"ASSESSMENT AND ANALYSIS OF H-2 BUILDING OF JUIT FOR GREEN FEATURE"

A

PROJECT REPORT

Submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision

of

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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HIMACHAL PRADESH INDIA

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STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"ASSESSMENT AND ANALYSIS OF H-2 BUILDING OF JUIT FOR GREEN FEATURE"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision **Mr. Akash Bhardwaj** and **Mr. Niraj Singh Parihar**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"ASSESSMENT AND ANALYSIS OF H-2 BUILDING OF JUIT FOR GREEN FEATURE"** in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Devendra Ahlay (191624)** and **Pem Dorji (191627)** during a period from August 2020 to May allowing us 2021 under the supervision of **Mr. Akash Bhardwaj** and **Mr. Niraj Singh Parihar** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. The above statement made is correct to the best of our knowledge.

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ABSTRACT

The construction of buildings is responsible for a sizable portion of the world's energy, power, water, and material use. Around 35–40% of the energy produced globally was used by buildings during their construction and resident use, according to the United Nations' 2020 Global Status Report and other sources. The same also contributed about 33% to the global emission. Therefore, there is an urgent need to adopt new technologies to tackle the problems in the industry of construction which is one of the biggest in the world and is also rapidly growing. Therefore, to mitigate the problem of high energy consumption and pollution from the industry of construction, the concept of green building was started.

This project discusses about the green building, its need and the benefits of adoption of such methods and technology in the construction sector. There is also a brief discussion some of the widely followed rating system for the green building. Green building rating system gives us the idea about sustainability and other green features adopted in the construction and throughout the life of the structure.

As there has been a huge amount of build environment already in use before the green concept even came in construction sector, it has become a huge problem environmentally all the while giving huge strain to the natural resources. Beginning with the CO_2 emission to consuming more than sustainable amount of energy for the day-to-day operation of the building, it has become one of the prime problems for us to find solution.

Therefore, the main part of this project lies in the conversion of the Hostel-2 (H-2) building of the Jaypee University of Information Technology, Waknaghat, Solan. After conducting the survey of the building various green features that can be adopted considering cost and benefit has been suggested. Some of the simple technique to reduce energy consumption in various use in day-to-day life of the building, water use by the occupants and waste management technique has been outlined and the benefit of using such method has been analysed.

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LIST OF ABBRIVATION

Acronym	Full Form
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BREEAM	Building Research Establishment Environmental Assessment Methodology
CFC	Chlorofluorocarbon
GBS	Green Building Studio
GRIHA	Green Rating for Integrated Habitat Assessment
HVAC	Heating Ventilation and Air Conditioning
IGBC	Indian Green Building Council
IS	Indian Standard
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
MNRE	Ministry of New and Renewable Energy
NBC	National Building Code
RRWH	Rooftop Rain Water Harvesting
TERI	The Energy and Resource Institute
TRP LoE	Triple Pane Low Emissivity
USGBC	United States Green Building Council
WWR	Window Wall Ratio

CHAPTER 1
INTRODUCTION

1.1 General

In this chapter we will be discussing about the introduction to green building and green retrofitting. This chapter also contains some green building rating system in brief.

1.2 Introduction to green building

The world is seeing massive infrastructure development due to population rise and the unparalleled advancement of civilization. Rapid urbanisation has become the leading cause of environmental degradation, material resource use, and the destruction of numerous local ecosystems, primarily committed to providing rapid engineering solutions. Buildings developed and built generate major environmental issues due to excessive energy and resource use. Therefore, numerous researches have been done and is still doing to develop solution to the harmful practices in construction. One such solution is the practice of green construction for 'Green Building'.

As defined by the American Society for Testing and Materials (ASTM), a green building is "A building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional and global eco-systems both during and after its construction and specified service life".

An environmentally and resource-conscious building, commonly referred to as a "green building," is one that is constructed, refurbished, restored, utilised, or recycled in an environmentally and resource-conscious way. It takes into account a structure's whole life span, which covers organising, creating, constructing, managing, maintaining, demolition, and disposing. All factors, such as a structure's overall consequences on the environment, economy, and society are taken into account.

Any building, whether residential, commercial, educational, medical, community, industrial, or any other type of building can be considered a green building as long as it has green features and is built through green practices. However, it is crucial to remember that not all green structures can or ought to be exactly the same. distinct regions and countries have distinctive traits, such as pronounced climatic conditions, culture and customs, various structure kinds and ages, or enormous ecological, financial, and societal needs, which have an impact on how green buildings are approached.

1.3 Need of green building

Local communities, the environment, and the economy are all significantly impacted by building design, construction, utilisation, servicing, and its demolition, according to studies conducted worldwide. Building construction has an impact not just on the areas immediately surrounding the building sites, but also on locations farther away. Forests, watersheds, air quality, travel patterns, and frequently local communities' social cohesion are all impacted. There is evidence that buildings are to blame for about:

- Almost half of the world's energy use
- A quarter of the total timber harvest
- Around one-sixth of the fresh water withdrawal
- Half of the ozone-depleting CFCs still in use
- Almost one-third of raw materials consumption
- Over a third of the world's CO_2 emissions
- Two-fifths of municipal solid waste that is sent to local landfills

Urban development over in recent years, the industry has emerged as one of the most powerful consumers. Lately, the industry has emerged as one of the most powerful consumers of natural resources, primary cause of environmental deterioration, and the cause of the disappearance of numerous local eco-systems in various countries. It is abundantly obvious that there is an urgent need for more careful assessment and sensitive transformation among the techniques used currently in the creation and construction practises.

1.4 Characteristics of green construction

Builders, designers, and tenants that care about the environment are gravitating towards green buildings in greater numbers. These buildings are made to have as minimal of a footprint on the environment as possible while nonetheless presenting their occupants with a number of amenities. The most notable characteristics of green buildings, such as their energy efficiency, waste management expertise, water optimisation, and indoor air quality, will be addressed;

a) Energy efficiency and optimisation

The energy efficiency of green structures is one of its key characteristics. These buildings are made to utilise less energy than typical ones, thereby lowers energy costs and improves greenhouse gas emissions. The following are some subtopics pertaining to energy efficiency in green buildings:

- Insulation: To limit heat loss during the winter and prevent overheating during the summer, green buildings are designed with high levels of insulation. In conjunction with this, there is less of a demand for heating and cooling systems, which means less energy is used.
- Efficient Lighting Systems: Green buildings also have energy-saving lighting fixtures like LEDs, which require less power than typical lighting. Additionally, motion sensors may be introduced to these lighting systems, permitting automatic lighting control based on occupancy scales.
- Renewable Energy Sources: Renewable energy sources, including solar or wind power, are frequently used in green structures. These systems can produce the building's own electricity, minimising its demand for grid power.

b) Water efficiency and optimisation

Green buildings concentrate great emphasis on water conservation, particularly within regions with water deficits. Green buildings can cut water use and reduce revenue on water usage by adding water-saving features. The following are some segments pertaining to water optimisation in green buildings:

- Rainwater Harvesting: Rainwater harvesting systems, which gather precipitation from the roof and stores it for later use, frequently feature in ecologically conscious structures. There will be less need for municipal water if this water is used for toilet flushing or irrigation.
- Low-Flow Fixtures: In addition to using less water than typical fixtures, green buildings additionally incorporate low-flow fittings including showerheads, plumbing, and toilets. This lowers the building's water bill and promotes water conservation practises.

- Greywater recycling systems: These systems acquire water from sinks, showers, and washing machines and repurpose it for uses other than flushing toilets or watering plants. They are used in certain environmentally friendly buildings.

c) Waste Reduction

Environmentally friendly buildings are made to reduce waste and promote recycling rates. These structures can lessen the volume of waste that winds up in landfills through employing efficient waste management techniques. The following are some subtopics pertaining to waste administration in green buildings:

- Composting on-site: Numerous environmentally friendly structures integrate onsite composting amenities, which can lessen the volume of organic waste dumped in landfills. Organic waste can be composted to provide a nutrient-rich soil amendment for gardens or landscaping.
- Reusing materials is another way that green buildings can use recycled or repurposed resources. Reclaimed wood from ancient structures, for instance, can be utilised to create wall or floor panels, lowering the requirement for new timber to be cut down.
- Design for Disassembly: When planning green frameworks, "disassembly" is frequently kept in mind. This indicates that when the structure reaches the end of its useful life, its components may be easily disassembled and reused or recycled.

d) Indoor air quality

Increased indoor air quality, which can have a substantial impact on building occupants' health and welfare, is a goal of green building design. A healthy indoor atmosphere can be fostered in green buildings through certain elements like natural ventilation, negligible-toxic building materials, and air filtration technologies. In relation to indoor air quality in green buildings, a few subtopics include:

- Natural ventilation systems are frequently used in green buildings to control indoor air quality by leveraging temperature variations and natural air flow. By using this strategy, the building's mechanical cooling and heating systems may not be required, thereby boosting energy efficiency whilst decreasing energy expenses. Furthermore, natural ventilation can aid in facilitating the elimination of pollutants and the improvement of indoor air quality, both of which are crucial in areas with substantial population density or in buildings with high levels of outdoor pollution. Utilising natural forces, green buildings can reduce their environmental impact while providing occupants with a cosy and healthy indoor environment.

- HVAC Systems: For monitoring the temperature and interior air quality in buildings that are environmentally friendly, HVAC (heating, ventilation, and air conditioning) systems are frequently utilised. As they evolved to filter pollutants and allergens from the air, high-efficiency HVAC systems can assist in drastically reducing energy usage and enhancing indoor air quality. Additional energy-saving features that HVAC systems can include heat recovery ventilation, which uses heat from emitted air to warm incoming air.
- Maintenance and Cleaning: Ensuring an optimal quality of indoor air requires periodic maintenance and cleaning of HVAC systems. Protocols for routine HVAC system cleaning and maintenance as well as regular air quality testing could possibly be incorporated into green buildings. In order to validate that the system is running successfully in removing pollutants while maintaining high indoor air quality, this might help uncover any potential system problems.

1.5 Need for green retrofitting

The most recent value-added service in facility management is sustainability. The facility management team, however, does not fully understand or recognise the practise of sustainability in the field of facility management. Therefore, the building industry accounts for the main global source of greenhouse gas emissions. In truth, there is a compelling commercial rationale for green building, but these structures are the ones of the future.

Green retrofitting is an alternative approach because the bulk of the existing stock of buildings was not constructed sustainably and because it is not practicable to demolish every existing building. The benefits associated with the retrofitting of existing building to green building are:

- Reduces pressure on the environment by efficient use of energy, water and resources.
- An improvement in people's health and wellbeing.
- Structures with a longer lifespan and greater durability, which lowers maintenance expenses.
- Better construction investment returns and long-term economic performance.

- Greater tenant happiness as a result of thoughtful design and planning.

Some characteristics of converting an existing structure into a green building are:

- A design that allows for environmental adaptation.
- Utilising resources wisely entails the effective utilisation of water, electricity, and numerous other resources.
- Acknowledging the use of renewable energy sources.
- Waste and pollution reduction strategies, as well as encouraging recycling and reuse.
- The use of ecological, moral, and non-toxic materials.
- The environment is taken into account during design, building, and operation.

1.6 Green building rating systems

In India, the use of green building rating systems has grown in popularity as a way to encourage sustainable growth and lessen its negative environmental effects. GRIHA, LEED, IGBC, and BREEAM are some of the rating systems that are most frequently utilised. Each of these grading systems assesses buildings according to particular standards and assigns credit points in several categories to determine how sustainable they are.

1.6.1 LEED

The US Green Building Council (USGBC) created the LEED (Leadership in Energy and Environmental Design) international green building rating system. India is one of more than 160 nations that accept LEED certification. Several categories, including sustainable site development, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality are given credit points by LEED. Higher scores lead to higher levels of certification, such as LEED Certified, Silver, Gold, and Platinum. Buildings are evaluated based on the number of credit points they receive.

Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Air Quality are the five main categories under which India awards LEED credit points. Each of these categories offers a possible 100 points. Four points are given for satisfying regional priorities, and six points can be obtained under the "Innovation in Design" category. Based on how well they perform in these categories, buildings can earn various certification levels thanks to this credit point system.

1.6.2 BREEAM

An international green building grading system was created in the UK and is called (Building Research Establishment Environmental Assessment Method). India is one of several nations in the globe that accept BREEAM certification. Energy and water use, materials and waste, health and well-being, and pollution are only a few of the categories for which BREEAM awards credit points. Higher scores lead to higher levels of certification, including Pass, Good, Very Good, Excellent, and Outstanding. Buildings are evaluated depending on the number of credit points they receive.

The BREEAM green building rating system in India awards a total of 100 points in each of its six core categories: Management, Health and Wellbeing, Energy, Transport, Water, and Materials and Waste. Additional points can be earned through innovation credits, with each credit contributing 1% to the final score of the relevant category (up to a maximum of 7%). Buildings are then assigned a rating based on their total score, with classifications ranging from "Outstanding" for scores of 85 or higher, down to "Unclassified" for scores below 30.

1.6.3 IGBC

Sustainable building methods are promoted in India through the non-profit IGBC (Indian Green Building Council). In addition to IGBC Green Homes, IGBC Green Factories, and IGBC Green Townships, IGBC also offers a number of other grading systems. Each grading system assesses structures using particular standards for site selection and planning, water conservation, energy efficiency, materials and resource efficiency, and indoor environmental quality. Buildings are rated according to their credit point totals, and those with higher scores are certified at higher levels, such as Certified, Silver, Gold, and Platinum.

This system gives points for enhancing the design of steel and cement structures and recognises the value of passive architectural components. Credits are also given for cutting down on water use during construction, which provides project teams with a learning opportunity and establishes baselines for later use. These distinctive features of the rating systems are a reflection of how sustainable construction practises are becoming more and more important in India and throughout the world.

1.6.4 GRIHA

The Energy and Resources Institute (TERI) developed the green evaluation for Integrated Habitat Assessment (GRIHA), an Indian green construction evaluation system. Its main objective is to promote sustainable construction methods throughout the nation. GRIHA was adopted by the Indian government as the country's national green building rating system in 2007. A detailed evaluation system, GRIHA evaluates a building's environmental performance throughout the course of its whole life cycle, from design and construction to use and maintenance. Assessment Criteria:

GRIHA rating system assesses buildings based on various criteria grouped into 34 parameters. These parameters are classified into four categories: site planning, building planning, energy and resource use, and indoor environment quality. Each parameter is further divided into sub-parameters that assess various aspects of the building's performance.

The assessment criteria for GRIHA rating system include aspects such as site selection, site planning, water conservation, energy efficiency, materials, and waste management, among others. The system evaluates buildings on a 100-point scale, with points awarded for compliance with the criteria. How Points are Achieved:

Points are awarded based on the level of compliance with the criteria. The number of points awarded varies based on the level of compliance achieved. The criteria are designed in a way that encourages the adoption of sustainable practices and the use of innovative technologies. For example, buildings that use renewable energy sources such as solar or wind power can earn more points than those that rely on conventional sources.

In addition to the 100-point scale, GRIHA also includes bonus points for innovation and regional priority. Projects can earn up to 10 bonus points for innovation, which encourages the use of new and innovative technologies, materials, and practices that are not covered by the regular criteria. Regional priority points are awarded to projects that address the specific environmental challenges of the region in which they are located.

Rating Pattern:

GRIHA rating system has five levels of certification: 1-Star, 2-Star, 3-Star, 4-Star, and 5-Star. The rating is based on the total number of points earned by the project, with each level requiring a minimum number of points. The rating pattern is as follows:

- Star: 40-49 points
- Star: 50-59 points
- Star: 60-74 points
- Star: 75-89 points
- Star: 90-100 points

CHAPTER 2

2.1 General

This chapter contains literature review of the various paper and aim, objective and methodology of this project.

2.2 Literature review

In nations like Russia, China, Brazil, and India, the energy demand for buildings is expected to move up by almost threefold by the year 2050 (Berardi et al. 2017). Therefore, there is going to be huge strain in nature resources especially energy sector, to feed the ever-growing construction industry. The energy sector of the world has already taken a big hit due to geopolitical tension and pandemic. As per US Department of Energy the buildings in US consume approximately thirty nine percent of the energy and seventy four percent of the total electricity production happening in United States.

So for the above mentioned reasons, it is essential that there should be an all-round innovation in the construction sector. One of the most innovative ideas put forward is the idea of 'Green Building.' Green building refers to the approach of constructing and operating buildings in an environmentally responsible and resource-efficient manner throughout their entire life cycle, encompassing site selection, design, construction, operation, maintenance, renovation, and ultimately, demolition. The main objective of green building is to reduce the overall environmental impact of buildings while promoting the health and well-being of occupants. This is achieved by implementing sustainable practices and technologies that help conserve natural resources, reduce energy consumption, minimize waste, and optimize the use of renewable energy sources. (Romm & Browning et al. 1998). This construction method of structure makes use of less water, optimizing energy efficiency, conserving natural resources, generating less waste overall and providing healthier environment for occupants, as compared to the case of a conventional building.

Although there has been setback in fully implementing the concept of green building in all the construction going around the world due to initial cost surcharge that it takes compared to the conventional construction method (Ming Hu and Miroslaw Skibnewski et al. 2021) the same study also shows that there has been significant improvement in the number of people willing to venture into green construction.

The green building technique has helped a lot in making the construction sector sustainable and more occupant friendly as per many studies. But there are also a huge number of already existing buildings taking up huge number of resources and contributing greatly to the environmental pollution leading to climate change and global warming. To combat this problem of pollution from already existing building a concept of green retrofitting has been introduced. Adding green features to already existing building has shown to improve greatly in energy utilization (Donglin Zhen, Lijun Yu and Lizhen Wang et al. 2019) and considerably decreasing their contribution to climate change. This study has shown that by replacing the appliances in the building with energy efficient one there was a significant drop in energy consumption leading to cost saving as well as better quality of life to occupants.

2.3 Objectives of the project

- ✓ Research on the various green retrofitting technique in the already existing ordinary building.
- ✓ Determine the features and technique that could be incorporated in a selected building.
- ✓ Analyse the green features in software (Revit, Insight, Green Building Studio) determine the feasibility of green features.

2.4 Methodology

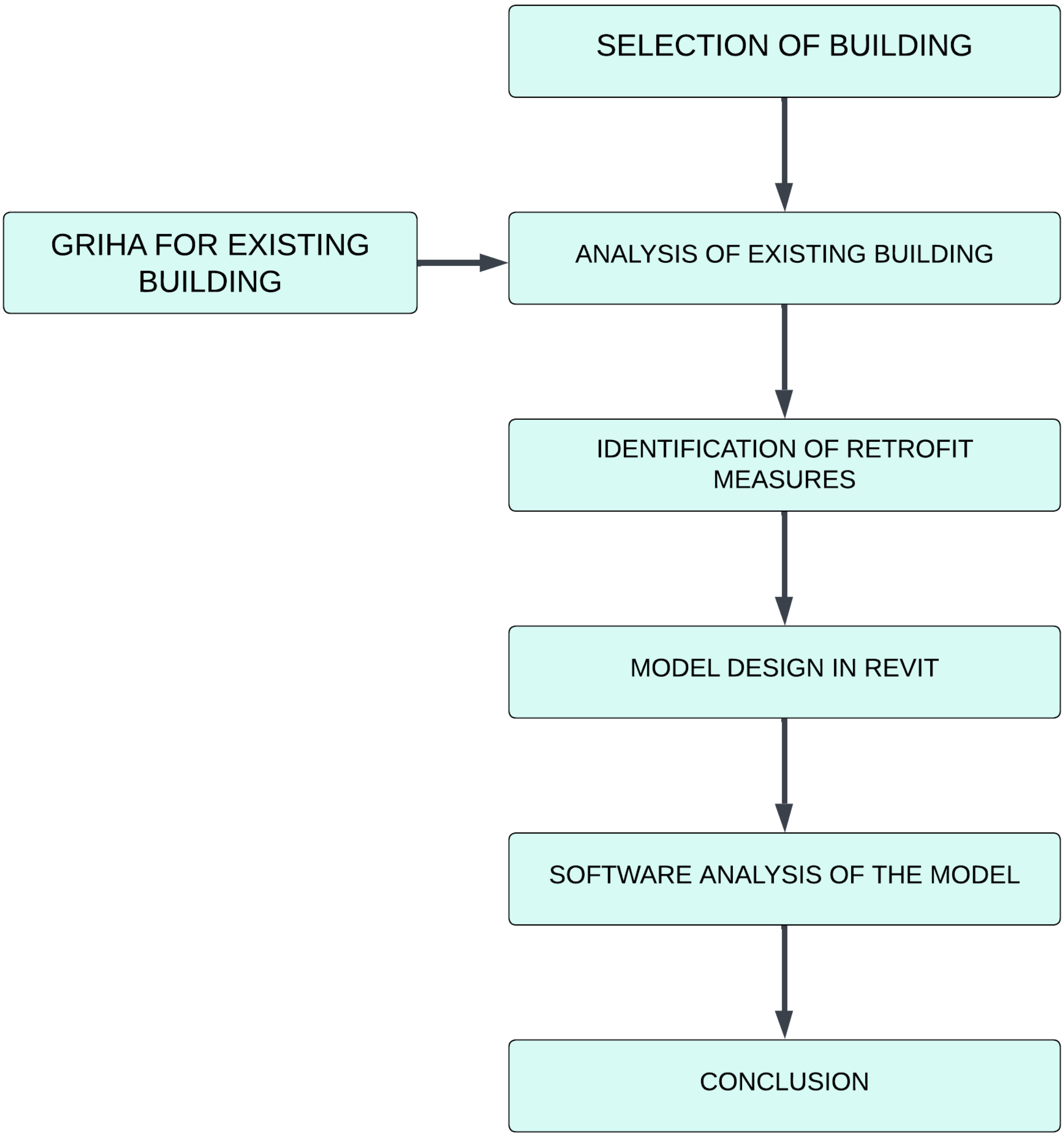

Figure 2.1 Methodology

Table 2.1. Criteria and their weightage (GRIHA for existing building: Version 1)

Section	Criterion Name	Intent	Max. Points
Section I. Site Parameters	**Criterion 1** *Accessibility to Basic Services*	Promote walking, cycling, and public transport	2
	Criterion 2 *Microclimatic Impact*	Lower the impact of Urban Heat Island Effect (UHIE), and promote plantation of trees	4
Section II. Maintenance & Housekeeping	**Criterion 3** *Maintenance, Green Procurement and Waste Management*	Ensure good practices for safety, waste management, and green procurement	7
	Criterion 4 *Metering & Monitoring*	Promote reliable metering and monitoring	10
Section III. Energy	**Criterion 5** *Energy Efficiency*	Ensure energy efficiency	20
	Criterion 6 *Renewable Energy Utilization*	Promote use of renewable energy	15
Section IV. Water	**Criterion 7** *Water Footprint*	Implement potential water conservation strategies	15
	Criterion 8 *Reduction in Cumulative Water Performance*	Reduce overall water demand of the habitat	10
Section V. Human Health & Comfort	**Criterion 9** *Achieving Indoor Comfort Requirements*	Ensure that building spaces provide for thermal, visual, and acoustical comfort	8
	Criterion 10 *Maintaining Good IAQ*	Ensure good indoor air quality	4
Section VI. Social Aspects	**Criterion 11** *Universal Accessibility & Environmental Awareness*	Promote accessibility for the persons who are differently-abled & the elderly and to increase environmental awareness amongst the building users & visitors	5
Section VII. Bonus Points	**Criterion 12** *Bonus Points*	Adoption and implementation of innovative strategies in improving the sustainability of the project	4

CHAPTER 3:
ANALYSIS OF EXISTING BUILDING

3.1 General

In this chapter we are going to assess the site of study according to the criteria mentioned in the GRIHA for Existing Building criteria.

3.2 Site parameters

The location of study is inside the Jaypee University of Information Technology (JUIT). It is the boys Hostel no.2 (H-2) of JUIT. It lies at 31.0166^o N and 77.0702^o E. It is one of the buildings in a block consisting of 11 buildings. The climate of this area has hot summer and cold winter.

Figure 3.1 Satellite image of selected site (Picture courtesy: Google earth)

i) Accessibility to basic services

1-Main academic block.

2-Civil Engineering block

3-Gym

4-Football Ground

5-University gate (Bus service to the main national highway at Waknaghat)

6-Dispensary

7-Basketball and Volleyball court

8-Dhabas (Grocery store, restaurants etc.)

9-Bank

Since all the occupants in the building are students, the classrooms are nearby only in the radius of about 100 m. Other facilities such as bank, gym, infirmary, and recreational areas such as playgrounds are also in and around 200 m radius (within the campus area). Therefore, there is no need to take any mode of transportation to reach above mentioned facilities and can be walked to reach from the site of study.

3.3 Maintenance and house keeping

3.3.1 Maintenance

There is a designated 'Maintenance Department' of JUIT responsible for electrical, HVAC, plumbing systems, and civil repair work. They come for the regular inspection of the above-mentioned system. In case of any problem in the rooms occupied by the students, they can lodge a complaint in the register book in maintenance department and the follow up is done as soon as possible.

There are basically 3 types of appliances for HVAC system for the hostel:

i) Regular fan (cooling in room)

ii) Hot air regulator/Fan coil unit (heating in room)

iii) Exhaust fan (cooling and air regulator in toilet)

iv) There is a fire extinguisher in every floor in case of any fire disaster.

v) All HVAC equipment are CFC free

3.3.2 Waste Management

A waste bin is kept on every floor where occupants can throw the waste produced. Everyday a cleaner comes to pick up the waste which is then packed in a disposable bag and then thrown taking outside the campus in a government designated place. Some of the waste that can be segregated for the recycle purpose are segregated and recycled. 99% of the waste generated constitute of plastic, paper and biodegradable items (food, fruit etc)

3.3.3 Metering and monitoring

The metering system for the electrical energy from the government provided grid is done at the utility grid situated at each building. The other sources of energy which is seldom used is generated via diesel run generator. The energy metering is done at the generator itself. There is no metering done on the water supply.

3.4 Energy

There are basically two sources of energy:

i) Government provided electricity (Hydroelectricity)

This source of energy is used most of the time. There is a 220 V connection of electricity in this building through which all the appliances are run.

ii) Diesel Generator

This source of energy is used when there is no electricity supply form the normally used grid.

Table 3.1. Hostel occupancy data

Hostel Floor	No. of Rooms	No. of occupant
1	6	2
2	8	11
3	8	12
4	8	12
5	8	12
6	8	12
7	8	12
Total	**54**	**73**

Table 3.2. Appliance use data

Floor No.	Room Fan	LED tube light	LED light bulb	Exhaust fan	Hot air regulator
1	1	4	8	1	1
2	8	13	13	2	8
3	8	13	13	2	8
4	8	13	13	2	8
5	8	13	13	2	8
6	8	13	13	2	8
7	8	13	11	2	8
Total	**49**	**82**	**84**	**13**	**49**

3.5 Water efficiency

The university campus has a private supply of water for 24/7. That same source of water is provided to this building through the water supply system.

There is no metering system in the building, therefore it is not feasible to determine the exact water use for a day. Since there is incessant supply of water so water utilization should be equal to demand. As per IS 1172:1993 code the water demand for hostel is 135 lpcd.

Give below is the estimated water usage for given purposes:

Table 3.3. Estimated water demand

Usage	Estimated demand (lpcd)
Toilet flushing	25
Urinal flushing	5
Bathing	75
Cloth washing	10
Wastage	5

The water usage information is important for the purpose of water reuse system design if need be to venture into it. The water that could be reused easily without much process of going through is grey water.

3.6 Human health and comfort

Room ventilations system is through the window located on the side wall. Natural daylight system is only through the one window provided in each room only. The rooms have been designed as per the space requirement for the intended number of people (maximum two) to stay.

Smoking is absolutely forbidden anywhere on the campus of the university, including the chosen site. If found smoking on university property, strict disciplinary action was taken that could lead to expulsion from the dorm.

3.7 Social aspect

The building has been designed and built as per the needs and intended purpose. Although the building might seem uninhabitable for physically challenged people but it was not built keeping that in consideration. As it is a one of the university hostels, there are facilities for disabled in other hostels.

3.8 Green feature recommended

Table 3.4 Possible green features to adopt

Criteria	**Green feature recommended**
Site Parameters	➢ Place solar panel on the roof
Maintenance & Housekeeping	➢ Proper waste management strategy. ➢ Segregation at source in at least two categories. ➢ Proper waste storage facilities.
Energy	➢ Install on-site renewable energy source. ➢ Solar panel installation to harness solar energy onsite.
Water	➢ Use of water efficient equipment ➢ Water conservation measures to be adopted
Human Health & Comfort	➢ Increase efficiency of HVAC system
Social Aspects	➢ Environment awareness action plan
Innovations	➢ Incorporate new technology

CHAPTER 4
WASTE AND WATER MANAGEMENT

4.1 Waste Management

Effective waste management is critical for sustainable development. On-site waste segregation has become a widely adopted approach to waste management in various sectors, including residential, commercial, and industrial buildings. Proper waste segregation allows for better handling and disposal of waste, thereby reducing environmental pollution and promoting recycling. One popular method of on-site waste segregation is the use of colour coded waste bins.

A waste bin is kept on every floor where occupants can throw the waste produced. Everyday a cleaner comes to pick up the waste which is then packed in a disposable bag and then thrown taking outside the campus in a government designated place. Some of the waste that can be segregated for the recycle purpose are segregated and recycled. 99% of the waste generated constitute of plastic, paper and biodegradable items (food, fruit etc).

The handling of waste recycling contracts by the waste management department is an important part of waste management. The waste management department is responsible for identifying and contracting with recycling companies to ensure that the recyclable materials are properly disposed of. This process involves negotiating contracts with recycling companies, monitoring the collection and transportation of recyclable materials, and ensuring that the materials are properly processed and recycled.

Currently, the site does not have colour coded waste bins in place for waste segregation. As part of our waste management plan, it has been decided to install colour coded waste bins for effective segregation of waste at the source. To ensure the effective segregation of waste, it is best to provide colour-coded waste bins on each floor.

Figure 4.1. Colour coded waste bin.

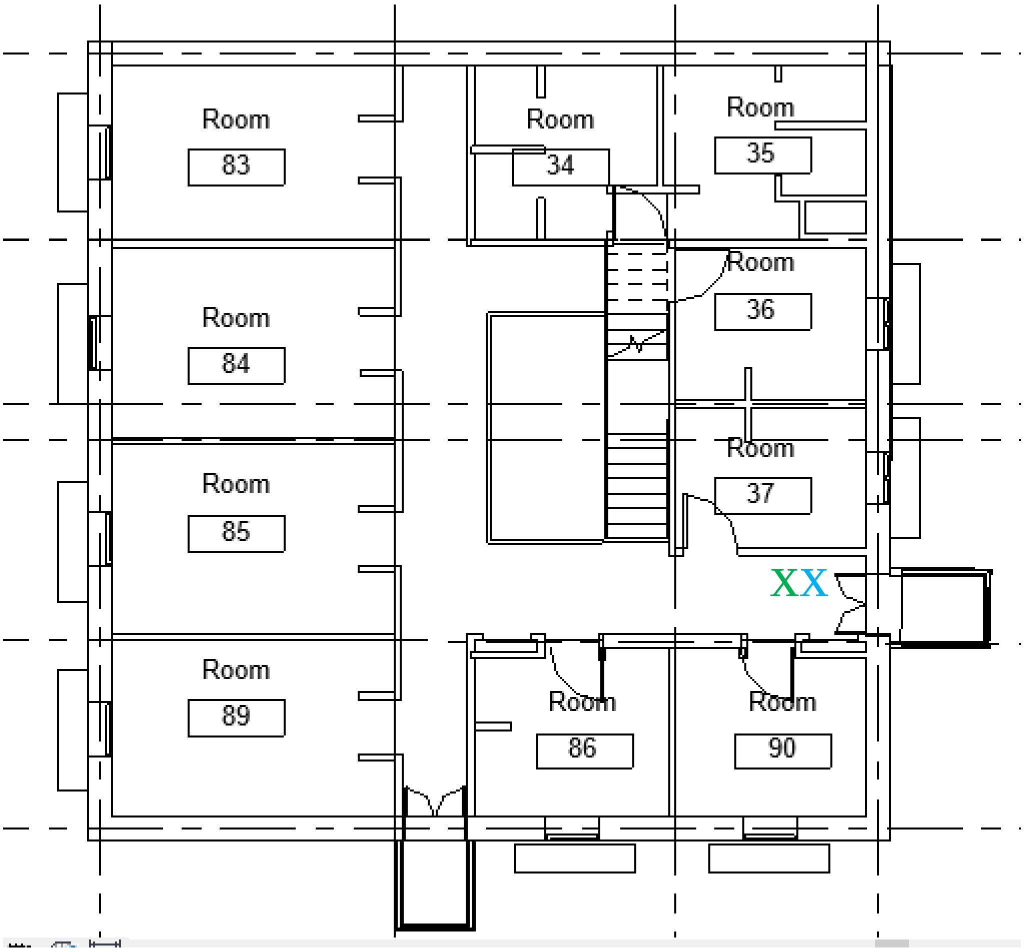

Figure 4.2. Location of colour coded waste bin at the X mark on the floor plan.

4.2 Water efficiency and water optimisation

The water supply for the university campus comes from a pump house at Domehar Bani, which is situated at 3km from the university. The water tank serves as the university's secondary supply of water as well. That same source of water is provided to this building through the water supply system.

There is no metering system in the building, therefore it is not feasible to determine the exact water use for a day. Since there is incessant supply of water so water utilization should be equal to demand. As per IS 1172:1993 code the water demand for hostel is 135 lpcd.

Give below is the estimated water usage for given purposes:

Table 4.1. Estimated water demand

Usage	Estimated demand (lpcd)
Toilet flushing	25
Urinal flushing	5
Bathing	75
Cloth washing	10
Wastage	5

4.2.1 Building water usage report.

The purpose of this report is to provide a summary of a building's water usage and costs based on the occupancy rate and number of fixtures installed. The building in question is occupied by a total of 85 people and has an occupancy rate of 49%. The building has 15 toilets, 15 urinals, 22 sinks, and 15 showers, and has a total water usage of 5769461 litres per year. The cost of water for the building is Rs.9289 per year.

Water Usage and Costs

Total:	5,769,461 L / yr	₹9,289 / yr
Indoor:	5,769,461 L / yr	₹9,289 / yr
Outdoor:	0 L / yr	₹0 / yr
Net Utility:	5,769,461 L / yr	₹9,289 / yr

Building Summary						Efficiency Savings		
	Total	Male	Female	Employee Only	Efficiency	Percent of Indoor Usage (%)	Gallons per Year	Annual Cost Savings (₹)
Toilets:	15	15	0	0	Standard	0	0	0
Urinals:	15	15		0	Standard	0	0	0
Sinks:	22	22	0	0	Standard	0	0	0
Showers:	15	15	0		Standard	0	0	0
Clothes Washers:	0				Standard	0	0	0
Dishwashers:	0				Standard	0	0	0
Cooling Towers:	0				Standard	0	0	0
☐Include cooling tower blowdown in sewer costs					Total Efficiency Savings:	0%	0	₹0

Figure 4.3. Autodesk GBS generated output of water usage data

4.2.2 Water Usage:

Based on the number of occupants and the fixtures installed, the building's water usage is estimated at 5769461 litres per year. This includes water usage for toilets, urinals, sinks, and showers. The highest water usage is from the toilets and showers, accounting for approximately 75% of the total water usage. The occupancy rate of the building is 49%, which means that only about half of the building is occupied at any given time. This occupancy rate has a significant impact on the building's water usage, as the water usage is directly proportional to the number of occupants.

Fixture Summary:

The building has 15 toilets, 15 urinals, 22 sinks, and 15 showers. The toilets and urinals are the most water-intensive fixtures, consuming approximately 4.6 million litres per year. The sinks and showers account for the remaining 1.7 million litres per year.

4.2.3 Water Cost:

The cost of water for the building is Rs.9289 per year. This cost is based on the total water usage and the cost per unit of water. The cost of water can be reduced by implementing water-efficient fixtures, which will lower the building's overall water usage and save money on water bills.

4.2.3 Recommendations:

To reduce water usage and costs, it is recommended that the building implement water-efficient fixtures. This can include low-flow toilets, urinals, sinks, and showers. These fixtures are designed to use less water without compromising performance or user experience. By installing these fixtures, the building can reduce water usage and costs, while also improving the sustainability of the building.

4.2.4 Water usage report using Low flow rate fixture.

Low flow rate fixtures are plumbing components that limit water flow from faucets, showers, toilets, and urinals, lowering water consumption per use without sacrificing functionality or user comfort. Building owners and occupants can considerably cut their water usage and related costs by choosing low flow rate fixtures, which will also help with water conservation efforts and lower the danger of water scarcity and drought. Additionally, low flow fixtures can improve indoor air quality, ease the strain on wastewater treatment facilities, and reduce energy costs.

The use of low flow rate fixtures for toilets, showers, sinks, and urinals can have a significant impact on water savings and cost reduction in a residential or commercial building. By implementing these fixtures, the total water demand can be reduced to 2644178 litres/year, resulting in an annual cost reduction of Rs. 3989. This represents a significant efficiency saving, with toilets achieving a 22.3% reduction, urinals 3.9%, sinks 13.6%, and showers 14.4%.

The water savings achieved through the use of low flow rate fixtures are impressive. For toilets, we can save a total of 1285044 gallons per year, while for urinals, we can save 224981 gallons per year. Sinks contribute to a saving of 786488 gallons per year, while showers add up to a total saving of 828,770 gallons per year.

Moreover, the annual cost savings are equally significant. With low flow rate fixtures, we can save Rs. 2069 for toilets, Rs. 362 for urinals, Rs. 1226 for sinks, and Rs. 1334 for showers. These savings may seem small on an individual basis, but when calculated on a yearly basis, the amount adds up, providing financial benefits.

Water Usage and Costs

Total:	2,644,178 L / yr	₹4,142 / yr
Indoor:	2,644,178 L / yr	₹4,142 / yr
Outdoor:	0 L / yr	₹0 / yr
Net Utility:	2,477,350 L / yr	₹3,989 / yr

Building Summary / **Efficiency Savings**

	Total	Male	Female	Employee Only	Efficiency	Percent of Indoor Usage (%)	Gallons per Year	Annual Cost Savings (₹)
Toilets:	15	15	0	0	Low-Flow	22.3	1,285,044	2,069
Urinals:	15	15		0	Low-Flow	3.9	224,981	362
Sinks:	22	22	0	0	Low-Flow	13.6	786,488	1,266
Showers:	15	15	0		Low-Flow	14.4	828,770	1,334
Clothes Washers:	0				Standard	0	0	0
Dishwashers:	0				Standard	0	0	0
Cooling Towers:	0				Standard	0	0	0
Include cooling tower blowdown in sewer costs					Total Efficiency Savings:	54.2%	3,125,283	₹5,032

Figure 4.4. Autodesk GBS generated water usage data using low flow rate fixtures.

Implementing low flow rate fixtures not only reduces the cost of water consumption but also contributes towards sustainable practices, encouraging water conservation and reducing the carbon footprint of the building. It is a win-win situation, where we can achieve cost savings while contributing to environmental sustainability, making it a viable solution for both residential and commercial buildings.

The analysis mentioned in this report was conducted using Autodesk Green Building Studio.

4.2.5 Roof top rain water harvesting.

Rooftop rainwater harvesting (RRWH) is a sustainable water management solution that has gained widespread attention in recent years. RRWH involves capturing and storing rainwater that falls on roofs and other impermeable surfaces for later use.

This report aims to evaluate the feasibility of implementing RRWH in a H2 building with a total water demand of 5769461 litres/year and an annual cost of Rs.9289. The report will also consider the annual rainfall, rooftop catchment area, and roof surface type to determine the potential annual cost savings.

4.2.6 Methodology

The feasibility analysis was conducted using the Autodesk Green Building Studio, which employs an hourly simulation of building performance based on the actual weather data. The first step was to determine the annual rainfall in the area of the hostel building. The rainfall data was collected from the Indian meteorological department, Shimla, and the average annual rainfall was found to be 1415 mm.

Next, the rooftop catchment area was determined, which was measured to be 131 square meters. The roof surface type was found to be concrete, which is a good surface for rainwater harvesting.

The total water demand for the hostel building was calculated to be 5769461 litres/year, and the cost of water was found to be Rs.9289/year. The next step was to evaluate the potential annual cost savings if RRWH was implemented in the hostel building.

4.2.7 Analysis:

Net-Zero Measures		Annual Rainfall (mm)*	Catchment Area (m²)	Surface Type	Net-Zero Savings Liters per Year	Annual Cost Savings (₹)
Rainwater Harvesting:	Yes	1415	131	Concrete/Asphalt	166,829	115
Native Vegetation Landscaping:	No				0	0
Greywater Reclamation:	No				0	0
Site Potable Water Sources:	No	Yield:	50	L / day	0	0
*Source: National Climactic Data Center, #CLIM81.				**Total Net-Zero Savings:**	**166,829**	**₹115**

Figure 4.5. Autodesk GBS generated water saving from RRWH.

The feasibility of RRWH in the hostel building depends on several factors such as the annual rainfall, rooftop catchment area, and the type of roof surface. In this case, the annual rainfall is 1,415 mm, and the rooftop catchment area is 131 m2, with a concrete roof surface. Based on these factors, the estimated litres per year generated from RRWH is 166,829. However, the annual cost savings from using RRWH are only Rs. 115, which is not feasible compared to the high initial cost of installing an RRWH system.

4.2.8 Conclusion:

Although RRWH is a sustainable and effective method of water conservation, its feasibility depends on various factors. In the case of the hostel building, the annual cost savings from RRWH are not significant enough to justify the high initial cost of installing an RRWH system. However, it is essential to consider the long-term benefits of RRWH, such as reduced water bills, and the positive impact on the environment. Therefore, it is recommended to conduct a detailed cost-benefit analysis and assess the feasibility of RRWH in other buildings with different water demands and climatic conditions.

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CHAPTER 5
INDOOR ENVIRONMENT QUALITY

5.1 General

The term "indoor environmental quality" describes how comfortable, healthy, and well-being-promoting the indoor environment is for its users. It includes a variety of elements, including ergonomics, lighting, acoustics, thermal comfort, and indoor air quality. Numerous advantages of a high-quality indoor environment include increased productivity and satisfaction, fewer health issues, and lower energy costs. A holistic strategy that considers all the relevant aspects is necessary to achieve good indoor environmental quality, which aims to provide inhabitants with a cosy, healthy, and sustainable indoor environment.

5.2 Indoor Air Quality Assessment

The quality of indoor air is crucial for the health, comfort, and productivity of occupants in buildings. As per the National Building Code (NBC) guidelines, the indoor air quality should meet the minimum requirements for temperature, humidity, ventilation, and air purity to ensure occupant comfort and safety. The purpose of this report is to assess the indoor air quality of the H2 building in Jaypee University of Information and Technology in Solan, and to determine whether it is acceptable as per the NBC guidelines. In addition, this report will examine the natural ventilation potential of the building and recommend possible improvements.

As per NBC 2016, the acceptable indoor air quality is defined by the following parameters:

1. Temperature: The indoor temperature should be maintained within the range of 23°C to 26°C.

2. Relative Humidity: The indoor relative humidity should be maintained within the range of 40% to 70%.

3. Ventilation: The indoor air should be ventilated with fresh air at a rate of 10-20 litres per second per person or 0.15-0.25m/s.

5.2 Methodology

The data for this assessment was obtained from Autodesk GBS, including monthly design data, dry bulb frequency distribution, wind speed frequency distribution, relative humidity frequency distribution, and total sky cover frequency distribution. The wind rose diagrams for winter and summer were also generated using Autodesk Revit software.

The methodology involved analysing the data to determine whether the indoor air quality meets the NBC guidelines for temperature, humidity, and ventilation. The natural ventilation potential was also evaluated based on the window-to-floor ratio of 15%.

5.3 Heating Ventilation and Room Fans:

The building has a heating ventilation system that uses hot air to heat the indoor environment during colder months. Additionally, there are room fans installed throughout the building to circulate air and improve indoor air quality.

5.4 Monthly Design Data:

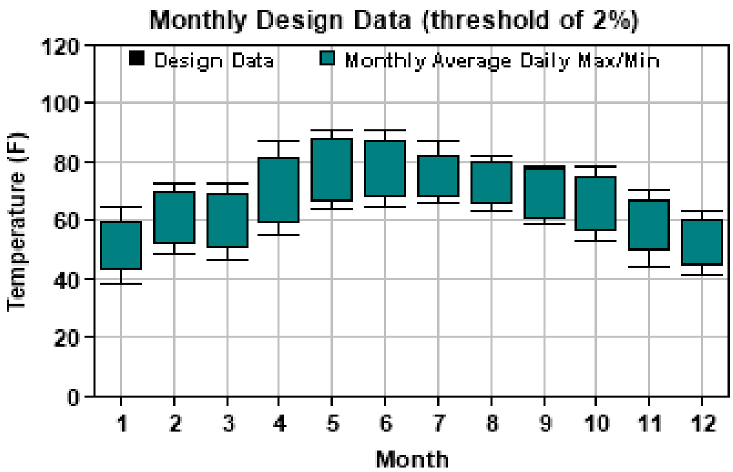

Figure 5.1. Monthly design data

The monthly design data shows that the temperature range for the site varies from 41°F to 90°F throughout the year. The design data falls within the threshold of 2% for all months, which indicates that the indoor temperature is within the acceptable range as per the NBC guidelines.

5.5 Dry Bulb Frequency Distribution:

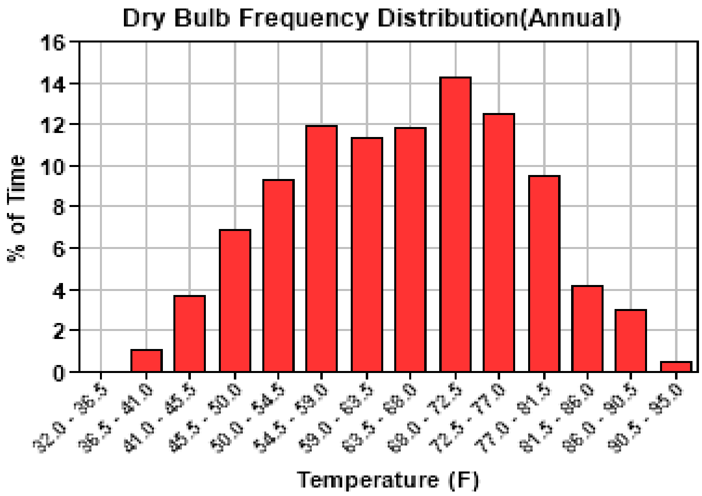

Figure 5.2. Autodesk generated annual Dry bulb frequency graph

The dry bulb frequency distribution graph shows the temperature range and the percentage of time that the temperature falls within each range. The data indicates that the temperature ranges from 36.5°F to 95°F annually, with the majority of the time (14.2%) falling within the range of 68°F to 72.5°F. This indicates that the indoor temperature is maintained within a comfortable range.

5.6 Wind Speed Frequency Distribution

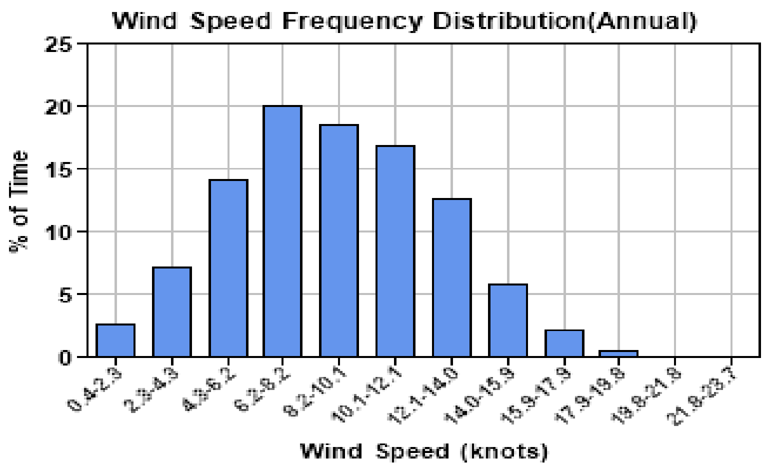

Figure 5.2. Autodesk generated wind speed frequency distribution

The wind speed frequency distribution graph shows the percentage of time that wind speeds fall within a particular range. The data indicates that wind speeds range from 0.4 knots to 19.8 knots annually, with the majority of the time (20%) falling within the range of 6.2 knots to 8.2 knots. This indicates that there is sufficient airflow in the building, which helps to improve indoor air quality.

5.7 Wind Rose Diagram:

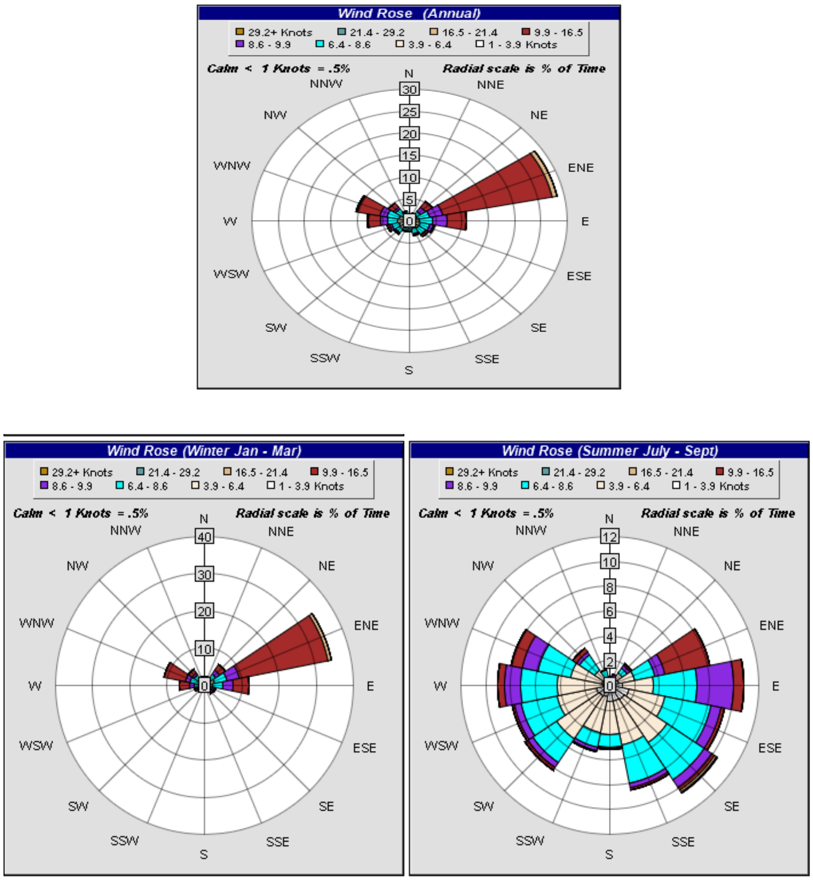

Figure5.4. Autodesk generated wind ross diagrams

The wind rose diagram shows the direction and intensity of winds during winter and summer months. In winter, winds blow predominantly from the East Northeast at speeds ranging from 9.9 to 16.5 knots, as well as from the West Northwest. In summer, winds blow from all directions except North, North Northeast, North Northwest, and South.

5.8 Relative Humidity Frequency Distribution:

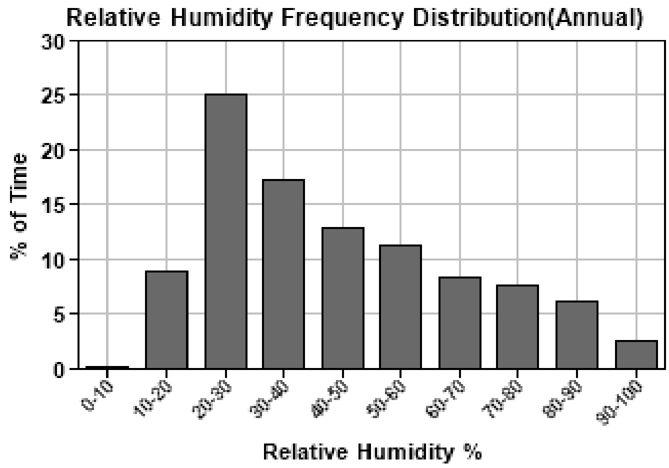

Figure 5.5. Autodesk generated Annual relative humidity frequency distribution graph

The relative humidity frequency distribution graph shows the percentage of time that the relative humidity falls within a particular range. The data indicates that the relative humidity ranges from 0% to 100% annually, with the majority of the time (25%) falling within the range of 20% to 30%. This indicates that the indoor environment is not excessively dry or humid.

5.9 Total Sky Cover Frequency Distribution:

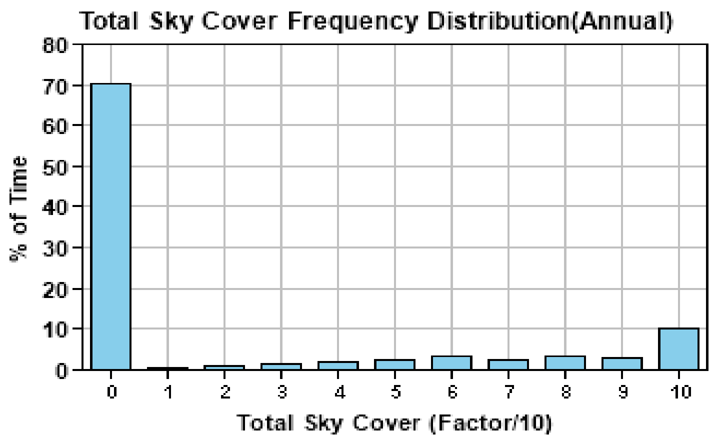

Figure 5.5. Autodesk generated Annual total sky cover frequency distribution.

The total sky cover frequency distribution graph shows the percentage of time that the sky is cloudy or clear. The data indicates that the sky is mostly clear, with the majority of the time (10%) having a total sky cover factor of 10. This indicates that there is ample natural light in the building.

5.10 Recommendations

Based on the assessment, it is recommended that the natural ventilation potential of the building be improved by increasing the window-to-floor ratio, if possible. This will not only improve the natural ventilation but also increase the amount of natural daylight entering the building, resulting in a more comfortable and healthier indoor environment for occupants.

5.11 Discussion

In conclusion, the indoor air quality at Jaypee University of Information and Technology, Solan, meets the NBC guidelines for temperature and relative humidity. The natural ventilation potential is moderate, but it can be improved by increasing the window-to-floor ratio. Overall, the recommendations aim to enhance the indoor environment and promote the health and well-being of building occupants.

CHAPTER 6
ENERGY ANALYSIS OF THE BUILDING

6.1 Introduction

One of the main aims of the green building is to optimize the energy use of the building. This can be achieved by lowering of energy consumption in lighting, air conditioning, and other building operations and through the maximum use of renewable energy and energy sources at the site which does not produce any harmful emissions.

Renewable sources of energy at the site includes the solar panels to generate energy from the sun and using natural day lighting in order to reduce the use of artificial light.

Since our building for the study is an existing building that we aim to convert to the green building, methods such as passive solar design can be difficult and economically not feasible option. Therefore, the main strategy for the energy optimization of our project will be to minimize the building energy use by the heating, cooling and lighting equipment which are the major source of energy consumption of the building. The other method is to produce renewable energy on site so that we can reduce the dependency on grid supplied electricity.

6.2 Energy Analysis of the building in Revit

The energy analysis of the building was done on the model that we created of the building in Revit. Room configuration was used to generate the energy model of the design in Revit and analysis was performed in Autodesk insight 360.

The outdoor environment data for this analysis was taken from the nearest weather station automatically located in the Revit software once we set the project location through internet mapping in the Revit software itself.

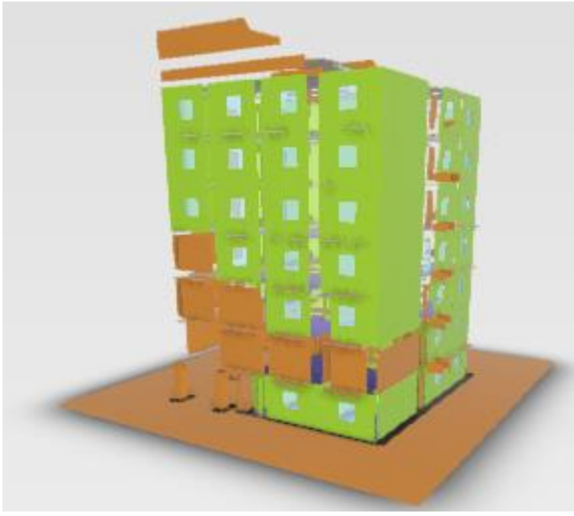

Figure 6.1.Energy model in insight 360

6.2.1 Benchmark Comparison and Model History

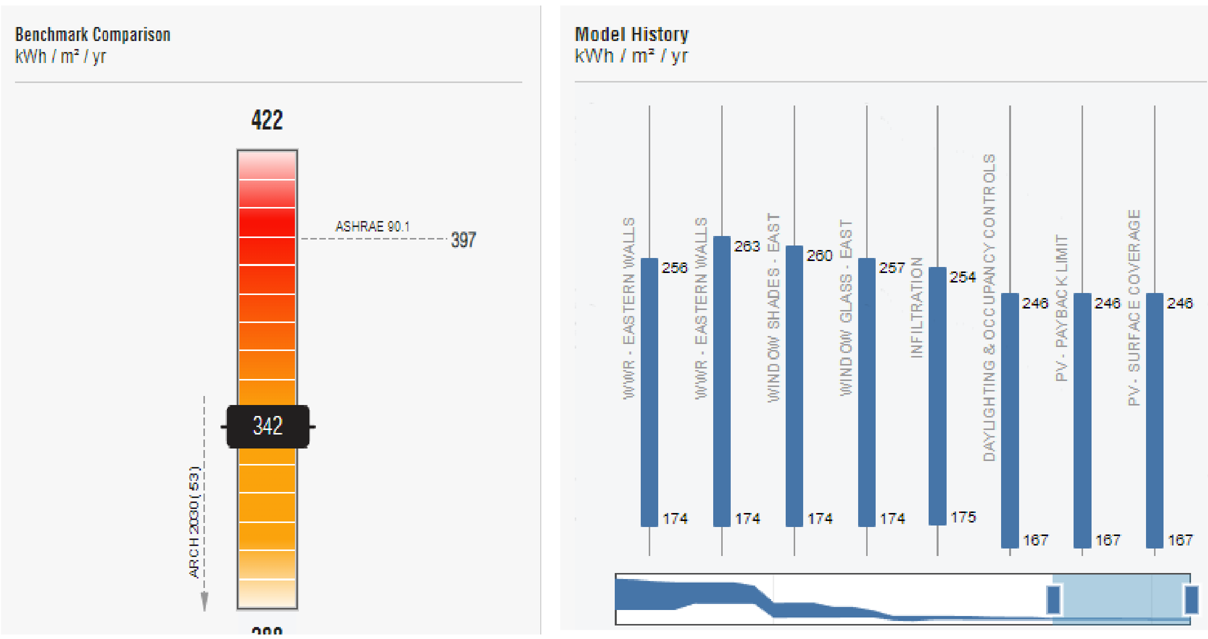

Table 6.1. Benchmark comparison and model history

In this analysis of the building the benchmark for building energy consumption to be compared with our model is the above benchmark used by Autodesk insight 360. Using this as the benchmark the energy consumption comparison is performed for different aspect and element of the building.

As shown in the above figure the energy consumption of our building compared to our benchmark value is quite below in terms of ASHRAE 90.1 but comparatively higher in terms of ARCH2030 (53).

Building model history chart above shows the timeline of the design iterations, with each iteration showing the building's energy performance metrics. We will in the later part analyse and try to optimize the energy usage of the building by comparing the different design iteration and identify most effective design changes that will optimize the building energy consumption.

Note that since our building is an existing building and not all design changes can be incorporated to our change however effective it may be. The design changes that can be incorporated should not be costly or should not degrade the structural integrity of the building.

6.2.2 Window wall ratio, Window shades and Window glass

Window wall ratio, shades and glass type are some of the very important design criteria to be considered for the energy efficient building. They determine the amount of sunlight that will enter the building into each room in the cold season or the ability to obstruct the heat of sunlight into the building in hot season.

Revit also provides the cost that can be saved as a result of changing these criteria.

1. Southern wall

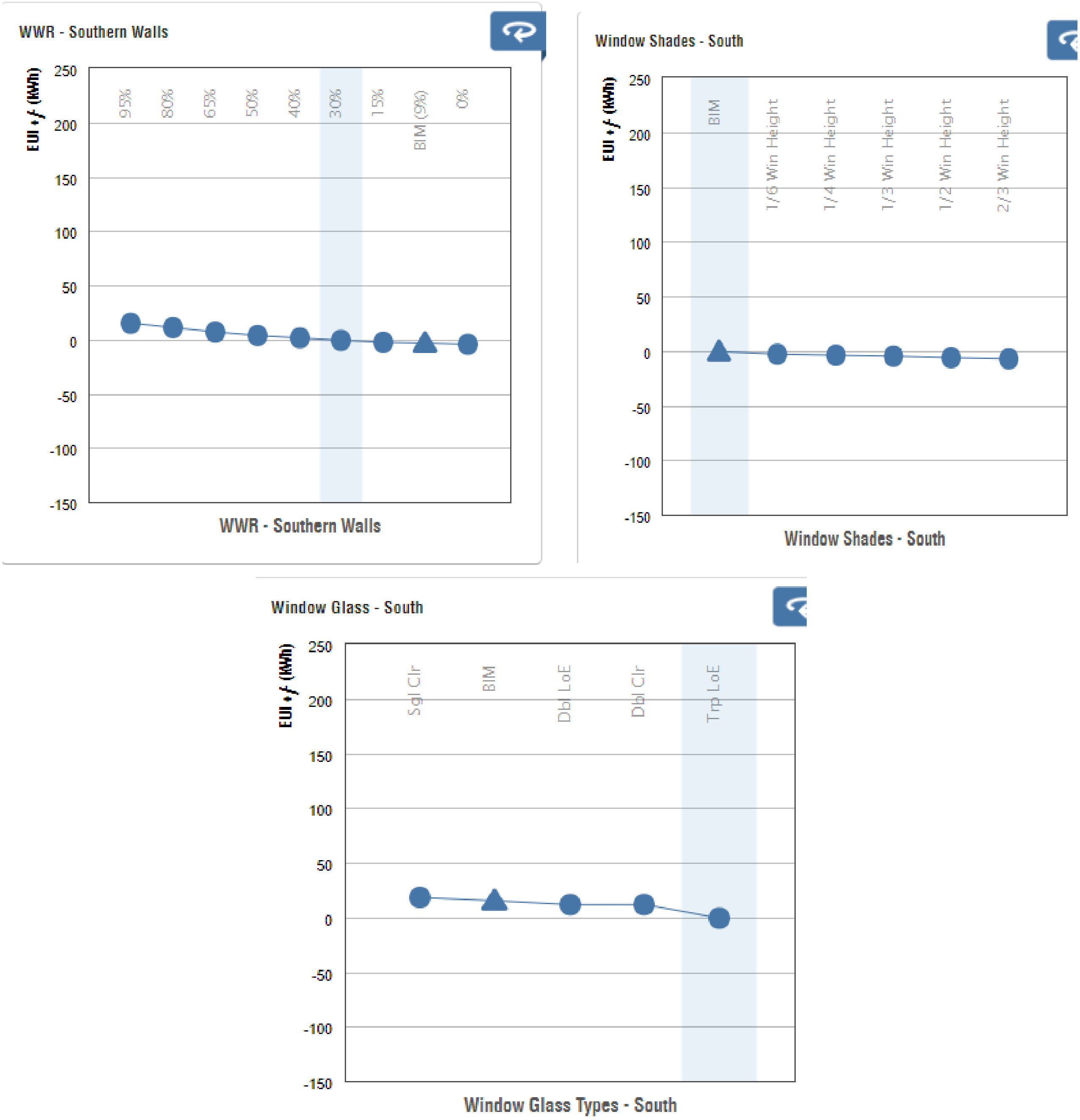

Figure 6.2. WWR, Shades and Glass Type for Southern windows

2. Western wall

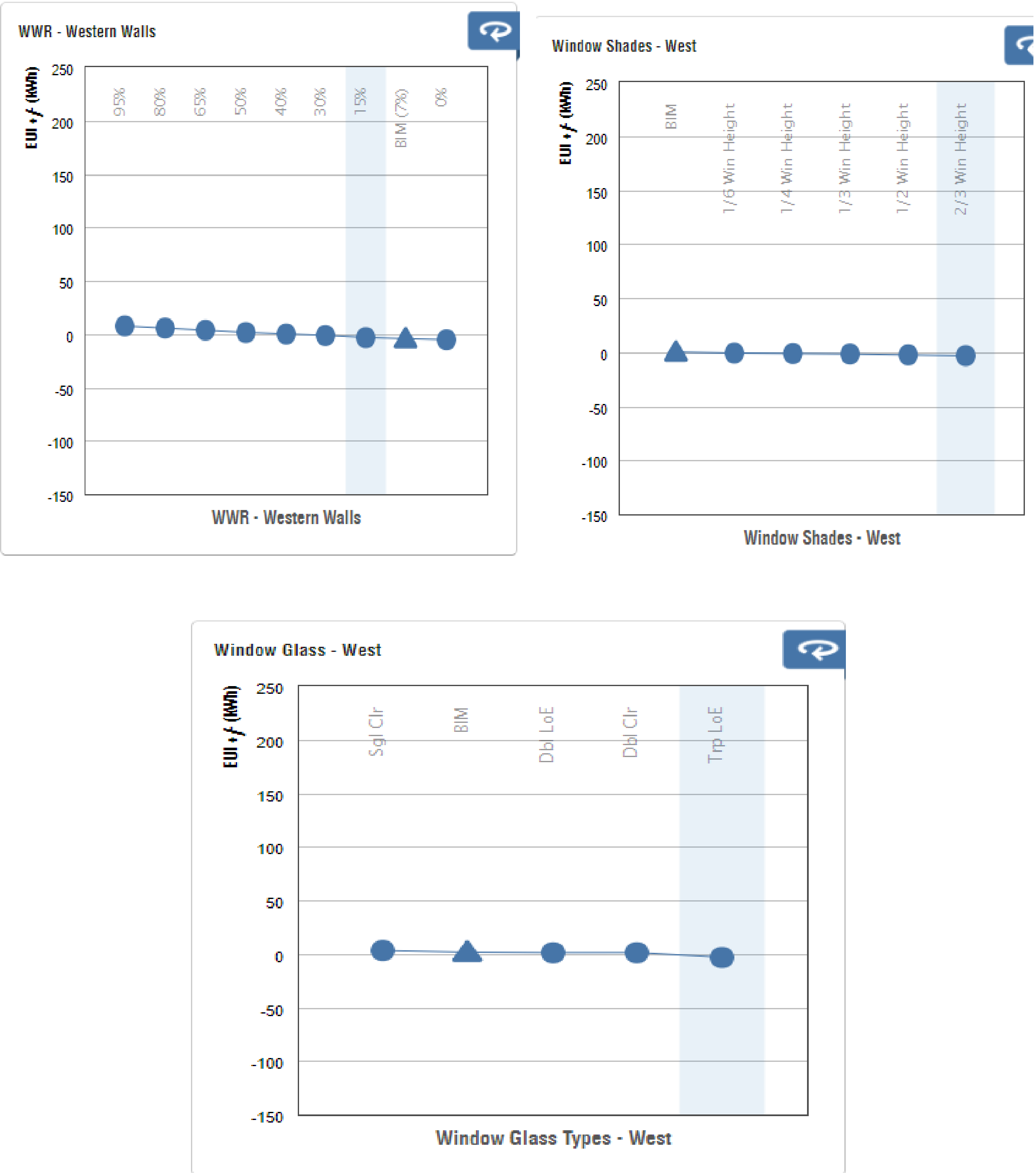

Figure 6.3. WWR, Shades and Glass type for Western Wall

3. Eastern Wall

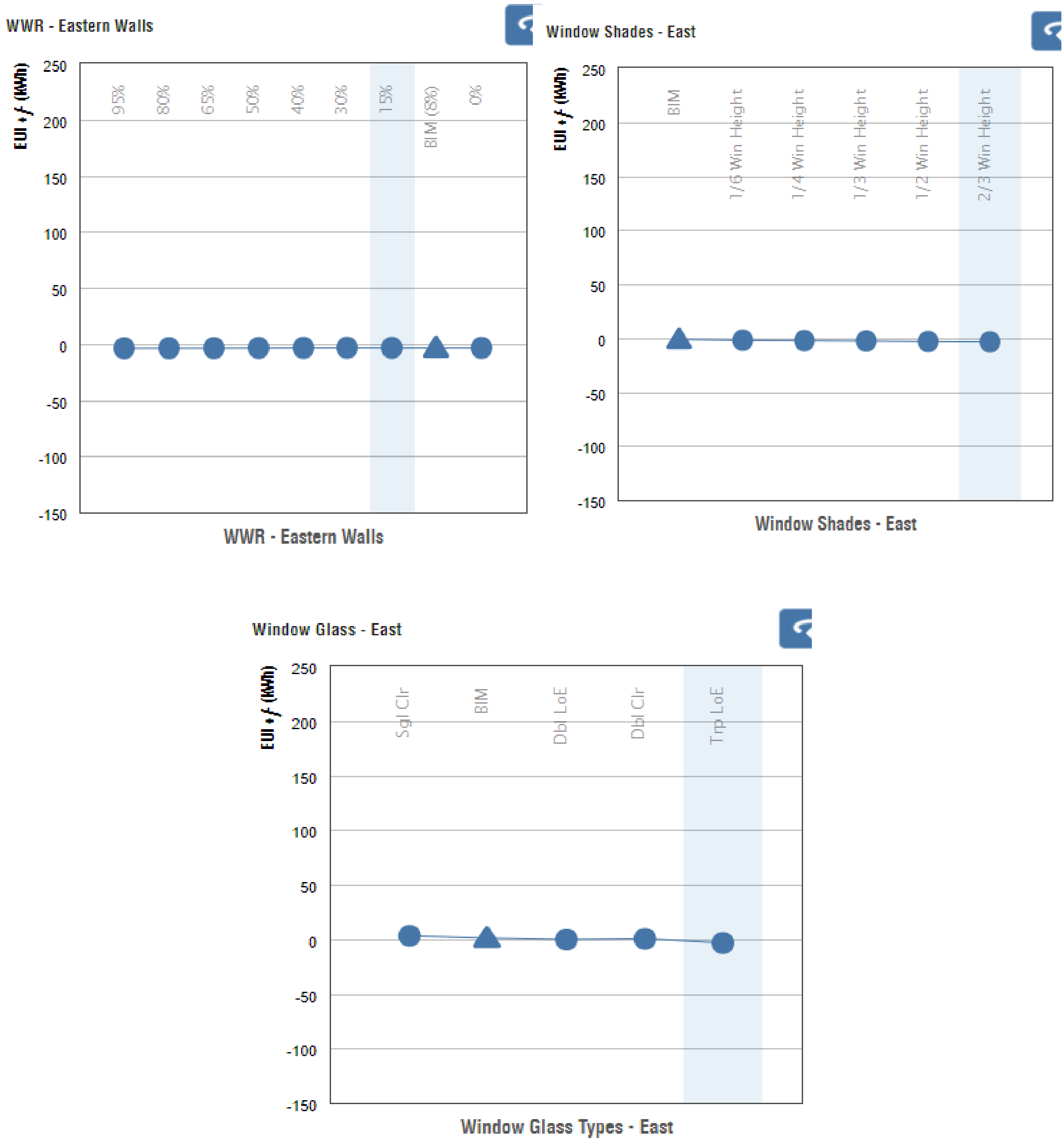

Figure 6.4. WWR, Shades and Glass type for Eastern Wall

6.2.2 Discussion:

The figure above shows the optimum condition of WWR, shading and glass type for the windows on southern, eastern and western walls. As it is apparent from the figures above that the most efficient window wall ratio is the smaller one. Therefore, we can conclude that bigger windows are not needed. This can perhaps be explained because the location of the building is on a cold region as per the weather station data and bigger windows can lead to less inside insulation. Smaller windows lead to less energy usage and hence less cost.

Window shades on the other hand should be increased to increase the efficiency as is evident in the above figures given by the Autodesk insight 360. Since solar insolation can be high in the summer the window shade will reduce the direct solar radiation entering into the room thus keeping the indoor environment cool. This consequently will reduce the cooling energy that is needed to run cooling equipment and cost associated with it. It will also reduce direct glare in the room due to reflected light causing visual discomfort in the residents in the building.

Although the window shade should be increased but it has minimal impact in terms of building energy consumption because the solar insolation is not of that high intensity due to the building location.

When it comes to window glasses the most efficient one interims of building energy efficiency is TRP LoE (Triple Pane Low Emissivity). This type of window glass is energy-efficient glazing offering superior thermal performance and energy saving. This type of glass has three panes separated by insulated gas and coating that are efficient in trapping the heat inside as well as reflecting the outside heat when not needed.

Although there are good choice from the energy efficiency point of view but has to invest comparatively high initial cost due to high market price of this type of window glass. But this cost can be recovered in the long run from the energy saved.

6.2.3 HVAC System

Heating, Ventilation and Air Conditioning plays a very crucial role in maintaining indoor environment quality. Although in green building it is imperative that maximum natural ventilation be used to maintain the indoor environment quality, some amount of heating and cooling system should be used to regulate temperature inside the building.

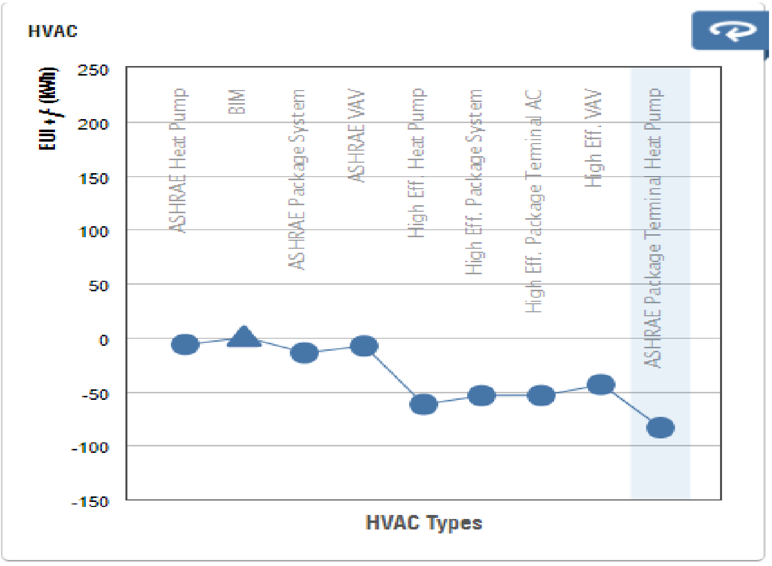

Figure 6.5. HVAC types

Discussion:

From the above given figure, we can see that different HVAC types require different amount of energy to run. The most efficient one in terms of energy efficiency is the ASHRAE Package Terminal Heat Pump.

6.2.4 Lighting Efficiency

Lighting in green building has to be made as much as possible with the use of natural light. GRIHA EB manual requires building rooms to achieve artificial lighting lux limit within the specification as required in NBC 2005 or ASHRAE 55 or requirement of Indian Adaptive Comfort Model. It also specifies that daylight factor of at least 25% of all living area should meet the adequate levels as prescribed in SP 41.

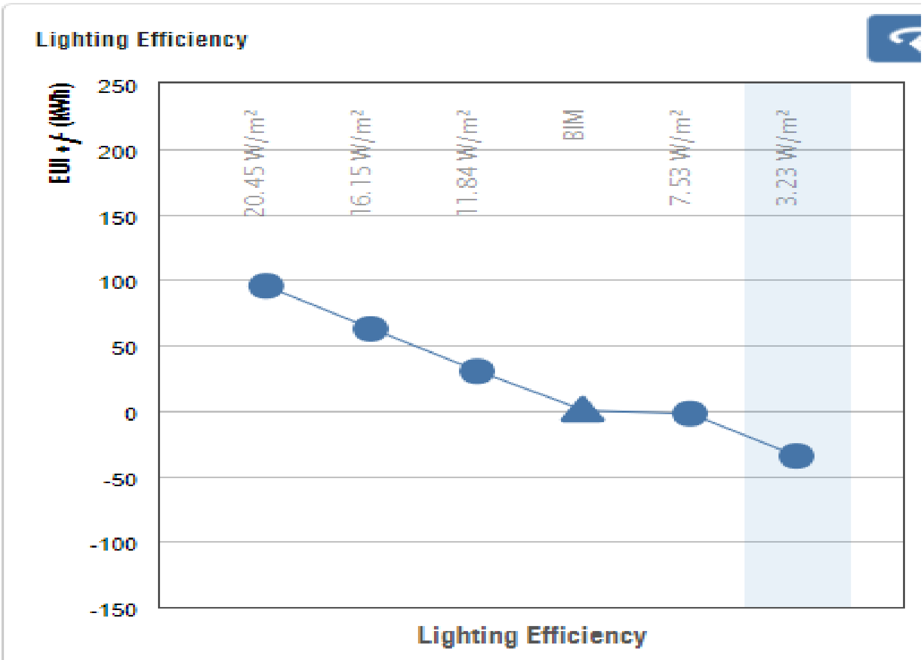

Figure 6.6. Lighting Efficiency

Discussion:

The above figure gives us the amount of lighting power density that is most efficient in terms of the energy usage and the requirement in each room. This analysis is made after the considering the illuminance level in each room and also the amount of daylight that can be used in the building without artificial lighting.

Therefore, the lighting power density of 3.23 W/m^2 is the most efficient when is comes to energy consumption.

6.2.5 Day lighting and Occupancy Controls

Day lighting refers to the use of natural light to supplement or replace artificial lighting in a building. Factors such as building orientation, window design, glazing and day lighting controls are considered by the Autodesk insight 360 to determine the day lighting efficiency.

Occupancy control refers to the use of sensors and other controls to manage building systems based on occupancy patterns. Factors such as occupancy pattern, sensor placement and HVAC controls are analysed by the Autodesk insight 360 to optimize the energy use of the building.

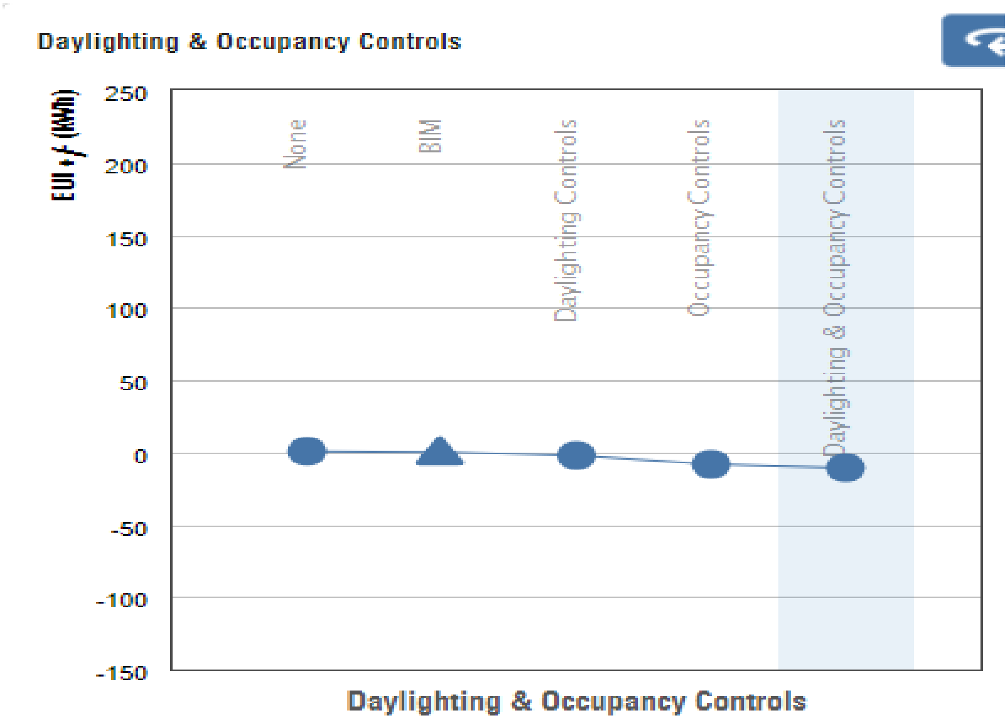

Figure 6.7. Day lighting and Occupancy Controls

Discussion:

From the above figure we can determine that the most efficient energy usage for the building can be achieved when we use maximum daylight. The occupancy control measures should also be followed as to optimize energy by using sensors to make lighting more efficient.

6.3 Solar Analysis on Revit

Solar analysis is an analysis process of a building used to evaluate the amount and distribution of solar radiation on a building. It shows us the concentration and amount of solar radiation falling on a surface of the building. This information can be useful for making informed decision about potential impact of solar radiation on the building and its occupants which in turn can be used to make decision about the building on optimized design.

The Solar Insight tool allows us to create and customize solar analysis studies for a specific location and time period. We can set the latitude and longitude of the building site, the orientation and tilt angle of the building surfaces, and the date and time range of the analysis.

After specifying the study parameters, the Solar Insight plugin generates a solar radiation map that shows the amount of solar radiation that each surface of the building receives throughout the day and year. The map is color-coded to indicate areas of high and low solar radiation, which can help us to identify areas of potential overheating or underutilization.

By implementing a solar system, designers can improve the building energy efficiency, comfort, and energy savings by analysing the sun and its impact. The model shows the overall solar distribution on the building. The yellow, green, and purple colour indicate the maximum, normal and minimum solar experiences respectively.

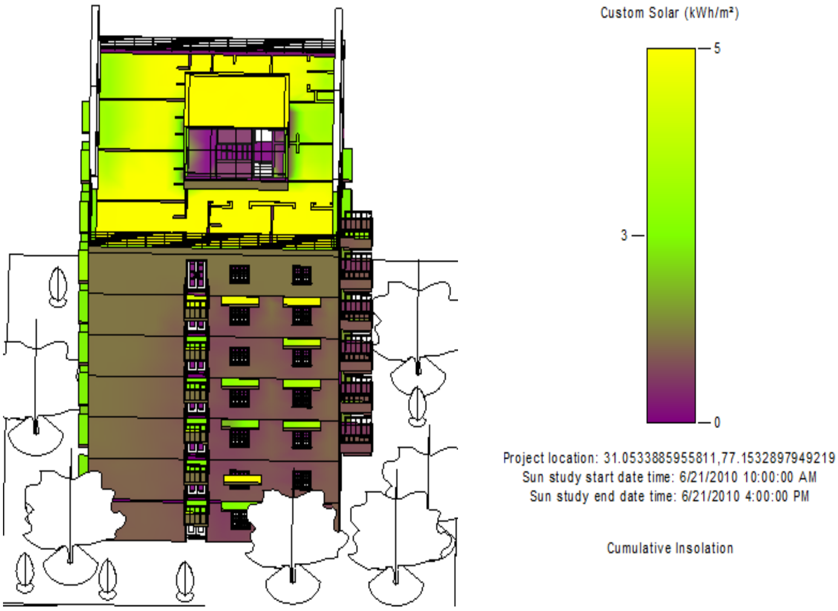

Figure 6.8. Solar Analysis model, summer solstice (21st June)

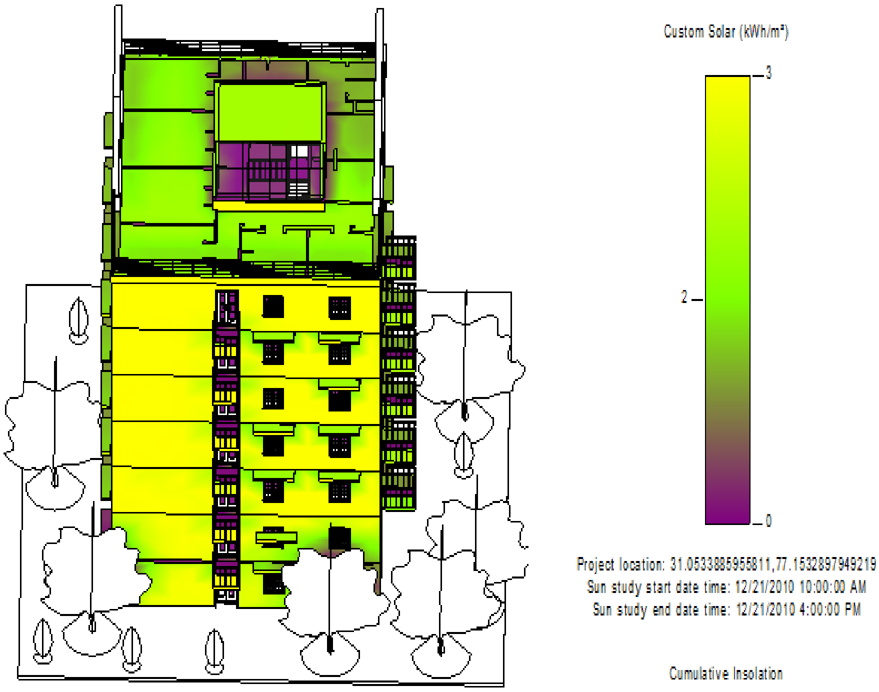

Figure 6.9. Solar Analysis model, Winter solstice (12th December)

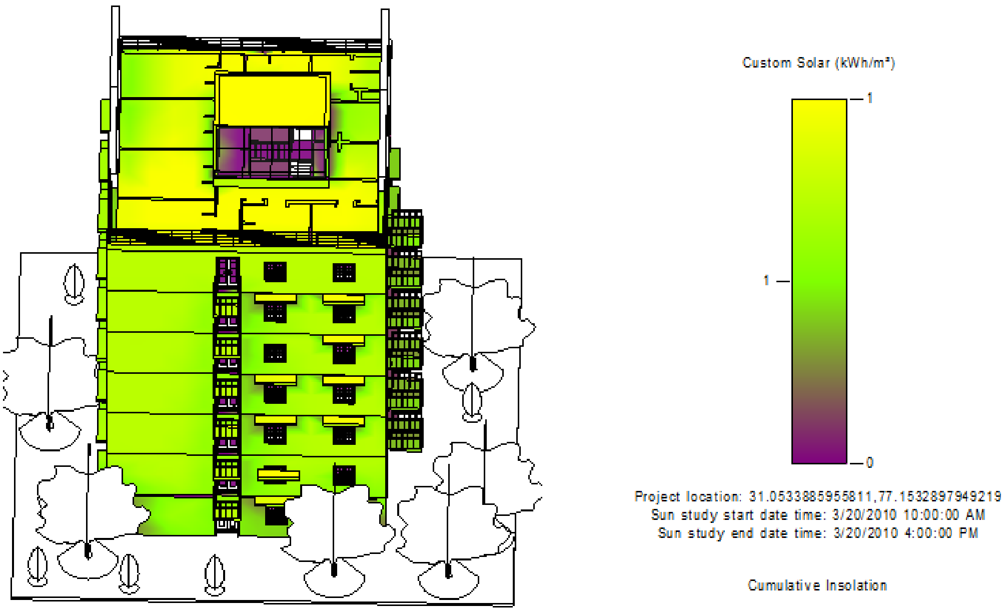

Figure 6.10. Solar Analysis model, Spring equinox (20th March)

Figure 6.11. Solar Analysis model, Autumn Equinox (22nd October)

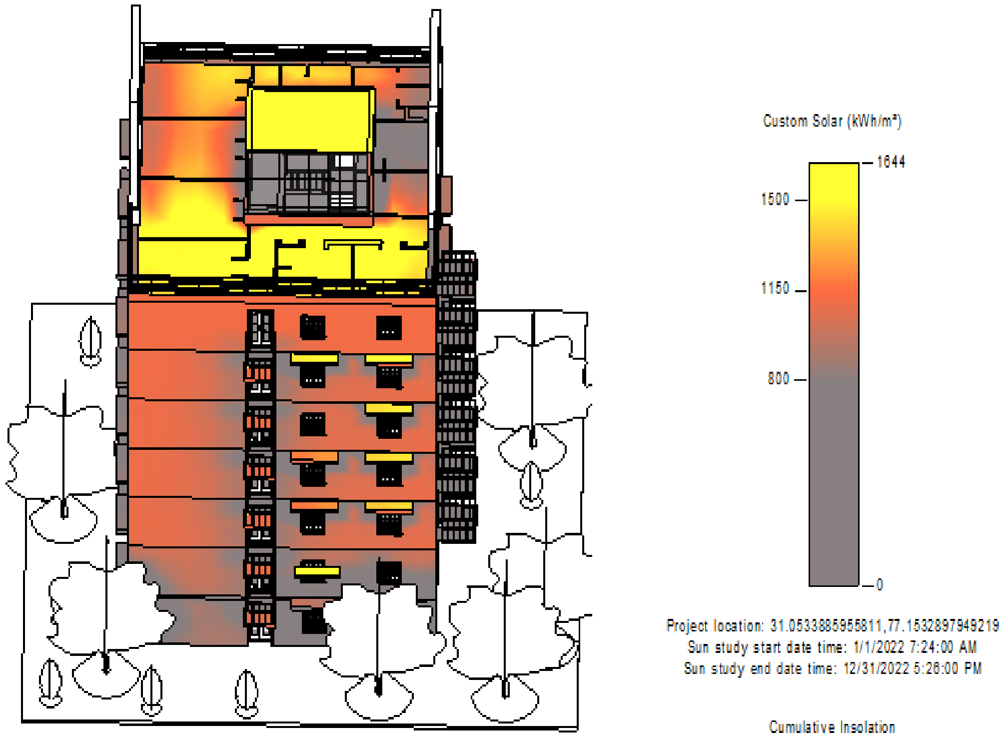

Figure 6.13. Solar Analysis model, Annual solar insolation

Figure 6.12. Solar Energy-Annual PV

Discussion:

We can clearly see in the above figures that the maximum insolation falls on the roof followed by the south facing wall. Therefore, these surfaces are also the ones receiving maximum amount of sun's energy. This information can be very useful if we want to install solar photovoltaic panels for the onsite generation of renewable energy.

6.3.1 Solar Energy Feasibility Analysis

Onsite generation of renewable energy is one of the main aims of the green building. GRIHA maintains a mandatory criterion for energy efficiency to have onsite generation of renewable energy. This can be very useful to reduce dependency on electricity generated from fossil fuel. Consequently, it can reduce negative consequences on environment.

Estimation using MNRE solar rooftop calculator

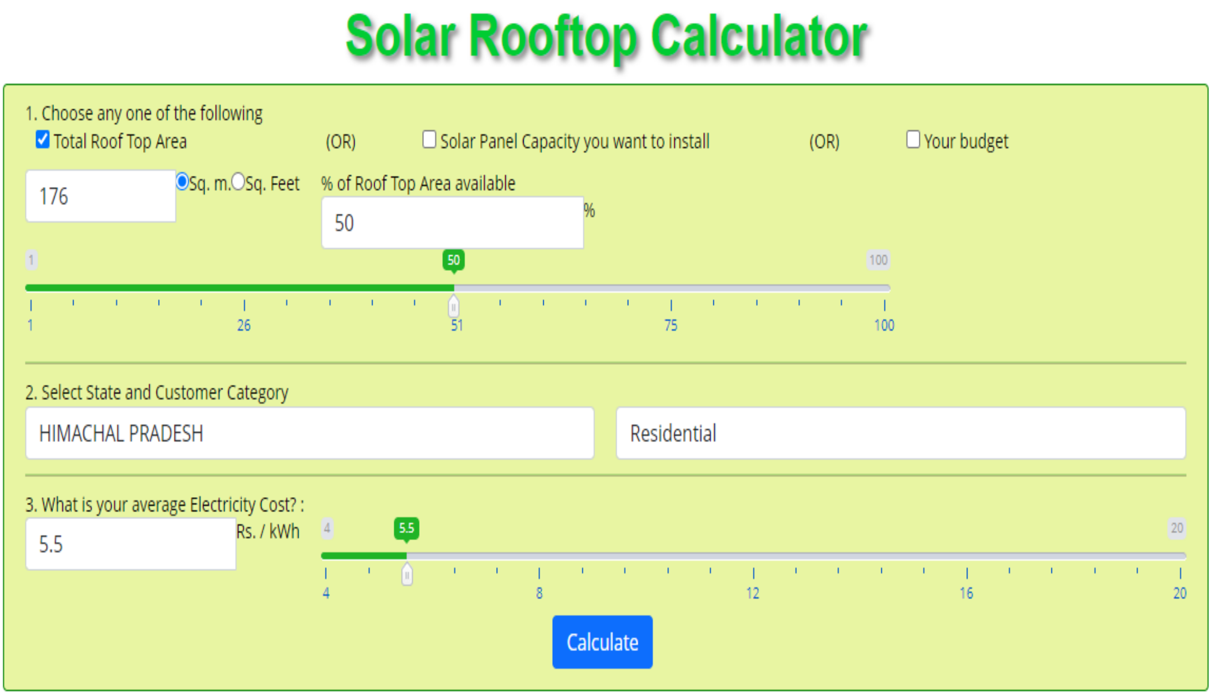

Figure 6.14. Solar rooftop calculator (Input)

Result:

Average solar irradiation in HIMACHAL PRADESH state is 1046.26 W / sq.m
1kWp solar rooftop plant will generate on an average over the year 4.1 kWh of electricity per day (considering 5.5 sunshine hours)

1. Size of Power Plant	
Feasible Plant size as per your Roof Top Area :	8.8kW
2. Cost of the Plant :	
MNRE current Benchmark Cost (without GST) :	Rs. 45087 Rs. / kW
View Benchmark Cost List	
Without subsidy (Based on current MNRE benchmark without GST) :	Rs. 396766
With subsidy 40% upto 3kW & 20% above 3kW upto 10kW (Based on current MNRE benchmark without GST) :	Rs. 290361
3. Total Electricity Generation from Solar Plant :	
Annual :	10824kWh
Life-Time (25 years):	270600kWh
4) Financial Savings :	
a) Tariff @ Rs.5.5/ kWh (for top slab of traffic) - No increase assumed over 25 years :	
Monthly :	Rs. 4961
Annually :	Rs. 59532
Life-Time (25 years) :	Rs. 1488300

Carbon dioxide emissions mitigated is	222 tonnes.
This installation will be equivalent to planting	355 Teak trees over the life time. (Data from IISc)

Figure 6.15. Solar calculator output

6.3.2 Power consumption analysis

The analysis of power consumption of lighting and HVAC appliances are computed below:

I. LED tube light

Total number of LED tube lights = 82

Power of each LED tube light = 20 Watt

Total power all LED tube lights = 1460 Watt

Total power consumption per hour = 1460 Watt = 1.46 Kilo Watt

If we assume 270 working days and 8 working hours each day, then

Total power consumption per year of LED tube light = 1.46 X 8 X 270

= 3153Kilo Watt

II. LED light bulb

Total number of LED light bulb = 84

Power of each LED light bulb = 5 Watt

Total power all LED light bulb = 84 X 5

= 420 Watt

Total power consumption per hour = 420 Watt = 0.42 Kilo Watt

If we assume 270 working days and 12 working hours each day, then

Total power consumption per year of LED tube light = 0.42 X 12 X 270

= 1360.8 Kilo Wat

III. Room fan

Total number of Room fan = 49

Power of each Room fan = 78 Watt

Total power all Room fan = 49 X 78

= 3822 Watt

Total power consumption per hour = 3822 Watt = 3.822 Kilo Watt

If we assume 183 working days and 12 working hours each day, then

Total power consumption per year of all room fan = 183 X 12 X 3.822

= 8393 Kilo Watt

IV. Exhaust fan

Total number of Exhaust fan = 13

Power of each Exhaust fan = 55 Watt

Total power all Exhaust fan = 13 X 55

= 715 Watt

Total power consumption per hour =715Watt = 0.715 Kilo Watt

If we assume 270 working days and 15 working hours each day, then

Total power consumption per year of all Exhaust fan = 270 X 15 X 0.715

= 2895 Kilo Watt

Total power consumption of all lightings and HVAC appliances used in the selected site is 15,802 Kilo Watt.

According to HPSEBL the electricity tariff for FY23 for commercial supply (after subsidy) = Rs. 5.10 per kWh

Therefore, total cost of power consumption for a year = Rs. 80589.18

6.3.3 Energy consumption of lighting and HVAC systems

Note: 1 Kilo watt hour = 3600 Kilo joules (KJ)

Table 6.2. Energy consumption per hour

Type	Number used	Power (Watt)	Daily usage (h)	Power consumption (Kilo watt hour)	Energy consumed (kJ)
LED light bulb	84	5	12	0.42	1512
LED tube light	82	20	15	1.64	5904
Room fan	49	78	12	3.822	13759.2
Exhaust fan	13	55	15	0.715	2574

The energy in kilo joules is calculated by

E(kJ) = P(W) x t(s) / 1000

Which is

Kilo joules = watts x seconds / 1000

Total energy used per hour on the selected site for lighting and HVAC system = 23749.2 kJ.

Discussion

The lighting system in the building are all LED lights which consumes less energy compared to the other lighting appliances. These falls as within the recommendation of the guideline provided in GRIHA for existing building.

The HVAC system used in the building tends to consume more energy and their performance are not up to the efficiency standard expected and needed. The heating system used in the room does not heat the room as expected. Therefore, there is need to find more efficient equipment.

6.3.4 On-Site solar calculations.

Design Considerations: The following factors were taken into account while designing the solar panel system:

- Available rooftop area: 176m2
- Average energy consumption for lighting and ventilation: 62.56 KWh
- Annual solar radiation: 1046.26 KWh/m2/year
- Peak sun hour: 5.5 hours (as per Govt. of India)
- Panel efficiency: 16%
- Cost of electricity: Rs. 5.5/KWh

Solar Panel System Design: The following calculations were made to determine the optimal solar panel system design:

1. Total Energy Consumption: Total energy consumption for lighting and ventilation per year = 62.56 KWh x 365 days = 22,815.4 KWh
2. Total Energy Generation: Total energy generated by solar panel system per year = 176m2 x 1046.26 KWh/m2/year x 16% efficiency = 2,956.89 KWh
3. Required Solar Panel Capacity: Required solar panel capacity = Total Energy Consumption / Total Energy Generation = 22,815.4 KWh / 2,956.89 KWh = 7.71 KW

4. Number of Solar Panels: Number of solar panels required = Required Solar Panel Capacity / Individual Solar Panel Capacity

Assuming a standard solar panel capacity of 330W, the number of solar panels required = 7.71 KW / 0.33 KW = 23.36 panels (rounding up to 24 panels).

5. Space Requirement: Space required for 24 solar panels = 24 panels x 1.96m2 per panel = 47.04m2 Available rooftop area = 176m2 Space available for solar panels = 176m2 - 47.04m2 = 128.96m2

6. Installation and Cost: Assuming an installation cost of Rs. 80,000 per KW and a panel cost of Rs. 30 per watt, the total cost of the system can be calculated as follows:

- Solar Panel System Cost = 7.71 KW x Rs. 30/watt = Rs. 2,31,300
- Installation Cost = 7.71 KW x Rs. 80,000/KW = Rs. 6,12,800
- Total System Cost = Solar Panel System Cost + Installation Cost = Rs. 8,44,100

Discussion:

It is recommended that the system consists of 24 solar panels with a total capacity of 7.71 KW. The system will provide a total of 2,956.89 KWh of energy per year, which will meet the average energy consumption of the building for lighting and ventilation. The cost of the system is estimated to be Rs. 8,44,100, assuming standard installation and panel costs. This system will help reduce the energy costs and carbon footprint of the building while providing a sustainable energy source.

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CHAPTER 7
CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The location of this building is in a very feasible place for the residents to reach all the necessary basic facilities for its residents like banks, shops, playground, and dispensary in a walking distance. Therefore, a lot of fuel cost and pollution which otherwise could have been generated due to travelling by vehicle can be eradicated.

Upon assessing the building according to the GRIHA manual for the existing building we found that a number of green features as mentioned in earlier chapters needs to be adopted for this building to be considered a green building. These are the necessary features for the building to become more efficient in terms of energy consumption and also for the residents' health and comfort.

Indoor air quality of the building is according to the guideline. A simple water conservation measure to be followed is to use low flow equipment.

In the subsequent chapters upon testing our Revit designed model of the building in various software like insight 360 and green building studio we found that the energy efficiency can be achieved by using window shading, changing window glasses and using more efficient HVAC system. But the most important one is the generation of onsite renewable energy. By installing PV panels on the rooftop of our building we could generate 2956.89 kWh per year which will save a cost of energy by Rs.16262 every year.

7.2 Recommendation

This project has been done mostly in the software. Almost all the analysis are done in the software for the green features. Therefore, this study cold be furthered by doing real time onsite analysis of the building according to green building guidelines.

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