5	0.5						1			0.5	0.5			0.5	0.5		4.50	0.07
	Dining Room	Socket				0																									0.00	0.00
	Dining Room	Power Socket				0																									0.00	0.00
	Dining Room	HVAC Pumps				0																									0.00	0.00
	Utility	Lights	Manageable	5	2	10																									0.00	0.00
	Utility	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Utility	Socket				0																									0.00	0.00
	Utility	Power Socket				0																									0.00	0.00
	Utility	Dishwasher	Non-essential			0														0.5								0.5			1.00	0.00
	Utility	Washing Machine	Non-essential	360	1	360										1															1.00	0.36
	Living Room	Lights	Manageable	24	4	96									0.5		1	1				1	1			1	1	0.5	0.5		7.50	0.72
	Living Room	Fan	HVAC	30	0	0									0.5		1	1				1	1			1	1	0.5	0.5		7.50	0.00
	Living Room	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Living Room	Socket				0																									0.00	0.00
	Living Room	Power Socket				0																									0.00	0.00
	Living Room	HVAC Pumps				0																									0.00	0.00
	Living Room	Television	Non-essential	120	1	120										1											1				2.00	0.24
	Bedroom GF	Lights	Manageable	11.75	8	94																1	1								2.00	0.19
	Bedroom GF	Fan	HVAC	35	1	35	1	1	1	1	1	1										1	1							1	9.00	0.32
	Bedroom GF	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Bedroom GF	GF FCU Pump	HVAC			0																									0.00	0.00
	Bedroom GF	Power Socket				0																									0.00	0.00
	Bedroom GF	HVAC Pumps				0																									0.00	0.00
	Electrical Room	Lights	Manageable	5	1	5																									0.00	0.00
	Electrical Room	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Electrical Room	Socket				0																									0.00	0.00
	Electrical Room	Power Socket				0																									0.00	0.00
	Electrical Room					0																									0.00	0.00
	Toilet GF	Lights	Manageable	5	2	10						0.5	0.5	0.5										1							2.50	0.03
	Toilet GF	Exhaust Fan	HVAC	15	1	15						0.5	0.5	0.5																	1.50	0.02
	Toilet GF	Socket				0																									0.00	0.00
	Toilet GF	Power Socket				0																									0.00	0.00
	Sitout Area	Socket				0																									0.00	0.00
	Sitout Area	Power Socket				0																									0.00	0.00
First Floor	Bedroom FF	Lights	Manageable	11.75	8	94																				0.5	1	0.5			2.00	0.19
	Bedroom FF	Fan	HVAC	35	1	35	1	1	1	1	1	1														0.5	1	0.5		1	9.00	0.32
	Bedroom FF	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Bedroom FF	FF FCU Pump	HVAC			0																									0.00	0.00
	Bedroom FF	lbatross Dehumidifie	HVAC			0																									0.00	0.00
	Bedroom FF	HVAC Pumps				0																									0.00	0.00
	Family Living	Lights	Manageable	10	8	80																				1	1	1	1	1	5.00	0.40
	Family Living	Fan	HVAC	30	1	30																									0.00	0.00
	Family Living	Exhaust Fan	HVAC	15	1	15																									0.00	0.00
	Family Living	Socket				0																									0.00	0.00
	Family Living	Power Socket				0																									0.00	0.00
	Balcony	Lights	Manageable	5	7	35																				1	1	1	1		4.00	0.14
	Balcony	Socket				0																									0.00	0.00
	Balcony	Power Socket				0																									0.00	0.00
	Toilet FF	Lights	Manageable	5	2	10							0.5											1							1.50	0.02
	Toilet FF	Exhaust Fan	HVAC	15	1	15							0.5																		0.50	0.01
	Toilet FF	Socket				0																									0.00	0.00
	Toilet FF	Power Socket				0																									0.00	0.00
Other	Parking	Lights	Manageable	6	0	0																				1	1	1	1	1	5.00	0.00
	Parking	Socket				0																									0.00	0.00
	Parking	Power Socket				0																									0.00	0.00
	Parking	EV Charger	Manageable	3000	1	3000					1	0.5																			1.50	4.50
	Roof/Mumpty	Lights	Manageable	5	2	10																									0.00	0.00
	Roof/Mumpty					0																									0.00	0.00
	Misc	Lights	Manageable	6	0	0	1	1	1	1	1	1	1													1	1	1	1	1	12.00	0.00
	Misc	HVAC Pumps	HVAC	248.6666667	6	1492	0.254	0.085	0.068	0.060	0.055	0.073	0.061	0.289	0.279	0.185	0.264	0.296	0.115	0.374	0.287	0.249	0.337	0.202	0.082	0.071	0.225	0.184	0.152	0.142	4.39	6.55
	Misc	Hot Water Heater		4000	1	4000							1																		1.00	4.00
	Misc	Wifi Router	Manageable		2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24.00	0.00

Figure 12 - Load Profile

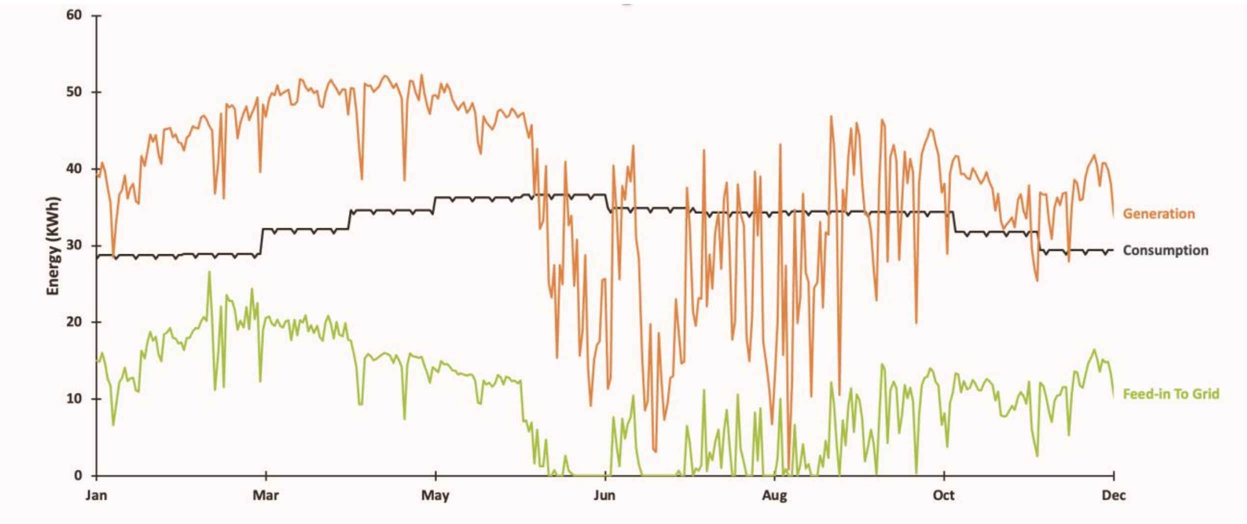

Figure 13 - Annual Energy Profile

Table 4 - Generation Results Outline

	Min	Average	Max	Total
Loads	24.497	34.205	44.508	12484.682357
Generation	0.832	37.358	52.272	13635.708
Feed-in To Grid	0.000	10.204	26.634	3724.355
Consumption-From-Grid	0.000	9.491	33.024	3464.279

Structural Analysis

Table 5 - IS Codes Referred for the Structure Design

Code	Description
For Loads Considerations	
IS 875	Code Of Practice For Design Loads (Other Than Earthquake) For Buildings And Structures
IS 875 – Part 1 (1987)	Dead Loads – Unit Weights of Building Materials and Stored Materials
IS 875 – Part 2 (1987)	Imposed Loads

IS 875 – Part 3 (2015)	Wind Loads
IS 875 – Part 5 (1987)	Special Loads and Combinations
IS 1893 (2016)	Criteria for Earthquake Resistant Design of Structures
For Design	
IS 800 (2007)	General Construction in Steel – Code of Practice
Eurocode 4	Design of composite steel and concrete structures

Table 6 - Unit Weights for Dead Loads

Material	Unit Weight (kN/m^3)
Precast Hollow Core Concrete Panels	16
Ecoboard	16
Fibre Cement Boards	16
Steel Fe-410	78.5
Insulation	0.7

Table 7 - Live Loads considered as per IS 875-Part 2 (1987)

Occupancy Classification	Live Load (kN/m^2)
All rooms and kitchen	2
Toilet and Bathrooms	2
Corridors, Passages, Staircases including Tire Escapes and Store Rooms	3
Balconies	3
Accessible Flat Roof	1.5
Sloping Roof (21 degrees) (access provided only for maintenance)	0.53

Table 8 - Earthquake Parameters used as per IS 1893(Part 1): 2016

Zone	III
Importance Factor	1
Response Reduction factor	3
Soil Type	III (Soft Soil)
Moment Frame	Steel Building with Ordinary Moment Resisting Frame

Table 9 - Wind Load parameters used as per IS 875(Part 3): 2015

Basic Wind Speed	44 m/s
Terrain category	Category 2
Risk coefficient	1
Terrain height and roughness factor	1
Topography factor	1
Importance factor for cyclonic region	1.15
Design Wind speed	50.6 m/s
Design Wind pressure	1536.216 N/m^2
Wind Permeability	Normal
Internal Wind Pressure Coefficient	0.5
External Wind Pressure Coefficient	As per clause 7.3.3

Table 10 - Steel Fe-410 Requirements corresponding to IS 2062

Ultimate Strength (fu)	410 MPa
Yield Strength (fy)	250 Mpa
Modulus of Elasticity (ϵ)	200 Gpa
Poisson's ratio (μ)	0.3

Modulus of Rigidity (G)	79.6 Gpa
Unit Weight	7850 Kg/m^3

Table 11 - Partial Safety factors for Limit State of Collapse

Partial safety factors for Loads	DL	LL	WL/EQ
DL + LL	1.5	1.5	
DL + WL/EQ	1.5		1.5
	0.9*		1.5
DL + LL + WL/EQ	1.2	1.2	1.2

Note: At a time only WL or EQ load is considered because probability of both these loads occurring at the same time is very less.

* DL effect is reduced when it is the resisting force as in case of overturning due to lateral loads.

Table 12 - Partial Safety factors for Limit State of Serviceability

Partial safety factors for Loads	DL	LL	WL/EQ
DL + LL	1.0	1.0	
DL + WL/EQ	1.0		1.0
DL + LL + WL/EQ	1.0	0.8	0.8