TEAM NIVAS 2.0

COMPETITION DIVISION: MULTI FAMILY HOUSING

FINAL DESIGN REPORT - APRIL 2022

PROJECT PARTNER :
MAHINDRA LIFESPACES

LEAD INSTITUTE :

INSTITUTE OF ENGINEERING & MANAGEMENT KOLKATA

PARTNER INSTITUTE :

ASHOKA SCHOOL OF PLANNING AND ARCHITECTURE,HYDERABAD.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY,SULTANPUR.

NATIONAL INSTITUTE OF TECHNOLOGY(NIT), RAIPUR.

GOA COLLEGE OF ARCHITECTURE,GOA.

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1. Executive Summary

Team NIVAS 2.O has come up with a solution in the multi-family housing sectors. Our members from different backgrounds along with the technical support faculty and industry partners, leading the team to come forward with a plan and direct the project towards its potential.

BUILDING CATEGORY:	Multifamily housing Residential building
TEAM NAME:	Team NIVAS-2.0
PROJECT PARTNER NAME:	Mahindra Lifespaces
BUILDING DETAIL:	Total built Up area-3.07 Acres Total (Approx), FAR –9.73, Location: Pimpri-Chinchwad, Pune, Maharashtra, India
ESTIMATED PROJECT COST:	223 Cr. (INR)
INDUSTRY PARTNER:	D2O services LLP, LLYOD insulation, Only Yours.

ARCHITECTURAL DESIGN	External CFD analysis for air movement across the building envelope done. Design of green terrace garden proposed and parametric facade design.
ENERGY PERFORMANCE	65% EPI reduction achieved compared to base case. EPI achieved: Moat efficient: 33.76 kWh/m2/Yr and Most economical: 41.24 kWh/m2/Yr.
WATER PERFORMANCE	Using low flow rate plumbing fixtures and the various water conservation measures. Overall water reduction achieved is around 46% and the recycled water is 45% of total consumption and Net Water positive achieved by putting addition water source : Water harvester
HEALTH AND WELLBEING	Star rated split Ac at higher set point with BLDC fan recommended.,Low cost Evaporative cooler and VRF sizing done in club house.
INNOVATION	Successfully developed Residential Operational Energy Evaluator prototype, an IOT and AI enabled web portal to evaluate the post occupancy energy efficiency of individual flat via enabled smart meters. Appreciation received at ISHRAE and ASHRAE platforms.
ENGINEERING & OPERATIONS	Electrical load estimation and transformer sizing done. Solid waste management plan proposed. HVAC designing for the clubhouse partly. 25.01% common area demand reduction achieved.Achieved 60% near Zero Waste (Organic) for Landfill.
SCALABILITY AND MARKET POTENTIAL	Team NIVAS marketing survey reveals that more than 90% is willing to pay for green housing. 20.3%, 50%, 22.5% is willing to pay 4-5%, 2-3%, 1% more respectively.Scalable cloud platform development.Terrace garden premium floor designed.
AFFORDABILITY	Differential wall and glass intervention explored for highly solar exposed direction. Best construction practice identified for expediting project execution.
RESILIENCE	Energy resilience was estimated by providing a hybrid DG set. Water resilience was ensured by using shallow well. WiFi sizing done with battery power backup for network resilience. Automatic fire detection system proposed.
COMMUNICATION	Social media reach:276+ followers, 2725+ likes, comments, views, 2950+ total reach, 400+ mails promotion, team journey coverage by news channel: SAPTAK NEWS. Promotion through internal events like Wall Writing on Climate Change, publication in departmental newsletter and website. Advocacy with professional societies named IGBC GRIHA, ISHRAE and SUNREF.

2. Team Introduction

Team name: TEAM NIVAS 2.0

Lead institution: Institute of Engineering & Management, Kolkata

Partner member institute(s): Ashoka School of Planning and Architecture,Hyderabad Jawaharlal Nehru Technological University,National Institute of Technology (NIT), Raipur ,Goa college of Architecture.

Division: Multi-family Housing.
Team NIVAS 2.0 is a multidisciplinary team of 15 dynamic members who have been involved in various real- life projects, architectural projects, internships on building performance and are even winners of various building design and HVAC competitions conducted by ISHRAE. In the last year our Team NIVAS had participated in Solar Decathlon India 2020-2021 for the first time and made it to top 6 under the Multi-Family Housing domain. Also, the majority of the team members are a part of ISHRAE-IEM Model Student Chapter. The focused team of 15 members have already segmented themselves to work in the allocated domains to serve the best to the project.

Team members:

Associate team members:

Acknowledgements:
We would also like to extend our regards to Professor. Ayan Kumar Panja, Mr.Debdut Bosu, Mr.Avinish Kumar, Mr Nikunj Verma, Mrs Riya Kasliwal , Shubhra Pal, Sushant Shandilya, Gaurav Kumar, Suhail Haider, Subhankar Sabaru, Subhankar Das, G. Sanjana.Josyula, Lakshmi Pratysha, Pratwusha Sahoo for their support.

Approach: Team Nivas 2.0 is having team members from diverse domains. Keeping Sustainability as our fundamental objective our approach is based on two main considerations, Environmental and Economical. We will analyze the site and climatic condition for our project location. Moving to the design stage, first we will sort the potential strategies and will set the goals to achieve. Adaptive comfort with visual comfort and thermal comfort will be taken into consideration following NBC and Green Homes guidelines. Following the parametric design approach, we will study the base case scenario for conventional building envelopes and understanding the project requirement we will incorporate insulation and shading materials with mixed- mode ventilation to find the most efficient design. For the operational period, we will estimate solar generation capacity to cut down the energy demand and reduce overall maintenance cost and water consumption to make this project an affordable net-zero project. We will try to integrate SMART HOME Technology to monitor real-time building performance. Finally, we will explore some innovative strategies to improve the overall building performance.

Institution details: Institute of Engineering & Management (IEM), Kolkata is the first and the oldest private engineering college in the West Bengal state. The IEM group is an acclaimed educational group amongst the industry-centred academic training organizations of today with two Universities at Jaipur and Kolkata. IEM has been ranked 'A' Category by NAAC.

Faculty lead:

Prof. Gunjan Kumar, Alumnus of ISM (IIT), Dhanbad, Assistant Professor, Department of Mechanical Engineering, IEM Kolkata. Research scholar Jadavpur University. National Student Activities Vice Chair ISHRAE & BOG Member – ASHRAE East India. He was awarded the best faculty advisor for SDI 2020-2021. 16+ years experience.

Prof.Pinaki Mukherjee, Technical Assistant, Department of Mechanical Engineering, IEM Kolkata. He has an industrial experience of over 8.5 years with companies like TractorsIndia Limited, Besco Limited, Jaypee Hydraulics and Texaco Limited.

Prof.Debashish Ghosh, faculty of Electrical engineering in IEM who holds a M.Tech in Illumination technology and design from Jadavpur University along with an experience of 9 years.

Prof. Amartya Mukhejee, the HOD of CSE(AIML),CSBS in IEM with 14 years of experience in the field has written numerous books and research articles.

Prof. Anju Manikoth from Ashoka School of Planning and Architecture is an Architect/ Associate Professor. She is in this field of teaching for1.5 years.

Industry partners:

Design2Occupancy Services LLP (D2O) is a leading consulting organization providing a wide range of services in green building certification facilitation, energy and daylight simulation, CFD analysis, etc. Mr.Anuj Gupta from D2O service LLP guided the team .

Lloyd Insulations specialize in the supply, contracting and manufacturing of insulation, fireproofing and many more. Mr.A.S. Chowdhury, AGM, Technical and Marketing of Lloyd Insulations guided the team as an instructor and mentor for Insulation and U – Value Simulation.

Only Yours is a unit of Technine Ventures dealing with various fields of technology. Mr Arijit Neogi helped and guided the team especially in the Innovation segment.

Team, Faculty, Alumni, Project/Industry Partner Meeting Details

MEETING SEGMENT	NO. OF MEETINGS	AGENDA
Full Team	50 (Every week)	Team – wide segment progress updates, Coordination with other segments for inputs
Energy	11	Design Builder model development, Energy simulation, Solar System sizing
Water	10	Water demand, Rainwater harvesting, Suggestion Review
Resilience	6	Identification of work scope, Estimation of DG sets for power resilience
Affordability	7	Affordable materials and insulation, Affordability of innovation, Fixture price and cost estimation analysis
Innovation	8	Brainstorming, Tech stack allocation, Research

Health & Wellbeing	10	Thermal comfort hour analysis, HVAC system sizing, Heat load calculation
Engineering & Operations	9	Electrical load estimation, Transformer sizing, Waste generation calculation
Architectural Design	12	Site analysis, Building area calculation, External CFD
Scalability & Market Potential	6	Research on modern construction practice, Survey creation
Communication	7	Audience identification, Communication schedule development, News article development, Awareness handout, Internal event launch

*Platforms used for communication were Google Meet, In – person meeting, Google Drive, WhatsApp and Miro.

Project and Industry Partner and Mentor Meetings

PROJECT/INDUSTRY PARTNER/MENTOR	NO. OF MEETINGS	AGENDA
Mahindra LifeSpaces Developers Limited (Project Partner)	7	Project understanding and suggestions, Design development discussion, Cost input, Simulation input parameter review
Design2Occupancy Services LLP (D2O) (Industry Partner)	8	Architecture, Solar, Energy discussed, Solid waste procedure and report writing feedback received
Lloyd Insulation (Industry Partner)	4	Necessity and choice of insulation, Effect on U – Value, U – Value Simulation Review
Only Yours	3	Guidance to Innovation, Scalability
Mr.Debdut Bosu, Mr.Avinish Kumar	18	Guidance to Scalability, Communication, Affordability segments,cost estimation

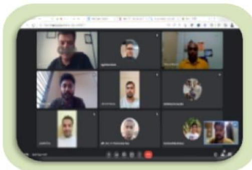
**Platforms used for communication were Google Meet and email.

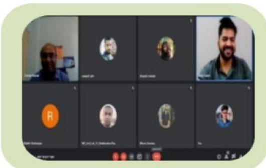
Total meetings done: 176

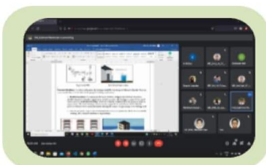
Meeting Screenshots:


Project Partner Meeting


Industry Partner Meetings


Industry Partner Meetings


Industry Partner Meetings


Faculty Review Meetings


Team in Progress

Challenges faced:

Negation of claustrophobic air pockets in base case design:

- ✓ Service cores in inner parts of the towers created air pockets,Pocket identification and solution planning done using CFD simulations.
- ✓ Parametric/kinetic facades, appropriate construction materials used
- ✓ Green courtyard with wind - stack ventilation added to improve space between towers and cross - ventilation

Maximizing rain catchment and meeting potable water requirements despite area constraints:

- ✓ Ground water supplemented rain water recharge silo
- ✓ 25 m deep pits in 22 m deep ground water level causes 10 m water rise; 12 - 15 m rainwater catchment
- ✓ Groundwater integration ensures water supply on dry days; removes need for maintenance
- ✓ Potable water demand compensated using 4 - step humidity filtration

Reduction of high - rise tower energy demand using cost - sensitive approach:

- ✓ Composite intervention proposed for facades having higher solar radiation.
- ✓ Common area demand reduction using automatic light dimming.
- ✓ Scalable innovation solution targeting post - occupancy consumption.

3. Project Background

Project Name: Home Ground, Project partner: Mahindra Lifespaces Developers Limited

Dr. Sunita Purushottam- Head of Sustainability and Project Partner POC.

Email: PURUSHOTTAM.SUNITA@mahindra.com

Mr. Abhishek Palit – Sustainability Manager and Project partner coordinator with Team Nivas 2.0.

Description of the Project Partner: Mahindra Lifespaces Ltd. is one of the most reputed residential property developers in India. They have projects across the country and provide thoughtfully designed living spaces. They espouse responsible, green design and development, and are driven by our mission of Sustainable Urbanization. Some of the Notable Achievements of Mahindra Lifespaces Ltd. Include-17.47 million sq. ft. of completed residential projects, 7.9 million sq. ft. of ongoing and forthcoming residential projects, over 5000 acres of ongoing and forthcoming integrated cities and industrial clusters in three cities, Projects in Mumbai Metropolitan Region, Pune, Nagpur, Ahmedabad, Delhi NCR, Jaipur,Hyderabad, Chennai & Bengaluru. About, Pimpri-Chinchwad, Pune: Pune, situated in west-central Maharashtra, India, is also known as the “Queen of the Deccan”. It is the seventh most populous city in India and the second-largest city in the state with an estimated population of 7.4 million as of 2020. It has been ranked as "the most livable city in India" several times. Pune lies on the western margin of the Deccan Plateau, at an altitude of 560 m (1,840 ft) above sea level. It is on the leeward– side of the Sahyadri mountain range, which forms a barrier from the Arabian Sea. Our project site, located in the Pimpri-Chinchwadarea, falls on eastern side of the Western Ghats called Sahyadri ranges. The site is situated near major urban and industrial groups of Pune and Pimpri Chinchwad. The topographical elevation ranges between 589m to 586m. Northern portion has been observed to be little elevated compared to the southern portion of the study area.

Brief description of the Project: Mahindra Lifespaces (MLDL) intends to develop an area of 3.07 Acres, located in Pimpri-Chinchwad Haveli Tahsil of the north-western part of Pune district. The study area comes under the SOI topographic sheet number 47F/13 on the 1: 50,000 scale and is located between 180 30’N to 190 05’N. Latitude 730 32’E to 740 15’E longitudes.

Climate Zone: Warm and humid zone as per ECBC-2017, Status of the project: Still in concept and design, Hours of operation: 24hours.

Profile of occupants: As building configuration is of mixed type (2BHK-3BHK) so the intended target audience are the migrants working for various industries like IT, Electronics, Education, Pharma, etc.

Total Site Area (in m2) = 12423.85 sq.m, Permissible Built-up Area (in m2) = 67000 sq.m, Proposed Built- up area (in m2) = 16.4 acres, 66368.45 sq.m, Ground Coverage Area (in m2) = 1.15 acres, 4653.885 sq.m, 37.40%

Total Built Up Area:

Total plot area= 3.07 Acres Total Appx. Built Up area that need to be constructed = 16.44 Acres Project site area= 1.15 Acres, FAR= 9.73, Total no. of Tower to be construed = 4, Total number of Units = 484 nos., Target EPI: 45kWh/sqm., However, we will try to reduce it by 20-25%, Estimate of on-site renewable energy generation potential: 35-45 MWh annually.

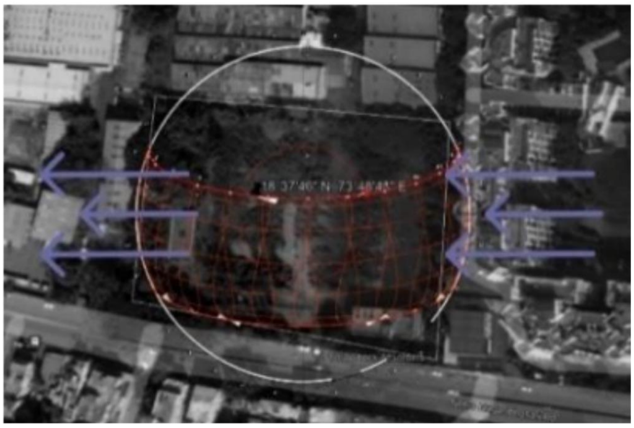
Specific Target for the Project: IGBC Green Homes, Climate Responsive Design, Reduction in cost after post

maintenance of operation.

Timeline: The project is in concept and Design stage and approximately it would take 46 months.

Construction Budget: The preliminary construction cost is approximately around 223 Crores INR

Pimpri-Chinchwa site imges:



4. Performance Specifications

Wall	U Factor = 0.745 W/m2 K (Exposed) 2.64 W/m2 K (Under Shading)
Roof	U Factor = 0.585 W/m2 K
Glass	U Factor = 3.8 W/m2K, VLT = 56%, SHGC = 0.45, Single Glazing Unit (Viridian EVantage BlueGreen #2 6mm)
Lighting Power Density (LPD)	3.5 W/m2
Light Fixtures	Philips Luminaire DN125B D234 and DN125B D187
Equipment Power Density (EPD)	29.5 W/m2 (24 Hour)
HVAC Systems	5 Star rated Split AC, Seasonal COP 4.6, Clubhouse – VRF System with R410A refrigerant, ODU of 6, 12 and 18 HP, Cassette AC of 2.0, 2.6, 3.3 and 4.12 TR
Resultant EPI	41.24 kWh/m2 (most economical design case) 33.18 kWh/m2 (best design case)

Fig: Building envelope details

Electrical:

Brand	Nissar
Rating	1500KVA,2000 KVA
Phase	Three Phase
Frequency	50 Hz
Type	Oil cooled

Fig: Transformer specification

Brand	Kirloskar
Genset Rating KVA	110KVA
Phase	Single Phase
Voltage	240Volt
Frequency	50 Hz
Noise level	Silent

Fig: Diesel generator specification

Plumbing fixture specification table:

Fixtures	Model	Catalog No	No. of Units
Water Closets	Jaquar Metropole	FLV-CHR-1089N	650
Health Faucet/Bidet, Hand-held spray*	Hindware Health Faucet ABS + ECO 365 AERATOR	F160038	650
Faucet*	Hindware Pillar Cock (Foam Flow) + ECO 365 AERATOR	F200001FT	650
Kitchen Sink*	Hindware Sink Cock with Swivel Casted Spout + ECO 365 AERATOR	F740024	320
Showerhead* /Hand-held Spray*	Jaquar Airshower	OHS-1709	650

5. Goals

SEGMENT	GOALS	STRATEGIES	ACHIEVEMENTS
Architecture:	Maximization of Passive System Design.	CFD analysis for air movement across building envelope. Selection of energy efficient material for wall roof and glass.	Service core shifted for wind estate ventilation. Parametric facade design. Design of green terrace garden proposed
Energy Performance:	Base case: 96 kWh/m2/Yr. EPI Target: 30 – 40 kWh/m2/Yr. RE Generation maximization.	30 – 40% Demand Reduction by passive and active measures. 10% overall energy reduction through energy profiling app. RE generation and business pan for Net Zero.	EPI achieved: Moat efficient: 33.76 kWh/m2/Yr. Most economical: 41.24 kWh/m2/Yr. RE generation: 4 scenario explored.
Water Performance:	Reduction of water demand by 50%. Ground water recharge.	Utilization and maximizing Rainwater harvesting, Use of star – rated efficient plumbing fixtures to prevent leakage and achieve superior efficiency	46% water demand reduction achieved. Net Water positive achieved by putting addition water source : Water harvester
Health and Well-Being:	Right sizing active HVAC system for tower and clubhouse.	Coupling of air conditioning with fan for tower. Vrf and evaporative coolinf ystem for clubhouse.	Running star rated split Ac at higher set point with BLDC fan. Low cost Evaporative cooling strategy in club house
Innovation:	Post Occupancy Benchmarking, Building Digital Footprint, Social engagement for Net Zero	Cloud - based UI and Benchmark, Forecast & Analysis using ML, Live reading & automation with IoT	Operational prototype developed. Appreciation received at ISHRAE and ASHRAE platforms.
Engineering & Operations	20-25 % common area demand reduction. Targeting 40-50% near Zero Waste (Organic) for Landfill.	Deeming control and occupancy sensor. Source segregation and recycling through organic waste composter and vermi composter.	25.01% common area demand reduction achieved. Achieved 60% near Zero Waste (Organic) for Landfill.
Marketability and Scalability:	To upscale the idea and unique selling proposition.	Marketing survey and USP for savings, comforts and brand.	Scalable cloud platform development. Terrace garden premium floor.
Resilience:	Power, water, network and fire resilience analysis.	Power backup estimation. Minimum 2 days water storage, fire system and Wi-Fi sizing	Diesel generator and solar battery sizing. Intelligent fire detection with automatic water sprinkler system.
Communication:	Climate awareness campaign and social media promotion.	Promotion through internal events, industry platforms and student body.	Social media reach: 276+ followers.Team journey coverage by news channel: SAPTAK NEWS, wall writing and video promotion.

6. Design Documentation

Architecture Design:

The intent of architectural design is improving thermal comfort of the place by using passive design strategies for better energy efficiency, improving the health & well-being quotient by improving the air-quality, enhancing day-lighting and natural ventilation in the complex, enhancing the greens in the complex for better user experience and livability and using natural ventilation strategies to enhance building performance and reduce the energy consumption for HVAC thereby reducing the total energy demand.Base architectural plans are evaluated for area of improvisation and a design architecture case proposed for getting the desired results as intended. Integrated approach using solar radiation, CFD analysis etc. is used for sound building science and to illustrate responses to other building systems and contests.

Figure 1.1: Comparatives of base and design

Figure 1.2: Basis for proposing a central

To better achieve the outlined goals, variety of changes are proposed in the existing layouts as described in figure 1.1& 1.2.

Shifting service cores (located in the center) to the sides thereby creating a large courtyard with greens that punctuate thru the entire building section as illustrated in figure 1.2.

It thereby creates a wind stack ventilation & introduces daylight in inner parts of the complex which enhances thermal comfort energy-efficiency, healthiness quotient of the complex.

The wind- The wind-stack ventilation shown at figure 1.2 helps improving the natural ventilation to all the residential units as well as the parking/retail podium levels below.

The courtyards and appropriate spacing between the residential towers allow free and abundant natural flow of air in all the parts of the complex including parking podiums levels thereby reducing the claustrophobic effects and instead actually improving the air-quality and thermal comfort of the place.

Figure 1.3: Comparatives of base and design architecture cases

The building concept revolves around net zero sustainable living with enough landscape and services provided to the residents of the building. Building is oriented in such way that it promotes passive design strategies contributing towards achieving net zero energy efficiency goals.

The design uses adequate ventilation strategies that involves dividing the apartment blocks into 4 towers, encompassing a large courtyard in the center of each of these towers, and analyzing the building dynamics in relation to solar and wind flow analysis. Tower A and B has 3 BHK and 2 BHK whereas Tower C and D has 1 BHK and 2

Garden Podium Residential Floor

Figure 1.4: Comparatives of base and design Architecture cases: Garden Podium level

By providing ample amount of day light and soft landscape on the podium floor an ecofriendly living space is achieved which in turn contributes to health and wellbeing of the users of the designated space. Public amenities like club house , swimming pool , joggers track (shown at figure 4) all contribute towards best marketing strategies thereby improving user experience and adds to the functional aesthetics of the complex.

The heat island effect is reduced largely by planning of large green areas at this podium level as also central courtyards in the towers that enhances the thermal comfort on all floors and improves daylighting of the place. The comparatives of the existing base case and proposed architecture case shows an enhanced greens courtyard space in the core of Towers C & D and exterior of Towers A & B. This improvements are done with minimal changes to the existing base design.

Parametric Facade Design

Parametric Modeling is becoming increasingly popular in architecture design. This approach differs from typical modelling systems in that 'elements of design interact and change in a coordinated manner.'

The most notable aspect of parametric modelling is the ease with which the design purpose may be changed by changing the parameters As a result, this approach has the potential to make the design process more efficient and manageable. It can assist designers in more precisely and simply meeting the design purpose.

The formula, which demonstrates how the parameters are connected and interact with one another, is another important component of parametric modelling. As a result, when one of the parameters is altered, the others follow suit.

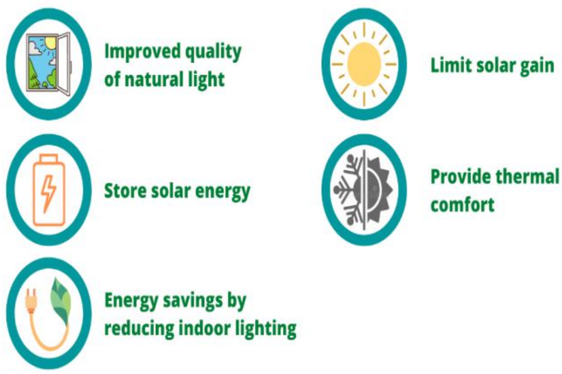


Fig 1.5:Objective of Parametric Façade Design

This technique is more than just a time saving; it also provides a variety of methods for individuals to experiment with.

The kinetic parametric Facade system is based on Masharabiya shading system of Al bahar Tower in Abu Dhabi which helps reduce solar gain by 50% (Client, 2012) on the surfaces of towers exposed to maximum solar radiation thereby reducing energy requirements for air conditioning. The responsive facade system uses computational design involving simulation of the facade panels in respect to solar exposure throughout the day, Month and year. The screen is mounted on an independent frame and functions as a curtain wall.

Figure 1.6 and 1.7: Comparatives of building with parametric façade and without parametric, Elevation of parametric facde facade

Solar radiation Studies and Proposals:

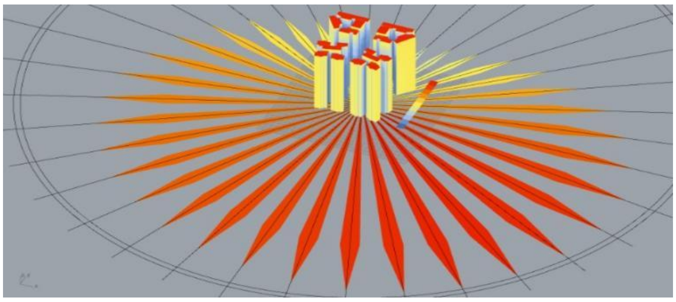
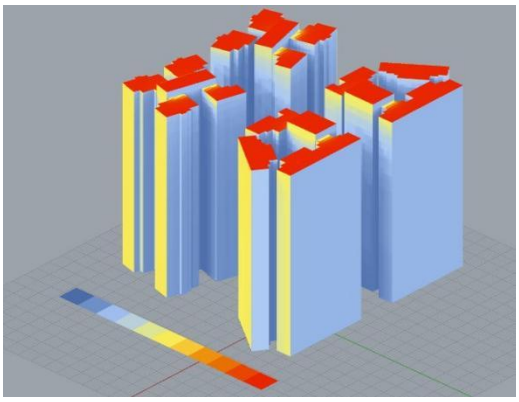


Figure 1.8: Solar Radiation Studies



The building orientation focuses on getting adequate daylight into the residential units but at the same time keeping the glare out. According to the solar radiation diagrams (fig.5), we understood that south and south-east directions gets most solar radiations throughout the year , these are offsetted by using composite wall & glazing recommendations as outlined in the energy segment of the study. The other energy efficient strategies are using AAC blocks for walls, horizontal & vertical shading devices, roof insulation and efficient glass systems. The window sizes are further moderated for the desired results.

Computational Fluid Dynamics (CFD) studies for Base & Design Architectural cases: (External CFD)

Computational Fluid Dynamics (CFD) studies illustrates how certain minimal changes in the base design viz. accommodating a central courtyard as discussed earlier, can effectively improve natural ventilation of the place thereby enhancing the overall comfort & performance of the building in terms of energy-efficiency & improving the healthiness quotient of the place. Natural Ventilation is used as a core passive strategy in the design to enhance the climate-responsiveness of the complex.

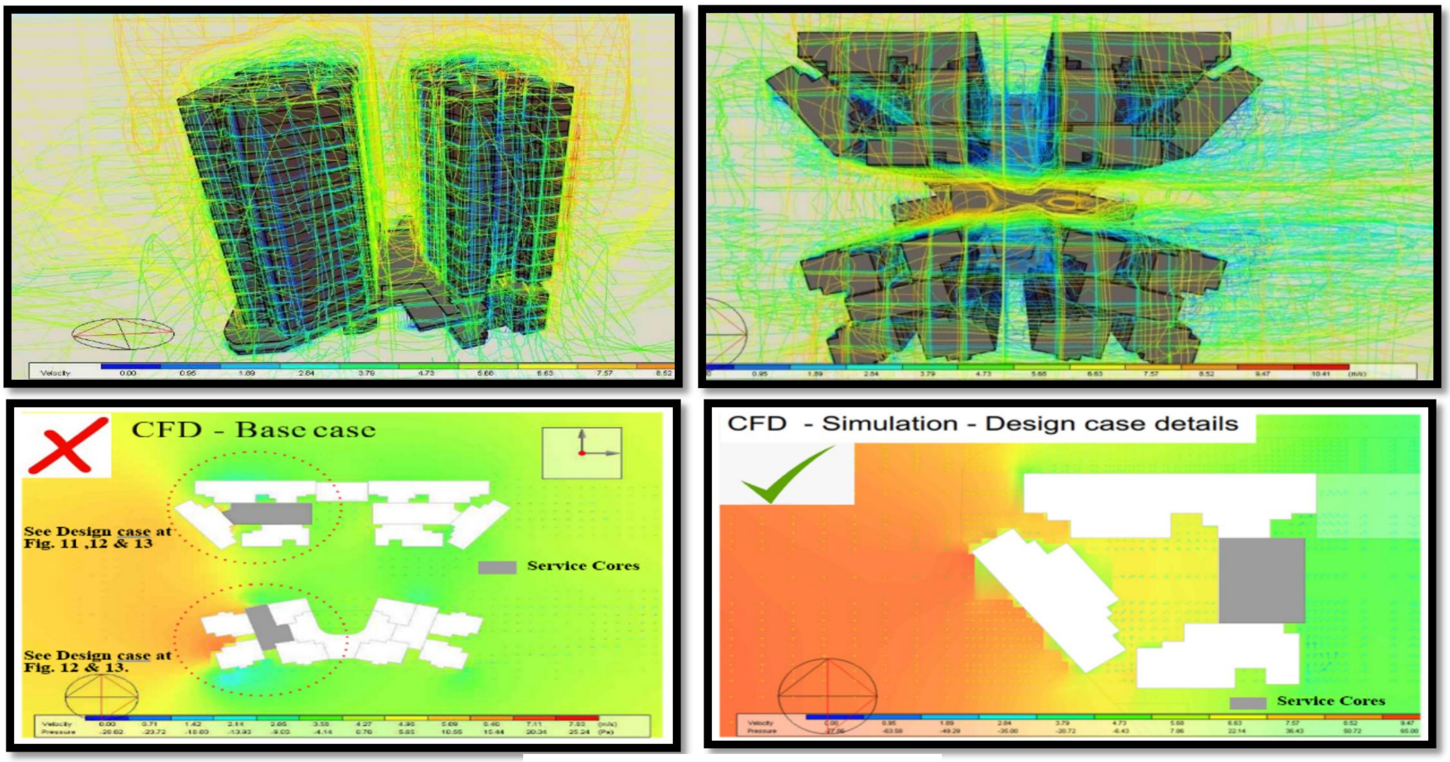


Figure 1.9: CFD Studies

Creating interactive spaces

A house is the most important need/ pre-requisite for any person. It not only provides dignity of life but also provides for the growth and development of the family and future generations. It provides a sense of peace and security to all. Therefore, having a good house which is adequate, decent, resilient and sustainable is crucial to the well-being of the people. This also leads us to the aspect of quality of life in the neighborhood. While there are several indicators for quality of life indices, some of the most important factors are wealth, employment, the environment, physical and mental health, education, recreation and leisure time, social belonging, religious beliefs, safety, security and freedom. Keeping this in mind, while designing a housing complex with over 484 number of units, it is paramount that aspects of recreation, leisure, social belonging and freedom is addressed through our design. The design is centered on the idea of sustainability and net zero building but since it is a high-rise building, it is of utmost importance that there are adequate spaces for recreation and leisure for people on the higher floors.

If we look the current development paradigm and also the culture of the people, there is very less interaction that is happening at the building and the neighborhood levels. The culture of the society has changed where the nuclear family system is being practiced extensively and furthermore, the parents of the children are extremely busy with no time to engage with the child for long periods. With the covid pandemic, the aspect of work from home has brought to light the need for areas of respite/ green lungs where the families can go and relax. Having understood the need for green lungs closer to their homes, the team felt that it is important that certain leisure/ recreational spaces are created at higher levels which can be private spaces exclusively for the units around it or can be open to those who want to have a buy in to use the space. Therefore, through design, the team has brought in the concept of creating terraces at three floors in the space between the two towers. See image for reference.

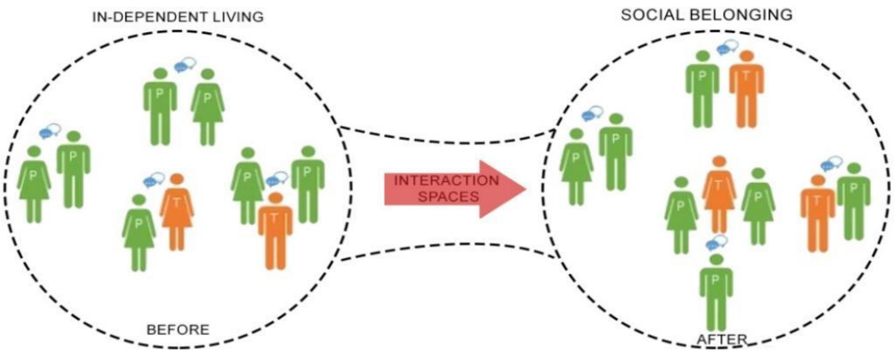


Figure 1.10: Creating interaction spaces for social belonging

Green cells inspire grey cells and also the children have spaces to play very close to their homes rather than to go elsewhere. The need for such spaces has become more relevant and critical for the well-being of future generation. These terraces are designated as “Sun Decks”, a space for interaction between families, neighbors, with children’s play areas, a barbeque stand etc. along with a lot of greenery and other simple facilities that would lead to creation of a comfortable space for the residents of the building.

We acknowledge that there is a cost factor in this new idea. However, having undertaken the cost estimation of the terrace, each terrace costs an addition of about 30 lakhs (12 +18) rupees. This additional amount can be collected from those flats who have access to these terraces which will be sold at a premium cost thereby making it profitable for the developer to undertake this venture while improving the quality of life and lived experiences of the residents.

The Design of green terrace

The terraces are planned to connect two towers A and B, and connect towers C and D. The terrace floors are planned between every 7 units - 8 floors with a height of over 25 m between the two terraces. The floors that have these terraces are the 3rd, 11th, 19th floors in a23 storeyed building.

The terraces span for 12m – between towers C & D thereby creating the green open space at higher levels. The proposed design is supported using coffer slabs (that rest of the shear walls) that will facilitate supporting the structure through this span as well as provide the clear space that will not hinder view or cause any spatial disruptions.

Between towers A & B the span is over 22 m and therefore we recommend the columns as designed to follow the bio-mimic style of the trees and also these structural members succeed in handling the load of these terraces.

The green terrace has seating spaces for adults and also has play areas for children as there are no exclusive playgrounds for the young. The terraces prove to be a safe place wherein the parents can supervise their children and make sure they are safe while playing. Required safety measures such as providing glass railings for 1.5 m height is made mandatory to ensure the safety of the children using the space.

The floors which are directly connected to the green terrace will be treated as premium floors and the transition can also be observed in the cost of the floor units.

Base Plan

Proposed case

Figure 1.11. Green Terraces – Base Plan vs Proposed

Energy Efficient materials used:

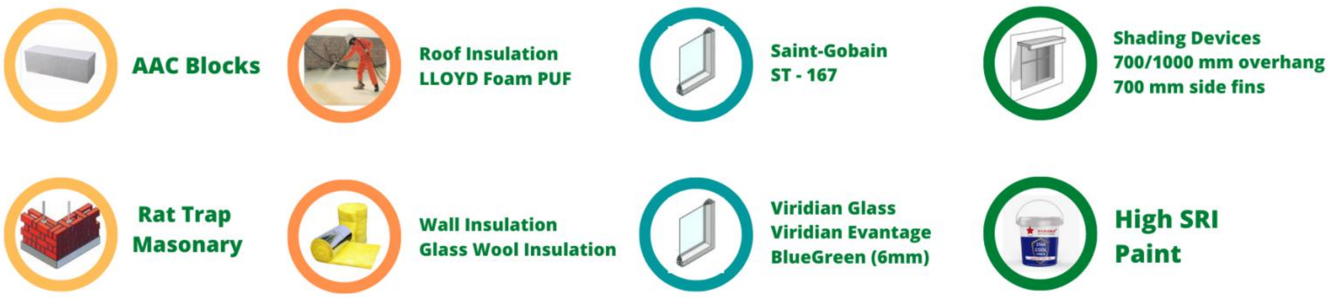


Figure 1.12: Energy Efficient materials used

Energy performance:

In this segment we have simulated the energy performance of our building in 10 different cases with combination of different interventions to minimize the EPI value of the building. Then, we have performed daylight simulation in order to choose the ideal glazing for the building in order to get maximum daylight and save the energy consumed by artificial lighting fixtures during daytime. Later on, we have simulated our artificial lighting model in order to get the Lighting Power Density (LPD) of the building. Lastly, we have designed rooftop PV Generation system and explored different scenarios of generation for Net Zero.

Energy Analysis

Our Pune location project consists of 4 towers (A, B, C & D) in two phase construction. At this stage our project partner is in process to develop Tower A along with common facilities. Orientation of tower A isnorth faced and building modelling has been done in Design Builder for Energy Analysis.

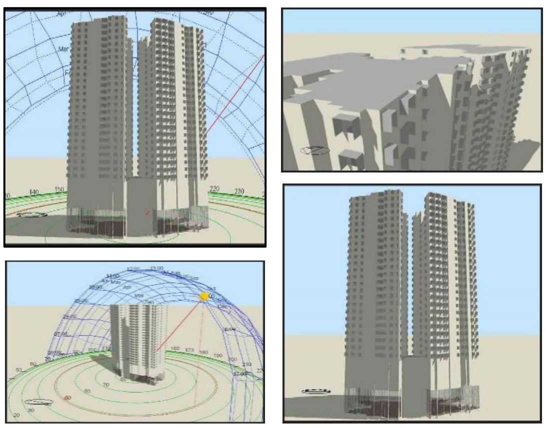


Fig 2.1: Design Builder Model

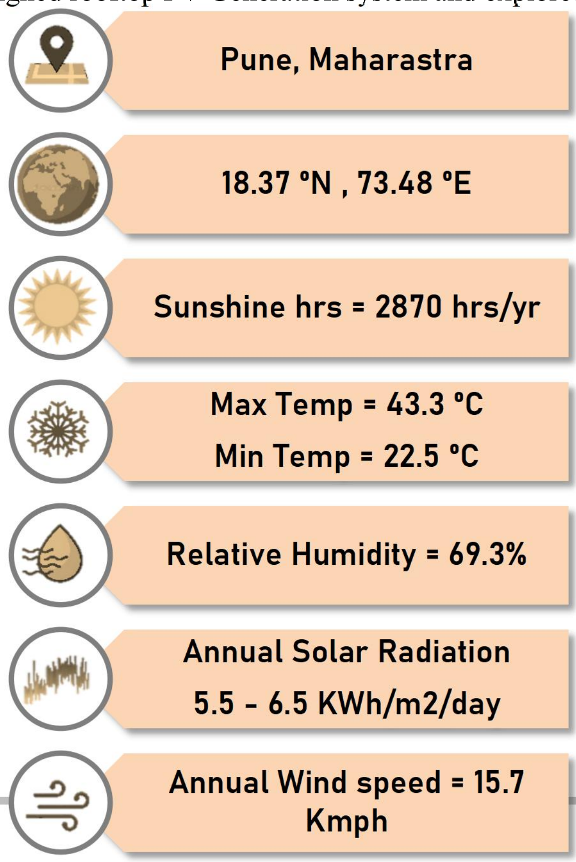


Fig 2.2:Design Constraints

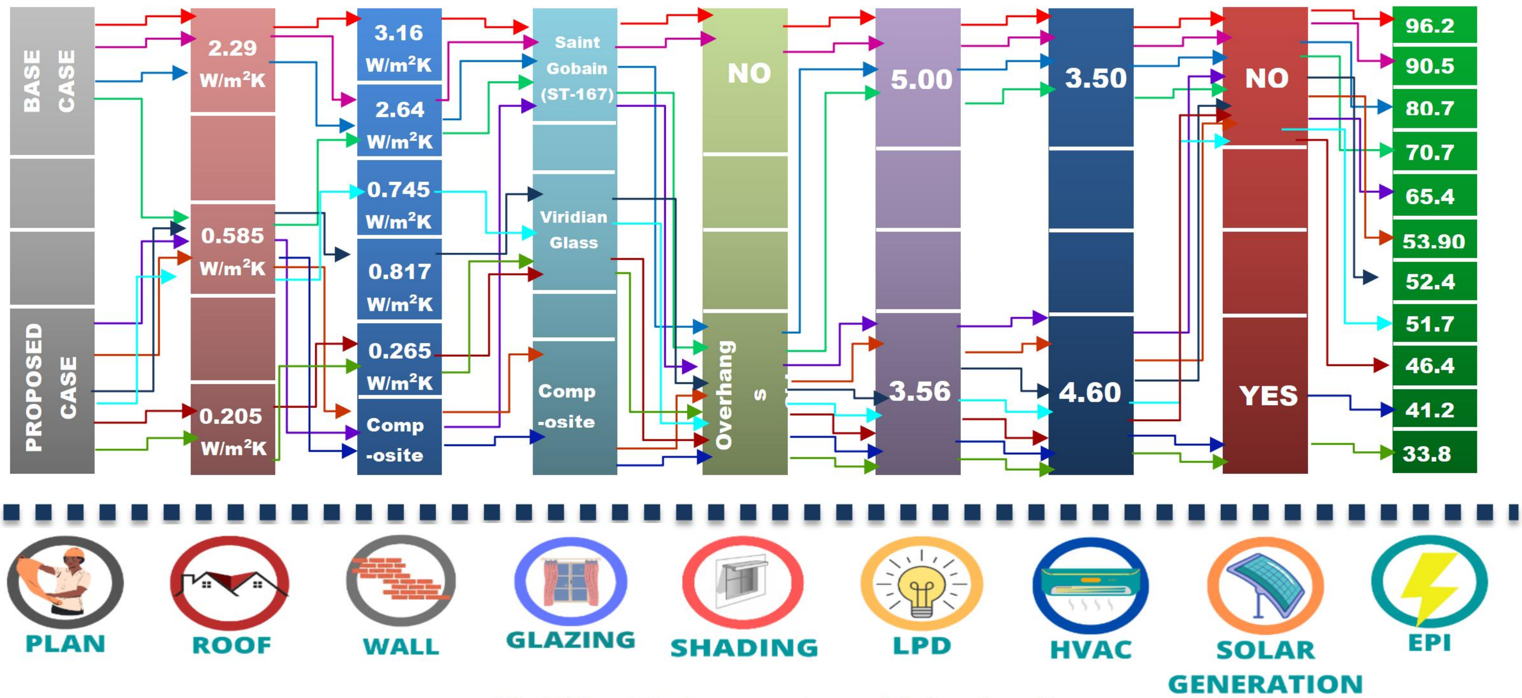


Fig 2.3:Input Design parameters and their end results

Here we have simulated different design cases by the intervention of construction materials of wall and roof, glazing, LPD, HVAC and other parameters. We have also simulated the composite case design which will be economically affordable to be implemented.

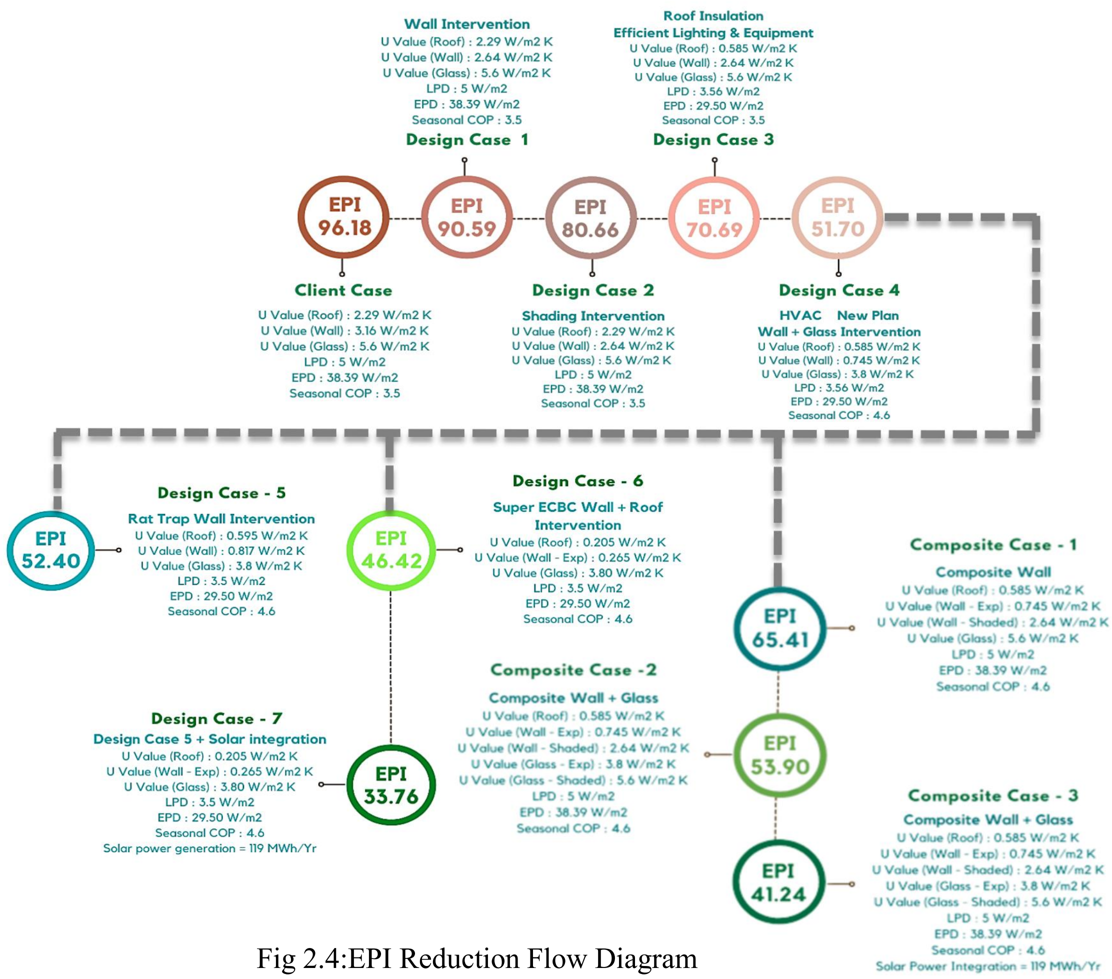
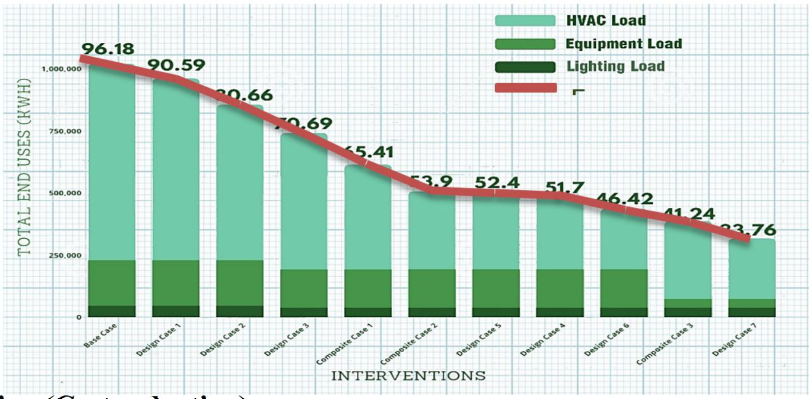


Fig 2.4:EPI Reduction Flow Diagram



Composite material selection (Cost reduction)

Fig 2.5: Loadwise EPI Distribution

Fig 2.6: Proposed Cases

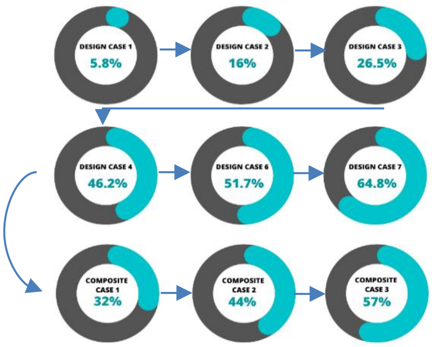


Fig 2.7:Percentage EPI Reduction

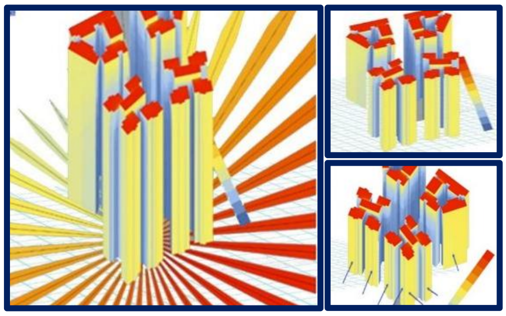


Fig 2.8: 1.Irradiation analysis of towers, 2.Radiation rose diagram, 3. Arrow marked walls with the highest Solar Gain potential

Design Case 4 included usage of construction materials with high Thermal Mass and efficient Glazing Details which led to an increase of the overall project cost. Team Nivas 2.0 is proposing a better strategy of using enhanced construction materials on only walls which are facing the highest amount of solar irradiation throughout the year.

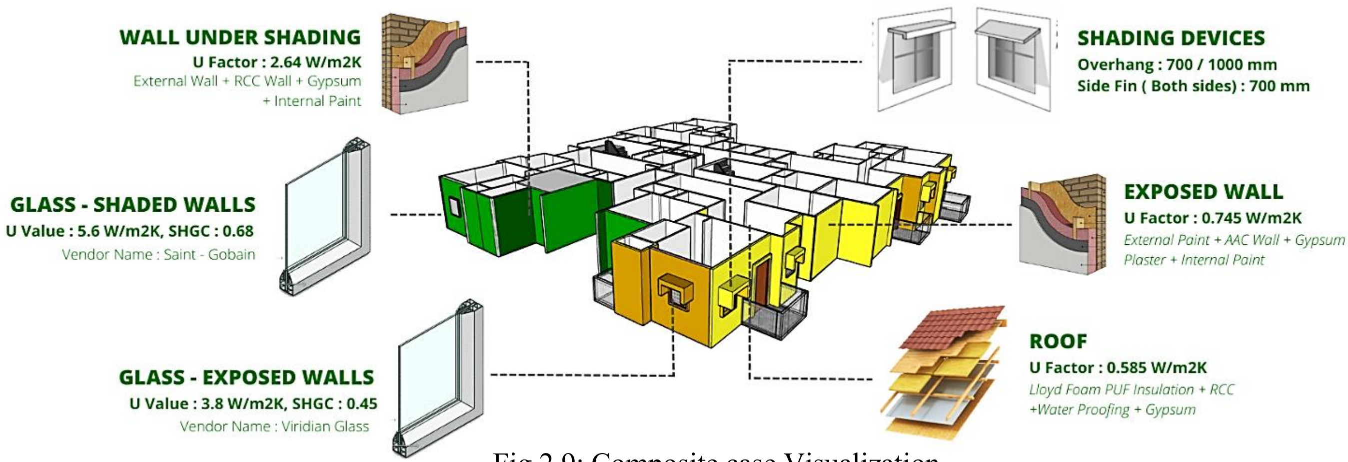
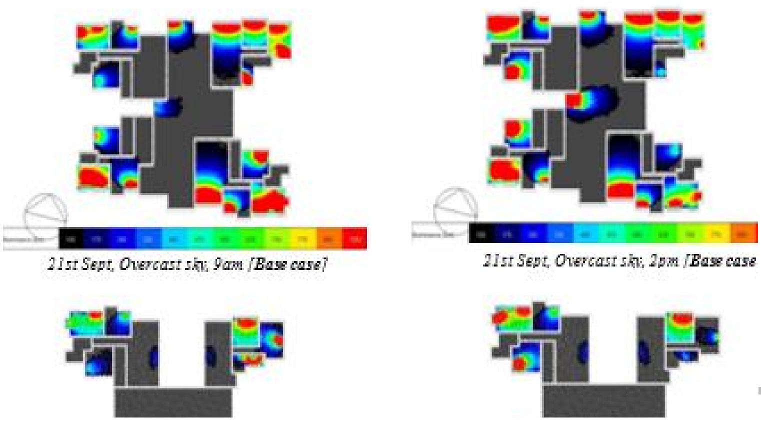


Fig 2.9: Composite case Visualization

Daylight simulation

Daylight stimulations:



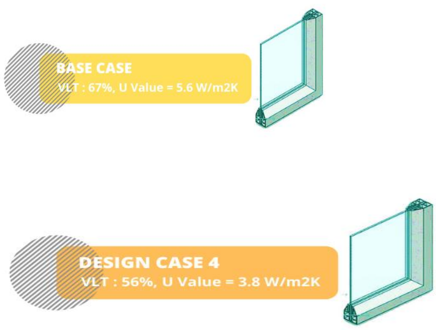


Fig 2.11: Gacing Parameters

Fig 2.10: Stimulations

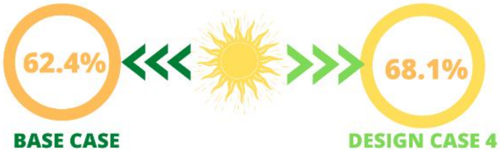


Fig 2.12: Average Daylight area percentage

100 to 1000 lux is represented in the simulation results. Glare observed in the base case is controlled by mutual shading of 4 towers and our selected glass with shading is providing 2.2% extra daylight area without creating discomfort to the eye. Hence we have selected Viridian glass since we are getting more Daylight area so that at daytime more energy can be conserved.

Artificial lighting design

Artificial lighting is an important parameter to enhance the visual comfort of the occupants. Since our main objective is to design a Net Zero Building, we have integrated highly energy efficient LED fixtures to reduce the overall carbon footprint and Lighting Power Density (LPD) of the building. The proposed lux levels of different rooms are considered as per IS 3646 standards.

The number of luminaires are calculated by the formula:

n = (Floor Area * Lux required)/ (UF * MF * Lumen per fixture)

The simulations are performed on **DIALux evo.**

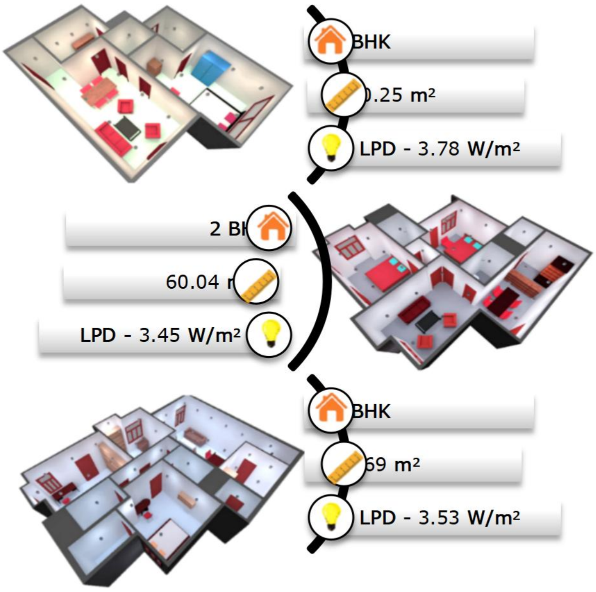


Fig 2.12: Flat wise LPD distribution

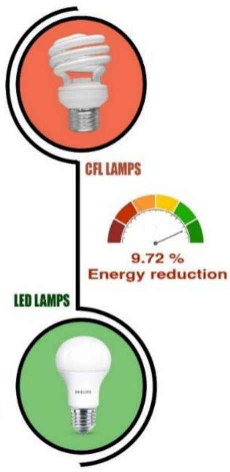


Fig 2.13: Comparison between CFL and LED

Solar generation potential

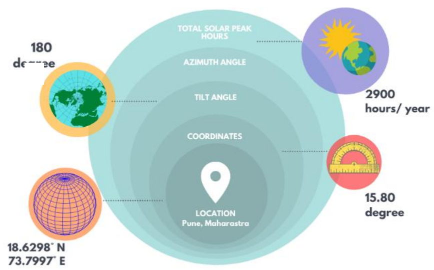


Fig 2.14: Design

As the project approaches Net Zero, the onsite solar generating potential is estimated in order to match therequirements. In this segment we have designed solar generation in four scenarios.

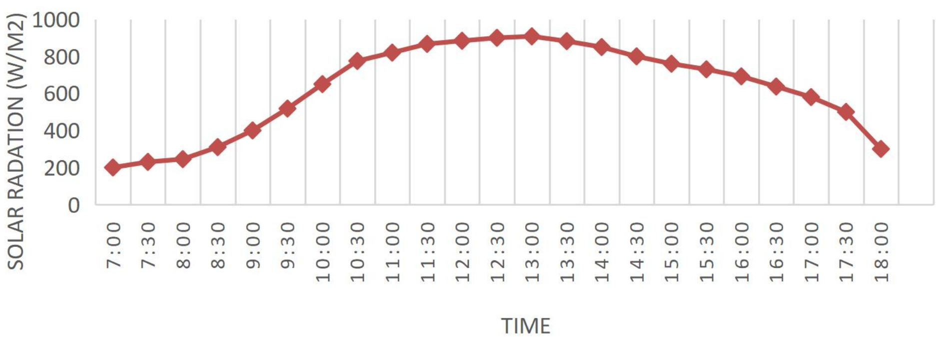


Fig 2.15:Radiation range in Pune

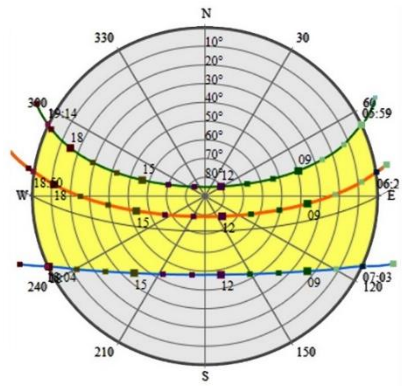


Fig 2.16:Sun path diagram of Pune

Scenario 1: Rooftop solar generation without superstructure

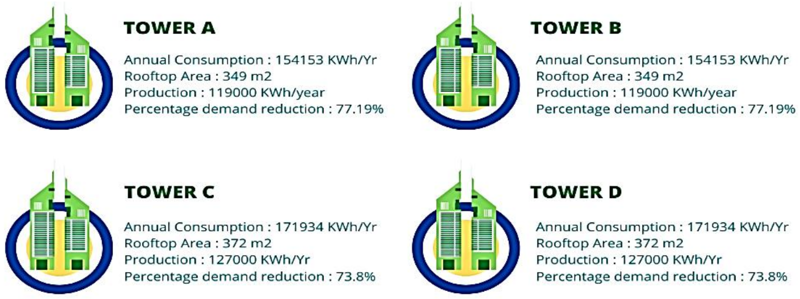


Fig 2.17:PV design Input and Output parameters

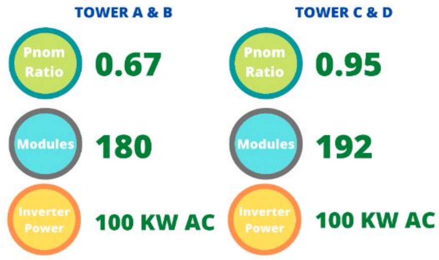


Fig 2.18: PV design simulation results

Scenario 2: Offsite solar generation

As the available areas are not sufficient for generating the potential requirement of the building, we can integrate offsite solar generation in our project to achieve net zero. The gap between the Energy production and requirement is to be fulfilled by an external Renewable energy generating plant which will not be directly connected to the grid, they have batteries which has the capability to store DC Energy. This plant might be at any other location within the state. In this way we can make our project completely self-sufficient in terms of energy consumption. We require a plant size of 160 MWh to fulfil the deficit energy requirement.

TOWER	ENERGY CONSUMPTION (KWh/yr)	ENERGY PRODUCTION (KWh/yr)
A	154153	119000
B	154153	119000
C	171934	127000
D	171934	127000

Table 2.1: Energy table

Total energy consumption of the project = 652174 KWh/annum
Total energy produced using Solar PV = 492000 KWh/annum
Deficit in energy = (652174-492000) = 160174 KWh/ annum

To reach the above, we need to install 160174 / 1787 = 89.63 KWp
Ground area required for 89.63 KWp SPV power plant = 143.41 m^2
Cost of the 89.63 KWp project (@ Rs 38000/KWp) = Rs. 3.4 Crores

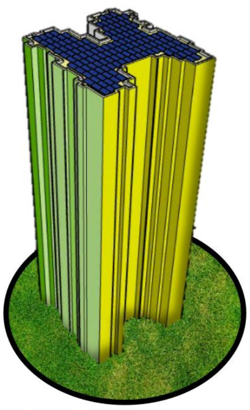


Fig 2.19: Rooftop solar panel installation model

Scenario 3: Partial Open Access Power Purchase Agreement

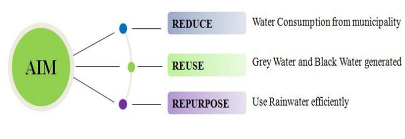
We have one more scenario as Partial open access power purchase agreement. Now, our building is having an EPI reduced up to 33.76, but we are still a way away from achieving net zero. In order to fulfil the deficient energy here we will come into agreement with an external PV generation plant to purchase the deficit power and make our building self-efficient. Therefore, we have to buy 160174 KWh power from external plant by Open access power purchase agreement at some pre-determined rates by the competent authority (Photoetch Energy Pvt. Ltd.) located in Pune, Maharashtra.

Scenario 4: Complete Open Access Power Purchase Agreement

Lastly, we are proposing a case in which the client doesn’t want to install the rooftop solar plant for initial cost controlling. In that case, the developer have to purchase the complete power requirement of the building from external agencies or plants which may be located inter-state or inter-nation. In this context, the developer has to buy 652174 KWh energy per annum in order to achieve net zero.

Water performance:

Water is an essential commodity required for proper thriving of a society. The quality and amount of water in a given area can often have a significant impact on a buyer's decision. As a result, "zero-waste" solutions have been created to meet water needs, and efficient wastewater treatment plants have been proposed to preserve the best possible quality of water for various uses such as drinking, home chores, building maintenance, gardening, and so on.



Water fixtures: According to NBC 2016 standards, the water requirement per capita per day is around 135 litres. Using efficient water plumbing fixtures we reduced total water consumption per capita per day to around 89 litres. Our overall occupants is about 2813 regular occupants which includes 60 (full time caretaker), 80 (part time caretaker) and taking 5% of total occupants as 130 (guests).

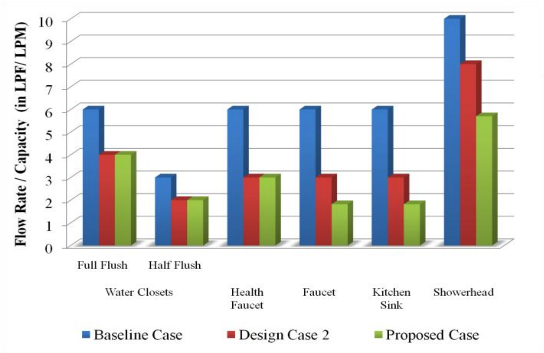


Fig3.1: Graphical comparison between baseline case, Design case 2 & Proposed case

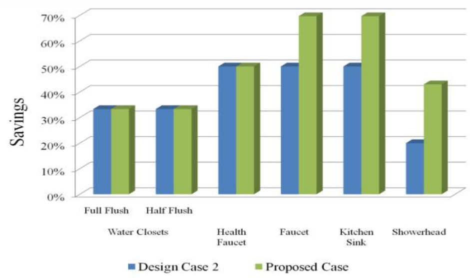


Fig 3.2: Savings comparison between Design case 2 & Proposed case

As per standard norms, our basecase value is around 326 KLD, for regular occupants. Basecase water usage per person per day is 140.5L out of which 20L is for drinking and cooking purposes. Using efficient fixtures along with aerators and closets our design case value reached around 175 KLD, which is shown in Fig 3.1. Proposed case water usage per person per day is around 91.25L out of which 20L is for drinking and cooking purposes, as shown in Table 1. Hence, we drop down our annual water savings around 46%.

Type of person	Annual total water need (KLA)	Daily total water need (KLD)	Total Water need	Potable Water	Grey water	flushing water	Number	days	Daily (KLD)			Annually (KLA)		
									TP	TG	TF	TP	TG	TF
Resident	82.6×10^3	226.3	91.25	20	58.5	12.75	2480	365	49.600	145.080	31.620	18.1×10^3	53×10^3	11.5×10^3
Care taker full time	1.9×10^3	5.475	91.25	20	58.5	12.75	60	365	1.200	3.510	0.765	438	1.3×10^3	279.23
Care taker	1.2×10^3	3.500	43.75	20	11	12.75	80	365	1.600	0.88	1.020	584	321.2	372.3
Guest	4.3×10^3	11.862	91.25	20	58.5	12.75	130	365	2.600	7.605	1.657	949	2.8×10^3	605
Shopkeepers	891.06	2.441	38.75	20	6	12.75	63	365	1.260	0.378	0.8	459.9	137.97	293.19
Total (Kilo litres)	**91×10^3**	**249.6**	**Total (Kilo litres)**						**56.26**	**157.45**	**35.87**	**20.5**	**57.5**	**13.09**

Table 3.1: Water Demand Design Case Table

Rainwater management: Rainwater harvested from rooftop, hardscape and softscape areas are the main source of rainwater collection. Based on the past 5 years record our annual rainfall is 1.45m. Annual rainwater collection from rooftop is around 6022.37 cubic metre, from hardscape is around 7254.3 cubic metre and softscape is around 531.22 cubic metre, as mentioned in Table 5. From the above table the annual average rainfall for the last 5 years is around 1.45m. Total Run Off Area in m^2 = **9523 m3.**

Rainwater harvesting surfaces	Area (m^2)	Runoff coefficient	Annual rainfall of site (m)	Harvested rain annually (kilo Litre/m^3)
Roof Surfaces	4372	0.95	1.45	6022.4
Hardscape areas	5266	0.95	1.45	7254.3
Softscape areas	1465	0.25	1.45	531.2

Table 3.2: Rain water collection record

Sr. No.	Non Roof Area	Runoff Co-efficient	Area (m^2)	Impervious Area (m^2)
1	Hardspace area	0.95	5266	5003
2	Softspace area	0.25	1465	366
		Total	**6732**	**5369**

Sr. No.	Roof Area	Runoff Co-efficient	Area (m^2)	Impervious Area(m^2)
1	Tower A	0.95	505	480
2	Tower B	0.95	505	480
3	Tower C	0.95	664	630
4	Tower D	0.95	664	630
5	Pordium area	0.95	2035	1933
		Total	**4372**	**4153**

Table 3.3: Runoff coefficient

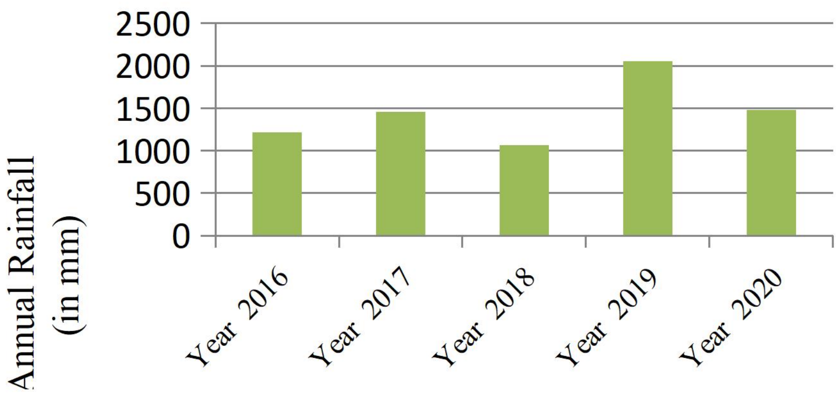


Table 3.4: Annual rainfall

Water balance Chart

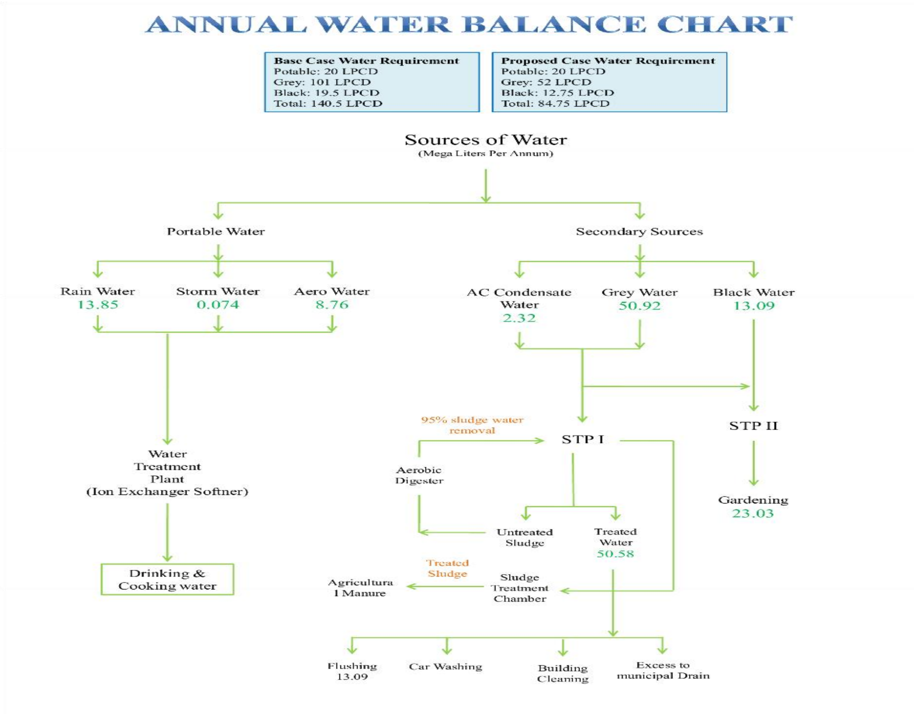


Fig 3.3: Water Balance Chart

Our primary source of water will be rainwater, stormwater and aerowater, which will be treated via Ion exchanger and used for drinking and cooking purposes. This helps in removing calcium and magnesium ions by replacing them with sodium ions. Our secondary source is AC Condensate water and greywater which is sent to STP where 95% of sludge water is removed. Treated water is used for flushing, car washing, building cleaning and excess to municipal drains. The leftover extract from the sludge treatment chamber is used as agricultural manure. Black water is treated and used for gardening. Flowchart representation is shown in Fig 3.

Sewage treatment plant

We encourage users to control resources and wastage of water because of the negative effect it has on the environment. These are constructed to transform the raw sewage into an easier manageable waste and to retrieve and re-use the treated sewage water. The end products are sludge and treated sewage water. From the environmental standpoint the most important aspect of a sewage treatment plant is the proposed disposal or use of the sludge and the treated sewage water. We proposed SBR and MBBR sewage treatment plant, and on further case study we finalized SBR because of its affordability.

Sequencing Batch Reactor

Here the raw sewage passes through three stage screening that is coarse→ fine→ grit removal collectively called as sludge separators used to make treatment more efficient and then reaches the SRB tank. Further the partially filled reactor containing biomass assimilated to wastewater constitutes. Once the reactor is full it behaves like a conventional activated sludge system. There, aeration and mixing is discontinuous after which biological reaction is stopped. At the end a batch of wastewater flows to the equalisation basin. Basically SRB consists of 5 stages i.e. Fill, Aeration, Settle, Draw Off, Idle.

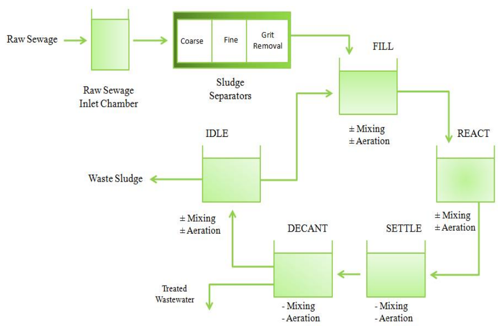


Fig 3.4: SRB Diagrammatic Representation

Net zero water approach

Based on our proposed solutions we concluded to be on the positive side to achieve a net zero water solution for this high rise multi-family housing building. Measures taken by us such as use of fully automated/wireless data communicated IOT water metre to spread awareness among users. Ultrasonic Technology to track real-time water usage and ensure uninterrupted relay of data to our IoT-based Cloud Consumer gets Monitor Consumption At every inlet in the house.

	MLA	MLA
	Basecase	Proposed Case
Annual Grey Water Demand	99.32	50.92
Annual Black Water Demand	20.02	13.09
Annual Potable Water Demand	20.53	20.53
Total	139.87	84.54
Rain Water Annual	13.85	13.85
Storm Water	0.074	0.074
Treated Grey Water	94.35	48.37
Treated Black Water	19.02	12.44
Annual Potable Water	20.53	8.76
AC Condensate Water		2.2
Total		85.69

Table 3.4: Net Zero Approach

Upon surveying the residential category options, we found WEGOT SMART WATER METERS. The construction is robust, having IP65 rain protection and fail – proof design due to no moving parts. Their ultraprecise metering excludes air flow and reverse flow for the most accurate flow reading, and uninterrupted monitoring is ensured with ultrasonic technology. Their user interface allows flow monitoring, remote inlet shutting, instant app notifications and direct bill payment. They also feature leakage alarms and have a well – managed logistics system.

Efficient water fixtures are used to save water. Through rainwater reuse and STP build-up we are able to save a certain amount of water. Hence, approaching a net zero solution

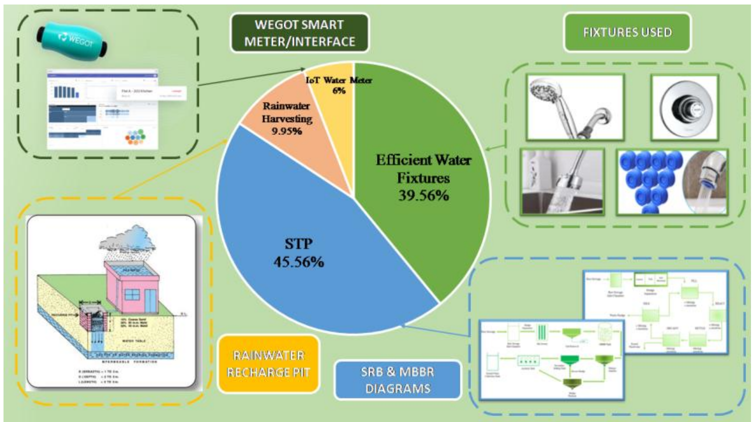


Fig 3.5: Net Zero Approach

Plumbing drawing:

We proposed tank size of domestic overhead tank should be 6m x 4.5m x 2.5m.

Where pipeline of domestic overhead tank is connected to wash basin and European water closet of toilet. Further flushing overhead tank to toilet for health faucets and water closets.. Domestic overhead tank is recharged with shallow well and treatment rain water. Flushing overhead tank get water from treated water storage tank from sewage treatment plant.

Fire overhead tank gets water from stp. Detailed plumbing drawing is as shown below

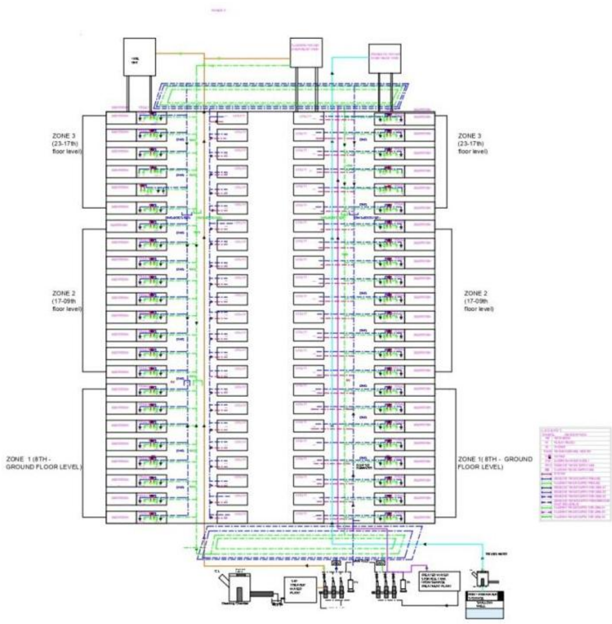


Fig 3.6: Plumbing drawing

Health & Wellbeing:

Every aspect of our life influences our state of Health & wellbeing. It's a complex combination of a person's physical, mental, emotional & social health factors.

Ventilation and Fresh Air units are designed to work in conjunction with air conditioning. It is also quite important to analyze the time during which the measures taken for better thermal comfort would be effective. This would also help us avoid any overdesigning in the project and reduce cost to some extent. For this, we used simulation to find the actual hours for which the measures need to be taken to ensure comfort.

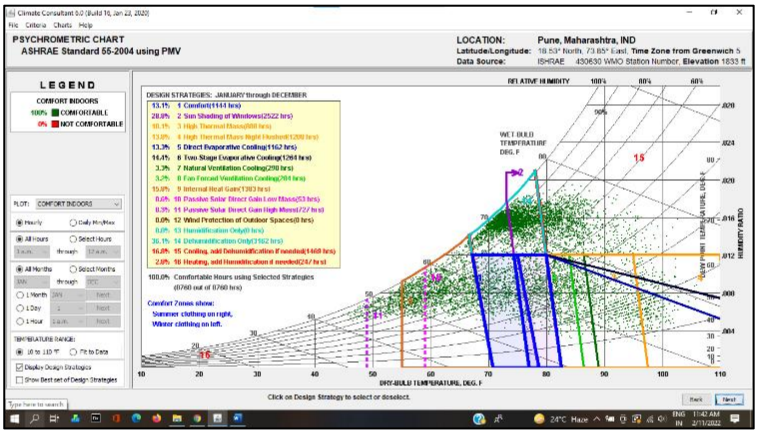


Fig 4.1:Psychrometric Chart

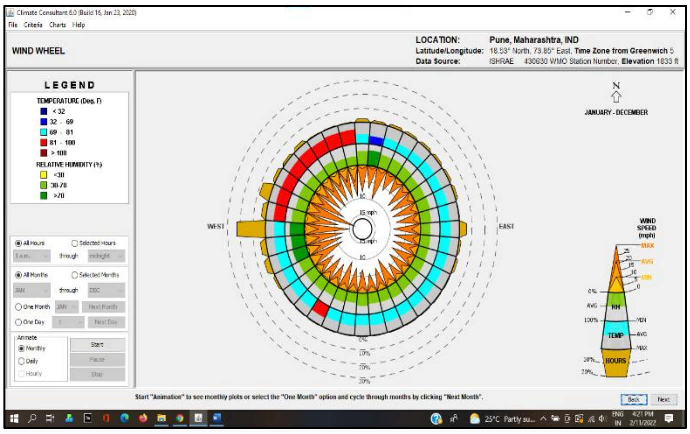


Fig 4.2: Wind Wheel formation for the site.

Software used- Climate Consultant 6.0

Standard Used- ASHRAE 55-2004 using PMV

The results obtained for Pune, Maharashtra are shown in the analysis. We found the exact hours of comfort with and without aid. Using this data, we can design the ventilation system and fresh air unit based on the following table:

Thermal Comfort Techniques deployed	Hours	Conclusion
Comfort without Aid	**1144**	The site won't need any aid for 13.1% of the total hours and will be comfortable
Sun shading of windows	**2522**	Providing shading on windows will increase the comfort hours upto 28.8% of yearly hours.
Evaporative cooling (inclusive of two-stage evaporative cooling, Direct evaporative)	**1264**	The swimming pool present on the site will increase the comfort hours cumulatively up to 14.4% of yearly hours.
	4828	**Comfort without Aid. 56.2% of yearly hours cumulatively**
Natural ventilation & Fan forced Ventilation	**574**	Predominant wind flow from the north & BLDC fan forced low cost cooling
Comfort with Aid	**3099**	For remaining of time, Mechanical aid is required for better thermal comfort. However, over a 24 HR period, as the temperature drops overnight, the coolness is absorbed and stored by the thermal mass in concrete and masonry.

Table 4.1: Thermal comfort techniques deployed

Different climatic segments

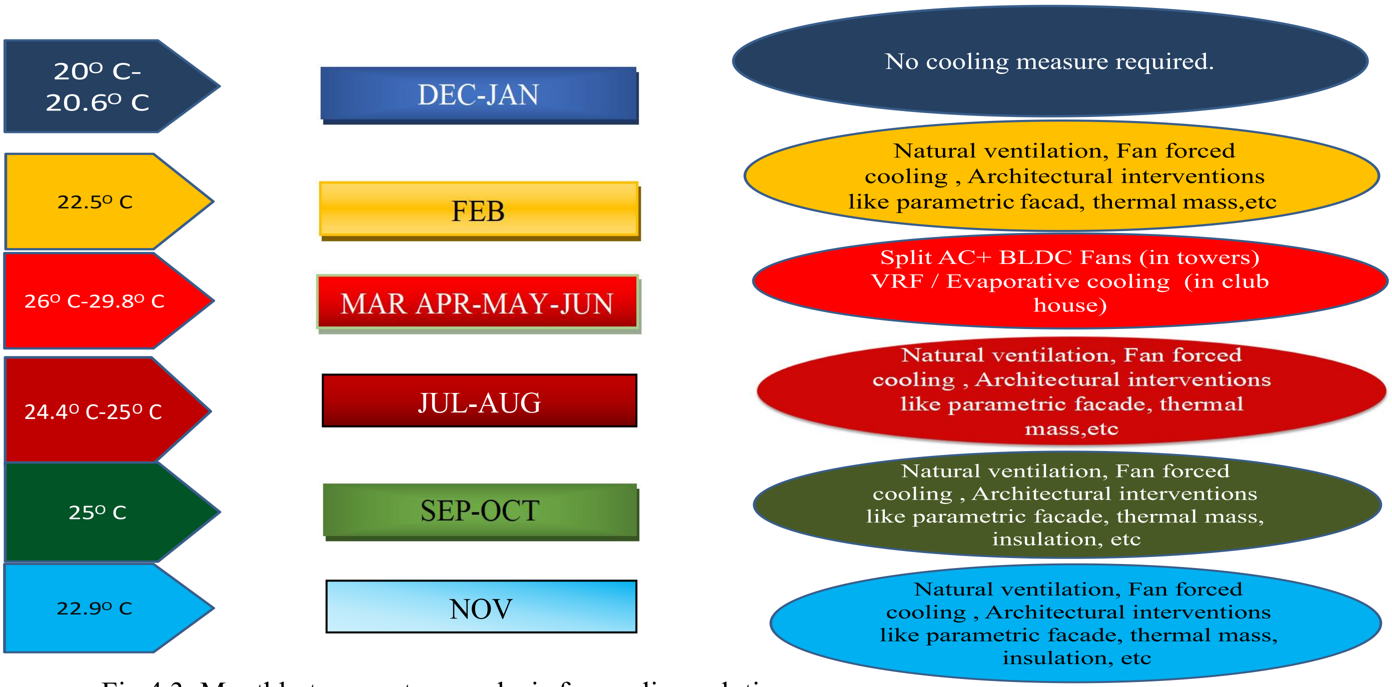


Fig 4.3: Monthly temperature analysis for cooling solution

HVAC System for towers

Split AC with BLDC Fan over just conventional Split AC system.

In todays time, people opt for ACs over fans for thermal comfort without keeping energy usage as concern. The following strategy of running AC & fan both can not only cut down the energy consumption & opex, but also can cater to the comfort need of the occupants. As per the study laid down by Center of Advanced Research in Building Science & Energy (CARBSE)-“AC on, fan speed between 1 & 3 is ideal”- for indoor conditions. With the same philosophy, in towers- if the AC runs with a higher set point of 27°C along with a BLDC fan running at 0.5 metres/second (2 in the regulator) indoor temperature can be lowered upto 3°C. This helps in power savings of 6% per degree increase in the set point temperature, as per BEE guideline.

BLDC fans over Induction Motor fans

Parameters	BLDC Fans	Ordinary Fans
Wattage (W)	28	75
Cost Price (in Rs)	3500	1800
Energy used per year (kJ)	134.4	360.0
Electricity cost per year (in Rs)	940.8	2520.0

Table 4.2: Comparision of BLDC and ordinary fan

Savings on power is 62% & on cost is Rs 1500 per year. Therefore, it is recommended to use a BLDC fans.

3D Software used	SOLIDWORKS
Simulation Software Used	Ansys
Simulation Model Used	ANSYS FLUENT

Mathematical Model 1 for CFD	**Ansys FLUENT Energy Model**
Mathematical Model 2 for CFD	Ansys FLUENT Large Eddy Simulation (LES Model)

Fig 4.4: Software used for CFD analysis

Internal CFD for a 1 BHK Tower C

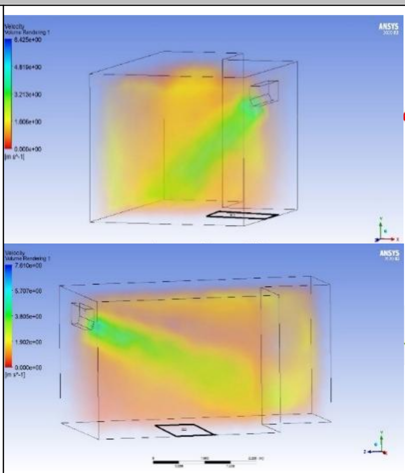
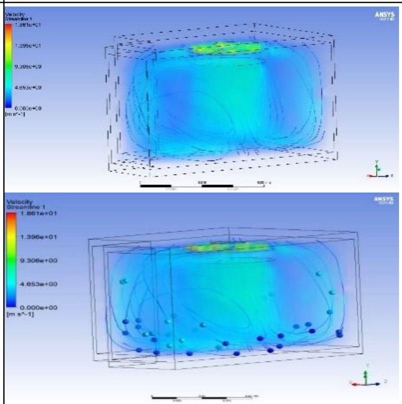
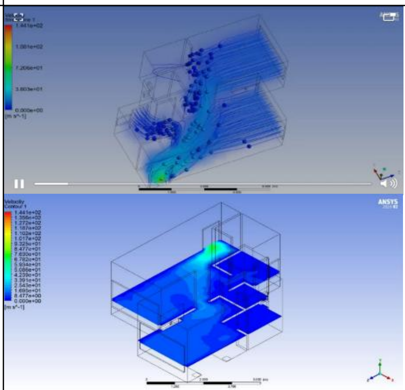
Simulations for optimal placement of Split AC		CFD analysis has been performed for a 1 BHK flat to find out the best wall for positioning of the air conditioner. Keeping in mind, energy efficiency, maximum turbulence achievable in the room & thermal comfort. Analysis for all the walls in the room has been performed. It is found that wall opposite to the southern wall is not in close proximity to it and doesn't deflect much chilled air directly to the occupant lying on bed unlike the eastern wall, which may cause a thermally uneasy state. Also, the conditioned air is reaching every corner of the room. Hence it is recommended to place the AC on the southern wall. The outdoor unit can be placed in the balcony in front of the living room, reducing the cost incurred in piping
Simulations for optimal placement of BLDC Fans		No wall motion and no-slip conditions have been used on the wall. At the walls: u= 0, v= 0, T= 1, At the inlet: u= 1, v= 0, T= 1, At the outlet: Neumann conditions have been set for fluid variables i.e. / = 0 Where n is the direction normal to the outflow boundary. Considered, for room Rh= 40% at inlet. With the help of CFD the optimum position of the Fan is inferred. The fan is placed in such a way that it circulates the cold air to every corners of the room & avoid strong draft.
Simulations for natural ventilation		In order to reduce some burden on HVAC systems, natural ventilation is preferred. Pune, having a reliable windspeed allows considerable cooling due to natural ventilation. Units having large north facing window/door openings make it ideal for ventilation. Air flow pattern for natural ventilation from northern windows of a 1 BHK unit is shown above. It increases the total comfort duration by 574 hours.

Table 4.3: CFD analysis optimal placement of Split AC,optimal placement of BLDC Fans and natural ventilation

System Proposal for Club house

For the club house building we are exploring 3 scenarios for thermal comfort.

Scenario 1: VRF system **Scenario 2:** Evaporative cooling technique

Scenario 1: Proposing VRF system as these systems are extremely energy efficient means of precisely regulating the temperature within commercial buildings. The combined effect of internal and external influences often means that some areas of the building require cooling, while simultaneously other areas require heating to maintain a constant and comfortable internal environment.

Location of the building:- Club house (Pune)

Outdoor temperature conditions:-

- Summer- DB(F)- 104, WB(F)- 76, RH%- 28
- Monsoon- DB(F)- 83, WB(F)- 79, RH%-

Indoor temperature conditions:-

DB(F)- 75, WB(F)- 63, RH%- 15

Indoor System selection:-

For the indoor unit we are using 4-way cassette model as it is very flexible system. It blends with any room interior and offers the ideal solution for small commercial applications where space is limited.

It has been designed to suit all standard 600 x 600mm grid, for easy installation and maintenance.

Fig 4.5:Indoor unit4-way cassette

Total rooms:- 8 Total IDUs= 17

Total air-conditioning load (considering each room):- 44.35

Corrected capacity A (considering temperature correction factor 1):- 50.2

Corrected capacity B (considering piping correction factor 0.92):- 46.17

Total Standard capacity selected for cooling considering requirement of each room:- 50.2

Outdoor System selection:-

Corresponding HP= 18HP (10HP+8HP)

MMY- AP1814HT8

UNITS in combination- MAP1004HT8 & MAP0804HT8

Standard Cooling Capacity:- 50.

Standard Heating Capacity:- 56.5

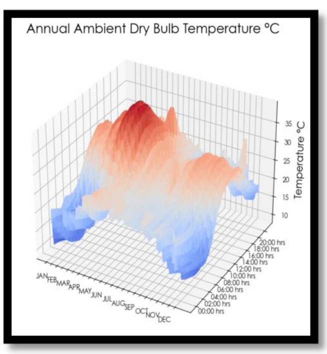
Maximum no. of connectable indoor units that can be achieved:- 30

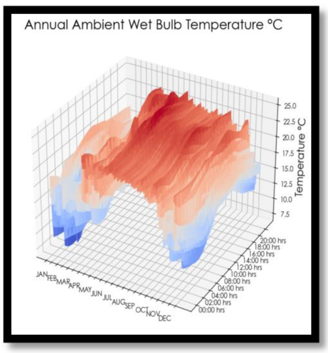
Fig 4.6:VRF outdoor unit

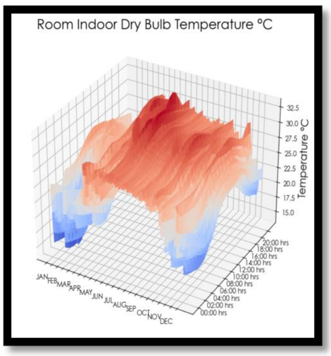
Scenario 2: 2 stage Evaporative cooling solution (For better IAQ)

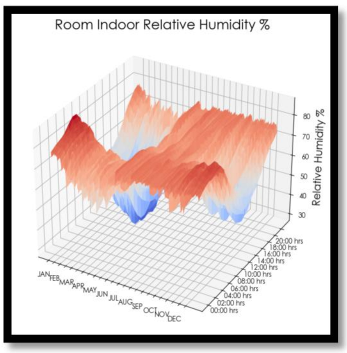
Software Used : EvapCal (by ISHRAE)

Ambient Design Data **Maximum Allowable Indoor Design condition**: -









Comfortable Hours within Design Range = 7823.33 hrs	% Comfortable Hours within Design Range = 89.33%	Peak Power Consumption = 8.43 kW, 12.14 kW & 15 kW @1 kW/TR	Evaporative Cooling Peak Power Consumption = 4 kW	Peak Water Consumption = 43 LPH,85 LPH & 76 LPH

Estimated Active Air Conditioning Capacity = 15 TR, 12.1 TR & 8.4 TR

Peak Power Saving With Evaporative Cooling = 64.33%

3 units of 2 stage Evaporative coolers required: 5858 CFM, 5248 CFM & 2985 CFM, by clubbing adjacent indiviual rooms into 3 zones

Indoor thermal comfort hours: 89% (of total operational hrs).

Media room is 30 mins operational daily. Hence, seperate Split AC is recommended

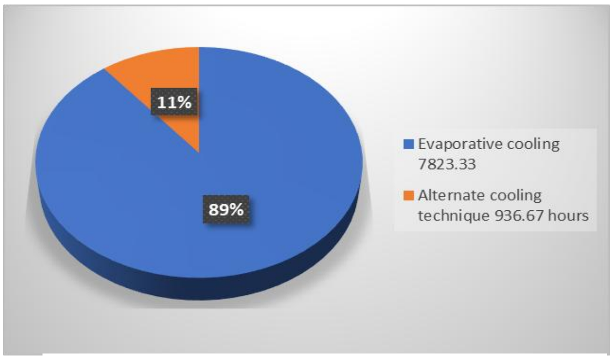


Fig 4.7:% comfort & discomfort hours

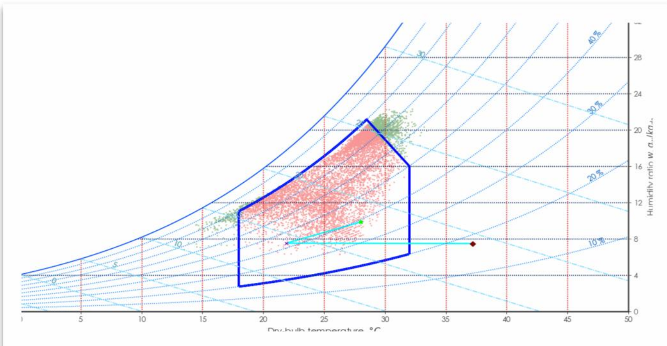


Fig 4.8:Psychrometric chart (EvapCooler philosophy)

Cost

Scenario 1	VRF system	Total cost for supply & Ancillary items in INR	**₹ 22,11,400**
Scenario 2	Evaporative cooler	Total cost+30% extra on installation & supply	**₹ 9,68,500**

Hence, Evaporative cooling solution is recommended in the club house as it provides :

89% of comfort hours

56% of savings in CAPEX

Fig 4.9: Benefits of Evaporative cooling solution

Innovation:

Every year the government sets targets for sustainable lifestyle and net – zero development. However, we noticed some problems holding us back from achieving these targets:

- Lack of tracking of residential building energy consumption post occupancy
- Poor awareness and push towards sustainable lifestyle despite available data
- Lack of digital footprint of building, leading to incompatibility with modern technology
- Monthly electricity bill data not being utilized

So, we wanted to develop an energy performance index for residential buildings post – occupancy using their electricity bill and live consumption data. Through allowing people to see how they perform against others; we want to make energy conservation a matter of pride. We want to become ambassadors for net zero lifestyle by promoting community engagement in events like Ganesh Chaturthi, Durga Puja, Eid and Christmas. To that end, our idea, called the Residential Energy Evaluator, uses a web portal as the interface to is a digital database of residential buildings, their appliances and energy consumption metrics, grouped by area. Users can register their buildings on the portal and feed their data manually, to evaluate their energy performance against similar properties and the flats within their building. IoT – enabled smart meters will make this process automatic and give periodic alerts based on real – time data. Sensor integration will make automatic appliance control possible. This data will later be analyzed by a machine learning model that will provide deep insights into inefficient patterns and equipment, and help formulate suggestions for improving efficiency. The innovation process flow and project connection has been shown in Fig. X.1.

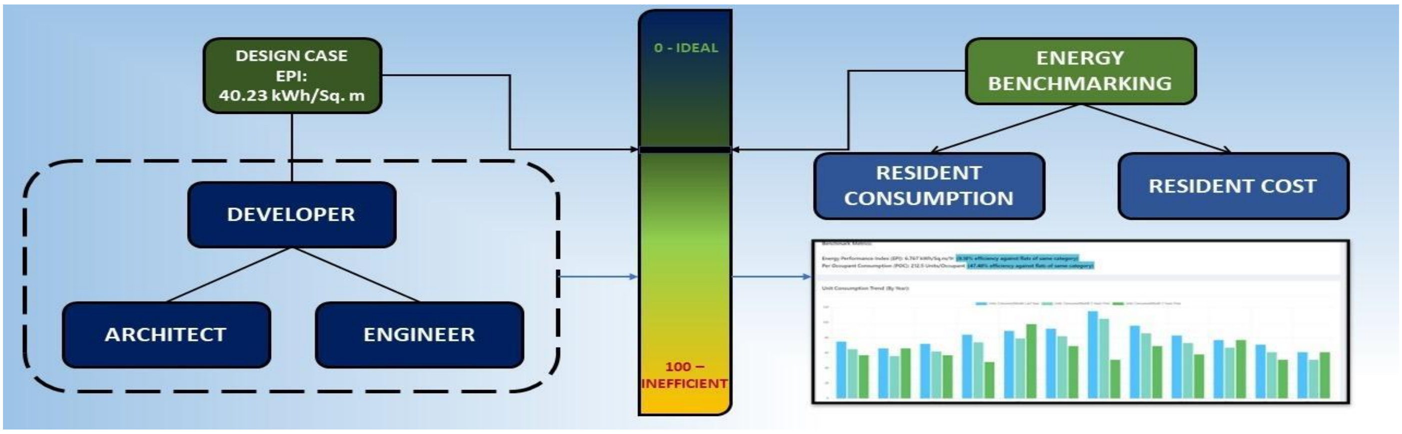


Fig 5.1: Innovation process flow and connection to project

Development Report: The master block diagram has been represented in Fig. 5.2.

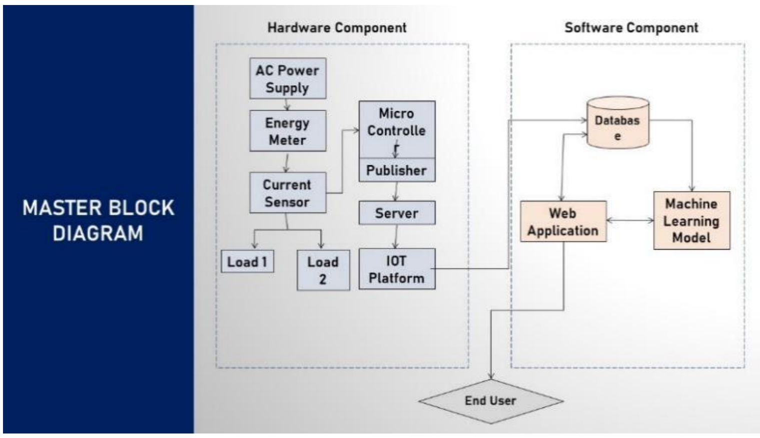


Fig 5.2: Master block diagram

Web Portal: Development Report shown in Fig 5.3, along with Portal Flow Diagram and its screenshots in Fig 5.4 and Fig 5.5 respectively.

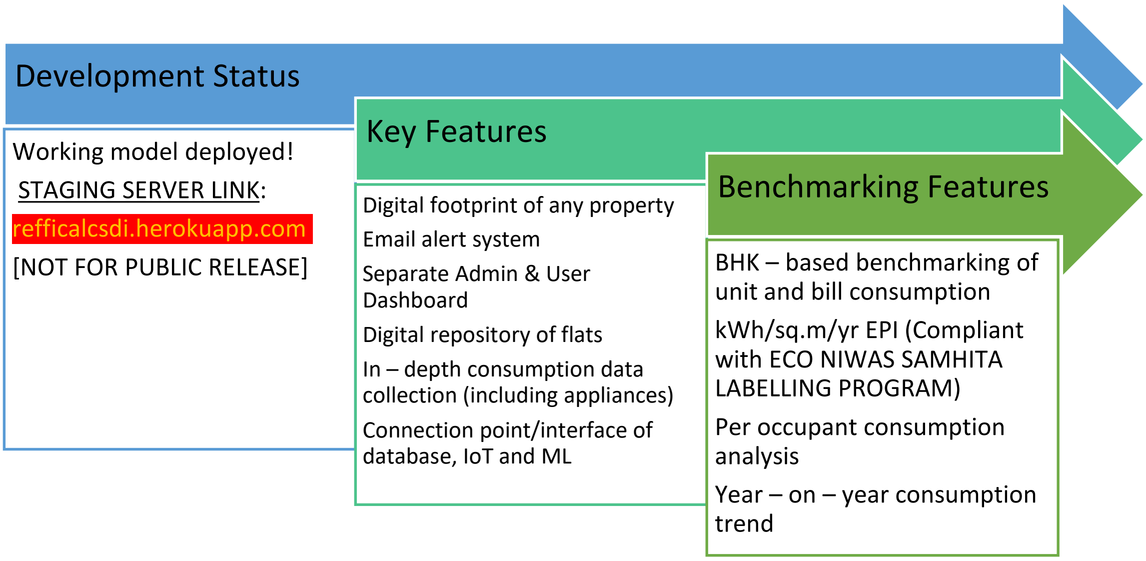


Fig 5.3: Web portal development report

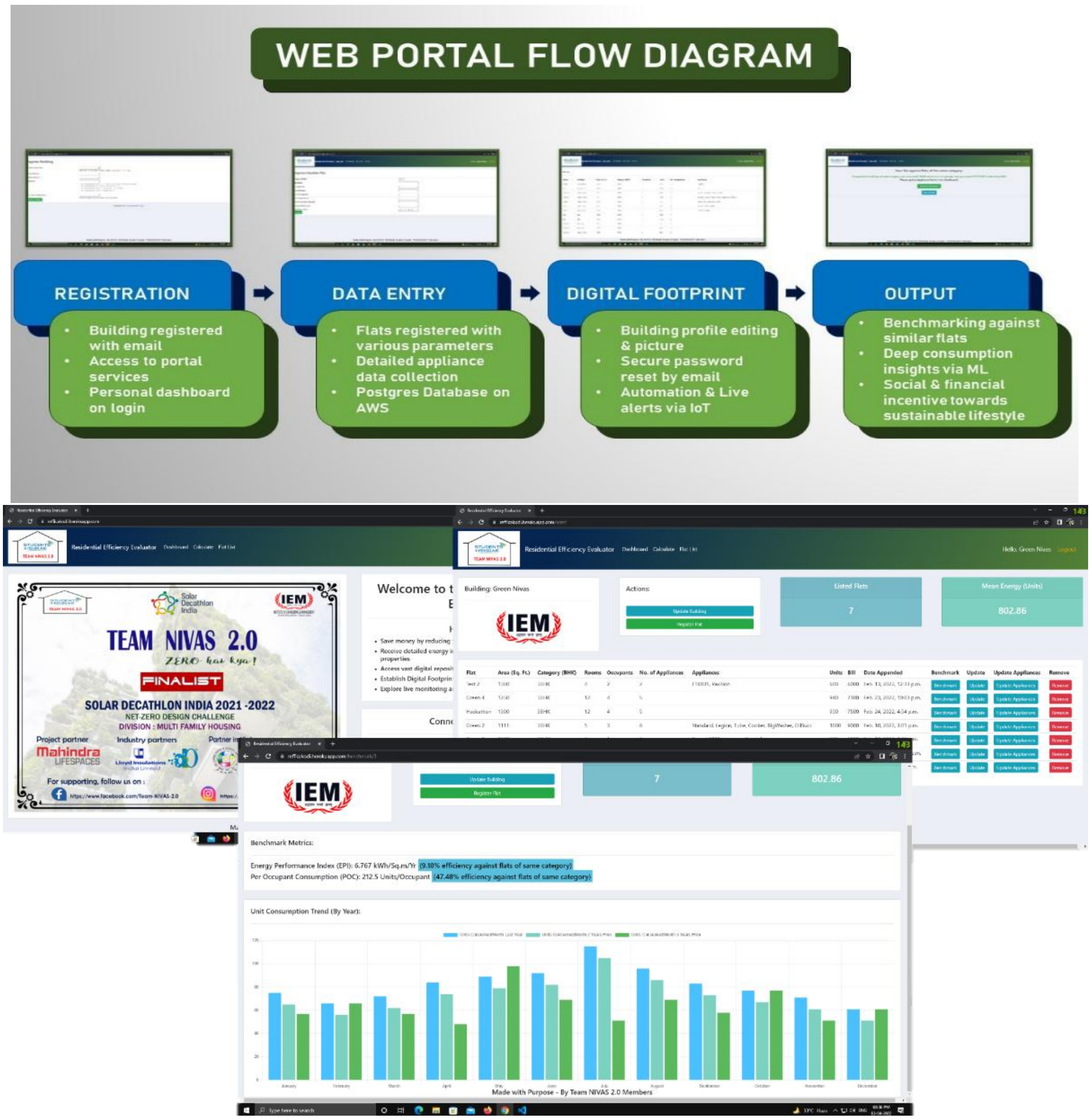


Fig 5.4 and 5.5: Web portal flow diagram and web portal screenshots

IoT: Development Report shown in Fig 5.6, along with working setup screenshots and equipment/load bank screenshots in Fig. 5.7 and Fig.5.8 respectively.

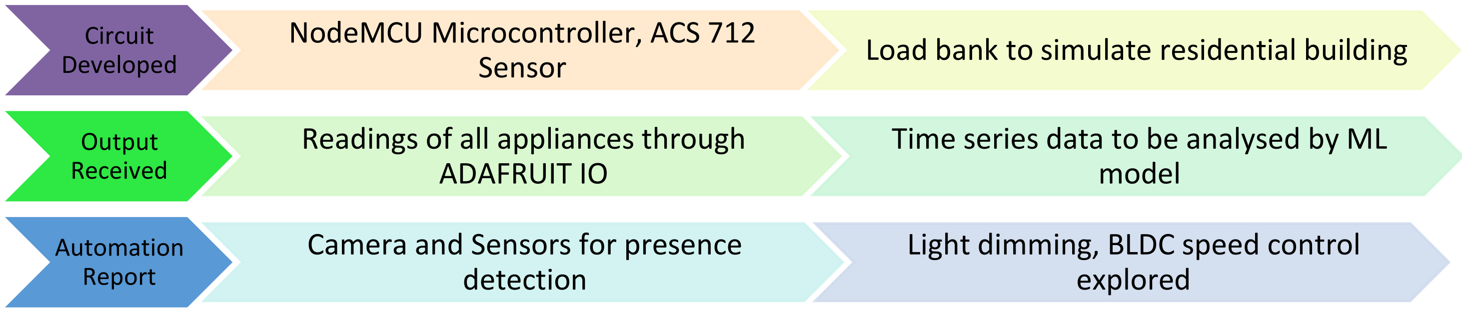
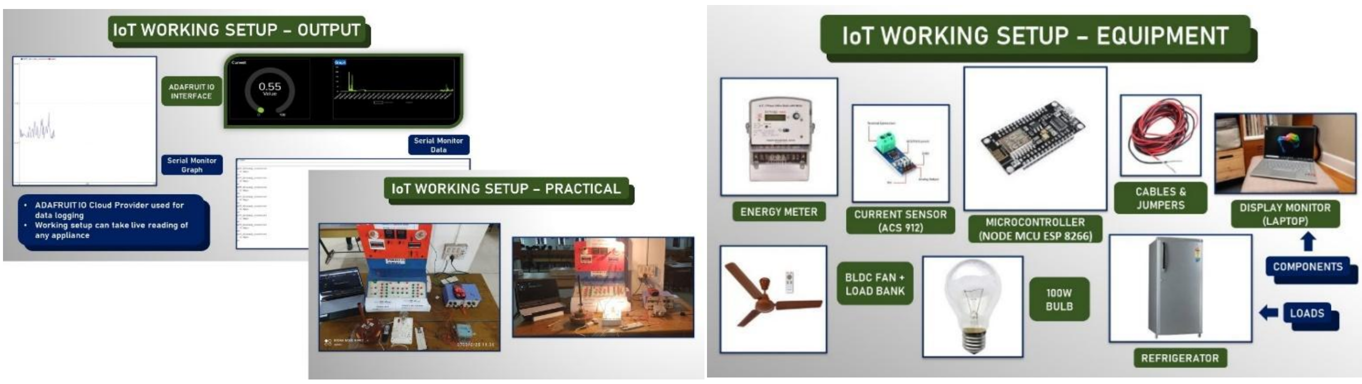


Fig 5.6: IoT Development report



FIig 5.7 and 5.8: IoT working setup and IoT equipment + load bank

MACHINE LEARNING: Development Report shown in Fig 5.9, along with model training accuracy/predictions and machine learning block diagram in Fig. 5.10 and Fig. 5.11.

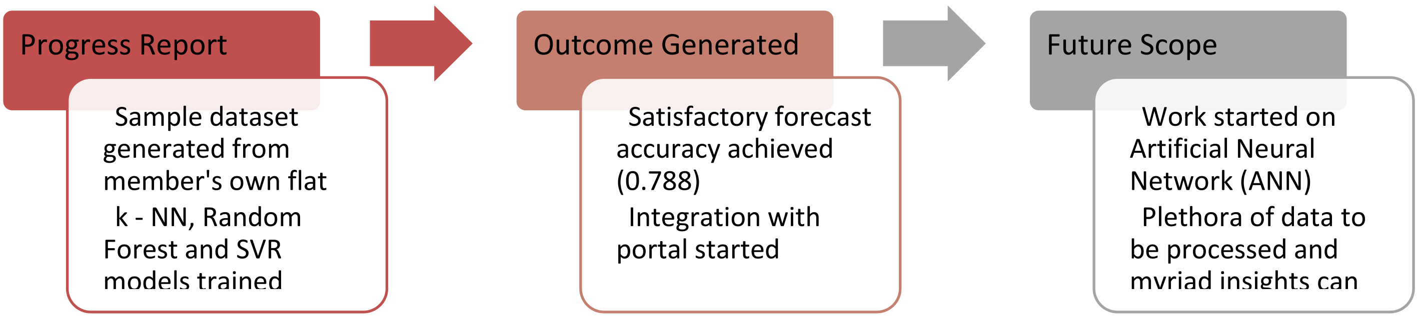


Fig 5.9: Machine learning development report

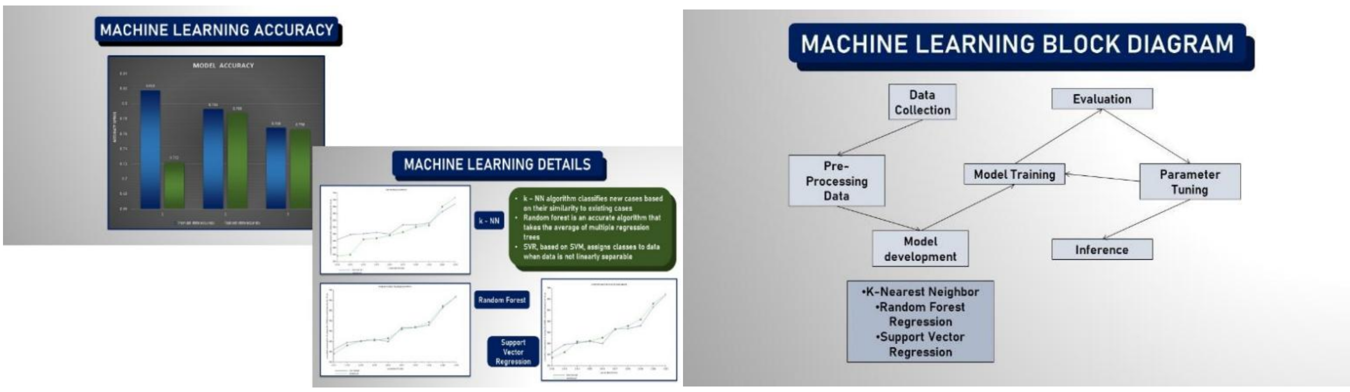


Fig 5.10 and 5.11: Machine learning prediction output and block diagram

Engineering design and operations:

In this segment, we estimated electrical grid connectivity, chose a transformer, and produced a power distribution diagram. In addition, we demonstrated waste management.

Electrical demand estimation:

Total demand (Phase 1,2,3)	1355.8	Kwatt
Diversity factor(0.75)	1016.85	Kwatt
80%	1016.22	Kwatt
100%	1219.464	Kwatt
KVA rating	1524.33	KVA
Transformer size	1500	KVA

Table 6.1 Transformer details for tower A, B

- Total maximum demand (Phase 1,2,3) =1795.8 KWatt.
- Required KVA rating=2020.22KVA.
- Required transformer =2000KVA.
- So, to complete the maximum demand of tower A and B we need 2000KVA rating transformer.
- There is solar invertor connected to the towers where it supplies electricity for some specific appliances.
- Also, we have introduced the Diesel generator to cover up the need due to any power disruption.

- Total maximum demand (Phase 1,2,3) =1795.8 KWatt.
- Required KVA rating=2020.22KVA.
- Required transformer =2000KVA.
- So, to complete the maximum demand of tower C and D we need 2000KVA rating transformer.
- There is solar invertor connected to the towers where it supplies electricity for some specific appliances.
- Also, we have introduced the Diesel generator to cover up the need due to any power disruption.

Total demand (Phase 1,2,3)	1795.8	Kwatt
Diversity factor(0.75)	1346.85	Kwatt
80%	1346.85	Kwatt
100%	1616.22	Kwatt
KVA rating	2020.275	KVA
Transformer size	2000	KVA

Table 6.2 Transformer details for tower C, D

The detailed calculation is shared in the Annexure.

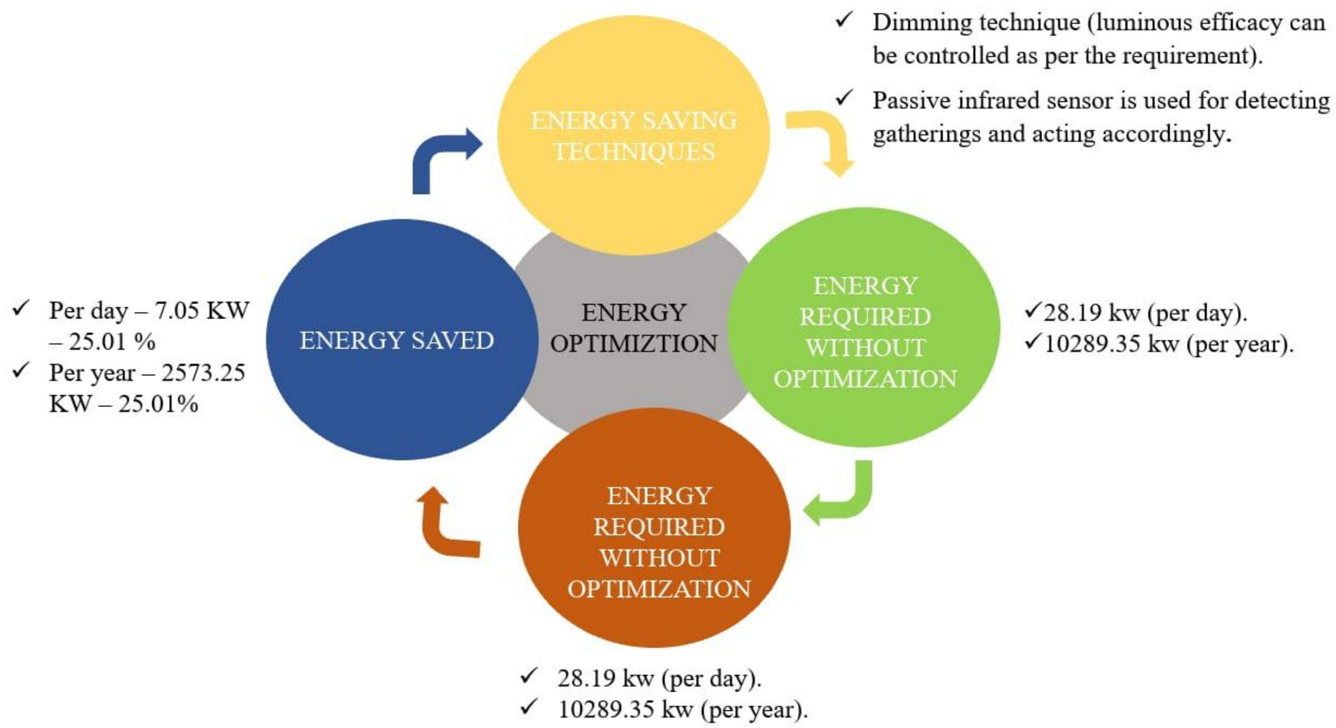


Fig 6.1: Energy optimization technique

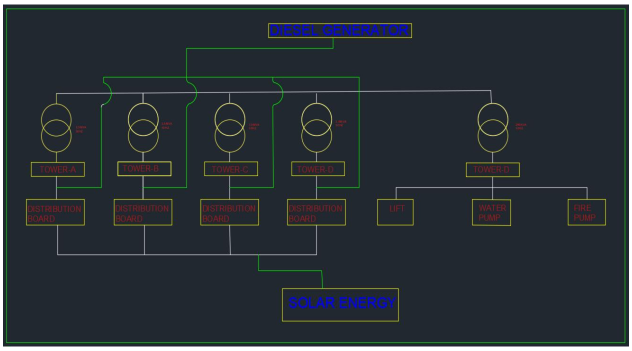


Fig. 6.2: Overall power distribution system

- Solar system sizing is shown in the Energy performance.
- Diesel generator calculations are shown in the resilience.
- Detailed HVAC estimations and system designing are shown in the health and wellbeing.

The Detailed power distribution SLD, Calculations and equipment ratings are given in the appendix-1.

Waste management:

TOTAL WASTE

- **Tower-A=365 Kg (Approx.)**
- **Tower-B=365 Kg (Approx.)**
- **Tower-C=229 Kg (Approx.)**
- **Tower-D=229 Kg (Approx.)**
- **Total generation=1186 Kg.**

- **Tower-A=146 Kg**
- **Tower-B=146 Kg**
- **Tower-C=91.6 Kg**
- **Tower-D=91.6 Kg**
- **Total generation=474.4 Kg**

- **Tower-A=219 Kg**
- **Tower-B=219 Kg**
- **Tower-C=137.4 Kg**
- **Tower-D=137.4 Kg**
- **Total generation=711.6 Kg**

Total waste is being segregated into two bins colours Green (Organic waste), Blue (Inorganic waste).

The total organic waste is then fed to an OWC (Organic Waste Composter or a Vermi composter

Rag pickers worked as recycling middlemen, collecting rubbish from homes and selling it to recycling companies. Rag pickers provided both a service and a modest source of revenue to customers by visiting homes and acquiring trash materials such as rags, worn papers, and abandoned metal.

Waste Bin layout:

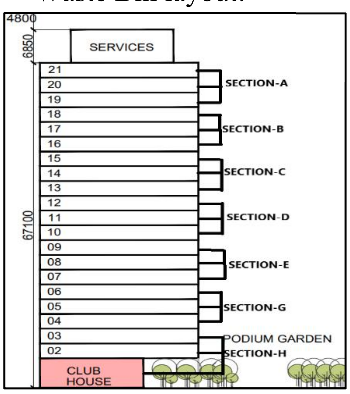


Fig .6.3 :Waste bin layout of tower-A

LAYOUT	ORGANIC WASTE BIN (100Lt., Green)	INORGANIC WASTE BIN (100Lt., Blue)
SEC-A	3	3
SEC-B	3	3
SEC-C	3	3
SEC-D	3	3
SEC-E	3	3
SEC-F	3	3
SEC-G	3	3

Table 6.3: Waste bin calculation of tower-A

Fig 6.4: Waste bin layout of tower-A

Waste dump yard layout:

Total Organic waste in Litre.	1697.12 Litre.
Required sizing(After an increase of 20%)	2000 Litre. (Approx.)

Table 6.4: Waste underground dump yard layout of Tower A and B

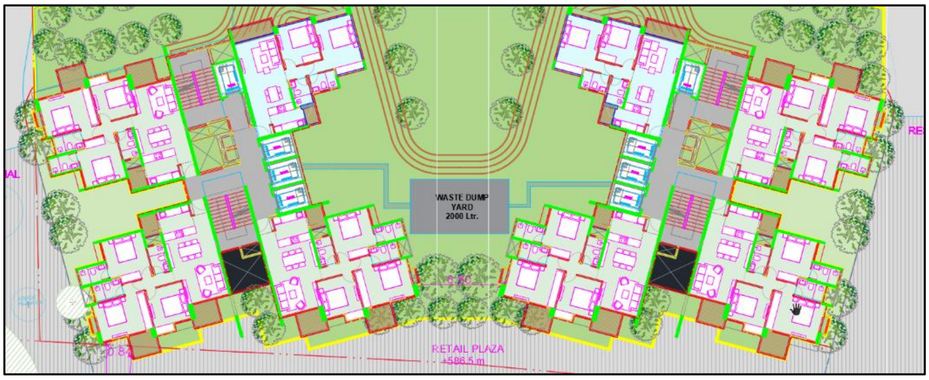


Fig 6.5: Underground waste dump yard for tower A,B

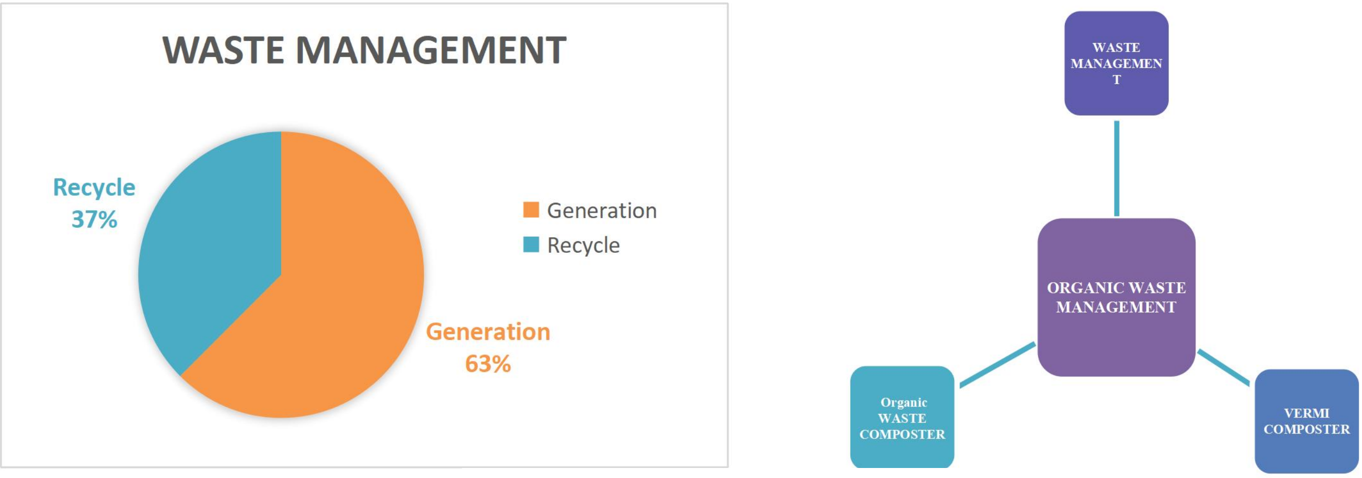


Fig 6.6: Segregation of waste management

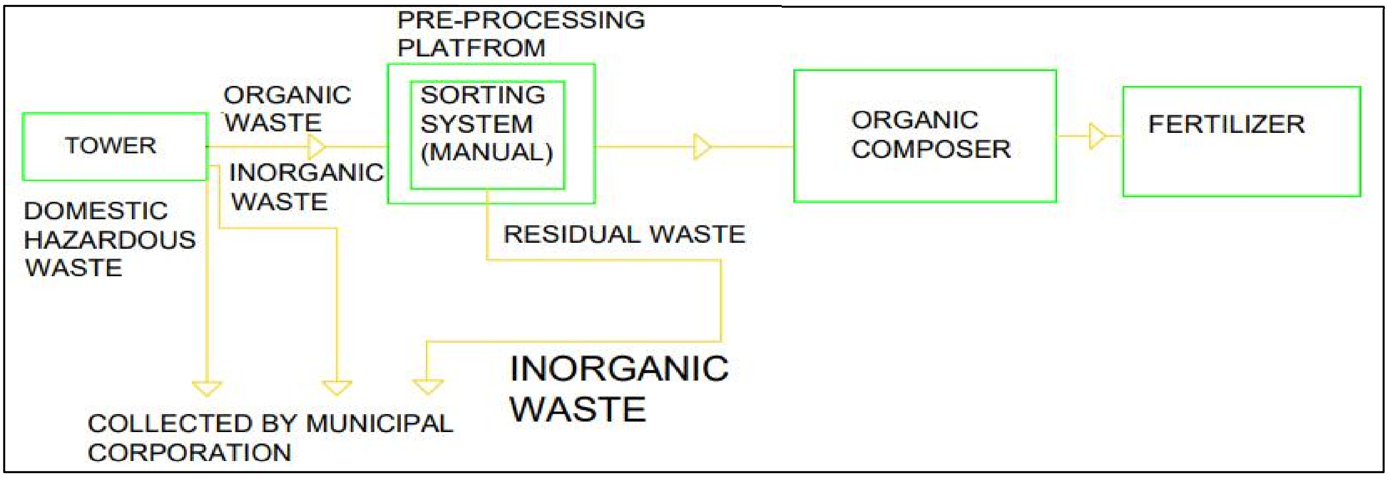


Fig 6.7: Organic Waste Composter layout

The detailed calculations and specifications are given in the Annexure.

Scalability and market potential:

Why Pune? The primary statistical reasons for picking Pune as our location are shown in Fig 7.1

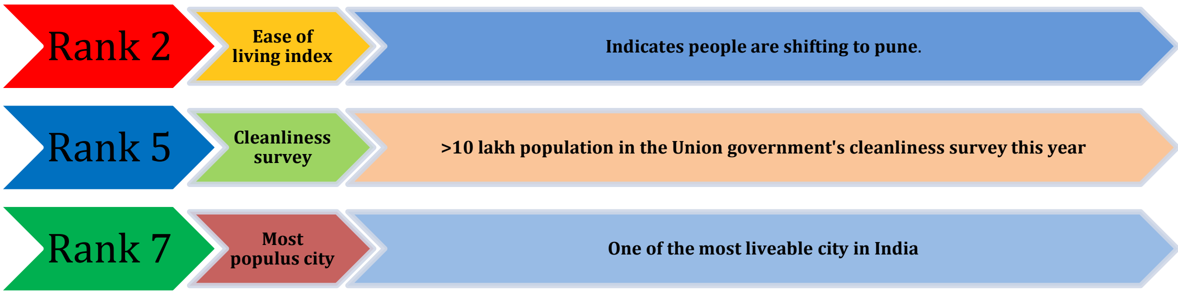


Fig 7.1: Top reasons for picking location

Business Climate and Environmental issues in Pune

Pune is one of the most important industrial centers of India. It is the seventh largest metropolitan economy with a solid industrial base and has the sixth highest income per capita in India. The evolution of industrialization and growth of rapid urbanization and globalization has brought mounting environmental problems including climate change, water shortage and pollution, hazardous waste, smog, loss of biodiversity and others like desertification which poses severe challenges to sustainable development.

Competitors: In Fig. 7.2, we can see how our project partner, Mahindra LifeSpaces Developers, stacks up against their competitors in terms of history and project volume.

Fig 7.2: Key competitors and their footprint

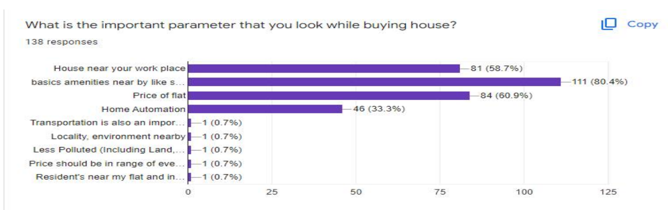
Collaborators:

Our team got the privilege to meet SUNREF representatives where we got to attend a conference held by SUNREF and IGBC, their logos pictured in Fig. 7.3 property listing agencies, Sustainability Influencers and do few advertisements to reach our potential customers**.**

Fig 7.3: IGBC and SUNREF logos

Potential Buyers: According to a survey conducted by CII and Anarock, nearly 80 per cent of prospective home buyers prefer to purchase properties that are ready-to-move-in or nearing completion, while only around 20 percent of customers want to buy newly launched flats. After pricing, the survey suggests that developer credibility, project design and location are the most important attributes while selecting a home. The potential buyers in Pune are IT sector, Defense, immigrants, NRI's, Real Estate Agents, Celebrities etc**.**

Market Survey conducted by Team NIVAS 2.0: We have done a survey digitally on green housing with 138 active participants of age range 20-30. Participants were from across the nation but major participants from Pune, Hyderabad and Kolkata. Link of survey: https://docs.google.com/forms/d/1EEFW9CKmlwlmUocQxvqwYrnRizDB5TNBBzBN9y9WEhY/edit?vc=0&c=0&w=1&flr=0. Results of the survey are given in Fig 7.4.



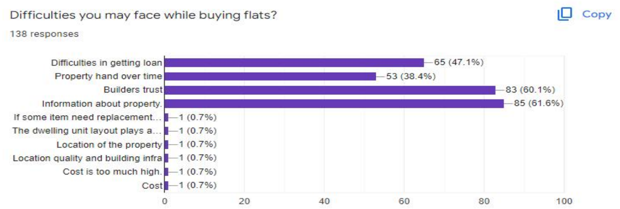


Fig 7.4: Marketing survey results represented graphically

Factors that attract customers and Segmentation Variables: While looking for a flat, consumers from HIG may not need the flat but wants to buy, one from MIG may need the flat but doesn't have enough Purchasing power. So, they will go to the bank for a loan. Considering these facts in mind we have selected two segmentation variables, those being purpose of usage and purchasing power. In terms of purchasing power, a potential buyer can be from any of the HIG, MIG and LIG. Fig. 7.5 gives a diagrammatic representation of the points discussed.

Fig 7.5: Segmentation variables and customer attraction factors

Unique selling proposition:

1. **Scalable and unique innovation:** The innovation prototype we have developed is scalable to all segments of our building, and has the potential to break new ground in the benchmarking and control of energy consumption and carbon footprint of residential buildings post occupancy, while establishing a stronger digital footprint. It has cloud – enabled live energy monitoring and appliance automation for comfort, awareness and cost saving. Working prototype pictured in Fig. 7.6.

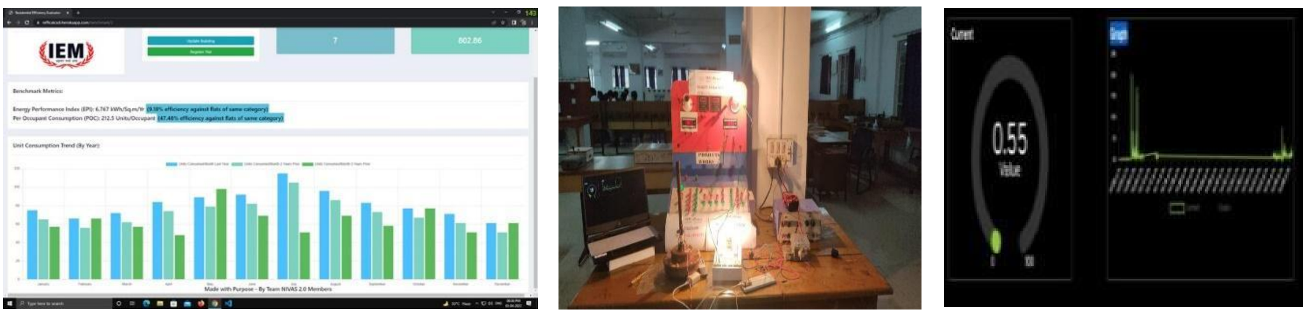


Fig 7.6: User interface, working prototype load bank/circuit and output

2. Hybridized thermal comfort: BLDC fans at 200 RPM integrated with our innovation will supplement split AC's running at 27°C to bring room temperature down to 24°C, for example. Since BLDC fans consume 1/3rd the power of induction motor fans, they make split AC's 15.3% more efficient.

3. High IAQ, Efficient clubhouse using proposed evaporative cooling solution: Using ISHRAE's EvapCal software, we developed a proposed evaporative cooling system for the Clubhouse. Our system is capable of cutting power demand by almost 65%, simulated at 90% of total comfort hours, making thermal comfort cheaper, more efficient and also improving Indoor Air Quality of a major social hotspot within the campus.

4. Innovative, Groundwater – Supplemented rainwater catchment silo: Rainwater silos dug down to the groundwater level cause water level to rise and allow catchment of rain water up to 15 meters. This enables compact rainwater catchment solution that is reinforced by ground water on dry days.

5. Terrace garden premium floor: Three Green Terraces with wind – stack ventilation serves as exclusive social spaces that improve resident well – being and cross – ventilation. The floors connected to these terraces are referred to as "Terrace Floors", and will be sold at a premium to retain exclusivity and make the idea economically viable.

Affordability:

Various cost effective construction techniques have been adapted in the design case in order to achieve the affordability goals for the target market. Further, alternative building materials have been explored to arrive at the best cost solution while taking into consideration the energy efficiency and eco sensitivity of the building materials along with the affordable cooling and water savings strategies. These resulted in reduced construction timeline and increased labour productivity.

Energy savings by affordable means:

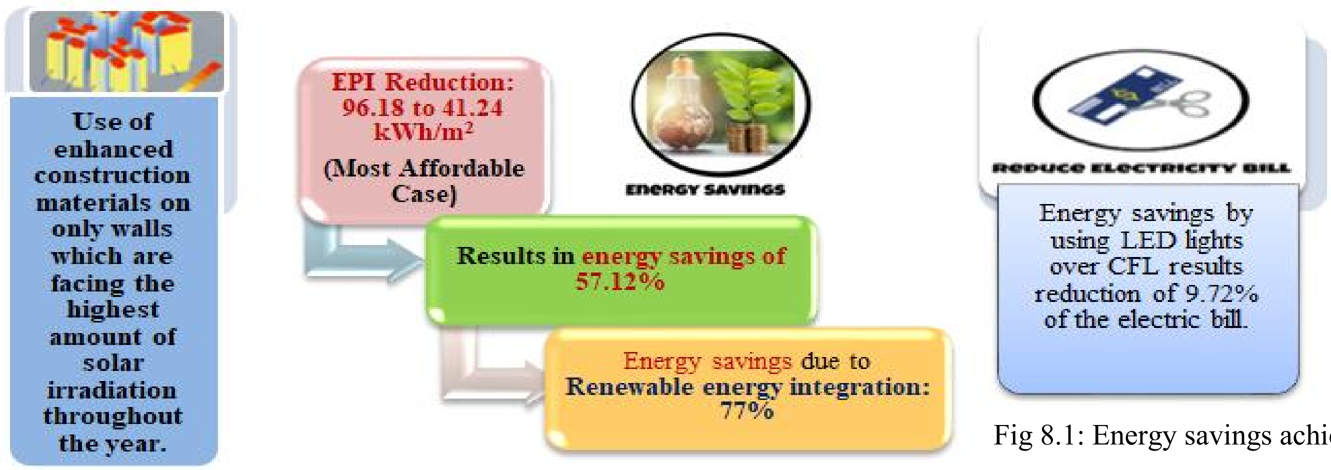


Fig 8.1: Energy savings achieved.

Composite Wall Recommendation: We have applied few costly interventions selectively in order to make the design solution more affordable.As explained earlier the composite wall construction like AAC Block,Rap Trap bricks,energy efficient SGU Glasses; Applied in the envelope design which is exposed more to solar radiation. Graphics and the table no. 8.1 explaines the energy and cost savings achieved.

Gross Wall Area		14763 m²	
Gross Area Exposed to Solar Irradiation		2970 m²	
COST		EPI	
Cost of Wall Assembly (Base case)	₹1087 / m²	Client Case	96.18 Kwh/m²
Cost of Wall Assembly (Design case 4)	₹1187 / m²		
Savings Per m²	₹ 100/ m²	Design Case 4	51.7 Kwh/m²
Total Cost of Wall (Base Case)	₹ 16047381		
Total Cost of Wall (Design Case 4)	₹ 17523681	Composite Case 1	65.41 Kwh/m²
Total Cost of Wall (Composite Wall)	₹ 16344381		
Savings	₹ 1179300	Improvement in EPI	32 %

Table 8.1: Energy and cost savings

Composite Wall and Glazing Recommendation:

Gross Wall Area (Approx.)		1000 m²	
Gross Area Exposed to Solar Irradiation		200 m²	
COST		EPI	
ST 167 6mm clear Glass (Base case)	₹393 / m²	Client Case	96.18 Kwh/m²
Viridian Glass (Design case 4)	₹542 / m²		
Savings Per m²	₹149 / m²	Design Case 4	51.7 Kwh/m²
Total Cost of Glazing (Base Case)	₹ 393000		
Total Cost of Glazing (Design Case 4)	₹ 542000	Composite Case 2	53.9 Kwh/m²
Total Cost of Glazing (Composite Wall)	₹ 422800		
Savings (From wall)	₹ 1179300	Improvement in EPI	44 %
Savings (From Glass)	₹ 119200		
Total Savings	₹ 1298500		

Table 8.2: Composite Wall and Glazing Recommendation:

-

Low cost affordable cooling solutions:

Split AC with BLDC fan saves power by 6 % per degree increase in the set point in flats.
With BLDC fans, annual power savings is 62% & opex is reduced by 1500 INR over ordinary fans.

Evaporative cooling technique in club house provides 89% of total comfort hrs in PUNE with 64.33% peak power savings.

56% savings in CAPEX with Evaporative coolers over VRF system.
EvapCooler (₹ 9,68,500) << (₹22,11,400) VRF system.

Affordable construction materials & techniques:

3D modular construction, prefabricated MEP, pre-stressed or post-tensioned construction can be also used for faster work along with precast or prefabrication which reduces the construction timeline.

Fig 8.2:Means to reduce the construction timeline.

Affordable water savings solutions:

Water systems make use of efficient plumbing fittings with low flow rates. Although these fixtures are more costly, **they will save money on your monthly utility bill since they consume less water**.

Each Humidity Harvesting machine used in our project has the **production capacityof 1000 litre per unit per day** and the cost of each unit is Rs. 9.5 Lakhs.

The system has a **Payback period of around 3 Years**.So **one person will save around Rs 29,200 per annum after 3 Years.**

Th overall water requrement is reduced by approximately **40%**.

As the water demand is reduced so the operation cost of pumps and motors as they will have to operate for **lesser amount of time**.

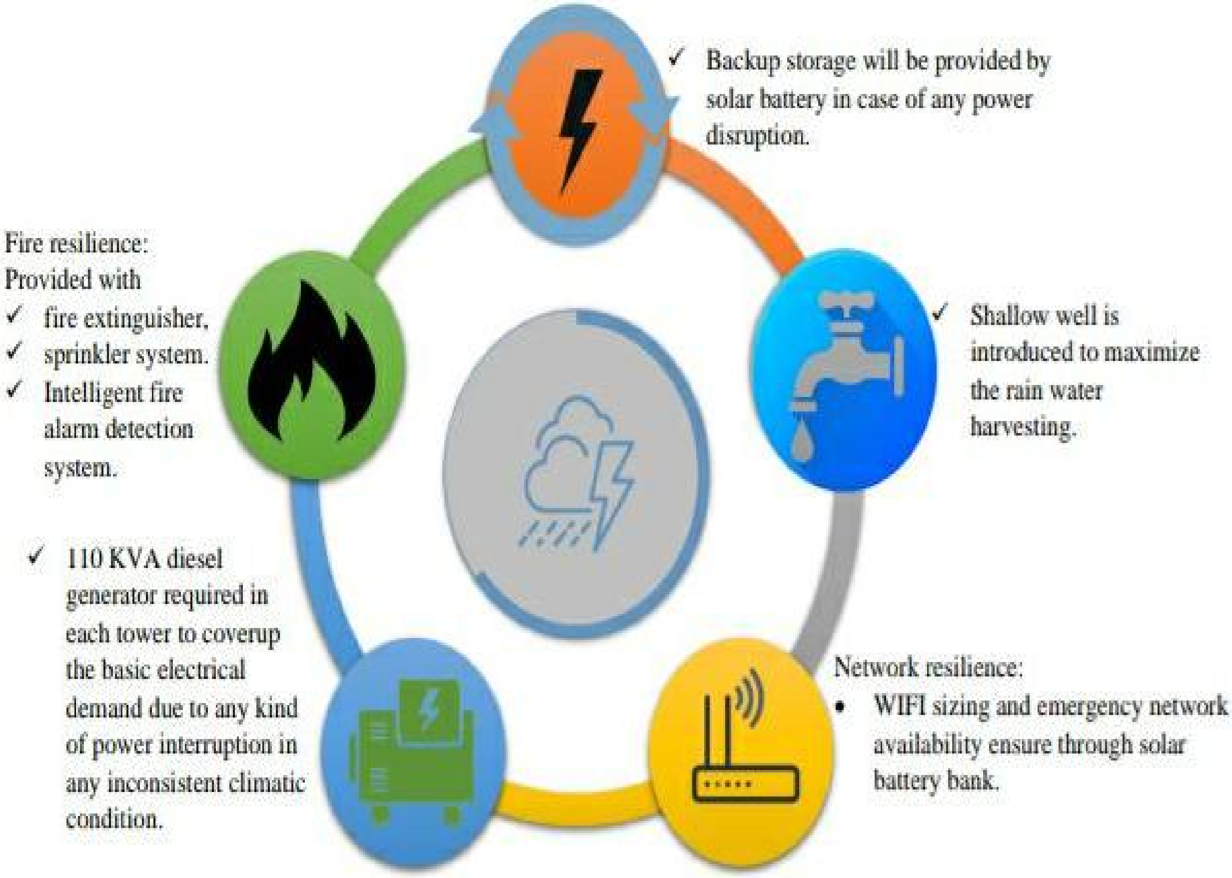
Life Cycle cost analysis:

Life Cycle cost is calculated for 30 years. Our CAPEX of proposed case was higher due to various energy efficient intervention like roof insulation, composite wall insulation, high efficient Glass, moisture harvester for net zero water, energy meter for energy profiling using IOT and Cloud Service Platform.

However, we have reduced the cost of HVAC System for club house by sizing evaporative cooler for our proposed case. As moisture harvester and the energy efficient measures is initial investment which reflects in the operational cost of the occupant in the life cycle cost of the building. Detils given n annexure.

Resilience:

Resilience is the ability to withstand adversity and bounce back from difficult life events. Our main objective is to make the building withstand natural hazards and climate changes by using efficient design, construction, materials, and passive design techniques to make the site self-sufficient.



Waster resilience:

To maximize rain water harvesting we have introduced shallow wells. The location of the well is given below in the masterplan.

Sl. No.	Shallow well No. (W)	Latitude	Longitude
1.	W-1	18.629784 °	73.812946 °
2.	W-2	18.629784 °	73.813131°
3.	W-3	18.629603°	73.812986°
4.	W-4	18.629457°	73.813017°
5.	W-5	18.629121°	73.813129°
6.	W-6	18.628972°	73.813280°
7.	W-7	18.628952°	73.813433°
8.	W-8	18.628904°	73.813785°
9.	W-9	18.628868°	73.814062°
10.	W-10	18.628966°	73.813947°
11.	W-11	18.629104°	73.814036°
12.	W-12	18.629662°	73.814091°

Table 9.1 Geographical Location of the Rain water recharge shallow wells

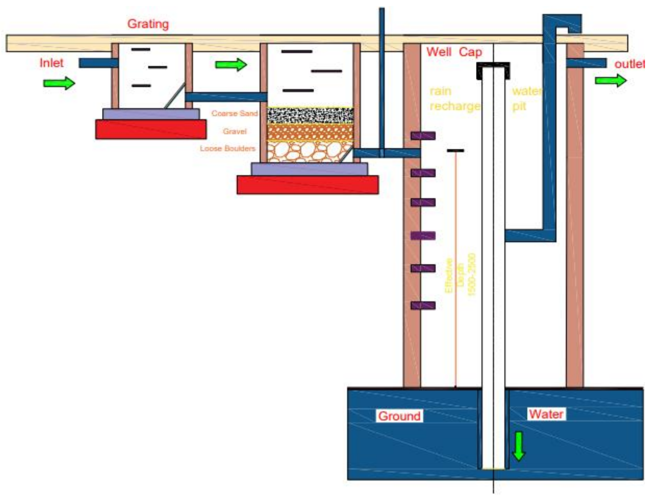


Fig 9.1 Internal design of Rain water recharge shallow wells

Throughout the rain water recharge shallow wells we can control floods as well as we can sent a significant amount of ground water throughout rainy season.

Network resilience:
The internet is a need in today's current digital society. WIFI-equipped houses are more robust than the rest, as the automation of every gadget develops into a smart era. The computations are included in the appendix and the simulation results.

Fig 9.2 Detailed floor plan of WIFI sizing

The detailed calculation and estimations are given in the appendix.
Power resilience:

Space	Total Wattage(Watt)	Full load Kwatt(KWatt)	Diversity Factor	Power Factor	Full load KVA
Tower-A	26000	20.8	0.8	0.8	26
Staircase, Coridors & Other Cmmon Areas in Tower A	2000	1.6	0.8	0.8	2
Maintenance Room, Pump Room, etc	1000	0.8	0.8	0.8	1
Parking	8000	6.4	0.8	0.8	8
Lift(8 KWatt/lift)	32000	25.6	0.8	0.8	32
Water pump & pannel	6000	4.8	0.8	0.8	6
Fire pump & pannel	3000	2.4	0.8	0.8	3
Other Equipments	2000	1.6	0.8	0.8	2
Demand factor(0.25)	0.5	0.0004	0.8	0.8	0.0005
Total connected load	80000.5	Watt			80.0005
Efficiency	80.0005	Kwatt			0.75
KVA rating for Diesel Generator					106.6673333
Required Diesel Generator					110 KVA

Table 9.2: Power resilience

The Generator specification has been shared in the Appendix.

Fire resilience: The detailed estimations and designs are given in the Appendix

Communication:

TEAM NIVAS 2.0 ("ZERO HAI KYA"). We have reached our audience through mail promotion , social media , news article promotion as well as some internal event . Our team has also visited nearby ongoing site of green housing Tech Park to get a physical exposure and also for our promotion purpose. Team NIVAS 2.0 has shown their video on the NEWS channel for the promotion and received good luck from various sources. We have also sent mails to ISHRAE President, ASHRAE President, ISHRAE Kolkata Secretary and received their good luck in mail as response. And published News Articles in Mech mirror departmental magazine of mechanical engineering and submitted in institutional Newspaper which is expected to print by April end. Team NIVAS has done its advocacy in SUNREF , ASHRAE and ISHRAE event. **In our unique wall writing 450 plus students and faculties have participated.** Team NIVAS has presented its project at college event Innovacia which is expected to have more than 8000 foots.

Promotion between 1st year students has been done which had an audience of 300 plus. We have reached more than 2900+ on social media platform which is given below in figures.

Drive link: https://drive.google.com/folderview?id=151sk1qRnCn6RzXbtloQPr-sS06Sj1T0J

Facebook page link: https://www.facebook.com/Team-NIVAS-20-105570155330500/?ti=as

Fig 10.1: Communication means

References:

- Eco Niwas: https://www.econiwas.com/tools.php
- Energy Star Benchmark: https://www.energystar.gov/buildings/benchmark/analyze_benchmarking_results

- Django (Portal Backend): https://www.djangoproject.com/
- ADAFRUIT IO (IoT): https://io.adafruit.com/
- Google Colab (ML): https://colab.research.google.com/

  https://www.thehindu.com/news/cities/mumbai/Fixing-Mumbai-Electricity-from-waste/article60527006.ece
- https://www.indiamart.com/proddetail/solar-power-purchase-agreement-service-10944075973.html

Codes and standards

IS 3646	CODE OF PRACTICE FOR INTERIOR ILLUMINATION
NBC 2016, VOL I AND VOL 2	NATIONAL BUILDING CODE OF INDIA
IGBC GREEN HOMES	INDIAN GREEN BUILDING COUNCIL
ECBC 2017	ENERGY CONSERVATION BUILDING CODE
UPC 2008	Uniform Plumbing Code
BEE	Bureau of Energy Efficiency
ASHRAE	American Society of Heating Refrigeration and Air – Conditioning Engineers
ISHRAE	Indian Society of Heating Refrigeration and Air – Conditioning Engineers
BIS	Bureau of Indian Standards