

# ENABLING PRIVATE SECTOR ENGAGEMENT WITH ECO NIWAS SAMHITA COMPLIANCE FOR AFFORDABLE HOUSING IN INDIA



An initiative by



The Global Buildings Performance Network (GBPN) is a globally organised and regionally focused organisation whose mission is to provide policy expertise and technical assistance to advance building energy performance and realise sustainable built environments for all. The GBPN assists governments and industry policymakers identify, adapt, and implement policy best practices for low-energy, affordable and healthy buildings, contributing to low carbon and resilient cities.

Their mission is to provide intelligence to optimise building energy policies and accelerate net-zero energy or positive energy for new buildings, deep renovation for existing buildings, and integrated renewables. The GBPN focus on the economies with the largest potential for energy savings from buildings, the current geographic focus being India and Southeast Asia.

This is the final report for the project "Enabling Private Sector Engagement with ENS Compliance for Affordable Housing".

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# ABBREVIATIONS

BMS	Building Management System
BOQ	Bill of quantities
CLSS	Credit Linked Subsidy Scheme
CAPEX	Capital expenditures
CSMC	Central Sanctioning And Monitoring Committee
CNA	Central Nodal Agency
ECBC	Energy Conservation Building Code
ECBC - R	Energy Conservation Building Code for Residential Buildings
ENS	Eco Niwas Samhita
EOI	Expression of Interest
EWS	Economically Weaker Sections
FSI	Floor Space Index
GDP	Gross domestic Product
LED	Light Emitting Diode
LIG	Lower Income Groups
MRV	Monitoring, Reporting & Verification
MIG	Middle Income Group
NCT	National Capital Territory
PMAY	Pradhan Mantri Awas Yojana
PMAY-U	Pradhan Mantri Awas Yojana – Urban
PMAY-G	Pradhan Mantri Awaas Yojana – Gramin
RETV	Residential Envelope Transmittance Value
SHGC	Solar Heat Gain Coefficient
VLT	Visible light transmittance
WFR	Window-to-floor area ratio
W.r.t	With Respect To
WWR	Window to wall area ratio

# INTRODUCTION

## Drivers for Affordable Housing in India

India has been witnessing increasing urbanisation and inward migration to cities, which has resulted in a significant change in the demographic profile of its urban centres. India's urbanisation rate has increased from 30% to 35% over the past decade and is likely to reach 40% by 2036<sup>1</sup>.

Out of India's population of 1.21 billion (2011), 377 million people were urban dwellers. With more than 10 million people being added to urban areas every year, India's urban population is expected to reach about 600 million by 2031<sup>2</sup>.

Amid the growth of urbanisation, the housing shortage in India touched 18.78 million units<sup>3</sup>. Of this urban housing shortage, EWS (economically weaker sections) and LIG (lower income groups) accounted for 95.6 per cent<sup>4</sup>. The shortage has led to a spike in "affordable" housing demand.

The central government has formulated and implemented several policies and/or initiatives in India to develop and deliver affordable housing. Some of these policies which are presently in force are listed below:

1. National Urban Housing & Habitat Policy (2007)
2. Model State Affordable Housing Policy (2015)
3. National Urban Rental Housing Policy (2015)
4. Pradhan Mantri Awas Yojana—Housing for All (2015)

These initiatives have created an enabling environment for the growth of the affordable housing sector in India. Since 2015, the reformatory steps taken under the Pradhan Mantri Awas Yojana have shown tremendous growth in affordable houses, and the process is still ongoing. Affordable urban housing program - PMAY

The Government of India launched the Pradhan Mantri Awas Yojana (PMAY) on 1 June 2015 to help India achieve housing for all by 2022. The PMAY initiative has two parts – Urban (U) and Gramin (G). This report will focus on PMAY-Urban.

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<sup>1</sup> Indian Housing Sector: Disrupted, Transformed & Recovering, Report from FICCI-ANAROCK, Sept 2020.

<sup>2</sup> Report by Task Force on Promoting Affordable Housing, Ministry of Housing and Urban Poverty Alleviation, 2012

<sup>3</sup> The Report on Trend and Progress of Housing in India – 2013, NHB

<sup>4</sup> Economic Survey of India



PMAY-U initiative is aimed at all areas classified as "urban" in India, including 4041 statutory towns<sup>5</sup>. 500 Class I cities have been prioritised for the 3-stage implementation process.<sup>6</sup> To be eligible for PMAY-U scheme:

1. Potential beneficiaries should have an income of less than INR 3 lakh for the EWS category (house sizes up to 30 sq.m),
2. Between INR 3 lakh (USD 4,000) and INR 6 lakh (USD 8,000) for the LIG category (house sizes up to 60 sq.m),
3. Between INR 6 lakh (USD 8,000) and INR 12 lakh (USD 15,864) for the MIG-I category (house sizes upto 160 sq.m),
4. Between INR 12 lakh (USD 16,000) and 18 lakh (USD 24,000) for the MIG-II category (house sizes upto 200 sq.m).

The beneficiaries of this program are eligible for lower interest rates based on their income category under the Credit Linked Subsidy Scheme (CLSS)<sup>7</sup> for the home loan they avail.<sup>8</sup> PMAY-U assists the central government to eligible beneficiaries through the applicable State and the Central Nodal Agencies (CNAs) once the claim for a dwelling under the scheme has been validated.<sup>9</sup>

As per the Central Sanctioning and Monitoring Committee (CSMC)<sup>10</sup>, over 11.4 million houses have been sanctioned so far under PMAY -U, as of November 2021. Out of this, close to 9 million houses have been grounded, and approximately 5.2 million houses have been completed.<sup>11</sup> This means almost 100 per cent of the total target of 11.2 million has been sanctioned in the six years of implementation of PMAY-U. Of the total houses sanctioned, about 46% have been completed as of November 2021. With this fast pace of approvals and construction, it becomes extremely important to see that the new buildings are thermally comfortable, energy-efficient and sustainable during construction and operational phases. The ongoing and upcoming affordable housing construction in the country brings an opportunity to reduce the impact of climate change by adopting energy-efficient and efficient building design practices.

## Need for Eco Niwas Samhita (ENS) compliance

The Energy Conservation Code for Residential Buildings (also termed as Eco-Niwas Samhita) has two parts.

1. ENS Part I was launched in 2018 by the Bureau of Energy Efficiency
2. ENS Part II was launched in 2021

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<sup>5</sup> Statutory town: All places with a municipality, corporation, cantonment board or notified town area committee, etc. Class I are cities with population of 100,000 and above. Source: <https://mohua.gov.in/cms/number-of-cities--towns-by-city-size-class.php>

<sup>6</sup> Pradhan Mantri Awas Yojana (PMAY), Updated on Jan 29, 2021, <https://cleartax.in/g/terms/pradhan-mantri-awas-yojana-pmay>. PMAY-U stage 1 covered 100 cities, stage 2 covered 200 additional cities and stage 3 refers to rest of the cities.

<sup>7</sup> CLSS is a component of PMAY which provides opportunity to economically weaker section and middle income groups to avail home loan at reduced monthly installments.

<sup>8</sup> How Urban Residents Can Get a House under PMAY – Urban, <https://www.bajajfinserv.in/insights/how-urban-residents-can-get-a-house-via-pmay#>: Assumption: 1 USD = 75 INR

<sup>9</sup> PM Awas: Five lakh houses grounded for construction in Maharashtra, <https://www.thehindubusinessline.com/news/real-estate/pm-awas-five-lakh-houses-grounded-for-construction-in-maharashtra/article31976874.ece>

<sup>10</sup> CSMC is central committee under Government of India to review the progress and monitoring of the mission. The committee assesses resource requirement based on 'Housing for All Plan of Action' and 'Annual Implementation Plan'. It provides approval for plans related to capacity building, monitoring, financial audit, social audit etc. It also devises financial and other norms for various activities undertaken as part of the mission.

<sup>11</sup> Source: [https://pmay-urban.gov.in/uploads/progress-pdfs/61dbf7b293d9c-National\\_1.pdf](https://pmay-urban.gov.in/uploads/progress-pdfs/61dbf7b293d9c-National_1.pdf)

ENS has been launched as a response to the increasing consumption of energy in residential buildings to help reduce the need for energy consumed. Buildings can employ active and passive strategies to reduce their energy needs and reduce overall energy consumption. Active strategies include using energy-efficient appliances, such as LED lights or energy-efficient fans, which, while using electricity, consume less energy than peer group products. Passive strategies are the use of design elements that suit the climate in which the building exists so that these buildings are more comfortable to live or work in and inhabitants do not feel the need for the use of weather making appliances such as air conditioners for cooling or heaters for warming their spaces.

Therefore, it is important to educate the builders in India to design and develop ENS compliant, affordable homes. The efficient way to do this is to organise design charrettes.

## Program context

GBPN India's mission is to support the government in decarbonising the residential building sector. GBPN has introduced this programme in collaboration with Environmental Design Solutions (EDS), which aims to provide support to the affordable housing sector of Gujarat and Maharashtra through design assistance towards establishing compliance with ECBC – R, also known as ENS.

## Objective

Provide design assistance to 10 housing projects in Gujarat and Maharashtra for ENS compliance by adopting a combination of passive architectural measures and the use of efficient building materials & technologies.

## Outcome

1. Compliance with ENS 2018 and 2021 was provided for each selected project through detailed design charrettes.
2. Technical capacity building for implementation of ENS complied housing project.

## Tasks

1. Engage with local builders/developers to identify and select a minimum of 10 affordable housing projects in Gujarat and Maharashtra, covering the three major climate zones
2. Design assessment for selected housing projects in compliance with ENS, the analysis includes the following:
  - a. Peak heat gain through the building envelope (Calculation of thermal transmittance (U value) of roof, wall and glass, Equivalent/Adjusted SHGC for glass).
  - b. Solar Analysis to determine shading and orientation requirements.
  - c. Wall window ratio & Openable window-to-floor area ratio optimisation.
  - d. Material selection.
3. Design charrettes for all stakeholders, including the project owner, architect, and engineers, to provide recommendations to develop an ENS compliant design.

4. Provide technical standards and specifications of building material and equipment to meet ENS requirements for affordable housing.
5. Prepare a monitoring and verification plan to ensure that final project design, building material and equipment & appliances selection complies with ENS requirement.

## Program methodology

A diagrammatic representation of the program methodology is provided in Figure 1, along with a list of total outputs alongside each task.

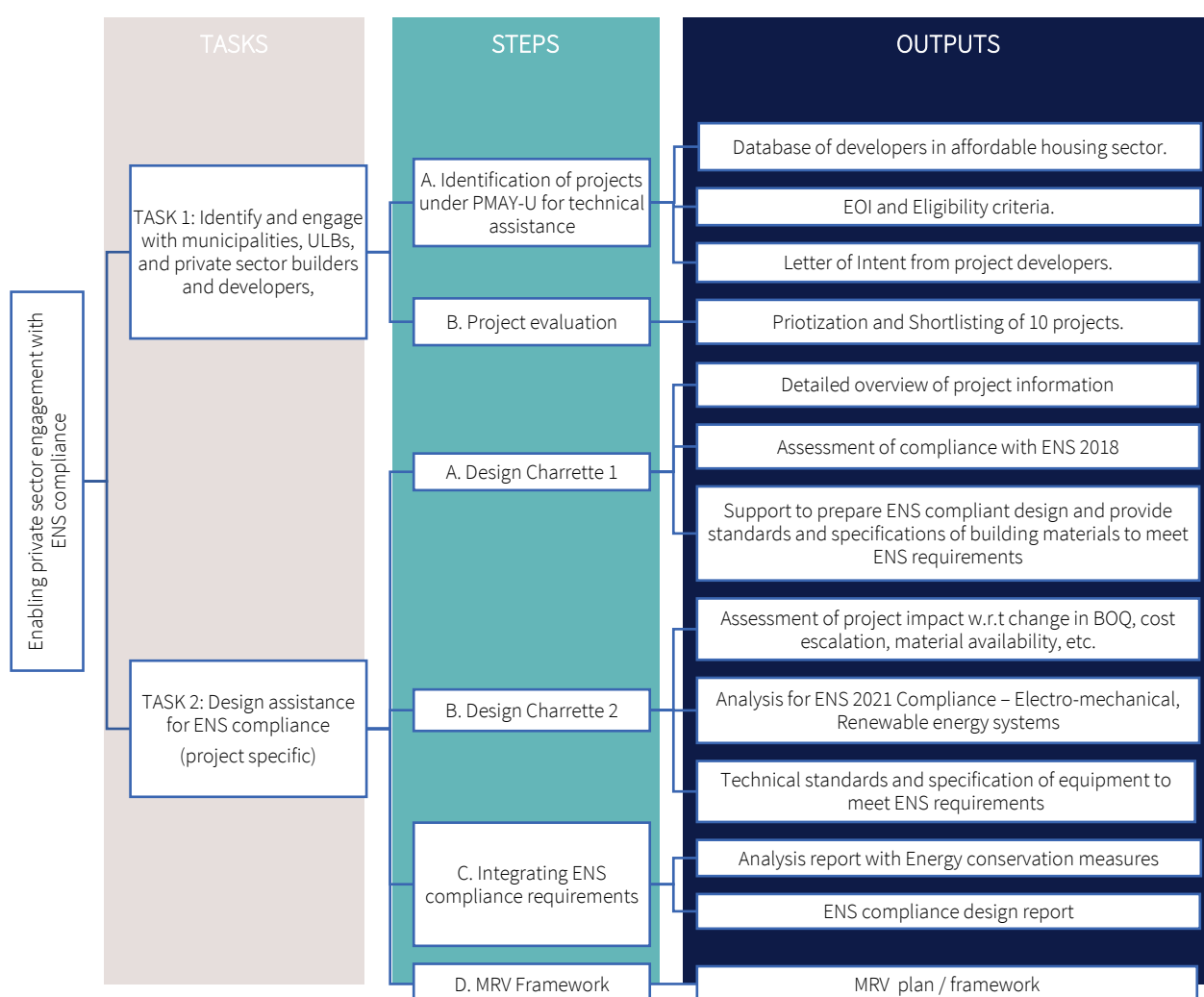


Figure 1: Detailed Program Methodology

An overview of key steps undertaken in this program is outlined below:

1. **Identification of affordable housing projects under PMAY-U and evaluation:** Mobilising the program information in Gujarat and Maharashtra on a large scale was one of the foremost steps undertaken. The project team adopted a multi-prong approach for a wide reach by contacting developers, owners, and the architectural community, national green building rating bodies - IGBC and GRIHA, etc. Rounds of virtual discussions were held with the stakeholders to apprise them about the program and process for participation. An Expression of interest was prepared and shared with the

potential project owners. The EOI covered detailed information on the application procedure for participating in this program, including the documents for project evaluation. The applications received from project developers were scrutinised based on the respective climate zones, types of dwelling units and wider coverage. The project team evaluated and shortlisted ten projects for design assistance based on several participants' comprehensive reviews of applications.

2. **Design charrettes 1 & 2:** Design charrettes were held with the developers, architects, and owners for each shortlisted project. The charrettes were designed and customised for each project depending on the stage. Before conducting the design charrettes, comprehensive project parameters w.r.t ENS requirements was carried out. Design charrette 1 focussed on providing support to prepare ENS compliant design to provide standards and specifications of building materials to meet ENS requirements. The second design charrette focused on clarifying all queries of the project team w.r.t requirements for ENS compliant design. During the second charrette, the technical standards and specifications of technologies were also shared to meet ENS compliance.
3. **Integrating ENS compliance requirements and MRV:** A thorough report on ENS compliance and suggestions/ modifications needed for each shortlisted project was prepared and shared with the developer's /project teams. Further, to ensure that the housing project development is performing as per the design intent, a Monitoring, Reporting & Verification framework has been prepared. The MRV plan /framework has been designed to map ENS requirements within the three stages of any project i.e., design & tender, construction, and post-occupancy.

# ECO NIWAS SAMHITA (ENS)

## Overview of ENS 2018 & 2021<sup>12</sup>

Eco Niwas Samhita 2018 (Part-I: Building Envelope), the residential building energy code, was launched by the Ministry of Power in December 2018. Building envelope consists of walls, roof, and fenestration (openings including windows, doors, vents, etc.). Eco Niwas Samhita 2021 (Code Compliance and Part-II: Electro-Mechanical and Renewable Energy Systems) is developed to set the minimum benchmark to achieve energy efficiency in residential buildings. The code specifies compliance approaches and minimum energy performance requirements for building services, indoor electrical end-use and renewable energy system in addition to the envelope parameters as prescribed in Eco Niwas Samhita 2018.



Figure 2: Source - Eco Niwas Samhita 2021

Project's compliance towards ENS 2021 is demonstrated by accessing the project performance for requirements enlisted in Chapter 4 (mandatory requirements) and Chapter 5 (prescriptive requirements).

ENS 2021 requires projects to achieve a minimum ENS score, as per project type (affordable, low rise, high rise), to show compliance. For the affordable category, each project should meet all mandatory requirements and a minimum of 70 points.

The following table summarises the component wise distribution of available points in ENS 2021.

<sup>12</sup> Source: ENS 2021 launched by Bureau of Energy Efficiency

Table 1: Component wise distribution of ENS Score

Components	Minimum Points	Additional Points	Maximum Points
<b>Building Envelope</b>			
Building Envelope	47	40	87
<b>Building Services</b>			
Common area & exterior lighting	3	6	9
Elevators	13	9	22
Pumps	6	8	14
Electrical Systems	1	5	6
<b>Indoor Electrical End- Use</b>			
Indoor Lighting		12	12
Comfort Systems		50	50
<b>Renewable Energy Systems Components</b>			
Solar Hot Water Systems		10	10
Solar Photo Voltaic		10	10

1. Minimum points: a set of points that are compulsory to achieve for each component to show compliance for ENS
2. Additional Points: a set of points awarded for adopting additional or better energy efficiency measures in a respective component.
3. Maximum points: total points available for each component.
4. To demonstrate compliance with the code using Point System Method, the ENS building must obtain the applicable minimum points and achieve remaining points by meeting the requirements labelled as 'additional points' of building envelope and/or 'additional' of 'Building Services' & Indoor Electric End-Use and/or 'additional' of 'Renewable Energy Systems'.

# LIST OF PROJECTS

The programme identified and approached over 50 potential developers /architects/ owners of upcoming affordable housing schemes and affordable housing projects, under PMAY-U, in Gujarat & Maharashtra. Multiple discussions were held with these potential project partners to explain the programme and its benefits. An invitation for expression of interest was circulated, and after going through the applications received from interested developers, 20 potential affordable housing projects were identified. Based on an extensive study of Eco Niwas Samhita, three aspects, i.e., climatic zone, dwelling unit typology, and orientation, were considered the key factors for selecting the projects.

1. There are 3 major climatic zones within Gujarat & Maharashtra i.e., warm, humid, hot and dry and composite.
2. Typology of the dwelling unit, i.e., 1 BHK (bedroom, hall, kitchen), 1.5 BHK etc., impacts the wall window ratio and the solar heat gain. The project selection methodology covered all dwelling unit types that are part of the proposed development.
3. Orientation factor as mentioned in ENS 2018, Part 1: Building envelope Annexure 6 plays an important role while conducting RETV calculations. This factor accounts for and gives weightage to the fact that the solar radiation falling on different orientations of walls is not the same. Eight orientation factors have been defined based on the eight different directions in the ENS 2018.

The key factors listed above ensured that assistance for ENS compliance was available for a wider group and would prove beneficial to over 4000 dwelling units across all the three climatic zones of Gujarat and Maharashtra.

These 20 potential projects were further shortlisted as per programme requirements, and ten projects were identified for the study.

The below section provides information on the shortlisted affordable housing projects to which design assistance has been provided for ENS compliance. The shortlisted projects include EWS, LIG and MIG-I housing types and 50% of the projects are aspiring PMAY status. All of the below projects are in the design stage, allowing the project teams to incorporate recommendations based on respective project analysis for ENS Compliance.

## Projects in Gujarat

No.	Name & Location	Aspiring PMAY (Y/N)	No. of Dwelling Units	Carpet Area /DU (m <sup>2</sup> )	Housing Category*	Climate Zone
1	Plot No. 75/78, Rajkot	Y	1022	28.5	EWS	Composite
2	Plot No. 50A, Rajkot	Y	868	38.5	LIG	Composite
3	Plot No. 78B, Rajkot	Y	462	38.5	LIG	Composite

No.	Name & Location	Aspiring PMAY (Y/N)	No. of Dwelling Units	Carpet Area /DU (m <sup>2</sup> )	Housing Category*	Climate Zone
4	Plot No. 964/2P, Jethpur	Y	56	28.1	EWS	Warm & humid
5	Gujarat Housing Board, Patan	Y	32	33.7	LIG	Hot & dry
6	Aarambh Housing, Ahmedabad	N	392	45.4	LIG	Hot & dry
7	Parshwa Housing 01, Sanand	N	221	52.7	LIG	Hot & dry
8	Parshwa Housing 02, Ognaj	N	104	75.7	MIG I	Hot & dry

\* Source - <https://pmay-urban.gov.in/about>

## Projects in Maharashtra

No.	Name & Location	Aspiring PMAY (Y/N)	No. of Dwelling Units	Carpet Area /DU (m <sup>2</sup> )	Housing Category*	Climate Zone
1.	Residential Tower, Badlapur, Thane	N	144	62.8	MIG I	Warm & humid
2.	Kumar Parv, Pune	N	716	77.8	MIG I	Warm & humid

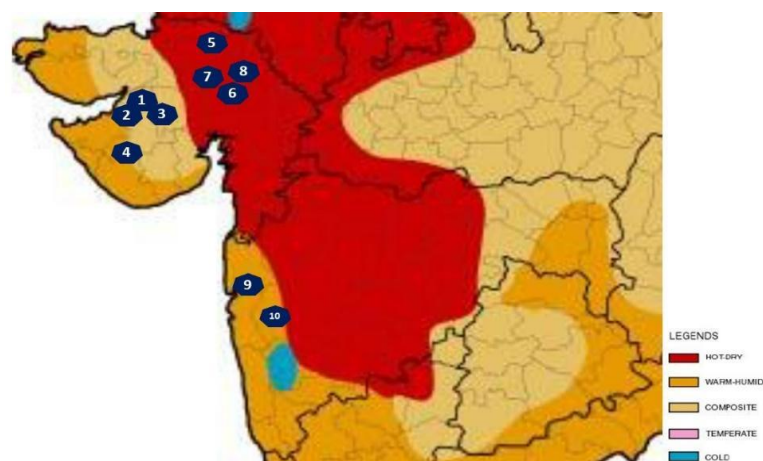


Figure 3: Location of 10 projects On Climate Zone Map

(Source – Energy Conservation Building Code -2017)

\* Source - <https://pmay-urban.gov.in/about>



# OBSERVATIONS & RECOMMENDATIONS

## Overview of ENS compliance assessment

The shortlisted projects were assessed for ENS compliance in 2 steps.

The first step dealt with ENS 2018 part 1: Building envelope. The design layouts and identified building materials for each project were studied. These parameters were analysed in compliance with the ENS 2018 requirements to evaluate the project's performance and required measures to mitigate any observed non-compliance. Most of the projects met the three sections of the window to floor area ratio, visual light transmittance and RETV requirements. Meeting the roof u-value requirement was a major challenge for all projects. Extensive analysis was done to provide the projects with options that would help meet the RETV and roof u-value requirements in terms of alternate building materials, changing the parameters of the existing material, and adding insulation. Case studies of executed projects were shown to the respective project teams to build confidence and showcase possible implementation measures with minimum changes in the project cost.

The second step of analysis dealt with assessing the projects regarding their electro-mechanical and renewable energy systems. Information on standard practices and guidelines were shared with the project teams. Based on this, a scorecard was generated as per ENS 2021, and the projects were assigned points based on their ENS 2018 performance and standard practices. For all other sections, recommendations were provided, based on which detailed discussions were held for improving the scorecard and addressing requirements for ENS.

## Key observations

In terms of overall awareness about ENS, most of the project teams were informed about ENS 2018 (Part I: Building envelope). However, the requirements of ENS 2021 (Code compliance and Part II: Electro-Mechanical and Renewable Energy Systems) were unknown to many project teams.

Some of the key observations are listed below:

Table 2: Key observation and results

No.	Requirement	Observations
MANDATORY	<b>Building Envelope</b>	
	Openable Window-to-Floor Area Ratio (WFR <sub>op</sub> )	Easily attainable by all almost all the projects

No.	Requirement	Observations
	Visible Light Transmittance (VLT)	Attained by all the projects
	Thermal Transmittance of Roof ( $U_{roof}$ )	Practical constraints like cracks and subsequent water leakage from the roof proved to be the major hindrance in providing insulation, leading to non-compliance for all the projects.
	Residential envelope transmittance value (RETV)	Most of the projects were compliant with the requirement. Non-compliant projects have shown a willingness to explore alternate construction technologies if the financial and construction schedule are met as per the current design.
	Power Factor Correction	Some reluctance was observed in incorporating the requirement as it has a major cost implication. The developer will welcome some incentives or third-party investments to help them meet the project's incremental cost.
	Energy Monitoring	There were some reservations in incorporating the requirement as it has a major cost implication. The developer will welcome any support in the form of incentives or third-party investments. One of the design charrettes also highlighted that the end-users (Housing Societies) might not utilise the installed systems (e.g., BMS) to their full capacity during operations due to lack of technical capacity.
	Electric Vehicle Charging System	Projects opting for other green building certifications were the only ones to provide charging facilities. However, all the project teams agreed to install the systems if ENS code compliance is mandatory and follows the installation requirements.
	Electrical systems	Some reluctance was observed in incorporating the requirement as it has a major cost implication in cabling requirements.
ADDITIONAL COMPLIANCE	<b>Building Services</b>	
	Common area and exterior lighting	All projects agreed to meet the lighting requirements as prescribed in ENS 2021.
	Elevators	The minimum requirements listed in ENS 2021 are standard practice with most developers.

No.	Requirement	Observations
	Pumps	The minimum requirements of pumps are standard practices with most developers.
	Electrical Systems	For all the projects (Gujarat and Maharashtra), the Distribution Company provides transformers, and the project team has no choice of selecting the transformer type or efficiency. Installation of Transformer type and its related efficiency is one of the minimum requirements of ENS 2021 and project teams do not have any control over it.
	Indoor Electrical end-use	As a standard practice, developers not to provide end-use electrical systems like lighting fixtures, ceiling fans, and ACs in the dwelling units. Also, the developer has no control over the end-user's selection and preferences for these systems.
	<b>Renewable Energy Systems</b>	
	Solar Water Heating	Due to practical constraints of end usage of hot water, most projects are reluctant to provide Solar hot water systems in their projects
	Solar Photo-Voltaic	Most of the projects have shown an inclination towards installing Solar Photovoltaics (Solar PV) rather than the Solar Hot Water system. The intention is to avail Net metering benefits so that the Housing Societies formed within the project benefit from the Solar PV system.

## Program impact

The programme is one of the first initiatives in the country to support affordable housing sector developers in implementing the ENS Code. The programme format enabled detailed one on one interaction sessions with the project teams, including developers, architects, design engineers, etc. which resulted in productive discussions around the subject and resolving technical queries during the discussions.

A few of the program impacts are as below:

1. Although only a limited no. of projects was facilitated for design assistance awareness about **the program was communicated to more than 50 developers /architects from the State of Gujarat and Maharashtra**. This has helped create awareness and understanding of the ENS code at the user level.
2. Ten shortlisted projects covering all climate zones and dwelling types within the Gujarat and Maharashtra were identified for detailed facilitation of design assistance.

Case studies of these projects can act as a ready reference for projects within a similar climate zone to meet ENS Compliance.

3. Through the programme over 4000 dwelling units have been accessed for ENS Compliance. Several low cost strategies have been discussed and agreed by the project teams to be incorporated in the project. These strategies will ensure better daylight access, cross ventilation, and lower heat gains for over 4000 dwelling units.
4. **The programme has acted as capacity building session for all project stakeholders.** The stakeholders got acquainted with ENS compliance requirements, project gaps in meeting ENS Compliance, low-cost building materials and technologies, etc. **These stakeholders are now equipped to use the acquired knowledge in all their future projects** and impart the same to any other project they may work with, creating a domino effect of sharing the ENS Code Compliance with a larger audience.
5. As a part of the programme, a monitoring, reporting and verification plan has been shared with all participants to track the project's progress in compliance with ENS. The plan will ensure that ENS Compliant dwelling units are built over a period.

## Challenges

One of the major challenges observed is the non-availability of an incentive to implement ENS compliance in the project. Developers/owners cannot invest additional CAPEX since the projects fall under the affordable category.

As a standard practice, affordable housing societies are handed over to the local authorities for sale post-construction. In such cases, the operations and maintenance team are the third party and look after the basic plumbing and electrical maintenance. The monitoring systems enlisted as part of the code require technical knowledge and constant monitoring, which is beyond the maintenance team's scope.

Developers/ Architects do not have access to simple, user-friendly tools which will enable them to verify the project's compliance with ENS during the design stage.

### A. Policy integration

1. ENS Compliant affordable homes are devoid of incentives provided by the State ULB's, unlike Green Building developments. States of Gujarat, Maharashtra, Kerala, West Bengal, Uttar Pradesh, etc. have executed various incentives for Green Building development for, e.g., fast track environmental clearance, discounts in property tax, additional Floor Area Ratio (FAR) free of charge, exemption of building scrutiny fee, etc. Provision of similar or other financial incentives for ENS compliant affordable homes will significantly boost ENS code's overall demand and implementation. To identify and develop the potential financial incentives schemes and the respective modalities, it would be important first to evaluate and learn from similar measures undertaken in the past nationally and internationally. This shall facilitate in understanding the key drivers of success for such incentive measures. The next step shall be the consultative discussion between stakeholders such as State ULBs, State financial departments, etc., to collaboratively work out potential incentives for the ENS compliant affordable

homes. Technical assistance to support the overall process for identifying and developing potential incentive measures for the ENS compliant affordable homes can be one of the next phase activities of this programme.

2. Certain financial institutions like State Bank of India (SBI), IIFL Home Finance, and HDFC have announced green home loans for green building developments; however, these loans are unavailable for ENS Compliant affordable homes. SBI Green Home loans offer 5% concession in the margin, 0.25% concession in the interest rate and waiver of processing fees under their Green Banking Policy. Banking institutions implementing green loans can be approached with a proposal to make green home loans available for ENS Compliant affordable homes. Some of the potential ways to facilitate such loans for the ENS compliant affordable homes would require the following actions:
  - a. Evaluate the existing models and schemes for green buildings and identify the provisions needed to include ENS compliant affordable homes as an additional category to the ongoing schemes of financial institutions.
  - b. Develop awareness and capacity building programs and provide training to build financial institutions' capacity and know-how towards considering ENS compliant affordable homes as opportunities for loan provision. Provide requirements from a financial institution perspective to build credibility in such loan provisions.
  - c. Support in the expansion of existing schemes or working out new loan schemes specifically for ENS compliant affordable homes.
3. State ULBs should be approached with an action plan to include ENS Compliance as a part of the building approval process. The action plan can include a set of strategies that will help State 'ULB's implement the ENS programme. For example:
  - a. Conducting training sessions for the developer community for ENS awareness and use to ENS tool,
  - b. Demonstration of ENS tool for ULB staff approving building plans,
  - c. Preparing ENS Compliance guidelines and building material product library, which will be available on Sate 'ULB's web portal as a ready reference for the developer community,
  - d. Creating content for social media and print media, which will be used by 'ULB's to demonstrate the progress of ENS implementation, etc.

## **B. Focused support to the developer community**

1. During the design charrette, it was identified that the local builders require support in identifying building materials that are energy efficient. A regional level directory including details like building materials with its properties, equipment & appliance, list of manufacturers & suppliers, and their details, can be prepared, which will act as a ready reference for the developer community. This directory can be made digitally available via various platforms of GBPN, NZEB, BEE, ULB's, etc.
2. The design charrettes conducted under this program provided an opportunity further to disseminate technical assistance to the developers for ENS compliance. Therefore, a structured YouTube animated series can be prepared for wider reach. The series can

include various topics like introduction to ENS, detailed guidance on part I and II compliance, building material and technology, use of ENS tool, case studies, etc.

3. Training sessions can be conducted with a focused group of architects, developers, building service consultants, etc. to build their technical knowledge and capacity. In person training can include doubt clearing sessions, strengthening the understanding required for ENS Compliant designs and product selection.

#### **c. Continuous monitoring and verification**

1. Monitoring and verification of the affordable housing project provide an opportunity to track and ensure the implementation of a project concerning ENS compliance. One of the immediate next steps of this programme shall be to monitor and track the progress of these ten projects, which have been provided technical assistance for ENS compliance. A Monitoring and verification plan has been developed as tools to check the project progress and the individual requirements for ENS compliance. A provision of technical assistance to support the comprehensive monitoring and verification process for these projects and provide necessary guidance on potential deviations (if occurring) shall be considered in this programme. This will include continuous support to the project teams by providing a technical evaluation of building material, recommendation on purchasing building materials, appliances and equipment, review of electrical design, renewable energy systems etc.

#### **D. New areas of development within the affordable housing**

1. Honourable Minister of Finance announced that around 8 million new Affordable Housing units would be developed in FY 2022-23. This is a significant push by the Government of India towards Housing for All. The 'government's push for new construction will drive demand in all the associated sectors such as building materials, equipment, utilities etc. Therefore, it is proposed that future affordable housing programmes of GBPN could focus on:
  - a. Targeting the new developments for ENS compliance through technical assistance in design charrettes beyond the States of Gujarat and Maharashtra
  - b. Expand the programme to include sustainable/green slum redevelopment, design charrettes for net-zero affordable housing, and ensure thermal comfort in low-rise construction. Etc.

A study to understand the qualitative and quantitative measures needed for the affordable housing sector with a few selected pilot demonstrations shall be considered in future programmes.

# ANNEXURE - EVALUATION REPORT OF THREE HOUSING PROJECTS

Ten projects were evaluated under the programme, out of which three projects have been show cased in this report. All climatic zones of Gujarat and Maharashtra (Composite, Hot & Dry and Warm & Humid) and building typologies; Economically Weaker Section, Low-Income Housing and Middle-Income Housing are covered in the following ENS compliance reports.

For further details related to the below mentioned projects or the other projects covered under the programme please contact [gautam.nagar@gbpn.org](mailto:gautam.nagar@gbpn.org)

# EVALUATION OF HOUSING PROJECT – PLOT NO. 75/78, RAJKOT, GUJARAT

## Project Details

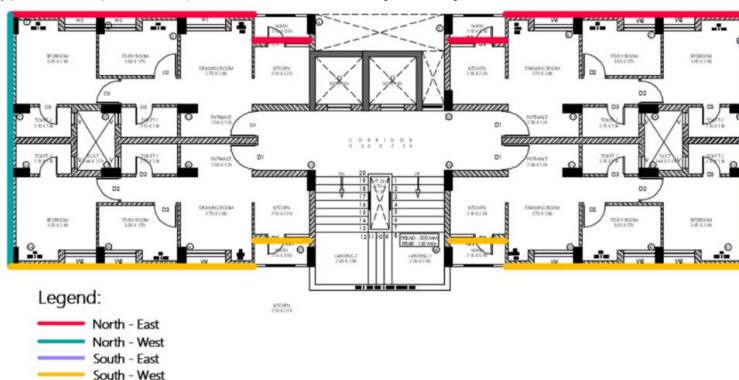
Project Name	Plot No. 75/78
Location	Rajkot, Gujarat
Number of Tower	16
Number of Dwelling Units	1022
Carpet Area/DU (sqm)	38.5
Climate Zone	Composite

## Layout



Figure 4: - Site plan, Plot No. 75/78, Rajkot, Gujarat

Figure 5:- Typical floor plan (Site plan, Plot No. 75/78, Rajkot, Gujarat)





# ENS 2021 Compliance Evaluation

## Step 1- Compliance check for mandatory requirements

### 1. Building Envelope

All requirements for building envelope under mandatory section as mentioned in Chapter 4 of ENS Part I [Min points 47]

The project was assessed for the 4 codes defined under ENS 2018 compliance as specified below:

1. Window to Floor Area Ratio
2. Minimum Visual Light Transmittance Requirement by calculating the overall Window to Wall Area Ratio
3. Maximum Roof Thermal transmittance (U Value)
4. Residential envelope transmittance value (RE TV) for building envelope (except roof)

#### Project data:

Table 3 - Envelope Parameters (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Climate:	Composite
Wall Material	AAC Block
U Value:	0.78 W/m <sup>2</sup> K
Roof Material	150 mm RCC
U Value:	5.2 W/m <sup>2</sup> K
Glass	5 mm thick clear Glass
U Value:	5.7 W/m <sup>2</sup> K
SHGC:	0.85

Table 4 - Details on non - opaque areas (Plot No. 75/78, Rajkot, Gujarat)

Window Detail (Non-Opaque Area), unit of measurement - meters	
W1	1.5 x 1.4
W2	1.2 x 1.4
KW	0.9 x 1.15
V	0.55 x 0.4
Vertical Fin Depth	0.4
Horizontal Projection Depth	0.9

#### Evaluation

Code 1: Window to Floor Area Ratio [WFR]

ENS requirement – Based on climate condition (composite) minimum WFR for the project should be 12.50%

Table 5- Window to Floor area (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Total Carpet Area (m <sup>2</sup> )	38.5
Openable Area (m <sup>2</sup> )	6.9
<b>Window to Floor Area Ratio</b>	<b>18 %</b>

**Project performance** – calculations conducted for 1 typical unit highlight that requirements are met.

*Code 2- Minimum Visual Light Transmittance (VLT)*

ENS requirement – Based on Window- to – wall ratio of 0 – 30% , minimum VLT of glass should be 0.27

Table 6 Window to Wall Ratio (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Parameters	Orientation				Total
	NW	SE	NE	SW	
Wall Area	28.8	28.8	68.5	68.5	194.6
Glazing Area	0	0.00	12.99	12.99	25.98
Window to Wall Ratio	<b>0%</b>	<b>0%</b>	<b>19%</b>	<b>19%</b>	<b>14%</b>

**Project performance** - Proposed glass of SHGC 0.85 will meet min VLT of 0.27. However, it is recommended that glass of lower SHGC of 0.4 – 0.45 should be utilised in the project to decrease in peak heat gain through Building Envelope. Additionally, Window to wall ratio (WWR) can be increased to 13% which will ensure better daylighting indoors.

*Code 3: Thermal Transmittance for Roof (U value Roof)*

ENS requirement – Thermal transmittance of roof shall comply with the maximum  $U_{roof}$  value of 1.2 W/m<sup>2</sup>·K

**Project performance** –Thermal transmittance of proposed 150 mm RCC Slab +water proofing, is 5.263 W/m<sup>2</sup>K. Compliance requirements are not met. The project team can re-design the roof cross section to include insulation. Various Insulation options include Extruded polystyrene (XPS) 25 mm, Expanded polystyrene (Thermocol) (EPS) 25mm, or Polyurethane Foam (Density-36±2Kg/3) 25 mm, U Value of the roof achieved after application of insulation will be 0.92 W/m<sup>2</sup>·K,1.16 W/m<sup>2</sup>·K, and 0.72 W/m<sup>2</sup>·K respectively. Thus requirements can be met with above recommendations.

*Code 4: Residential Envelope Transmittance Value (RE TV) for building envelope (except roof)*

ENS requirement - The Residential Envelope Transmittance Value (RETV) for the building envelope (except roof) for Composite Climate shall comply with the maximum RETV of 15 W/m<sup>2</sup>

Following tabular calculation confirm the achieved RETV value

Table 7 RETV formulae, as per ENS 2018

$$RETV = \frac{1}{A_{envelope}} \times \left[ \begin{array}{l} \left\{ a \times \sum_{i=1}^n (A_{opaque_i} \times U_{opaque_i} \times \omega_i) \right\} \\ + \left\{ b \times \sum_{i=1}^n (A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i) \right\} \\ + \left\{ c \times \sum_{i=1}^n (A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i) \right\} \end{array} \right]$$

Wall Conductive Heat Gains  
Window Conductive Heat Gain  
Window Radiation Heat Gain

Table 8 - Inputs for RETV calculations (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Component Description	U value	SHGC	NORTH-WEST Envelope (sq m)	SOUTH-EAST Envelope (sq m)	NORTH-EAST Envelope (sq m)	SOUTH-WEST Envelope (sq m)	TOTAL Envelope Area (sq m)
200 AAC	0.78		28.83	28.83	49.09	49.09	155.84
Door Frame (RCC)	11.76		0.00	0.00	0.63	0.63	1.26
Flush Door (Plywood)	4.35		0.00	0.00	3.15	3.15	6.30
Window Frame (Alum.)	9.09		0.00	0.00	2.60	2.60	5.20
Window	5.70	0.85	0.00	0.00	12.99	12.99	25.98
Total			28.83	28.83	68.46	68.46	194.58
Effective SHGC			0.00	0.00	0.59	0.58	
Achieved RETV for the project – 12.23 W/m <sup>2</sup>							

**Project performance** -Achieved Residential Envelope Transmittance Value (RETV) for the project is within the required limits, hence requirements are met.

## 2. Power Factor Correction

Requirement – All 3 phase shall maintain the power factor of 0.97 at the point of connection.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all 3-phase equipment (as applicable) shall maintain the power factor of 0.97 at the point of connection, to meet mandatory requirements.

### 3. Energy Monitoring

Requirements -

1. The project shall monitor the electrical energy use for each of the following separately:
  - a. Total electrical energy
  - b. Electricity consumption of following applicable end-use:
    - i. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)
    - ii. Elevators
    - iii. Water pumps
    - iv. Basement car parking ventilation system
    - v. Electricity generated from power back-up
    - vi. Electricity generated through renewable energy systems
    - vii. Lift pressurization system
2. The electrical energy use shall be recorded at an interval of minimum of every 15 minutes and reported at least hourly, daily, monthly, and annually. The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system. The digital control system shall be capable of maintaining all data collected for a minimum of 36 months.
3. The metering shall display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all the above requirements with respect to Energy Monitoring (as applicable) should be met, to meet mandatory requirements.

### 4. Electric Vehicle Charging System

Requirement –

If an Electric Vehicle Charging Infrastructure is installed in the premise, it shall be as per revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, or any subsequent amendments.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all of the above requirements with respect to Electric Vehicle Charging System (as applicable) should be met, to meet mandatory requirements.

### 5. Electrical Systems

Requirements –

1. The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.
2. Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all of the above requirements with respect to Electrical Systems (as applicable) should be met, to meet mandatory requirements.

## Step 2 – Compliance check for another component category of ENS

The below section enumerates each component category and associated minimum points which are required for an affordable project aspiring ENS Compliance

### 1. Common Area and Exterior Lighting

#### Minimum Requirement [ 3 points]-

The Lighting power density (LPD) and Luminous efficacy (LE) of permanently installed lighting fixtures in common area of the ENS compliant building shall meet the requirements of either maximum LPD or minimum luminous efficacy as per table below:

Table 9 Common Area Lighting (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Common Area	Maximum LPD (W/sqmts)	Minimum Luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt

**Additional Points [up to 3 points]:** Install all the permanently installed lighting fixtures with lamp luminous efficacy of 95 lm/W in areas mentioned below

Table 10 Score breakup for common area and exterior lighting – A (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Area/Zone	Points
Corridor lighting and stilt parking	1
Basement Lighting	1
Exterior Lighting Areas	1

**Additional Points [up to 6 points]:** Lamps for all exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch that is capable of

automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Installing all the permanently installed lighting fixtures in all corridor lighting, stilt parking, basement lighting and exterior lighting with lamp luminous efficacy of 105 lm/W.

Table 11 Score breakup for the Common Area and exterior Lighting – B (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Area/Zone	Points
Corridor lighting and stilt parking	2
Basement Lighting	2
Exterior Lighting Areas	2

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that minimum requirements with respect to Common area and exterior lighting (as applicable) should be met, to meet minimum requirements. The project team can further evaluate the products and lighting design to confirm if additional points can be met by fulfilling requirements as stated in the additional points above.

*Additional guidance: Requirements can be met by following any 1 of the following*

1. The requirement of luminous efficacy will be met by conventionally available light fixtures, eg LED, Tube lights, etc. While selecting the light fixtures enquire about the total available lumens of each fixture along with the wattage. Perform simple calculation (refer example below) to arrive at the lumens/watt values. Select fixtures which meet the ENS prescribed luminous efficacy i.e 85 lumens/watt.

*Example:*

*A 10-watt LED fixture has a luminous flux of 1000 lumens. Luminous efficacy of the fixture = luminous flux/power i.e 1000 lumens/10 watts = 100 lumens/watt. Hence the fixture can be installed meeting ENS requirements.*

2. While designing the outdoor lighting scheme, ENS guidelines of lighting power density as per below table, should be referred as guideline to design total lighting power for Corridor lighting, Stilt Parking, Basement lighting, driveways, pedestrian walkways, stairways, landscaping (as applicable).

Table 12 Outdoor Lighting Requirement (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Exterior Lighting Areas/ Zones	Watts/Sqmts
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

## 2. Elevators

### Minimum Requirements [13 points]-

The Elevators installed in the ENS compliant building shall meet the following requirements:

1. Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W
2. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied
3. Install minimum class IE 3 high efficiency motors
4. Group automatic operation of two or more elevators coordinated by supervisory control

**Additional points [9 points]** - Additional points can be obtained by:

5. Installing the variable voltage and variable frequency drives. (4 points)
6. Installing regenerative drives. (3 points)
7. Installing class IE4 motors. (2 points)

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that minimum requirements with respect to Elevators (as applicable) should be met, to meet minimum requirements. The project team can further evaluate available technologies and energy efficient equipment to meet requirements of additional points as above.

## 3. Pumps

### Minimum Requirements [6 points]-

Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed in the ENS building.

**Additional Points [8 points]:** Additional points can be obtained by:

1. Installation of BEE 5 star rated pumps (5 Points)
2. Installation of hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% (3 Points)

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that minimum requirements with respect to Pumps (as applicable) should be met, to meet minimum requirements. The project team can further evaluate available technologies and energy efficient equipment to meet requirements of additional points as above.

## 4. Electrical Systems

### Minimum Requirements [1 point]

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed the

values listed in Reference 1 below for dry type transformers and BEE 4-star rating in table below for oil type transformers.

**Additional points [5 points]:** Additional points can be obtained by providing all oil type transformers with BEE 5-star rating

**Project performance** – The project is in its initial design phase due to which details regarding electromechanical and renewable energy systems are under discussion, hence it is recommended that all minimum requirements with respect to Electrical Systems (as applicable) should be incorporated in the project to meet compliance. To achieve the additional points available in the scorecard, the project team can further evaluate the available energy efficient equipment options and incorporate them in the project wherever possible.

## 5. Indoor Electrical End-Use

The points mentioned under this section are not mandatory to show overall compliance. Provisions as per requirements can be provided if they fall under the scope of the developer.

### 5.1 Indoor lighting

**Minimum requirements [4 points, if opted] –**

All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall and kitchen.

**Additional Points [8 points]:** Additional points for indoor lighting by installing all lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following:

1. 95 lm/w (3 Points)
2. 105 lm/W (8 Points)

**Project performance** – The project is in its initial design phase due to which details regarding electromechanical and renewable energy systems are under discussion, hence it is recommended that above requirements should be evaluated with respect to tender documents and products to be installed in the project (as applicable) to understand the total points that can be achieved.

### 5.2 Comfort Systems

If comfort system for e.g. ceiling fans (in bedrooms and hall) and air conditioners (in bedrooms) are provided in dwelling units then following requirements will be mandatory.

**Ceiling Fans [Min 6 points if opted]:** Points for ceiling fans will be only applicable and could be achieved if all the bedrooms and hall in all the dwelling units are having ceiling fans and points could be gained, if

All ceiling fans installed in all the bedrooms and hall in all the dwelling units shall have a service value as given below:

1. For sweep size <1200 mm: equal or greater than 4 m<sup>3</sup>/minute/Watt
2. For sweep size >1200 mm: equal or greater than 5 m<sup>3</sup>/minute/Watt



BEE Standards and Labelling requirements for ceiling fans shall take precedence over the current minimum requirement, as and when it is notified as mandatory.

**Additional Points [4 points]:** Additional points for ceiling fans by installing in all the bedrooms and hall in all the dwelling units as per following:

1. 4 Star - 1 point
2. 5 Star – 3 points

**Air Conditioners [Minimum 20 points if opted]:** Points for air conditioners will be only applicable and could be achieved if all the bedrooms in all the dwelling units are having air conditioners (either unitary, split, VRF or centralized plant) and points could be gained, as per following compliance of energy efficiency for each system

1. Unitary Type: 5 Star
2. Split AC: 3 Star
3. VRF: 3.28 EER (Energy Efficiency Ratio)
4. Chiller: Minimum ECBC Level values as mentioned in ECBC 2017

**Additional Points [ 21 points]:**

1. Split AC: 5 Star
2. VRF: Currently, no star rating has been launched by BEE for VRFs. Once the rating is launched the projects would be required to choose VRFs with 5 Star rating.
3. Chiller: Minimum Super ECBC Level values as mentioned in ECBC 2017

**Project performance** – Based on discussion with the project team it is understood that any of the above comfort systems will not be provided. However, above requirements can be referred as guidance for future projects where comfort systems will be provided as a part of amenities from developers.

## 6. Renewable Energy Systems

### 6.1 Solar Hot Water System

Solar water heater shall meet the minimum efficiency level mentioned in IS 13129 Part (1&2) and for evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

**Minimum requirements, if opted [5 points]:** The ENS compliant building shall provide a solar water heating system (SWH) of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building. or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery.

**Additional Points [5 points]:** Additional points can be obtained by installing SWH system as per as per following:

1. 100% of the annual hot water demand of top 6 floors of the residential building (2 points)

2. 100% of the annual hot water demand of top 8 floors of the residential building (5 points)

**Project performance** – Based on discussion with the project team it is understood that Solar Water heating system is not proposed for the project. However, it is highly recommended to install Solar Water heating which will save electrical energy. Also, above requirements can be referred as guidance for future projects where comfort systems will be provided as a part of amenities from developers.

## 6.2 Solar Photo-Voltaic

**Minimum, if opted [5 points]:** The ENS compliant building shall provide a dedicated Renewable Energy Generation Zone (REGZ) – Equivalent to a minimum of 2 kWh/m<sup>2</sup>.year of electricity; or Equivalent to at least 20% of roof area. The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.

### **Additional Points [5 points]:**

Additional points can be obtained by installing solar photo voltaic as per following:

1. Equivalent to a minimum of 3 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 30% of roof area (2 points)
2. Equivalent to a minimum of 4 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 40% of roof area (5 points)

**Project performance** – Based on discussion with the project team it is understood that Solar Photo- voltaic system is not proposed for the project. However, it is highly recommended to install Solar Photo voltaic which will save electrical energy. Also, above requirements can be referred as guidance for future projects where comfort systems will be provided as a part of amenities from developers.

## ENS 2021 score for the project

ENS 2021 score has been derived for the project based on project design, discussions during the 2 design charrettes conducted for the project and recommendations provided during the design charrettes. Current score of 78 is achievable if requirements for all mandatory requirements are met along with other minimum requirements in respective sections as highlighted above. Below table summarises the mandatory requirements, minimum requirements and additional requirements and Project.

### Mandatory Requirement Checklist

Component	Mandatory Requirements
Site Area	The project should be located on a site of at least 500 m <sup>2</sup> area

Component	Mandatory Requirements												
<b>Openable Window-to-Floor Area Ratio (WFR<sub>op</sub>)</b>	$WFR_{op} = A_{openable} / A_{carpet}$ <p>Minimum requirement of window-to-floor area ratio:</p> <table border="1" data-bbox="619 248 1129 555"> <thead> <tr> <th>Climatic Zone</th> <th>Minimum WFR<sub>op</sub> %</th> </tr> </thead> <tbody> <tr> <td>Composite</td> <td>12.50</td> </tr> <tr> <td>Hot-Dry</td> <td>10.00</td> </tr> <tr> <td>Warm-Humid</td> <td>16.66</td> </tr> <tr> <td>Temperate</td> <td>12.50</td> </tr> <tr> <td>Cold</td> <td>8.33</td> </tr> </tbody> </table>	Climatic Zone	Minimum WFR <sub>op</sub> %	Composite	12.50	Hot-Dry	10.00	Warm-Humid	16.66	Temperate	12.50	Cold	8.33
Climatic Zone	Minimum WFR <sub>op</sub> %												
Composite	12.50												
Hot-Dry	10.00												
Warm-Humid	16.66												
Temperate	12.50												
Cold	8.33												
<b>Visible Light Transmittance (VLT)</b>	$WWR = A_{non-opaque} / A_{envelope}$ <p>Minimum requirement of glass VLT -</p> <table border="1" data-bbox="609 651 1123 952"> <thead> <tr> <th>Window-to-wall ratio</th> <th>Minimum VLT</th> </tr> </thead> <tbody> <tr> <td>0–0.30</td> <td>0.27</td> </tr> <tr> <td>0.31–0.40</td> <td>0.20</td> </tr> <tr> <td>0.41–0.50</td> <td>0.16</td> </tr> <tr> <td>0.51–0.60</td> <td>0.13</td> </tr> <tr> <td>61–0.70</td> <td>0.11</td> </tr> </tbody> </table>	Window-to-wall ratio	Minimum VLT	0–0.30	0.27	0.31–0.40	0.20	0.41–0.50	0.16	0.51–0.60	0.13	61–0.70	0.11
Window-to-wall ratio	Minimum VLT												
0–0.30	0.27												
0.31–0.40	0.20												
0.41–0.50	0.16												
0.51–0.60	0.13												
61–0.70	0.11												
<b>Thermal Transmittance of Roof (U<sub>roof</sub>)</b>	<p>Thermal transmittance of roof shall comply with the maximum U<sub>roof</sub> value of 1.2 W/m<sup>2</sup> .K.</p>												
<b>Residential envelope transmittance value (RETV) for building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate</b>	<p>The RETV for the building envelope (except roof) for, Composite Climate, shall comply with the maximum RETV of 15 W/m<sup>2</sup></p>												
<b>Power Factor Correction</b>	<p>All 3 phase shall maintain the power factor of 0.97 at the point of connection.</p>												
<b>Energy Monitoring</b>	<p>Monitor the electrical energy use for each of the following separately:</p> <p>Total electrical energy</p> <p>Electricity consumption of following applicable end-use:</p> <ol style="list-style-type: none"> <li>Common area lighting (Outdoor lighting, corridor lighting, basement lighting)</li> <li>Elevators</li> <li>Water pumps</li> <li>Basement car parking ventilation system</li> <li>Electricity generated from power back-up</li> <li>Electricity generated through renewable energy systems</li> </ol>												

Component	Mandatory Requirements
	g. Lift pressurization system
	Record the electrical energy at an interval of minimum of every 15 minutes and report at least hourly, daily, monthly, and annually.
	The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system.
	The digital control system should be capable of maintaining all data collected for a minimum of 36 months.
	The installed meter should display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.
<b>Electric Vehicle Charging System</b>	If an electric vehicle charging system is provided, it should meet the revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1 <sup>st</sup> October 2019, or any subsequent amendments
<b>Electrical systems</b>	The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained.
	Voltage drop for feeders shall not exceed 2% at design load.
	Voltage drop for branch circuit shall not exceed 3% at design load.

## Scorecard (Site plan, Plot No. 75/78, Rajkot, Gujarat)

Component	Requirements	Available points	Project Achievement								
<b>BUILDING ENVELOPE</b>											
Roof ( $U_{\text{roof}}$ )	Thermal transmittance of roof shall comply with the maximum $U_{\text{roof}}$ value of $1.2 \text{ W/m}^2 \cdot \text{K}$ .	3	3								
	Additional point shall be awarded as: maximum $U_{\text{roof}}$ value of $0.97 \text{ W/m}^2 \cdot \text{K}$ - <b>1 pt.</b> maximum $U_{\text{roof}}$ value of $0.74 \text{ W/m}^2 \cdot \text{K}$ - <b>2 pt.</b> maximum $U_{\text{roof}}$ value of $0.51 \text{ W/m}^2 \cdot \text{K}$ - <b>3 pt.</b> maximum $U_{\text{roof}}$ value of $0.28 \text{ W/m}^2 \cdot \text{K}$ - <b>4 pt.</b>	4	2								
RETV for building envelope (except roof) for four climate zones, i.e., composite climate, Hot-Dry climate, Warm-Humid climate, and Temperate climate	The RETV for the building envelope (except roof) shall comply with the maximum RETV of $15 \text{ W/m}^2$ Additional points shall be awarded as: RETV < 15 & upto $12 \text{ W/m}^2$ ; Score = $74 - 2 \times (\text{RETV})$ ( <b>Upto 50 pts.</b> )  RETV < 12 & upto $12 \text{ W/m}^2$ ; Score = $110 - 5 \times (\text{RETV})$ ( <b>Upto 80 pts.</b> )  RETV < $6 \text{ W/m}^2$ ( <b>80 pts.</b> )	80	50								
<b>BUILDING SERVICES</b>											
Common area and exterior lighting	The minimum luminous efficacy of all the installed light fixtures in the corridors, stilt parking, basement, and exterior lights, should be $85 \text{ lm/W}$ ; or Lighting power density should be maintained at the following levels: <table border="1" data-bbox="470 1496 1088 1805"> <tbody> <tr> <td>Corridor &amp; Stilt Parking – <math>3 \text{ W/m}^2</math></td> <td>Driveways &amp; parking – <math>1.6 \text{ W/m}^2</math></td> </tr> <tr> <td>Basement Lighting – <math>1 \text{ W/m}^2</math></td> <td>Pedestrian walkways – <math>2 \text{ W/m}^2</math></td> </tr> <tr> <td>Stairways – <math>10 \text{ W/m}^2</math></td> <td>Landscaping – <math>0.5 \text{ W/m}^2</math></td> </tr> <tr> <td colspan="2">Outdoor sales area – <math>9 \text{ W/m}^2</math></td> </tr> </tbody> </table>	Corridor & Stilt Parking – $3 \text{ W/m}^2$	Driveways & parking – $1.6 \text{ W/m}^2$	Basement Lighting – $1 \text{ W/m}^2$	Pedestrian walkways – $2 \text{ W/m}^2$	Stairways – $10 \text{ W/m}^2$	Landscaping – $0.5 \text{ W/m}^2$	Outdoor sales area – $9 \text{ W/m}^2$		3	3
	Corridor & Stilt Parking – $3 \text{ W/m}^2$	Driveways & parking – $1.6 \text{ W/m}^2$									
Basement Lighting – $1 \text{ W/m}^2$	Pedestrian walkways – $2 \text{ W/m}^2$										
Stairways – $10 \text{ W/m}^2$	Landscaping – $0.5 \text{ W/m}^2$										
Outdoor sales area – $9 \text{ W/m}^2$											
	Additional points shall be awarded as follows: a. Permanently installed lighting fixtures for corridor lighting and stilt parking, basement lighting, exterior lighting areas shall have lamp luminous efficacy of $95 \text{ lm/W}$ (1 point each,	6									

Component	Requirements	Available points	Project Achievement
	upto 3 points) or have lamp luminous efficacy of 105 lm/W (2point each upto 6 points) b. All exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch		
Elevators	Elevators installed shall meet all the following requirements: a. Lamps for lift car lighting having minimum luminous efficacy of 85 lm/W b. Automatic switch-off controls for lighting and fan inside the lift car. c. Minimum class IE 3 high efficiency motors d. Group automatic operation of two or more elevators coordinated by supervisory control	13	13
	Install variable voltage and variable frequency drives	4	
	Install regenerative drives	3	
	Install class IE4 motors	2	
Pumps	Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed.	6	6
	BEE 5 star rated pumps are installed	5	
	Hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% is installed	3	
Electrical Systems	For oil type transformers, select transformers that are a minimum of BEE 4 star rated & for dry type transformers, the minimum acceptable efficiency at 50% and full load should be in limits as mentioned in ENS.	1	1
	Oil type transformers with BEE 5-star rating are installed	5	
<b>INDOOR ELECTRICAL END USE</b>			
Indoor Lighting	All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall, and kitchen	4	
	Additional points shall be awarded as: a. All the lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following: 95 lm/w (3 pts.)	8	

Component	Requirements	Available points	Project Achievement
	105 lm/W (8 pts)		
Comfort Systems Ceiling Fans	Ceiling Fans installed in all bedrooms and hall in all dwelling units shall have service value (SV) as: a. For sweep size <1200 mm: SV>= 4m <sup>3</sup> /min.W b. For sweep size >1200 mm: SV>= 5m <sup>3</sup> /min.W	6	
	Additional points shall be awarded as: a. BEE 4-star fans are installed (1 pt.) b. BEE 5-star fans are installed (3 pts.)	3	
Comfort Systems – Air-Conditioners	Air-conditioners installed in all the dwelling shall be: <ul style="list-style-type: none"><li>● Unitary Type: 5 Star; or</li><li>● Split AC: 3 Star; or</li><li>● VRF: 3.28 EER; or</li><li>● Chiller: Minimum ECBC Level values as mentioned in ECBC 2017</li></ul>	20	
	Additional points shall be awarded as: <ul style="list-style-type: none"><li>● Split AC: 4 Star (9 pts.) or 5-star (21 pts.)</li><li>● VRF: BEE 4-star (9 pts.) or 5-star (21 pts.) rating upon rating launch by BEE</li><li>● Chiller: Minimum ECBC+ Level (9 pts.) or minimum super ECBC Level (21 pts.) values as mentioned in ECBC 2017</li></ul>	21	
<b>RENEWABLE ENERGY SYSTEMS</b>			
Solar Water Heating	A solar water heating system (SWH) of minimum BEE 3 Star capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building is provided or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery	5	
	Additional points shall be awarded as:  A SWH is provided of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of: <ul style="list-style-type: none"><li>● Top 6 floors of the building - 2 pts.</li><li>● Top 8 floors of the building - 5 pts.</li></ul>	5	
Solar Photo-Voltaic	A dedicated Renewable Energy Generation Zone (REGZ) shall be provided for equivalent to a	5	

Component	Requirements	Available points	Project Achievement
	minimum of 2 kWh/m <sup>2</sup> .year of electricity; or equivalent to at least 20% of roof area.		
	Additional points shall be awarded as: Solar Photo-Voltaic is provided: <ul style="list-style-type: none"> <li>● Equivalent to a minimum of 3 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 30% of roof area (<b>2 pts</b>)</li> <li>● Equivalent to a minimum of 4 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 40% of roof area (<b>5 pts</b>)</li> </ul>	5	



# EVALUATION OF HOUSING PROJECT: AARAMBH HOUSING, AHMEDABAD, GUJARAT

## Project Details

Project Name	Aarambh Housing
Location	Ahmedabad, Gujarat
Number of Tower	7
Number of Dwelling Units	392
Carpet Area/DU (sqm)	45.4
Climate Zone	Hot & Dry

## Layout



Figure 6: Site Plan (Aarambh Housing, Ahmedabad, Gujarat)

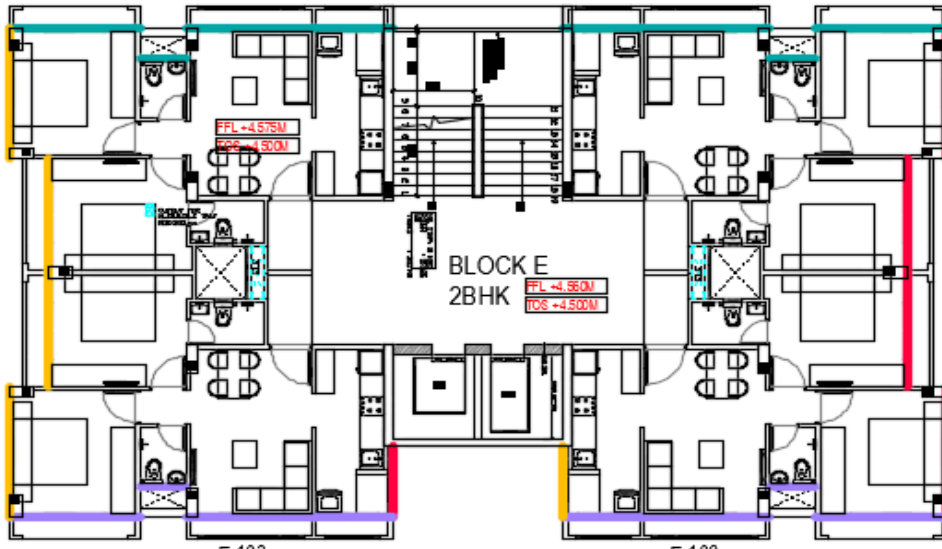


Figure 7: Typical Floor Plan (Aarambh Housing, Ahmedabad, Gujarat)

## ENS 2021 Compliance Evaluation

### Step 1- Compliance check for mandatory requirements

#### 1. Building Envelope

*All requirements for building envelope under mandatory section as mentioned in Chapter 4 of ENS Part I [ Min points 47]*

The project was accessed for the 4 codes defined under ENS 2018 compliance as specified below:

1. Window to Floor Area Ratio
2. Minimum Visual Light Transmittance Requirement by calculating the overall Window to Wall Area Ratio
3. Maximum Roof Thermal transmittance (U Value)
4. Residential envelope transmittance value (RE TV) for building envelope (except roof)

#### Project data:

Table 13 - Envelope Parameters (Aarambh Housing, Ahmedabad Gujarat)

Climate:	Hot & Dry
Wall Material	AAC Block
U Value:	0.78 W/m <sup>2</sup> K
Roof Material	150 mm RCC
U Value:	5.2 W/m <sup>2</sup> K
Glass	5 mm thick clear Glass
U Value:	5.7 W/m <sup>2</sup> K
SHGC:	0.85

Table 14 - Details on non - opaque areas (Aarambh Housing, Ahmedabad Gujarat)

Window Detail (Non-Opaque Area), unit of measurement - meters	
W1	1.4 x 1.02
V1	0.8 x 0.53
Vertical Fin Depth	0.6, 1.4
Horizontal Projection Depth	0.6

### Evaluation

#### *Code 1: Window to Floor Area Ratio [WFR]*

ENS requirement – Based on climate condition (hot and dry) minimum WFR for the project should be 10%

Table 15- Window to Floor area (Aarambh Housing, Ahmedabad Gujarat)

Total Carpet Area (m2)	45.4
Openable Area (m2)	6.61
Window to Floor Area Ratio	14.6%

**Project performance** – calculations conducted for 1 typical unit highlight that requirements are met.

#### *Code 2- Minimum Visual Light Transmittance (VLT)*

ENS requirement – Based on Window- to – wall ratio of 0 – 30%, minimum VLT of glass should be 0.27

Table 16 Window to Wall Ratio (Aarambh Housing, Ahmedabad Gujarat)

Parameters	Orientation				Total
	NW	SE	NE	SW	
Wall Area (m <sup>2</sup> )	55.52	55.52	44.25	44.25	199.54
Glazing Area (m <sup>2</sup> )	8.92	8.92	2.84	2.84	23.51
Window to Wall Ratio	16%	16%	6%	6%	12%

**Project performance** - Proposed glass of SHGC 0.85 will meet min VLT of 0.27. However, it is recommended that glass of lower SHGC of 0.4 – 0.45 should be utilised in the project to decrease in peak heat gain through Building Envelope. Additionally, the window to wall ratio can be increased to 23% for better daylight and natural ventilation.

#### *Code 3: Thermal Transmittance for Roof (U value Roof)*

ENS requirement – Thermal transmittance of roof shall comply with the maximum Uroof value of 1.2 W/m<sup>2</sup>·K

**Project performance** –Thermal transmittance of proposed 150 mm RCC Slab +water proofing, is 5.263 W/m<sup>2</sup>K. Compliance requirements are not met. The project team can re-design the roof cross section to include insulation. Various Insulation options include Extruded polystyrene (XPS) 25 mm, Expanded polystyrene (Thermocol) (EPS) 25mm, or Polyurethane

Foam (Density-36±2Kg/3) 25 mm, U Value of the roof achieved after application of insulation will be 0.92 W/m<sup>2</sup>·K, 1.16 W/m<sup>2</sup>·K, and 0.72 W/m<sup>2</sup>·K respectively. Thus requirements can be met with above recommendations.

*Code 4: Residential Envelope Transmittance Value (RE TV) for building envelope (except roof)*

ENS requirement - The Residential Envelope Transmittance Value (RETV) for the building envelope (except roof) for Composite Climate shall comply with the maximum RETV of 15 W/m<sup>2</sup>

Following tabular calculation confirm the achieved RETV value

Table 17 RETV formulae, as per ENS 2018

$$RETV = \frac{1}{A_{envelope}} \times \left[ \begin{array}{l} a \times \sum_{i=1}^n (A_{opaque_i} \times U_{opaque_i} \times \omega_i) \\ + b \times \sum_{i=1}^n (A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i) \\ + c \times \sum_{i=1}^n (A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i) \end{array} \right]$$

Wall Conductive Heat Gains  
Window Conductive Heat Gain  
Window Radiation Heat Gain

Table 18 - Inputs for RETV calculations (Aarambh Housing, Ahmedabad Gujarat)

Component Description	U value	SHGC	NORTH-WEST Envelope (sq m)	SOUTH-EAST Envelope (sq m)	NORTH-EAST Envelope (sq m)	SOUTH-WEST Envelope (sq m)	TOTAL Envelope Area (sq m)
200mm AAC	0.78		44.82	44.82	40.85	40.85	171.33
Window Frame (Alum.)	9.09		1.78	1.78	0.57	0.57	4.70
Window	5.70	0.85	8.92	8.92	2.84	2.84	23.51
Total			55.52	55.52	44.25	44.25	199.54
Effective SHGC			0.56	0.50	0.54	0.48	
Achieved RETV for the project – 11.13 W/m <sup>2</sup>							

**Project performance** -Achieved Residential Envelope Transmittance Value (RETV) for the project is within the required limits, hence requirements are met.

## 2. Power Factor Correction

Requirement – All 3 phase shall maintain the power factor of 0.97 at the point of connection.

**Project performance** – As conveyed by the project team during the design charrette, the power factor of 0.97 at the point of connection for all 3 phases shall be met.

### 3. Energy Monitoring

Requirements -

1. The project shall monitor the electrical energy use for each of the following separately:
  - a. Total electrical energy
  - b. Electricity consumption of following applicable end-use:
    - i. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)
    - ii. Elevators
    - iii. Water pumps
    - iv. Basement car parking ventilation system
    - v. Electricity generated from power back-up
    - vi. Electricity generated through renewable energy systems
    - vii. Lift pressurization system
2. The electrical energy use shall be recorded at an interval of minimum of every 15 minutes and reported at least hourly, daily, monthly, and annually. The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system. The digital control system shall be capable of maintaining all data collected for a minimum of 36 months.
3. The metering shall display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.

**Project performance** – As conveyed during the design charrette, the project team has agreed to install the advanced energy metering for the different end-uses (as applicable) in the project. Monitoring the electrical energy use requires installing Building Management System (BMS). The team has highlighted that since the project is for the affordable sector installing a BMS system will incur additional cost in the overall budget for the project. The team agreed to install BMS system if ENS Compliance is mandated as per statutory regulations. Also, certain incentives on implementing such measures are highly desirable by the project team.

### 4. Electric Vehicle Charging System

Requirement –

If an Electric Vehicle Charging Infrastructure is installed in the premise, it shall be as per revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, or any subsequent amendments.

**Project performance** – As conveyed during the design charrette, conventional electric vehicle charging systems are proposed to be installed in the project. The project team has agreed to upgrade the electric vehicle charging infrastructure as per revised guidelines issued by Ministry

of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, if ENS Compliance is mandated as per statutory regulations. The requirements are mentioned below.

Table 19: Electric Vehicle infrastructure requirements (Aarambh Housing, Ahmedabad, Gujarat)

Charger Type	S.No.	Charger Connectors*	Rated Output Voltage (V)	No. of Connector Guns (CG)	Charging Vehicle Type (W= Wheeler)
Fast	1.	Combined Charging System (CCS) (min 50 kW)	200-750 or higher	1 CG	4W
	2.	CHArge de MOve (CHAdeMO) (min 50 kW)	200-500 or higher	1 CG	4W
	3.	Type-2 AC (min 22 kW)	380-415	1 CG	4W, 3W, 2W
Slow/Moderate	4.	Bharat DC-001 (15 kW)	48	1 CG	4W, 3W, 2W
	5.	Bharat DC-001 (15 kW)	72 or higher	1 CG	4W
	6.	Bharat AC-001 (10 kW)	230	3 CG or 3.3 kW each	4W, 3W, 2W
*In addition, any other fast/slow/moderate charger as per approved DST/BIS standards whenever notified					
Note: Type-2 AC (min 22 kW) is capable of charging e- 2W/3W with the provision of an adapter.					

## 5. Electrical Systems

Requirements –

1. The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.
2. Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

**Project performance** – Load calculations for the project will be calculated up to panel level. Design Calculations accounting losses will be maintained. Additionally, distributions losses can also be limited to 3%. However, achieving a voltage drop for feeders and branch circuit as

per ENS requirements are too stringent for the project to achieve, it would also incur additional cost to the current project budget. If ENS Compliance is mandated as per statutory regulations, the team will consider ENS recommendations.

## Step 2 – Compliance check for another component category of ENS

The below section enumerates each component category and associated minimum points which are required for an affordable project aspiring ENS Compliance

### 1. Common Area and Exterior Lighting

#### Minimum Requirement [ 3 points]-

The Lighting power density (LPD) and Luminous efficacy (LE) of permanently installed lighting fixtures in common area of the ENS compliant building shall meet the requirements of either maximum LPD or minimum luminous efficacy as per table below:

Table 20 Common Area Lighting (Aarambh Housing, Ahmedabad Gujarat)

Common Area	Maximum LPD (W/sqmts)	Minimum Luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt

**Additional Points [upto 3 points]:** Install all the permanently installed lighting fixtures with lamp luminous efficacy of 95 lm/W in areas mentioned below

Table 21 Score breakup for common area and exterior lighting – A (Aarambh Housing, Ahmedabad Gujarat)

Area/Zone	Points
Corridor lighting and stilt parking	1
Basement Lighting	1
Exterior Lighting Areas	1

**Additional Points [upto 6 points]:** Lamps for all exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Installing all the permanently installed lighting fixtures in all corridor lighting, stilt parking, basement lighting and exterior lighting with lamp luminous efficacy of 105 lm/W.

Table 22 Score breakup for the Common Area and exterior Lighting – B (Aarambh Housing, Ahmedabad Gujarat)

Area/Zone	Points
Corridor lighting and stilt parking	2
Basement Lighting	2

Area/Zone	Points
Exterior Lighting Areas	2

Project performance – As conveyed by the project team during the design charrette, the basement lighting design is complete, and the achieved lighting power density is less than 1 W/ft<sup>2</sup>. Lighting design for other common area and exterior lighting is under design. The project team confirmed that compliance with ENS requirements is achievable within the project budget.

*Additional guidance: Requirements can be met by following any 1 of the following*

1. The requirement of luminous efficacy will be met by conventionally available light fixtures, eg LED, Tube lights, etc. While selecting the light fixtures enquire about the total available lumens of each fixture along with the wattage. Perform simple calculation (refer example below) to arrive at the lumens/watt values. Select fixtures which meet the ENS prescribed luminous efficacy i.e 85 lumens/watt.

*Example:*

*A 10-watt LED fixture has a luminous flux of 1000 lumens. Luminous efficacy of the fixture = luminous flux/power i.e 1000 lumens/10 watts = 100 lumens/watt. Hence the fixture can be installed meeting ENS requirements.*

2. While designing the outdoor lighting scheme, ENS guidelines of lighting power density as per below table, should be referred as guideline to design total lighting power for Corridor lighting, Stilt Parking, Basement lighting, driveways, pedestrian walkways, stairways, landscaping (as applicable).

Table 23 Outdoor Lighting (Aarambh Housing, Ahmedabad Gujarat)

Exterior Lighting Areas/ Zones	Watts/Sqmts
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

## 2. Elevators

### Minimum Requirements [13 points]–

The Elevators installed in the ENS compliant building shall meet the following requirements:

1. Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W
2. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied
3. Install minimum class IE 3 high efficiency motors



4. Group automatic operation of two or more elevators coordinated by supervisory control

**Additional points [9 points]** - Additional points can be obtained by:

1. Installing the variable voltage and variable frequency drives. (4 points)
2. Installing regenerative drives. (3 points)
3. Installing class IE4 motors. (2 points)

**Project performance** – As conveyed by the project team during the design charrette, the minimum requirements for the elevator such as high efficiency lamps, automatic switch-off controls for lighting and fans and class IE3 high efficiency motors shall be installed. However, since the project towers shall be equipped with one only one lift car per tower, hence the provision to group operation of two or more elevators coordinated by supervisory control is not applicable. For the additional points, the project has agreed to install variable voltage and variable frequency drives. Since installation of regenerative drives and class IE4 motors has a high-cost implication involved, hence these shall not be installed.

### 3. Pumps

**Minimum Requirements [6 points]-**

Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed in the ENS building.

**Additional Points [8 points]:** Additional points can be obtained by:

1. Installation of BEE 5 star rated pumps (5 Points)
2. Installation of hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% (3 Points)

**Project performance** – As conveyed during the design charrette, the project shall be equipped with both hydro-pneumatic for top 3 floors of the tower and gravity fed pumps. It was confirmed by the project team that minimum mechanical efficiency of 60% shall be met for the pumps.

### 4. Electrical Systems

**Minimum Requirements [1 point]**

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed the values listed in Reference 1 below for dry type transformers and BEE 4-star rating in table below for oil type transformers.

**Additional points [5 points]:** Additional points can be obtained by providing all oil type transformers with BEE 5 star rating

**Project performance** – As conveyed during the design charrette, the transformers shall not be installed by the project developer but directly supplied and installed at the project site by the

local DISCOM. As transformers are provided by DISCOM the project team has no control on type of transformer.

## 5. Indoor Electrical End-Use

The points mentioned under this section are not mandatory to show overall compliance. Provisions as per requirements can be provided if they fall under the scope of the developer.

### 5.1. Indoor lighting

#### Minimum requirements [4 points, if opted] –

All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall and kitchen.

**Additional Points [8 points]:** Additional points for indoor lighting by installing all lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following:

1. 95 lm/w (3 Points)
2. 105 lm/W (8 Points)

**Project performance** – As conveyed during the design charrette, the installation of the internal artificial lighting fixtures in all bedrooms, hall and kitchen does not fall under the scope of the project developer.

### 5.2. Comfort Systems

If comfort system for e.g. ceiling fans (in bedrooms and hall) and air conditioners (in bedrooms) are provided in dwelling units then following requirements will be mandatory.

**Ceiling Fans [Min 6 points if opted]:** Points for ceiling fans will be only applicable and could be achieved if all the bedrooms and hall in all the dwelling units are having ceiling fans and points could be gained, if

All ceiling fans installed in all the bedrooms and hall in all the dwelling units shall have a service value as given below:

1. For sweep size <1200 mm: equal or greater than 4 m<sup>3</sup>/minute/Watt
2. For sweep size >1200 mm: equal or greater than 5 m<sup>3</sup>/minute/Watt

BEE Standards and Labelling requirements for ceiling fans shall take precedence over the current minimum requirement, as and when it is notified as mandatory.

**Additional Points [4 points]:** Additional points for ceiling fans by installing in all the bedrooms and hall in all the dwelling units as per following:

1. 4 Star - 1 point
2. 5 Star – 3 points

**Project Performance** – As conveyed during the design charrette, installation of ceiling fans inside the dwelling unit is not under the scope of the project developer. However, the project

developer shall be installing ceiling fans in the common areas, which will meet the ENS requirement of BEE 5 star

**Air Conditioners [Minimum 20 points if opted]:** Points for air conditioners will be only applicable and could be achieved if all the bedrooms in all the dwelling units are having air conditioners (either unitary, split, VRF or centralized plant) and points could be gained, as per following compliance of energy efficiency for each system

1. Unitary Type: 5 Star
2. Split AC: 3 Star
3. VRF: 3.28 EER (Energy Efficiency Ratio)
4. Chiller: Minimum ECBC Level values as mentioned in ECBC 2017

**Additional Points [ 21 points]:**

1. Split AC: 5 Star
2. VRF: Currently, no star rating has been launched by BEE for VRFs. Once the rating is launched the projects would be required to choose VRFs with 5 Star rating.
3. Chiller: Minimum Super ECBC Level values as mentioned in ECBC 2017

**Project performance** – It was communicated by the project team during the design charrette that all the air conditioners to be installed by the project developer shall be split AC and BEE 5 star rated.

## 6. Renewable Energy Systems

### 6.1. Solar Hot Water System

Solar water heater shall meet the minimum efficiency level mentioned in IS 13129 Part (1&2) and for evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

**Minimum requirements, if opted [5 points]:** The ENS compliant building shall provide a solar water heating system (SWH) of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building. or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery.

**Additional Points [5 points]:** Additional points can be obtained by installing SWH system as per as per following:

3. 100% of the annual hot water demand of top 6 floors of the residential building (2 points)
4. 100% of the annual hot water demand of top 8 floors of the residential building (5 points)

**Project performance** – Based on discussion with the project team it is understood that Solar Water heating system is not provided for the dwelling units. However, it is highly recommended to install Solar Water heating which will save electrical energy. Also, above

requirements can be referred as guidance for future projects which can be provided as a part of amenities from developers.

## 6.2. Solar Photo-Voltaic

**Minimum, if opted [5 points]:** The ENS compliant building shall provide a dedicated Renewable Energy Generation Zone (REGZ) – Equivalent to a minimum of 2 kWh/m<sup>2</sup>.year of electricity; or Equivalent to at least 20% of roof area. The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.

### Additional Points [5 points]:

Additional points can be obtained by installing solar photo voltaic as per following:

1. Equivalent to a minimum of 3 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 30% of roof area (2 points)
2. Equivalent to a minimum of 4 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 40% of roof area (5 points)

**Project performance** – As per project data and discussion during design charrette it is understood that at least 42% of the roof will be installed with Solar PV. Hence, the project is likely to achieve all the applicable 10 points.

## ENS 2021 score for the project

ENS 2021 score has been derived for the project based on project design, discussions during the 2 design charrettes conducted for the project and recommendations provided during the design charrettes. Current score of 99 is achievable if requirements for all mandatory requirements are met along with other minimum requirements in respective sections as highlighted above. Below table summarises the mandatory requirements, minimum requirements and additional requirements and Project.

### Mandatory Requirement Checklist

Component	Mandatory Requirements												
Site Area	The project should be located on a site of at least 500 m <sup>2</sup> area												
Openable Window-to-Floor Area Ratio (WFR <sub>op</sub> )	$WFR_{op} = A_{openable} / A_{carpet}$ Minimum requirement of window-to-floor area ratio: <table border="1" data-bbox="619 1563 1238 1830"> <thead> <tr> <th>Climatic Zone</th> <th>Minimum WFR<sub>op</sub> %</th> </tr> </thead> <tbody> <tr> <td>Composite</td> <td>12.50</td> </tr> <tr> <td>Hot-Dry</td> <td>10.00</td> </tr> <tr> <td>Warm-Humid</td> <td>16.66</td> </tr> <tr> <td>Temperate</td> <td>12.50</td> </tr> <tr> <td>Cold</td> <td>8.33</td> </tr> </tbody> </table>	Climatic Zone	Minimum WFR <sub>op</sub> %	Composite	12.50	Hot-Dry	10.00	Warm-Humid	16.66	Temperate	12.50	Cold	8.33
Climatic Zone	Minimum WFR <sub>op</sub> %												
Composite	12.50												
Hot-Dry	10.00												
Warm-Humid	16.66												
Temperate	12.50												
Cold	8.33												

Component	Mandatory Requirements												
Visible Light Transmittance (VLT)	$WWR = A_{\text{non-opaque}} / A_{\text{envelope}}$ Minimum requirement of glass VLT - <table border="1" data-bbox="608 244 1200 517"> <thead> <tr> <th data-bbox="608 244 920 288">Window-to-wall ratio</th> <th data-bbox="920 244 1200 288">Minimum VLT</th> </tr> </thead> <tbody> <tr> <td data-bbox="608 288 920 333">0–0.30</td> <td data-bbox="920 288 1200 333">0.27</td> </tr> <tr> <td data-bbox="608 333 920 378">0.31–0.40</td> <td data-bbox="920 333 1200 378">0.20</td> </tr> <tr> <td data-bbox="608 378 920 423">0.41–0.50</td> <td data-bbox="920 378 1200 423">0.16</td> </tr> <tr> <td data-bbox="608 423 920 468">0.51–0.60</td> <td data-bbox="920 423 1200 468">0.13</td> </tr> <tr> <td data-bbox="608 468 920 517">61–0.70</td> <td data-bbox="920 468 1200 517">0.11</td> </tr> </tbody> </table>	Window-to-wall ratio	Minimum VLT	0–0.30	0.27	0.31–0.40	0.20	0.41–0.50	0.16	0.51–0.60	0.13	61–0.70	0.11
Window-to-wall ratio	Minimum VLT												
0–0.30	0.27												
0.31–0.40	0.20												
0.41–0.50	0.16												
0.51–0.60	0.13												
61–0.70	0.11												
Thermal Transmittance of Roof ( $U_{\text{roof}}$ )	Thermal transmittance of roof shall comply with the maximum $U_{\text{roof}}$ value of 1.2 W/m <sup>2</sup> .K.												
Residential envelope transmittance value (RETV) for building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate	The RETV for the building envelope (except roof) for, Composite Climate, shall comply with the maximum RETV of 15 W/m <sup>2</sup>												
Power Factor Correction	All 3 phase shall maintain the power factor of 0.97 at the point of connection.												
Energy Monitoring	Monitor the electrical energy use for each of the following separately: Total electrical energy Electricity consumption of following applicable end-use: a. Common area lighting (Outdoor lighting, corridor lighting, basement lighting) Elevators Water pumps Basement car parking ventilation system Electricity generated from power back-up Electricity generated through renewable energy systems g. Lift pressurization system												
	Record the electrical energy at an interval of minimum of every 15 minutes and report at least hourly, daily, monthly, and annually.												
	The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system.												
	The digital control system should be capable of maintaining all data collected for a minimum of 36 months.												
	The installed meter should display current (in each phase and the neutral), voltage (between phases and between each phase and												

Component	Mandatory Requirements
	neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.
Electric Vehicle Charging System	If an electric vehicle charging system is provided, it should meet the revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1 <sup>st</sup> October 2019, or any subsequent amendments
Electrical systems	The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained.
	Voltage drop for feeders shall not exceed 2% at design load.
	Voltage drop for branch circuit shall not exceed 3% at design load.

## Scorecard (Aarambh Housing, Ahmedabad Gujarat)

Component	Requirements	Available points	Project Achievement
<b>Building Envelope</b>			
Roof ( $U_{\text{roof}}$ )	Thermal transmittance of roof shall comply with the maximum $U_{\text{roof}}$ value of $1.2 \text{ W/m}^2 \cdot \text{K}$ .	3	3
	Additional point shall be awarded as: maximum $U_{\text{roof}}$ value of $0.97 \text{ W/m}^2 \cdot \text{K}$ - <b>1 pt.</b> maximum $U_{\text{roof}}$ value of $0.74 \text{ W/m}^2 \cdot \text{K}$ - <b>2 pt.</b> maximum $U_{\text{roof}}$ value of $0.51 \text{ W/m}^2 \cdot \text{K}$ - <b>3 pt.</b> maximum $U_{\text{roof}}$ value of $0.28 \text{ W/m}^2 \cdot \text{K}$ - <b>4 pt.</b>	4	
RETV for building envelope (except roof) for four climate zones, i.e., composite climate, Hot-Dry climate, Warm-Humid climate, and Temperate climate	The RETV for the building envelope (except roof) shall comply with the maximum RETV of $15 \text{ W/m}^2$ Additional points shall be awarded as: RETV < 15 & upto $12 \text{ W/m}^2$ ; Score = $74 - 2 \times (\text{RETV})$ (Upto 50 pts.)  RETV < 12 & upto $12 \text{ W/m}^2$ ; Score = $110 - 5 \times (\text{RETV})$ (Upto 80 pts.)  RETV < $6 \text{ W/m}^2$ ( <b>80 pts.</b> )	80	54
<b>Building Services</b>			

Component	Requirements	Available points	Project Achievement								
Common area and exterior lighting	<p>The minimum luminous efficacy of all the installed light fixtures in the corridors, stilt parking, basement, and exterior lights, should be 85 lm/W; or</p> <p>Lighting power density should be maintained at the following levels:</p> <table border="1"> <tr> <td>Corridor &amp; Stilt Parking – 3 W/m<sup>2</sup></td> <td>Driveways &amp; parking – 1.6 W/m<sup>2</sup></td> </tr> <tr> <td>Basement Lighting – 1 W/m<sup>2</sup></td> <td>Pedestrian walkways – 2 W/m<sup>2</sup></td> </tr> <tr> <td>Stairways – 10 W/m<sup>2</sup></td> <td>Landscaping – 0.5 W/m<sup>2</sup></td> </tr> <tr> <td colspan="2">Outdoor sales area – 9 W/m<sup>2</sup></td> </tr> </table>	Corridor & Stilt Parking – 3 W/m <sup>2</sup>	Driveways & parking – 1.6 W/m <sup>2</sup>	Basement Lighting – 1 W/m <sup>2</sup>	Pedestrian walkways – 2 W/m <sup>2</sup>	Stairways – 10 W/m <sup>2</sup>	Landscaping – 0.5 W/m <sup>2</sup>	Outdoor sales area – 9 W/m <sup>2</sup>		3	3
	Corridor & Stilt Parking – 3 W/m <sup>2</sup>	Driveways & parking – 1.6 W/m <sup>2</sup>									
Basement Lighting – 1 W/m <sup>2</sup>	Pedestrian walkways – 2 W/m <sup>2</sup>										
Stairways – 10 W/m <sup>2</sup>	Landscaping – 0.5 W/m <sup>2</sup>										
Outdoor sales area – 9 W/m <sup>2</sup>											
	<p>Additional points shall be awarded as follows:</p> <p>a. Permanently installed lighting fixtures for corridor lighting and stilt parking, basement lighting, exterior lighting areas shall have lamp luminous efficacy of 95 lm/W (1 point each, upto 3 points) or have lamp luminous efficacy of 105 lm/W (2point each upto 6 points)</p> <p>b. All exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch</p>	6	6								
Elevators	<p>Elevators installed shall meet all the following requirements:</p> <p>a. Lamps for lift car lighting having minimum luminous efficacy of 85 lm/W</p> <p>b. Automatic switch-off controls for lighting and fan inside the lift car.</p> <p>c. Minimum class IE 3 high efficiency motors</p> <p>d. Group automatic operation of two or more elevators coordinated by supervisory control</p>	13	13								
	Install variable voltage and variable frequency drives	4	4								
	Install regenerative drives	3									
	Install class IE4 motors	2									
Pumps	Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed.	6	6								
	BEE 5 star rated pumps are installed	5									

Component	Requirements	Available points	Project Achievement
	Hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% is installed	3	
Electrical Systems	For oil type transformers, select transformers that are a minimum of BEE 4 star rated & for dry type transformers, the minimum acceptable efficiency at 50% and full load should be in limits as mentioned in ENS.	1	
	<b>Oil type transformers with BEE 5-star rating are installed</b>	<b>5</b>	
<b>Indoor Electrical end use</b>			
Indoor Lighting	All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall, and kitchen	4	
	Additional points shall be awarded as: a. All the lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following: 95 lm/w ( <b>3 pts.</b> )  105 lm/W ( <b>8 pts.</b> )	8	
Comfort Systems Ceiling Fans	Ceiling Fans installed in all bedrooms and hall in all dwelling units shall have service value (SV) as: a. For sweep size <1200 mm: $SV \geq 4m^3/min.W$ b. For sweep size >1200 mm: $SV \geq 5m^3/min.W$	6	
	Additional points shall be awarded as: a. BEE 4-star fans are installed ( <b>1 pt.</b> ) b. BEE 5-star fans are installed ( <b>3 pts.</b> )	3	
Comfort Systems – Air-Conditioners	Air-conditioners installed in all the dwelling shall be:  <ul style="list-style-type: none"> <li>● Unitary Type: 5 Star; or</li> <li>● Split AC: 3 Star; or</li> <li>● VRF: 3.28 EER; or</li> <li>● Chiller: Minimum ECBC Level values as mentioned in ECBC 2017</li> </ul>	20	
	Additional points shall be awarded as:  <ul style="list-style-type: none"> <li>● Split AC: 4 Star (<b>9 pts.</b>) or 5-star (<b>21 pts.</b>)</li> <li>● VRF: BEE 4-star (<b>9 pts.</b>) or 5-star (<b>21 pts.</b>) rating upon rating launch by BEE</li> </ul>	21	



Component	Requirements	Available points	Project Achievement
	<ul style="list-style-type: none"> <li>Chiller: Minimum ECBC+ Level (9 pts.) or minimum super ECBC Level (21 pts.) values as mentioned in ECBC 2017</li> </ul>		
<b>Renewable Energy Systems</b>			
Solar Heating	Water	A solar water heating system (SWH) of minimum BEE 3 Star capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building is provided or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery	5
		<p>Additional points shall be awarded as:</p> <p>A SWH is provided of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of:</p> <ol style="list-style-type: none"> <li>Top 6 floors of the building - 2 pts.</li> <li>Top 8 floors of the building - 5 pts.</li> </ol>	5
Solar Voltaic	Photo-	A dedicated Renewable Energy Generation Zone (REGZ) shall be provided for equivalent to a minimum of 2 kWh/m <sup>2</sup> .year of electricity; or equivalent to at least 20% of roof area.	5
		<p>Additional points shall be awarded as:</p> <p>Solar Photo-Voltaic is provided:</p> <ol style="list-style-type: none"> <li>Equivalent to a minimum of 3 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 30% of roof area (2 pts)</li> <li>Equivalent to a minimum of 4 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 40% of roof area (5 pts)</li> </ol>	5

# EVALUATION OF HOUSING PROJECT: KUMAR PARV, PUNE, MAHARASHTRA

## Project Details

Project Name	Kumar Parv
Location	Pune Maharashtra
Number of Tower	5
Number of Dwelling Units	285 (approx.)
Carpet Area/DU (sqm)	77.8
Climate Zone	Warm-Humid

## Layout



Figure 8: Site Plan (Kumar Parv, Pune, Maharashtra)

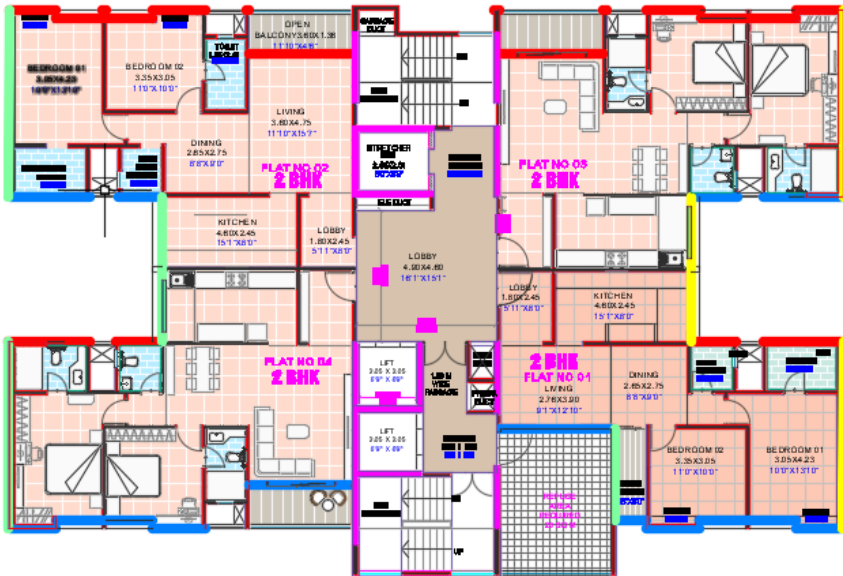


Figure 9: Typical Floor Plan (Kumar Parv, Pune, Maharashtra)

## ENS 2021 Compliance Evaluation

### Step 1- Compliance check for mandatory requirements

#### 1. Building Envelope

*All requirements for building envelope under mandatory section as mentioned in Chapter 4 of ENS Part I [ Min points 47]*

The project was accessed for the 4 codes defined under ENS 2018 compliance as specified below:

1. Window to Floor Area Ratio
2. Minimum Visual Light Transmittance Requirement by calculating the overall Window to Wall Area Ratio
3. Maximum Roof Thermal transmittance (U Value)
4. Residential envelope transmittance value (RE TV) for building envelope (except roof)

#### Project data:

Table 24 - Envelope Parameters (Kumar Parv, Pune, Maharashtra)

Climate:	Warm & Humid
Wall Material	Concrete + Flyash Brick
U Value:	5.33 W/m <sup>2</sup> K
Roof Material	150 mm RCC
U Value:	5.2 W/m <sup>2</sup> K
Glass	5 mm thick clear Glass
U Value:	5.6 W/m <sup>2</sup> K
SHGC:	0.68

Table 25 - Details on non - opaque areas (Kumar Parv, Pune, Maharashtra)

Window Detail (Non-Opaque Area), unit of measurement - meters	
W1	1.6 x 2.25
W2	2.4 x 2.25
W3	1.8 x 1.35
V1	0.6 x 1.2
Vertical Fin Depth	0.3, 1.5
Horizontal Projection Depth	0.3, 1.36

### Evaluation

#### *Code 1: Window to Floor Area Ratio [WFR]*

ENS requirement – Based on climate condition (composite) minimum WFR for the project should be 12.50%

Table 26 Window to Floor Area Ratio (Kumar Parv, Pune Maharashtra)

Total Carpet Area (m2)	28.07
Openable Area (m2)	4.24
<b>Window to Floor Area Ratio</b>	<b>15 %</b>

**Project performance** – calculations conducted for 1 typical unit highlight that requirements are met.

#### *Code 2- Minimum Visual Light Transmittance (VLT)*

ENS requirement – Based on Window- to – wall ratio of 0 – 30%, minimum VLT of glass should be 0.27

Table 27 Window to Wall Area Ratio (Kumar Parv, Pune Maharashtra)

Parameters	Orientation				Total
	NW	SE	NE	SW	
Wall Area	92.61	92.61	79.10	79.10	343.41
Glazing Area	8.39	8.39	4.37	4.37	25.50
Window to Wall Ratio	9%	9%	6%	6%	7%

**Project performance** - Proposed glass of SHGC 0.68 will meet min VLT of 0.27. However, it is recommended that glass of lower SHGC of 0.4 – 0.45 should be utilised in the project to decrease in peak heat gain through Building Envelope. Additionally, Window to wall ratio (WWR) can be increased to 13% which will ensure better daylighting indoors.

#### *Code 3: Thermal Transmittance for Roof (U value Roof)*

ENS requirement – Thermal transmittance of roof shall comply with the maximum Uroof value of 1.2 W/m<sup>2</sup>·K

**Project performance** –Thermal transmittance of proposed 150 mm RCC Slab +water proofing, is 5.263 W/m<sup>2</sup>K. Compliance requirements are not met. The project team can re-design the roof cross section to include insulation. Various Insulation options include Extruded polystyrene (XPS) 25 mm, Expanded polystyrene (Thermocol) (EPS) 25mm, or Polyurethane Foam (Density-36±2Kg/3) 25 mm, U Value of the roof achieved after application of insulation will be 0.92 W/m<sup>2</sup>·K,1.16 W/m<sup>2</sup>·K, and 0.72 W/m<sup>2</sup>·K respectively. Thus requirements can be met with above recommendations. As requested by the team, please find below is the roof section of a residential project in Gurugram that has used 75 mm thick XPS insulation.

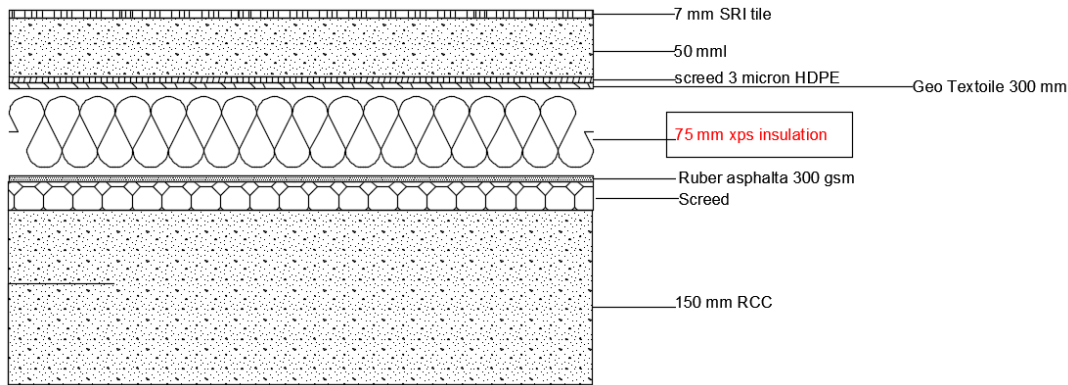


Figure 10: Sample Roof Section (Kumar Parv, Pune, Maharashtra)

*Code 4: Residential Envelope Transmittance Value (RE TV) for building envelope (except roof)*

ENS requirement - The Residential Envelope Transmittance Value (RETV) for the building envelope (except roof) for Composite Climate shall comply with the maximum RETV of 15 W/m<sup>2</sup>

Following tabular calculation confirm the achieved RETV value

Table 28 RETV formulae, as per ENS 2018

$$RETV = \frac{1}{A_{envelope}} \times \left[ \begin{array}{l} a \times \sum_{i=1}^n (A_{opaque_i} \times U_{opaque_i} \times \omega_i) \\ + b \times \sum_{i=1}^n (A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i) \\ + c \times \sum_{i=1}^n (A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i) \end{array} \right]$$

Wall Conductive Heat Gains  
Window Conductive Heat Gain  
Window Radiation Heat Gain

Table 29 - Inputs for RETV calculations (Kumar Parv, Pune, Maharashtra)

Component Description	U value	SHGC	NORTH-WEST Envelope (sq m)	SOUTH-EAST Envelope (sq m)	NORTH-EAST Envelope (sq m)	SOUTH-WEST Envelope (sq m)	TOTAL Envelope Area (sq m)
Shear Wall	5.4		73.98	75.32	44.33	52.14	245.78
Fly ash Brick	3.78		18.50	18.83	11.08	13.04	61.45
Frame (Aluminium frame)	9.09		2.78	2.54	0.49	0.49	6.30
Window	5.60	0.68	27.84	25.44	4.86	4.86	63.00
Total	123.10	122.14	60.76	70.52	376.53		
Weighted U value opaque wall			5.19	5.18	5.11	5.11	
Effective SHGC			0.55	0.46	0.68	0.68	
Achieved RETV for the project – 27.21 W/m <sup>2</sup>							

**Project performance** - Achieved Residential Envelope Transmittance Value (RETV) for the project is exceeding the required limits, hence requirements is not compliant. It is understood the project being a high-rise building has certain challenges with respect to its structural stability due to replacement of material for e.g. Fly ash to ACC or changing proportion of shear wall Vs block work for exterior walls. However, the project team is open for suggestions which can be incorporated for ENS compliance.

Multiple options as below have been worked for the project to meet ENS requirements. These options will allow the project with greater flexibility for material selection/replacements and will also help the team understand the cost impact for ENS Compliance.

Table 30 RETV achieved with proposed suggestions -1 (Kumar Parv, Pune, Maharashtra)

Suggested Envelope assemblies	Achieved RETV
Shear Wall (East & West) + Replacing shear wall to 200 mm AAC (North & South) + replacing Aluminium frame with uPVC Frames + 5mm Thick efficient Glass (SHGC:0.49, U Value: 5)	15
Shear Wall + 100 mm AAC block along with shear wall+ Aluminium Frames + 5mm Thick Clear Glass (SHGC:0.68, U Value: 5.6)	10.54

The project can also explore option of various available insulation options for envelope application which will allow the project to achieve RETV values between 9.6 – 10.38, as per table below

Table 31 RETV achieved with proposed suggestions -2 (Kumar Parv, Pune, Maharashtra)

Suggested Envelope assemblies	Achieved RETV
25 mm Polyurethane Foam (Density-36±2Kg/3 )+ Shear Wall + Aluminium Frames + 5mm Thick Clear Glass ( SHGC:0.68, U Value: 5.6)	8.95
25 mm Extruded polystyrene (XPS) + Shear Wall + Aluminium Frames + 5mm Thick Clear Glass (SHGC:0.68, U Value: 5.6)	9.6
25 mm Glass fibre and mineral fibre+ Shear Wall + Aluminium Frames + 5mm Thick Clear Glass (SHGC:0.68, U Value: 5.6)	10.26
25 mm Bonded Mineral wool (Rock/ glass wool) Density-64Kg/m3+ Shear Wall + Aluminium Frames + 5mm Thick Clear Glass ( SHGC:0.68, U Value: 5.6)	10.38
25 mm Expanded polystyrene (thermocole) (EPS)+ Shear Wall + Aluminium Frames + 5mm Thick Clear Glass (SHGC:0.68, U Value: 5.6)	10.9

## 2. Power Factor Correction

Requirement – All 3 phase shall maintain the power factor of 0.97 at the point of connection.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all 3-phase equipment (as applicable) shall maintain the power factor of 0.97 at the point of connection, to meet mandatory requirements.

## 3. Energy Monitoring

Requirements -

1. The project shall monitor the electrical energy use for each of the following separately:
  - a. Total electrical energy
  - b. Electricity consumption of following applicable end-use:
    - i. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)
    - ii. Elevators
    - iii. Water pumps
    - iv. Basement car parking ventilation system
    - v. Electricity generated from power back-up
    - vi. Electricity generated through renewable energy systems
    - vii. Lift pressurization system
2. The electrical energy use shall be recorded at an interval of minimum of every 15 minutes and reported at least hourly, daily, monthly, and annually. The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system. The digital control system shall be capable of maintaining all data collected for a minimum of 36 months.

3. The metering shall display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all the above requirements with respect to Energy Monitoring (as applicable) should be met, to meet mandatory requirements. Basis discussion during the charrette it is understood that the above requirements can be implemented with an additional cost. Post construction the project will be handed over to the Housing Society (operation team) who will be responsible to maintain the project and monitor all installed systems. However, the project team is unsure how the operation team will utilise the extracted data for any future use.

Discussion on the above issue covered additional guidance on building metering which allows building operators to track energy consumption over time, demonstrating variation in usage patterns. This crucial data can be used by the operation team to develop energy conservation strategies over lifetime of the building.

#### 4. Electric Vehicle Charging System

Requirement –

If an Electric Vehicle Charging Infrastructure is installed in the premise, it shall be as per revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, or any subsequent amendments.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all of the above requirements with respect to Electric Vehicle Charging System (as applicable) should be met, to meet mandatory requirements. The team looks forward to implementing the guidelines provided by the Ministry of Power.

#### 5. Electrical Systems

Requirements –

1. The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.
2. Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

**Project performance** – The project is in design phase and specific details are not available hence it is recommended that all of the above requirements with respect to Electrical Systems (as applicable) should be met, to meet mandatory requirements. The said requirements can be met with an additional cost as indicated by the project team.



## Step 2 – Compliance check for another component category of ENS

The below section enumerates each component category and associated minimum points which are required for an affordable project aspiring ENS Compliance

### 1. Common Area and Exterior Lighting

#### Minimum Requirement [ 3 points]-

The Lighting power density (LPD) and Luminous efficacy (LE) of permanently installed lighting fixtures in common area of the ENS compliant building shall meet the requirements of either maximum LPD or minimum luminous efficacy as per table below:

Table 32 Common Area Lighting (Kumar Parv, Pune, Maharashtra)

Common Area	Maximum LPD (W/sqmts)	Minimum Luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt

**Additional Points [up to 3 points]:** Install all the permanently installed lighting fixtures with lamp luminous efficacy of 95 lm/W in areas mentioned below

Table 33 Score breakup for common area and exterior lighting – A (Kumar Parv, Pune, Maharashtra)

Area/Zone	Points
Corridor lighting and stilt parking	1
Basement Lighting	1
Exterior Lighting Areas	1

**Additional Points [up to 6 points]:** Lamps for all exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Installing all the permanently installed lighting fixtures in all corridor lighting, stilt parking, basement lighting and exterior lighting with lamp luminous efficacy of 105 lm/W.

Table 34 Score breakup for the Common Area and exterior Lighting – B (Kumar Parv, Pune, Maharashtra)

Area/Zone	Points
Corridor lighting and stilt parking	2
Basement Lighting	2
Exterior Lighting Areas	2

Project performance – The project is in design phase and specific details are not available hence it is recommended that minimum requirements with respect to Common area and

exterior lighting (as applicable) should be met, to meet minimum requirements. The project team has confirmed that meeting the minimum luminous efficacy of the installed lamps is easily achievable. The team will further evaluate the products and lighting design to understand if additional points can be met by fulfilling requirements as stated in the additional points above.

*Additional guidance: Requirements can be met by following any 1 of the following*

1. The requirement of luminous efficacy will be met by conventionally available light fixtures, e.g. LED, Tube lights, etc. While selecting the light fixtures enquire about the total available lumens of each fixture along with the wattage. Perform simple calculation (refer example below) to arrive at the lumens/watt values. Select fixtures which meet the ENS prescribed luminous efficacy i.e. 85 lumens/watt.

*Example:*

*A 10-watt LED fixture has a luminous flux of 1000 lumens. Luminous efficacy of the fixture = luminous flux/power i.e. 1000 lumens/10 watts = 100 lumens/watt. Hence the fixture can be installed meeting ENS requirements.*

2. While designing the outdoor lighting scheme, ENS guidelines of lighting power density as per below table, should be referred as guideline to design total lighting power for Corridor lighting, Stilt Parking, Basement lighting, driveways, pedestrian walkways, stairways, landscaping (as applicable).

Table 35 Outdoor Lighting (Kumar Parv, Pune, Maharashtra)

Exterior Lighting Areas/ Zones	Watts/Sqmts
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

## 2. Elevators

### Minimum Requirements [13 points]–

The Elevators installed in the ENS compliant building shall meet the following requirements:

1. Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W
2. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied
3. Install minimum class IE 3 high efficiency motors
4. Group automatic operation of two or more elevators coordinated by supervisory control

**Additional points [9 points]** - Additional points can be obtained by:

1. Installing the variable voltage and variable frequency drives. (4 points)
2. Installing regenerative drives. (3 points)
3. Installing class IE4 motors. (2 points)

Project performance – The project confirmed that the recommended minimum requirements with respect to elevators are standard industry practice and the requirements will be met. Additional, the team confirmed on installation of variable frequency drives on all the projects for reduced energy consumption.

### 3. Pumps

#### Minimum Requirements [6 points]-

Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed in the ENS building.

**Additional Points [8 points]:** Additional points can be obtained by:

1. Installation of BEE 5 star rated pumps (5 Points)
2. Installation of hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% (3 Points)

**Project performance** – The project team confirmed that the minimum requirements in this section shall be met and further evaluation can be done to integrate BEE 5 star rated pumps in the project.

### 4. Electrical Systems

#### Minimum Requirements [1 point]

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed the values listed in Reference 1 below for dry type transformers and BEE 4-star rating in table below for oil type transformers.

**Additional points [5 points]:** Additional points can be obtained by providing all oil type transformers with BEE 5-star rating

**Project performance** – The project team conveyed that the transformers are provided by the Government identified distribution companies (DISCOM), as per State regulations.

### 5. Indoor Electrical End-Use

The points mentioned under this section are not mandatory to show overall compliance. Provisions as per requirements can be provided if they fall under the scope of the developer.

#### 5.1. Indoor lighting

#### Minimum requirements [4 points, if opted] –

All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall and kitchen.

**Additional Points [8 points]:** Additional points for indoor lighting by installing all lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following:

1. 95 lm/w (3 Points)
2. 105 lm/W (8 Points)

Project performance – It is understood that indoor lighting fixtures are not provided by the developer and above requirements are not applicable to the project. However, above requirements can be referred as guidance for future projects where indoor lighting fixtures will be provided as a part of amenities from developers.

## *5.2. Comfort Systems*

If comfort system for e.g. ceiling fans (in bedrooms and hall) and air conditioners (in bedrooms) are provided in dwelling units then following requirements will be mandatory.

**Ceiling Fans [Min 6 points if opted]:** Points for ceiling fans will be only applicable and could be achieved if all the bedrooms and hall in all the dwelling units are having ceiling fans and points could be gained, if

All ceiling fans installed in all the bedrooms and hall in all the dwelling units shall have a service value as given below:

1. For sweep size <1200 mm: equal or greater than 4 m<sup>3</sup>/minute/Watt
2. For sweep size >1200 mm: equal or greater than 5 m<sup>3</sup>/minute/Watt

BEE Standards and Labelling requirements for ceiling fans shall take precedence over the current minimum requirement, as and when it is notified as mandatory.

**Additional Points [4 points]:** Additional points for ceiling fans by installing in all the bedrooms and hall in all the dwelling units as per following:

1. 4 Star - 1 point
2. 5 Star – 3 points

**Air Conditioners [Minimum 20 points if opted]:** Points for air conditioners will be only applicable and could be achieved if all the bedrooms in all the dwelling units are having air conditioners (either unitary, split, VRF or centralized plant) and points could be gained, as per following compliance of energy efficiency for each system

1. Unitary Type: 5 Star
2. Split AC: 3 Star
3. VRF: 3.28 EER (Energy Efficiency Ratio)
4. Chiller: Minimum ECBC Level values as mentioned in ECBC 2017

**Additional Points [ 21 points]:**

1. Split AC: 5 Star
2. VRF: Currently, no star rating has been launched by BEE for VRFs. Once the rating is launched the projects would be required to choose VRFs with 5 Star rating.
3. Chiller: Minimum Super ECBC Level values as mentioned in ECBC 2017

**Project performance** – It is understood that comfort systems are not provided by the developer and above requirements are not applicable to the project. However, above requirements can be referred as guidance for future projects where comfort systems will be provided as a part of amenities from developers.

## 6. Renewable Energy Systems

### 6.1. Solar Hot Water System

Solar water heater shall meet the minimum efficiency level mentioned in IS 13129 Part (1&2) and for evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

**Minimum requirements, if opted [5 points]:** The ENS compliant building shall provide a solar water heating system (SWH) of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building. or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery.

**Additional Points [5 points]:** Additional points can be obtained by installing SWH system as per as per following:

1. 100% of the annual hot water demand of top 6 floors of the residential building (2 points)
2. 100% of the annual hot water demand of top 8 floors of the residential building (5 points)

**Project performance** – Based on discussion with the project team it is understood that Solar Water heating system is not proposed for the project due to practical usage constraint and electric water heaters are provided by the developer for each dwelling unit. However, it is highly recommended to install Solar Water heating which will save electrical energy.

### 6.2. Solar Photo-Voltaic

**Minimum, if opted [5 points]:** The ENS compliant building shall provide a dedicated Renewable Energy Generation Zone (REGZ) – Equivalent to a minimum of 2 kWh/m<sup>2</sup>.year of electricity; or Equivalent to at least 20% of roof area. The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.

**Additional Points [5 points]:**

Additional points can be obtained by installing solar photo voltaic as per following:

1. Equivalent to a minimum of 3 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 30% of roof area (2 points)
2. Equivalent to a minimum of 4 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 40% of roof area (5 points)

**Project performance** – Based on discussion with the project team it is understood that Solar Photo- voltaic system is being proposed for 30% of the roof area in the project, the project

would also participate in the net metering program. Hence, the project is able to score additional 2 points in this section.

## ENS 2021 score for the project

ENS 2021 score has been derived for the project based on project design, discussions during the 2 design charrettes conducted for the project and recommendations provided during the design charrettes. Current score of 79 is achievable if requirements for all mandatory requirements are met along with other minimum requirements in respective sections as highlighted above. Below table summarises the mandatory requirements, minimum requirements and additional requirements and Project.

### Mandatory Requirement Checklist

Component	Mandatory Requirements												
Site Area	The project should be located on a site of at least 500 m <sup>2</sup> area												
Openable Window-to-Floor Area Ratio (WFR <sub>op</sub> )	$WFR_{op} = A_{openable} / A_{carpet}$ Minimum requirement of window-to-floor area ratio: <table border="1" data-bbox="635 907 1150 1348"> <thead> <tr> <th>Climatic Zone</th> <th>Minimum WFR<sub>op</sub> %</th> </tr> </thead> <tbody> <tr> <td>Composite</td> <td>12.50</td> </tr> <tr> <td>Hot-Dry</td> <td>10.00</td> </tr> <tr> <td>Warm-Humid</td> <td>16.66</td> </tr> <tr> <td>Temperate</td> <td>12.50</td> </tr> <tr> <td>Cold</td> <td>8.33</td> </tr> </tbody> </table>	Climatic Zone	Minimum WFR <sub>op</sub> %	Composite	12.50	Hot-Dry	10.00	Warm-Humid	16.66	Temperate	12.50	Cold	8.33
Climatic Zone	Minimum WFR <sub>op</sub> %												
Composite	12.50												
Hot-Dry	10.00												
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Visible Light Transmittance (VLT)	$WWR = A_{non-opaque} / A_{envelope}$ Minimum requirement of glass VLT - <table border="1" data-bbox="627 1478 1142 1919"> <thead> <tr> <th>Window-to-wall ratio</th> <th>Minimum VLT</th> </tr> </thead> <tbody> <tr> <td>0–0.30</td> <td>0.27</td> </tr> <tr> <td>0.31–0.40</td> <td>0.20</td> </tr> <tr> <td>0.41–0.50</td> <td>0.16</td> </tr> <tr> <td>0.51–0.60</td> <td>0.13</td> </tr> <tr> <td>61–0.70</td> <td>0.11</td> </tr> </tbody> </table>	Window-to-wall ratio	Minimum VLT	0–0.30	0.27	0.31–0.40	0.20	0.41–0.50	0.16	0.51–0.60	0.13	61–0.70	0.11
Window-to-wall ratio	Minimum VLT												
0–0.30	0.27												
0.31–0.40	0.20												
0.41–0.50	0.16												
0.51–0.60	0.13												
61–0.70	0.11												
Thermal Transmittance of Roof (U <sub>roof</sub> )	Thermal transmittance of roof shall comply with the maximum U <sub>roof</sub> value of 1.2 W/m <sup>2</sup> .K.												

Component	Mandatory Requirements
Residential envelope transmittance value (RETV) for building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate	The RETV for the building envelope (except roof) for, Composite Climate, shall comply with the maximum RETV of 15 W/m <sup>2</sup>
Power Factor Correction	All 3 phase shall maintain the power factor of 0.97 at the point of connection.
Energy Monitoring	<p>Monitor the electrical energy use for each of the following separately:</p> <ul style="list-style-type: none"> <li>Total electrical energy</li> <li>Electricity consumption of following applicable end-use: a. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)</li> <li>Elevators</li> <li>Water pumps</li> <li>Basement car parking ventilation system</li> <li>Electricity generated from power back-up</li> <li>Electricity generated through renewable energy systems</li> <li>g. Lift pressurization system</li> </ul>
	Record the electrical energy at an interval of minimum of every 15 minutes and report at least hourly, daily, monthly, and annually.
	The monitoring equipment should be capable of transmitting the data to the digital control system/ energy monitoring information system.
	The digital control system should be capable of maintaining all data collected for a minimum of 36 months.
	The installed meter should display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.

Component	Mandatory Requirements
Electric Vehicle Charging System	If an electric vehicle charging system is provided, it should meet the revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1 <sup>st</sup> October 2019, or any subsequent amendments
Electrical systems	The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage in the ENS building. Record of design calculation for the losses shall be maintained.
	Voltage drop for feeders shall not exceed 2% at design load.
	Voltage drop for branch circuit shall not exceed 3% at design load.

## Scorecard (Kumar Parv, Pune Maharashtra)

Component	Requirements	Available points	Project Achievement
Building Envelope			
Roof ( $U_{roof}$ )	Thermal transmittance of roof shall comply with the maximum $U_{roof}$ value of $1.2 \text{ W/m}^2 \cdot \text{K}$ .	3	3
	Additional point shall be awarded as: maximum $U_{roof}$ value of $0.97 \text{ W/m}^2 \cdot \text{K}$ - 1 pt. maximum $U_{roof}$ value of $0.74 \text{ W/m}^2 \cdot \text{K}$ - 2 pt. maximum $U_{roof}$ value of $0.51 \text{ W/m}^2 \cdot \text{K}$ - 3 pt. maximum $U_{roof}$ value of $0.28 \text{ W/m}^2 \cdot \text{K}$ - 4 pt.	4	
RETV for building envelope (except roof) for four climate zones, i.e., composite climate, Hot-Dry climate, Warm-Humid climate, and	The RETV for the building envelope (except roof) shall comply with the maximum RETV of $15 \text{ W/m}^2$ Additional points shall be awarded as: RETV < 15 & upto $12 \text{ W/m}^2$ ; Score = $74 - 2 \times (\text{RETV})$ (Upto 50 pts.)  RETV < 12 & upto $12 \text{ W/m}^2$ ; Score = $110 - 5 \times (\text{RETV})$ (Upto 80 pts.)	80	44



Component	Requirements	Available points	Project Achievement								
Temperate climate	RETV < 6 W/m <sup>2</sup> (80 pts.)										
<b>Building Services</b>											
Common area and exterior lighting	<p>The minimum luminous efficacy of all the installed light fixtures in the corridors, stilt parking, basement, and exterior lights, should be 85 lm/W; or</p> <p>Lighting power density should be maintained at the following levels:</p> <table border="1" data-bbox="435 1151 1051 1547"> <tr> <td data-bbox="435 1151 746 1263">Corridor &amp; Stilt Parking – 3 W/m<sup>2</sup></td> <td data-bbox="746 1151 1051 1263">Driveways &amp; parking – 1.6 W/m<sup>2</sup></td> </tr> <tr> <td data-bbox="435 1263 746 1375">Basement Lighting – 1 W/m<sup>2</sup></td> <td data-bbox="746 1263 1051 1375">Pedestrian walkways – 2 W/m<sup>2</sup></td> </tr> <tr> <td data-bbox="435 1375 746 1487">Stairways – 10 W/m<sup>2</sup></td> <td data-bbox="746 1375 1051 1487">Landscaping – 0.5 W/m<sup>2</sup></td> </tr> <tr> <td colspan="2" data-bbox="435 1487 1051 1547">Outdoor sales area – 9 W/m<sup>2</sup></td> </tr> </table>	Corridor & Stilt Parking – 3 W/m <sup>2</sup>	Driveways & parking – 1.6 W/m <sup>2</sup>	Basement Lighting – 1 W/m <sup>2</sup>	Pedestrian walkways – 2 W/m <sup>2</sup>	Stairways – 10 W/m <sup>2</sup>	Landscaping – 0.5 W/m <sup>2</sup>	Outdoor sales area – 9 W/m <sup>2</sup>		3	3
	Corridor & Stilt Parking – 3 W/m <sup>2</sup>	Driveways & parking – 1.6 W/m <sup>2</sup>									
Basement Lighting – 1 W/m <sup>2</sup>	Pedestrian walkways – 2 W/m <sup>2</sup>										
Stairways – 10 W/m <sup>2</sup>	Landscaping – 0.5 W/m <sup>2</sup>										
Outdoor sales area – 9 W/m <sup>2</sup>											
	<p>Additional points shall be awarded as follows:</p> <p>Permanently installed lighting fixtures for corridor lighting and stilt parking, basement lighting, exterior lighting areas shall have lamp luminous efficacy of 95 lm/W (1 point each, upto 3 points) or have lamp luminous efficacy of 105 lm/W (2point each upto 6 points)</p>	6									

Component	Requirements	Available points	Project Achievement
	All exterior applications apart from emergency lighting shall be controlled by photo sensor or astronomical time switch		
Elevators	Elevators installed shall meet all the following requirements:  Lamps for lift car lighting having minimum luminous efficacy of 85 lm/W  Automatic switch-off controls for lighting and fan inside the lift car.  Minimum class IE 3 high efficiency motors  Group automatic operation of two or more elevators coordinated by supervisory control	13	13
	Install variable voltage and variable frequency drives	4	
	Install regenerative drives	3	
	Install class IE4 motors	2	
Pumps	Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated Pumps shall be installed.	6	6
	BEE 5 star rated pumps are installed	5	
	Hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% is installed	3	
Electrical Systems	For oil type transformers, select transformers that are a minimum of BEE 4 star rated & for dry type transformers, the minimum acceptable efficiency at 50% and full load should be in limits as mentioned in ENS.	1	1
	Oil type transformers with BEE 5-star rating are installed	5	
Indoor Electrical end use			

Component	Requirements	Available points	Project Achievement
Indoor Lighting	All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall, and kitchen	4	
	Additional points shall be awarded as: All the lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following: 95 lm/w (3 pts.) 105 lm/W (8 pts)	8	
Comfort Systems Ceiling Fans	Ceiling Fans installed in all bedrooms and hall in all dwelling units shall have service value (SV) as:  For sweep size <1200 mm: $SV \geq 4m^3/min.W$ For sweep size >1200 mm: $SV \geq 5m^3/min.W$	6	
	Additional points shall be awarded as:  BEE 4-star fans are installed (1 pt.) BEE 5-star fans are installed (3 pts.)	3	
Comfort Systems – Air-Conditioners	Air-conditioners installed in all the dwelling shall be:  Unitary Type: 5 Star; or Split AC: 3 Star; or VRF: 3.28 EER; or Chiller: Minimum ECBC Level values as mentioned in ECBC 2017	20	
	Additional points shall be awarded as:  Split AC: 4 Star (9 pts.) or 5-star (21 pts.) VRF: BEE 4-star (9 pts.) or 5-star (21 pts.) rating upon rating launch by BEE	21	

Component	Requirements	Available points	Project Achievement
	Chiller: Minimum ECBC+ Level (9 pts.) or minimum super ECBC Level (21 pts.) values as mentioned in ECBC 2017		
<b>Renewable Energy Systems</b>			
Solar Water Heating	A solar water heating system (SWH) of minimum BEE 3 Star capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building is provided or 100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery	5	
	<p>Additional points shall be awarded as:</p> <p>A SWH is provided of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of:</p> <p>Top 6 floors of the building - 2 pts.</p> <p>top 8 floors of the building - 5 pts.</p>	5	
Solar Photo-Voltaic	A dedicated Renewable Energy Generation Zone (REGZ) shall be provided for equivalent to a minimum of 2 kWh/m <sup>2</sup> .year of electricity; or equivalent to at least 20% of roof area.	5	5
	<p>Additional points shall be awarded as:</p> <p>Solar Photo-Voltaic is provided:</p> <p>Equivalent to a minimum of 3 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 30% of roof area (2 pts)</p> <p>Equivalent to a minimum of 4 kWh/m<sup>2</sup>. year of electricity or Equivalent to at least 40% of roof area (5 pts)</p>	5	2

# MONITORING, REPORTING & VERIFICATION PLAN FOR ENS COMPLIANCE

## Overview

The monitoring, reporting and verification plan has been developed for projects to track Eco Niwas Samhita (ENS) compliance at key project stages by using a comprehensive self-explanatory information.

The document should be shared with all key stakeholders i.e., planners, designers, procurements team, tendering team, execution team (PMC), etc to understand ENS requirements and related documentation that must be maintained on each project stage. As and when ENS compliance is mandated in the State, the documentation under each stage will be helpful to demonstrate the compliance.

The requirements have been structured in three stages of the project:

1. Design & tender stage
2. Construction stage
3. Post occupancy stage

## Project Stage – Design & Tender

ENS 2021 Compliance Requirement	
Section I. Building Envelope	
BE1	<p>Window to Floor Area Ratio as per ENS 2018 requirement</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Architectural plans, sections, elevations, and window schedule to demonstrate compliance.</li> </ol>
BE2	<p>Glass VLT in compliance to Window to Floor Area Ratio as per ENS 2018</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Manufacturer's data sheet stating glass specifications – U Value, SHGC, VLT, etc</li> <li>2. Tender document highlighting glass specifications</li> </ol>
BE3	<p>Roof design demonstrating U Value &lt;1.2 W/m<sup>2</sup>K</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Architectural drawing highlighting roof sections</li> <li>2. Calculations or Computer simulation output results confirming U Value of the roof assembly</li> <li>3. Tender document highlighting proposed materials for roof assembly</li> </ol>
BE4	<p>Building Envelope (except roof) design demonstrating RETV ≤ 15 W/m<sup>2</sup></p> <ol style="list-style-type: none"> <li>1. Site plan, architectural plans, sections, elevations, window schedule and, details of door and window frames</li> <li>2. Calculations confirming RETV of the building envelope</li> <li>3. Manufacturer's data sheet stating U value of all the envelope materials used in the project</li> <li>4. Tender document highlighting proposed materials for building envelope</li> </ol>
Section II. Electro-mechanical Systems	
EM 1	<p>Power Factor Correction - 0.97 for all 3 phases at the point of connection</p> <p>Documents required:</p>

ENS 2021 Compliance Requirement

	<p>1. Calculations confirming Power factor for all 3 phases</p>
<p>EM 2</p>	<p>Provision for Energy Monitoring:</p> <ul style="list-style-type: none"> <li>i. Total electrical energy</li> <li>ii. Electricity consumption of following applicable end-use:             <ul style="list-style-type: none"> <li>a. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)</li> <li>b. Elevators</li> <li>c. Water pumps</li> <li>d. Basement car parking ventilation system</li> <li>e. Electricity generated from power back-up</li> <li>f. Electricity generated through renewable energy systems</li> <li>g. lift pressurization system</li> </ul> </li> </ul> <p>Record the electrical energy at an interval of minimum of every 15 minutes and report at least hourly, daily, monthly, and annually.</p> <p>Smart Metering System with at least 1-way communication</p> <p>The digital control system should be capable of maintaining all data collected for a minimum of 36 months.</p> <p>The installed meter should display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current in case of transformers.</p> <p>Documents required:</p> <ul style="list-style-type: none"> <li>1. Narrative describing the proposed energy metering system/ equipment (or) building management system in the project.</li> <li>2. Single line drawing showing the proposed energy metering system/ equipment (or) building management system.</li> <li>3. List of all advanced meters to be installed, including type, energy source metered</li> <li>4. Manufacturers cut sheet/brochure for Energy meters highlighting meter capabilities</li> </ul>

ENS 2021 Compliance Requirement

	5. Tender documents highlighting proposed meter specifications or tender documents for building management systems.
EM 3	<p>Electric Vehicle Charging System - meet revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, or any subsequent amendments.</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Narrative, project drawings and compliance document</li> <li>2. Tender document highlighting</li> </ol>
EM 4	<p>Provision as mentioned below for Electrical systems</p> <p>Calculate the load calculation up to the panel level</p> <p>Record of design calculations for the losses need to be maintained/available</p> <p>Power Cabling should be sized in a way that distribution losses do not exceed 3% of the total power usage in the building</p> <p>Voltage drop for feeders should be lower than at least 2% at design load</p> <p>Voltage drop for branch circuits should be lower than at least 3% at design load</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Compliance calculations</li> <li>2. Tender document for all cabling works</li> </ol>
EM 5	<p>Minimum Luminous Efficacy of lighting fixtures for all external and common area lighting to be 85 lm/W OR</p> <p>Lighting power density as follows for all external and common area lighting to be maintained</p> <p>Corridor lighting &amp; Stilt Parking - 3.0 W/m<sup>2</sup></p> <p>Basement Lighting - 1.0 W/m<sup>2</sup></p> <p>Driveways and parking (open/ external) - 1.6 W/m<sup>2</sup></p> <p>Pedestrian walkways - 2.0 W/m<sup>2</sup></p> <p>Stairways - 10.0 W/m<sup>2</sup></p> <p>Landscaping - 0.5 W/m<sup>2</sup></p> <p>Outdoor sales area - 9.0 W/m<sup>2</sup></p>



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	<p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Lighting plans for common area and external lighting</li> <li>2. Manufacturer's brochure/cut sheet stating luminous efficacy of all external and common area lighting fixtures OR Lighting power density calculations for all external and common area lighting</li> <li>3. Tender documents specifying the luminous efficacy / wattage/ total number etc., of all external lighting fixtures</li> </ol>
EM 6	<p>Provisions for Efficient Elevators as per following requirement as applicable:</p> <p>Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W</p> <p>Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied</p> <p>Install minimum class IE 3 high efficiency motors</p> <p>Group automatic operation of two or more elevators coordinated by supervisory control</p> <p>Install variable voltage and variable frequency drives.</p> <p>Install regenerative drives.</p> <p>Install class IE4 motors.</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Lighting layout for Elevators</li> <li>2. Manufacturer's brochure/cut sheet stating luminous efficacy of light fixtures used in elevators</li> <li>3. Manufacturer's brochure/cut sheet highlighting control mechanisms</li> <li>4. Manufacturer's brochure/cut sheet highlighting efficiency of motors, details of variable voltage and variable frequency drives</li> <li>5. Manufacturer's brochure/cut sheet highlighting details of regenerative drives</li> <li>6. Tender document stating elevator details for lighting fixtures, motors, control mechanism, variable frequency drives, etc.</li> </ol>
EM 7	Provisions for pumps with following Requirement

ENS 2021 Compliance Requirement

	<p>Install pumps that are either hydro-pneumatic, having minimum mechanical efficiency of 60% or BEE 4 star rated</p> <p>Install BEE 5 star rated pumps</p> <p>Install of hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70%</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Manufacturer's brochure/cutsheet highlighting pump types, BEE Rating and related efficiency</li> <li>2. Tender documents highlighting pump efficiency/BEE Rating</li> </ol>
EM 8	<p>Provision for electrical systems as per following requirement</p> <p>For oil type transformers, select transformers that are a minimum of BEE 4 star rated</p> <p>For dry type transformers, the minimum acceptable efficiency at 50% and full load should be in limits</p> <p>Additional Points: Install a BEE 5-Star rated oil type transformer</p> <p>Documents required:</p> <p>Manufacturer's brochure/cut sheet highlighting transformer type and BEE Rating/efficiency</p>

Section III Renewable Energy Systems

<p>RE 1</p>	<p>Provision for solar Hot Water System with applicable requirement:</p> <p>100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery</p> <p>OR</p> <p>provide a solar water heating system (SWH) of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building</p> <p>provide a solar water heating system (SWH) of minimum BEE 3 Star label and is capable of meeting 100% of the annual hot water demand of</p> <p>top 6 floors of the building</p> <p>top 8 floors of the building</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Floor plan highlighting location of hot water system</li> <li>2. Calculations highlighting total hot water demand and total hot water available from hot water system</li> <li>3. Manufacturer’s brochure/cut sheet highlighting BEE Star Rating</li> <li>4. Tender documents confirming Hot water system capacity and BEE Star Rating</li> </ol>
<p>RE 2</p>	<p>Provision for Solar Photo Voltaic system with applicable Requirement:</p> <p>Equivalent to a minimum of 2 kWh/m<sup>2</sup>.year of electricity;</p> <p>OR</p> <p>Equivalent to at least 20% of roof area.</p> <p>Equivalent to a minimum of 3 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 30% of roof area</p> <p>Equivalent to a minimum of 4 kWh/m<sup>2</sup>.year of electricity or Equivalent to at least 40% of roof area</p> <p>Documents required:</p> <ol style="list-style-type: none"> <li>1. Solar Photovoltaic system design – drawings, efficiency details, proposed electricity generation (kWh)</li> <li>2. Roof plan highlighting location of Solar Photovoltaic System</li> </ol>

	3. Calculations highlighting proposed roof area to be installed with Solar Photovoltaic system
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## Project Stage – Construction

ENS 2021 Compliance Requirement			
Section I. Civil			
Construction Material installed		Yes/No	Remarks
C1	Window opening construction as per design		
C2	Glass installation as per design and tender specifications		
C3	Roofing material installed as per design and tender specifications		
C4	Building envelope material - block work, glass, door / window frames insulation, etc. installed as per design and tender specifications		
Section II. Equipment Installation			
Equipment Installed		Yes/No	Remarks
EQ1	Advanced Energy meters/Building management system installed as per design and tender specifications		
EQ2	Electrical Vehicle Charging systems installed as per guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles on 1st October 2019, or any subsequent amendments		
EQ 3	All power cables installed as per design and tender specifications		
EQ 4	Lighting fixtures for common area installed as per design and tender specifications		
EQ 5	Lighting fixtures for external lighting installed as per design and tender specifications		
EQ 6	Elevators installed as per design and tender specifications		
EQ 7	All pumps installed in the project are as per design and tender specifications		
EQ 8	Transformers installed in the project meet ENS 2021 requirements		
EQ 9	Hot Water systems installed are as per design and tender specifications		

ENS 2021 Compliance Requirement

EQ10	Solar Photo Voltaic system installed are as per design tender specifications		
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## Project Stage – Post Occupancy

Monthly Hot Water generated on site

Month	Litres
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

Monthly on-site electricity generated from Solar Photo voltaic

Month	kWh
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	

Area	Jan	Feb	Apr	May	Jun	Jul	Aug	Sept	Oct	No v	Dec
External Lighting											
Elevators											
Pumps											
Basement car parking											

ventilation system											
Electricity generated from power back-up											
Electricity generated through renewable energy systems											
Lift pressurization system											





**More information:**

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