GRIHA RATING OF DELHI TECHNOLOGICAL UNIVERISTY FOR GREEN BUILDING

A dissertation submitted in the partial fulfilment of the requirement for the award of degree of

MASTER OF TECHNOLOGY

(Environmental Engineering)

by

SURYA CHAUHAN

(2K15/ENE/14)

under supervision of

DR. BHARAT JHAMNANI

(Assistant Professor)

DEPARTMENT ENVIRONMENTAL ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

2015-17

Acknowledgement

Any achievement requires the sincere efforts of so many people and this work is no exception. I appreciate the contribution and support which various individuals have provided for successful completion of the study. It may not be possible to mention all by name but the following were singled out for their exceptional help.

I am eternally grateful to my project supervisor ***Dr. Bharat Jhamnani*** *, Assistant Professor, Department of Civil Engineering, Delhi Technological University, for giving me an opportunity to do this project work and providing me all support, guidance and valuable information regarding this project which made me complete the project on time.*

I am highly obliged and pay my gratitude to ***Dr. Anil Kumar Haritash,*** *Assistant Professor, Department of Environmental Engineering, Delhi Technological University, for providing me the required instruments and respective lab manual without which this work would not have been possible.*

I would like to thank ***Sh. Bimal Jain****, Chief Project Officer , Delhi Technological University, for providing me all the necessary information of DTU without which this work would not have been possible.*

I am grateful to Mr. Sunil and Mrs. Navita and all the Environmental Engineering Lab staff for their generous help and guidance during the lab work.

I would like to present my great gratitude towards my family who has supported me emotionally, mentally, physically as well as economically all throughout.

To conclude the same I would also like to convey my regards to my friends who have helped me complete this project.

SURYA CHAUHAN

Certificate

This is to certify that SURYA CHAUHAN, M.Tech student in the Department of Environmental Engineering has submitted a project report on "GRIHA RATING OF DELHI TECHNOLOGICAL UNIVERISTY FOR GREEN BUILDING" in partial fulfilment of the requirement for award of degree of Master of technology in Environmental Engineering during the academic year 2015-2017.

It is a record of the student's research work prepared under my supervision and guidance.

DR. BHARAT JHAMNANI
Assistant Professor
Department of Civil Engineering
Delhi Technological University

Declaration of Originality

I hereby undertake that Surya Chauhan, the sole author of this report. I undertake that this report neither infringes upon anyone's copyright nor violates any proprietary rights to the best of my knowledge. Any ideas, techniques, quotations, or any other material form of work of other people included in this report, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

I declare that this is the true copy of my report, including all revisions, as approved by my supervisor, and that this report has not been submitted for any other degree to any other University or Institution.

SURYA CHAUHAN

(2K15/ENE/14)

Abstract

In India, the emergence of our very own rating system of green building in the form of GRIHA (Green Rating Integrated Habitat Assessment) with green building design concept has transform the built environment in recent times. GRIHA's concept to make buildings green is developing very fast and many institutions are embracing its work and the massive impact and contribution it have on management of the construction and deliveries of the project in private/public sector.

The aim of this project work is to calculate the GRIHA rating of Delhi Technological University, Delhi for the green building on the basis of the criteria given in the GRIHA manual. There are total 9 sections (Site Planning, Energy, Occupant Comfort and Well Being, Water, Sustainable Building Materials, Construction Management, Solid Waste Management, Socio Economic Strategies, Performance Monitoring and Validation) which comprises of 30 criterions which has to be fulfilled by the project. Each points has some fixed points attached to it and if the project full fill the required criterion then those points are awarded to the project. In the end, the awarded points to Delhi Technological University are added and the rating (one star, two star, three star, four star, five star) is assigned to it. The rating will show that in what amount the green building technology is being used in the campus of Delhi Technological University, Delhi.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

DTU	Delhi Technological University
GRIHA	Green Rating for Integrated Habitat Assessment
TERI	The Energy and Resource Institute
CPCB	Central Pollution Control Board
IGBC	Indian Green Building Council
BIS	Bureau of Indian Standards
NBC	National Building code of India
NAAQS	National Ambient Air Quality Standards
LEED	Leadership in Energy and Environmental Design
CFC	Chlorofluorocarbons
UHIE	Urban Heat Island Effect
EPI	Energy Performance Benchmark
VOC	Volatile Organic Compound
ODP	Ozone Depletion Potential
OPC	Ordinary Portland Cement
RCC	Reinforced Cement Concrete
W.C.	Water Closet
L.C.	Lavatory Close
dB	Decibel
kWh	Kilo watt hour
NO_2	Nitrogen Dioxide
NH_3	Ammonia
PM	Particulate matter
SO	Sulphur Dioxide

CO	Carbon Monoxide
mg/l	milligrams per litre
ug/m³	micrograms per cubic meter
NTU	Nephelometric Turbidity Unit

List of Annexures

CHAPTER-1

INTRODUCTION

1.1 GREEN BUILDINGS : LOCAL AND GLOBAL PERSPECTIVE

A serious challenge possessing the environment these days is the construction sector. Globally, the building construction are responsible for about 40 % of the energy consumption. The consumption of water and other natural resources are about 42% and 50 % respectively by the buildings when taking the account of entire life cycle of the buildings. In addition to this, the activities of the building contribute about 50% of the air pollution that is created by the world , 50% of the water pollution , 50% of the total CFC's formed and 48% of the solid wastes to the environment.

India also faces too many challenges regarding construction sector. The gross built-up area adding to the spaces taken by residential sector and commercial sector is increasing at a rapid rate which has led to the increase in consumption of annual energy in both residential sector and commercial sector. Energy consumption will keep on increasing if no necessary actions are adopted immediately to improve the energy efficiency. As per the estimates of TERI , the annual use of electricity has increased to 5.4 billion units (kWh) annually in the demand to satisfy the energy demand of the both the commercial and residential buildings. During the entire life cycle of the building which includes both constructional and operational phase, buildings are the major consumers of water that require water to satisfy the demands of buildings occupants, cooling and landscaping. Water consumption per capita has been raised to a high level every decade. As per the Indian Government, the basic facilities such as drinking water are now accessible to approximately 93% of the urban population whereas the equal distribution of these facilities and provision of per capita of providing these basic facilities in some areas are not done as per prescribed norms such as poor people who live in slums are generally not getting these basic facilities.

Another major challenge that needs an urgent attention is the management of the solid wastes that are generated by the users of the building . As per CPCB estimates, the amount of solid waste generated in India is about 48 million tonnes per annum which is 25% of the wastes that are generated from the construction industry and management of these high quantity of wastes puts a high burden on solid wastes management system. The quantity of the solid waste generated daily in the urban areas is approximately 42 million metric tonnes which requires proper segregation of wastes, its management and treatment facilities. These days only a small amount of biodegradable solid wastes are segregated at source and the large mixed quantity of these wastes are dumped into low lying areas and in the depressions. The municipal solid wastes generally comprises of about 30%-55 % of biodegradable(organic) waste that can be recycled into useful resources such as biogas, manure and so on.

At macro levels, an uncontrolled 'heat island' effect is created due to the extensive urbanisation. The construction of buildings, pavements and other major structures in the urban areas

eliminate the cooling provide by the natural vegetation. This forms ground level ozone that has many negative effects on the environment and as on human being..

UHI (Urban Heat Island) impact also have an impact on temperature as it increases the temperature by 10 degrees Celsius which results in the increased use of air conditioners, coolers, fans . This increases the generation of electricity which leads to the formation of greenhouse gases.

So while we are on our development path , it will be beneficial for us to minimize the damage that we all create caused to the environment. Hence it is extremely important to carry out several necessary steps for the benefit of our Mother Earth and to save the useful resources for our future generations. Green buildings offers various benefits to minimize our consumption and to recycle and reuse the sources from the generated waste and to uses more and more renewable sources which will offer a great solution for us and for the environment.

1.2 DEFINITION OF GREEN BUILDING

The large environmental effects that the building have during its entire period of life is known as green building. The construction of the building reduces the resources that are naturally available to us such as vegetation, water, energy and ground cover. Green building help in reducing the exhaustion of these resources to a minimum quantity at the period of construction of the building and its entire operational period. The main aim to design a green building is to reduce the use of non renewable energy by maximizing the utilisation of renewable energy. Green building basically works on the principle of recycle and reuse of the renewable sources as it increases the use of sources that are available on site which results in better construction practices and increases the utilisation of the efficient building material. It reduces the consumption of energy by replacing it with the more efficient source like solar energy. This is used to satisfy its requirement of lighting, air conditioning and various other needs. It uses the generated waste in a very efficient way and thus enhance the waste management practices and thus provide great hygienic, working and living conditions to the users of the buildings. Certain criteria to design a building that are looked into as an integrated way in a designing agreen building are:

- Site planning.
- Design to reduce the Urban Heat Island Effect (UHIE)
- Control of Air pollution
- Waste water management.
- Solid waste management
- Construction management practices
- Renewable energy utilisation

1.3 BENEFITS OF GREEN BUILDING.

The consumption of resources by the green building is very less as compared to the consumption of resources by traditional buildings. Large amount of percentage reduction is there in the use of resources .

- 40-60 % lesser electricity is used by the green building as compared to the electricity consumed by the traditional buildings. This is mainly because it uses high efficiency materials and various advanced technique in designing the building.
- Green buildings also use to work towards the on-site energy generation to full fill its need. For example, solar energy which is a renewable source of energy is used in the form of solar voltaics to minimize the consumption of energy generated by grid power. Solar water heaters are used to heat the water that replaces the traditional water geyser.
- It uses 40%-60% less water as compared to traditional buildings. By using low flow fixtures which reduces the flow of water and results in less wastage of water. Rain water harvesting is an effective technique to collect the water that falls in the form of rain and reuse it. Green buildings not only reduces the demands of water of building occupants, landscape and other demands but it also uses the on-site source of water available .
- By adopting various waste management techniques , the waste that are generated in of green building is less as compared to the waste generated in the traditional buildings. In green buildings, various strategies are adopted to reuse the waste generated on-site and to convert it into a more valuable resource such as biogas, compost and this reduces the pressure on solid waste management facilities and it minimizes the waste to be disposed of in landfill sites.
- In green building the amount of pollution formed is less in both its construction and operational phase and thus thereby ensure safety of the workers working at the construction site or of the building occupants in the operational phase. Various practices are adopted in order to ensure that the impacts are reduced on the surrounding environment such as providing adequate storage facilities for storing construction materials , adequate barricading of the area is done to prevent the air and noise pollution, proper hygienic storage places are provided to store solid wastes, proper segregation of waste and disposal of these wastes are done during both construction and operational period of the project.
- In case of green building, proper safety of health are ensured and adequate sanitation facilities are provided for the labourers during construction phase and for the building occupants during operational period of the building.
- Use of high ozone depleting potential substances are restricted in the green buildings.
- The image and market value offered by the green buildings is very high.

All these advantages of the green building are provided at a minimal incremental cost and its payback period of approximately 5-10 years can be enjoyed.

CHAPTER-2

LITERATURE REVIEW

In the recent decades , the idea of green building has increased rapidly in the world. The theory of green rating of buildings has taken roots in India. It has become a trend in which many rating systems that are developed by different countries have set benchmarks for green measures of constructing and operating the buildings to make it environment friendly.

2.1 GREEN BUILDING RATING SYSTEM

It is an assessment tool that assess the environmental performance of the building during its entire life. It involves various criteria that comprising of various factors related to design of the green building, its construction and operation. Each criterion has some fixed points and a set of benchmarks which has to be full filled to score points. The points scored in the various criterion are added up and the final rating of the building is evaluated. Hence , green building rating systems are helping in creating awareness and promoting the green building designs.

2.2 INTERNATIONAL GREEN BUILDING RATING PROGRAMMES

Some of the successful international green building rating programmes are :

2.2.1 BREEAM

Building Research Establishment's Environmental Assessment Method was developed in the year of 1990 in United Kingdom . It is one of the oldest building environmental evaluation methods. It involves a large range of building types which includes homes, offices ,retail units, school and industrial units. When the building is evaluated , point are secured for each criterion and hence the points are finally added to give the total score of the building. The performance of the building is awarded as 'Pass', 'Good', and 'Very Good' or 'Excellent' rating on the basis of score secured by the building. It has separate criteria for assessment of Design, Management and Operations of buildings. An additional set of core credits can be applied if the building wants to go in the 'Core only' evaluation for building performance.

The major sections which has various criteria that BREEAM includes in its process of Evaluation of a building performance are:

- Management, which include water and waste management, minimization of pollution level, energy consumption in different activities of the site.
- Health and comfort of the building occupants which includes ample amount of ventilation, energy efficient lightning, low noise and air pollution levels.
- Materials used in the construction of the building which includes sustainable timber, structure reuse, utilisation of crushed aggregate)

- Energy consumption which is measured by meters.
- Transport, which includes various types of vehicles used form and to the site and several alternative transport facilities)
- Land use
- Ecology (Low ecological value of the land or the change in the ecological value is minimal, minimization of various biodiversity impacts)

2.2.2 CASBEE

CASBEE refer to as Comprehensive Assessment System for Building Efficiency (CASBEE) . This rating system was developed in Japan in the year 2001. The assessment tools of this rating system is based on the entire life cycle of the building: pre-design, new construction, existing buildings and renovation. It presents a new concept of evaluation that differentiate between environmental load from environmental quality and building performance. Two spaces are there under CASBEE , one is internal and another one is external. In CASBEE, these two factors are defined under Q (Quality) and L (Loading). These are two main evaluation categories and are evaluated separately.

Q (Quality) : Environmental quality and performance of the building. It evaluate the improved living conditions for the building occupants .

L (Loading) : Environmental loadings of the building.

On a graph, the results of the this rating system are plotted with environmental load on one axis and quality on the other axis. The best buildings will fall under the category which shows highest quality and lowest environmental load. From level 1 to level 5,each criterion is assigned with some points in which level 1 is to satisfy the minimum requirements , level 3 is to satisfy the social and technical levels at the period of evaluation and level 5 will represent the highest level of achievement.

The major sections of criteria that are include in CASBEE are :

Quality and performance of the building.

- Indoor environment , which includes maintaining good air quality, low level of noise.
- The services provided at great quality (Reliability and durability, adaptability and flexibility)
- Site's outdoor environment (preservation of landscape, biotope, outdoor amenities)

Environmental loadings of the building

- Energy (energy consumption by the buildings, use of natural energy, efficiency of the service system that are installed in the building)
- Materials and resources (use of low environmental impact materials, conservation of water by applying various strategies to recycle and reuse water on site)

- Environment outside the project site (air and noise pollution of nearby areas of the project site, sunlight obstruction by the neighbouring buildings, minimize urban heat island effect on the site)

2.2.3 HK BEAM

HK BEAM is defined as Hong Kong Building Environmental Assessment Method. It was first developed in December 1996 in Hong Kong. It is a system which is based on its performance and it takes a view of the performance of the building with its life cycle impacts. In this type of rating system the evaluation is not completed until and unless the construction of the building is completed and ensures that 'Green and Sustainable' practices are adopted during its entire project cycle and the performance of the project meets its desired goals. The New Building Certification System' of this rating system is very well synchronized with its very own 'Existing Building ' certification . For example ,if a new building that is certified under this rating system of HK-BEAM 4/04 is very well operated and maintained then it will get a similar grade under the rating system of HK-BEAM 5/04 after some years.

HK-BEAM evaluates many key features of the performance of the building.

- Health and hygiene of the building occupants.
- Utilization of the land, impacts of the site, mode of transport used from and to the site.
- The environment's indoor quality is evaluated by its indoor air quality, proper ventilation, relative humidity, daylight, temperature and noise level.

2.2.4 LEED

LEED is defined as Leadership in Energy and Environmental Design (LEED) . This rating system was made in the United States of America in the year 1998. It involves various specific impacts that are related to environmental building and it uses an approach that covers the entire building performance. LEED system has been adapted by the Indian Green Building Council and they have launched the Indian version of LEED to rate the new construction of buildings. There are several products that has been launched by the IGBC for rating different categories of buildings such as school, house, factories, hospitals. Various key components of the LEED system are as follows:

- Sustainable sites. It includes various pollution prevention strategies related to construction of building, alternative mode of transportation management of the storm water, minimization of Urban Heat Island Effect, impacts of the site development)
- Water efficiency . It includes reduction in the utilisation of water demand of landscape, reduction in the water demand for indoor use, several management measures to manage wastewater)

- Atmosphere and energy (Reduction in the use of energy performance of the whole building, management techniques to manage refrigerant, utilisation of renewable source of energy)
- Materials and resources (Specified locations for recycling of resources, recycle and reuse the construction and demolition waste, purchase materials that can be recycled easily, use of renewable materials)
- Indoor quality of the environment (preventive measures to control the smoke of tobacco, regular monitoring of the air quality, increased area for ventilation, use of low emitting materials, measures to control lightning systems)
- Innovation and design (adopt innovative strategies to design sustainably.

2.3 INTRODUCTION TO GRIHA

Majority of the international green building rating system have been designed to suit the building industry of their country. TERI , being committed to sustainable development of buildings in India took the responsibility to promote green buildings by developing a rating system known as GRIHA . GRIHA is used to rate a building based on its greenness.

Approximately 300 projects in India are being built based on GRIHA guidelines. This rating system will provide huge benefit to the community in improving the environment by reducing the green house gas emissions and by reducing the burden on natural resources.

The rating is applied to provide new building stocks to various sectors such as residential, institutional and commercial. GRIHA is basically a five star rating system which ensures that the solar techniques are used to improve energy efficiency, optimization of the building design is done to reduce the traditional energy demand of the building.

2.3.1 GRIHA-2015 Evaluation Process

There are 9 sections under which there are 30 criterions on the basis of which building is evaluated and rated. The table list the structure of GRIHA rating system.

Sections	Criterion Number	Criterion Name	Maximum Points
Site Planning	1	Site Selection	1
	2	Low Impact Design	4
	3	Design to mitigate Urban Heat Island Effect (UHIE)	2
	4	Site Imperviousness	1
Construction Management	5	Air and Water Pollution Control	1
	6	Protect and Preserve Landscape During Construction	4
	7	Construction Management Practices	4
Energy	8	Energy Efficiency	13
	9	Renewable Energy Efficiency	8
	10	Low ODP Materials	0
Occupant Comfort and Well Being	11	Noise Level	2
	12	Maintaining Good Air Quality	4
	13	Use of low- VOC paints	2
Water	14	Use of Low-Flow Fixtures and System	4
	15	Reducing Landscape Water Demand	4
	16	Water Quality	2
	17	On-site water reuse	5
	18	Rainwater Recharge	2
Sustainable Building Materials	19	Utilisation of Waste Materials In building Structure as Recommended by BIS	6
	20	Reduction in Embodied Energy of Building structure	4
	21	Use of Low- Environmental Impacts in Building Interiors	4
Solid Waste Management	22	Avoided Post-Construction Landfill	4
	23	Treat Organic Waste on Site	2
Socio- Economic Strategies	24	Labour Safety and Sanitation	1
	25	Design for Universal Accessibility	2
	26	Dedicated Facilities for Service Staff	4
	27	Increase in environmental awareness	2
Performance Monitoring and Validation	28	Smart metering and monitoring	4
	29	Performance Assessment for Final Rating	0
	30	Innovation	4
		Total	100

Table 2.1 Sections and criteria of GRIHA rating system

The points awarded to different criterions in the GRIHA-2015 version have been modified from the previous version of GRIHA on the basis of survey conducted to better reflect the current resource priorities of India. The point split in various sections in shown in Figure

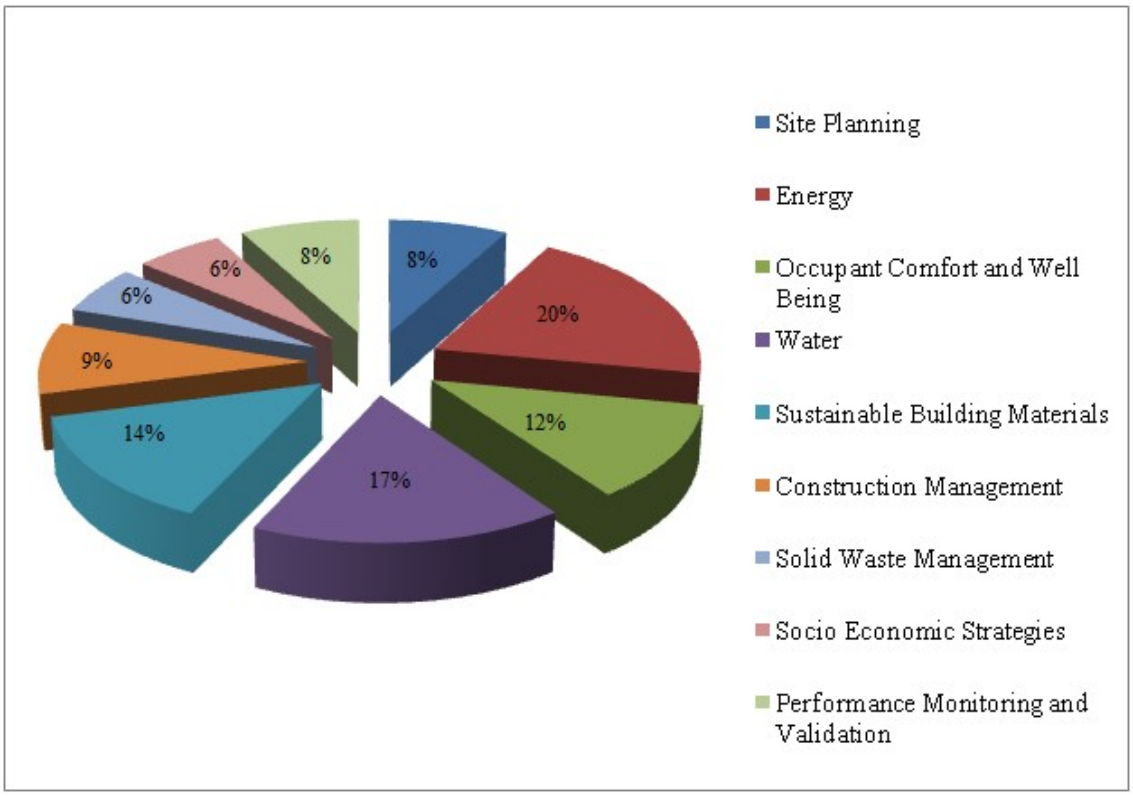

Figure 2.1 Various sections of GRIHA-2015 Rating System

The scores for achieving GRIHA-2015 rating are as follows:

Points Secured	GRIHA RATING
25-40	1 star
41-55	2 star
56-70	3 star
71-85	4 star
86 or more	5 star

Table 2.2 Star rating of GRIHA

CHAPTER -3

METHODOLOGY AND DATA ANALYSIS

3.1 SECTION 1: SITE PLANNING

3.1.1 Criterion 1 : Site Selection

The first step of this project is the site selection which has to be done very carefully as it is related to provide an imperishable habitat.

Maximum Points to be awarded in this criterion is 1 Point.

Appraisal**:** The site of the project should have at least 5 services (listed below) inside the campus or within a distance of 500 meter from the main entrance gate of the campus. : 1point

Services :- 1: Bank/ATM

2: Departmental Store

3: Restaurant/Cafe

4: Metro Station

5: School

6: Gym

7: Community Centre

Observations:

Following Services are provided in DTU or within the 500 meter from the main entrance gate of DTU.

1: Bank/ATM :- There is a branch of State Bank of India in the DTU situated adjacent to Kalpana Chawla Girls Hostel and opposite to Type- 3 Girls hostel.

2: Restaurant/Cafe :- Dahi Ram cafe is situated at within 50 meter from the main entrance gate of DTU.

3: Departmental Store :- Guru kreepa store which is a grocery store is situated opposite to the main entrance gate of DTU.

4: Gym :- DTU has its own gymnasium inside the campus which is situated at the back side of the State Bank of India and adjacent to ramanujan hostel office.

5: Park:- DTU have a sports complex which has a facility of 450meter track, ground for football, cricket, two courts of basketball and volleyball, three courts of tennis and five courts of badminton.

Figure 3.1 State Bank of India, DTU

Figure 3.2 Dahi Ram cafe outside the gate of DTU

Figure 3.3 Guru Kreepa store opposite to the gate

Figure 3.4 Gymnasium of DTU

Figure 3.5 Inside view of gymnasium of DTU

Figure 3.6 Park adjacent to the entrance gate of DTU

Figure 3.7 Football field in the sports complex of DTU.

1 Point is awarded in this criterion.

3.1.2 Criterion 2: Low Impact Design

Promote low impact design strategies which will help the project in many ways such as to protect the natural topographical site features and to incorporate it in the design of the project.

Maximum Points to be awarded in this criterion are 4 points.

Appraisal:- Determine the reduction in the environmental impacts by adopting various low impact design strategies in the project.

Number of strategies adopted	Points
1	1
2	2
3	4

Table 3.1 Number of strategies with points in low impact design

Strategy 1: Internal layout of the floor plate

Analysis Done :-

- Determining that the total external wall area on unfavourable orientation such as west have buffer zones or services areas.
- Various buffer zones and services areas are provided in various blocks of departments such as at the entrance of the Civil and Environmental Engineering Department from the Mechanical Canteen side, Wind Point which is in the Science block opposite to the parking of the Science block, entrance of the Electrical Engineering Department from Nescafe/Administration block, Computer Science and Information Technology Engineering Department, Mechanical and Production Engineering Department, Biotechnology Engineering Department , Delhi School of Management Department.

Figure 3.8 Entrance of Civil and Environmental Engineering Department

Figure 3.9 Wind Point in Science Block

Figure 3.10 Entrance of Electrical Department from Nescafe/Administration Block

Figure 3.11 Computer Science and Information Technology Engineering Department

Strategy 2: Designing of the building is done in such a manner so that it does not obstruct the solar access of the adjacent buildings or block specially to those buildings that have solar panels (to produce solar energy) installed on the roof the building.

Analysis Done:-

- There is an ample space between each and every engineering blocks/buildings of DTU so that the solar access of the neighbouring blocks/buildings are not obstructed.
- Such buildings/blocks of DTU which do not obstruct the sun path of neighbouring buildings are : Department of Training and Placement Block and Science Block, Mechanical and Production Engineering Department Block and Civil and Environmental Engineering Department Block, Science Block and Mechanical Engineering Block, Canteen and Civil and Environmental Engineering Department Block, Electrical Engineering Department Block and Administration Building.
- Various hostels which have adopted this solar access strategy are
    - Sir Visvesvaraya hostel and Varahmihira hostel.
    - Homi Jehangir bhabha hostel and Bhaskaracharya hostel.
    - Bhaskaracharya hostel and Varahmihira hostel.
    - Sir M Visvesvaraya hostel and Homi Jehangir bhabha hostel.
    - CV Raman hostel and Sir JC Bose hostel.
    - Sister Nivedita Girls hostel and Kalpana Chawla Hostel.

Figure 3.12 Space between Department of Training & Placement Block and Science Block

Figure 3.13 Space between Mechanical and Civil/Environmental Engineering Block

Figure 3.14 Space between Science Block and Mechanical Engineering Block

Figure 3.15 Space between Canteen and Civil and Environmental Engineering Block

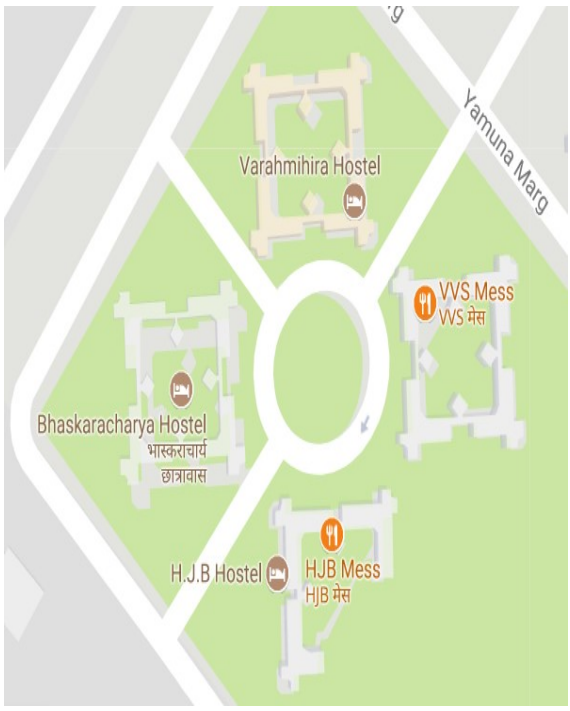

Figure 3.16 Spaces between Homi Jehangir Bhabha hostel Bhaskaracharya hostel, Varahmihira hostel , Sir Visvesvarya hostel.

Figure 3.17 Spaces between CV Raman hostel and J.C. Bose hostel

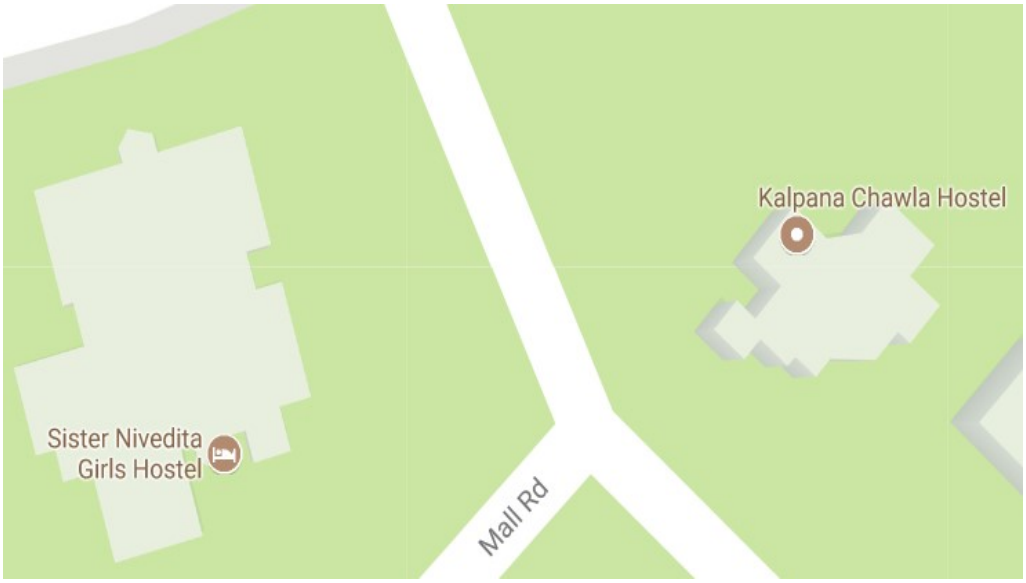

Figure 3.18 Spaces between Sister Nivedita Girls Hostel and Kalpana Chawla Hostel.

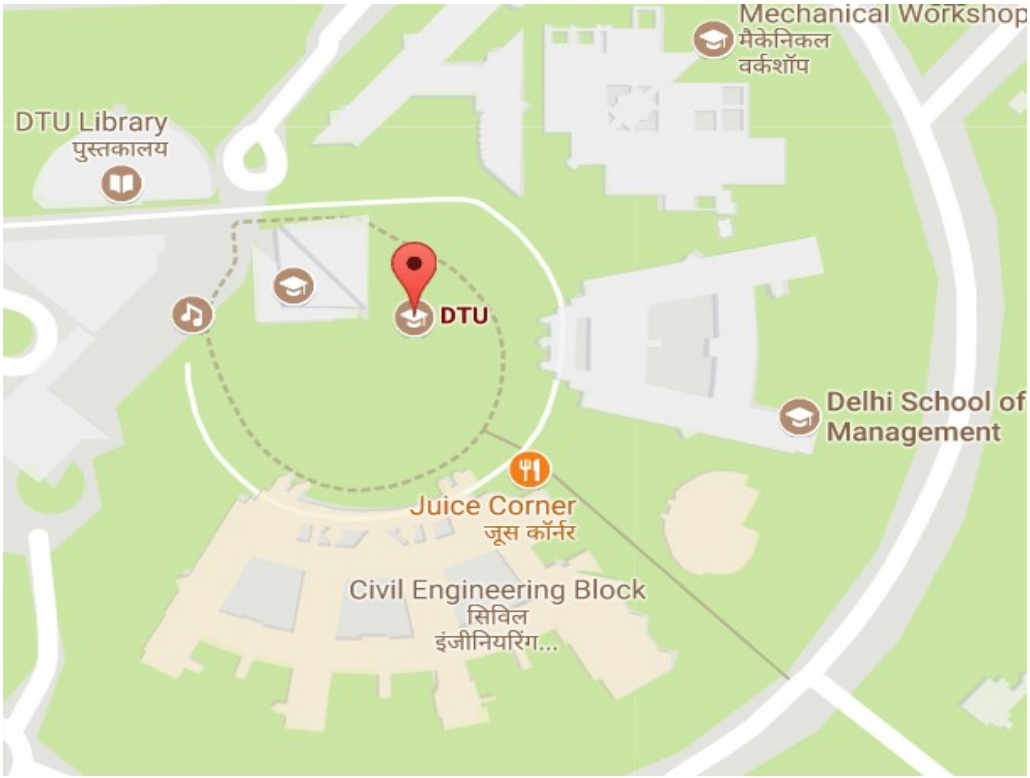

Figure 3.19 Spaces between Civil Engineering Block, Delhi School of Management, Mechanical Workshop, DTU library

Strategy 3: Site is to be planned in such a way that the existing vegetation/water bodies can be preserved .

- At the time of construction, DTU pond was the only existing water body available at the campus and it has been preserved since then.

Figure 3.20 DTU Pond

Hence 4 points are awarded in this criterion.

3.1.3 Criterion 3: Design To Mitigate Urban Heat Island Effect (UHIE)

Promote certain design strategies that are to be adopted at the project site in order to reduce the Urban Heat Island Effect (UHIE).

Maximum Points awarded in this criterion are 2 Points.

Appraisals:

- More than 25% of the surface of the site area that are visble to the sky that includes building roof but not the landscape area are either soft paved with a high Solar Reflectance Index coating usually greater than 0.5 or that area is shaded by trees or shaded by solar panels or the area covered by any combination of these strategies. :- 2 Points
- More than 50 % of the surface of the site area that are visible to the sky that includes building roof but not the landscape area are either soft paved with a high Solar Reflectance Index coating usually greater than 0.5 or that area is shaded by tress or shaded by solar panels or the area is covered by any combination of these strategies. :- 4 Points

Observation:

- DTU has solar photovoltaics installed on the roof of every departmental block whereas these solar photovoltaics are not installed on the roof of the hostels and on of the residental buildings of DTU.
- The name of the project is "432 KWp Grid Connected Solar Photovoltic Power Plant at Delhi Technological University,Rohini, Delhi."
- Total power generated by the solar panels in this project are 432 KW per day.
- These are installed under IPGCIL ROOFTOP SOLAR SCHEME DESIGN,SUPPLY,INSTALLATION,COMMISSIONING & OPERATION and the owner of this project is " Hero Solar Energy Pvt. Ltd."
- Solar panels that are installed are divided into 3 main buildings:
  - Electronic Building (Civil and Environmental Engineering Department, Computer science and Information Technology Department, Electronic and Electrical Engineering Department) which generates 174 KWp per day.
  - Mechanical Building (Mechanical and Production Engineering Department, Biotechnology Engineering Department ,Mechanical Workshop, Delhi School of Management) which generates 150KWp per day.
  - Science Block (Applied physics Engineering Department ,Applied Chemistry Engineering Department ,Applied Mathematics Engineering Department) which generates 108 KWp per day.

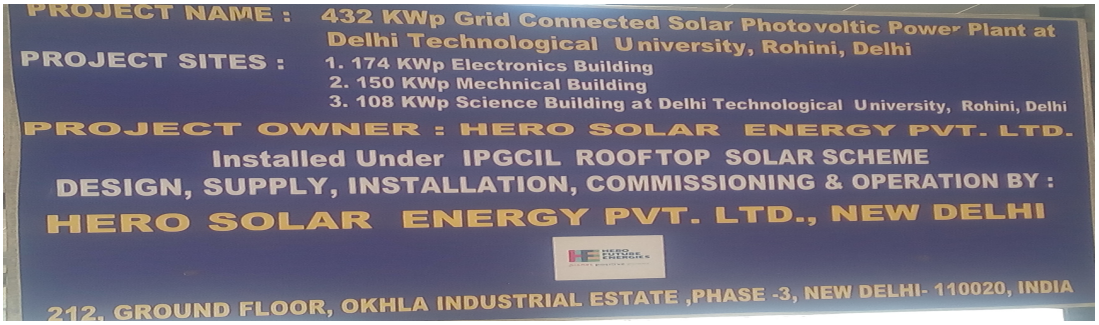

Figure 3.21 Details of the solar panel project

Figure 3.22 Solar Panels Installed in various Engineering Departments of DTU.

Residential (Faculty housing) Area

S.No	Description Of Building	Area In Square Meter
1	Type 1 Quarters	1003.91
2	Type 2 Quarters	1679.38
3	Type 3 Quarters	878.28
4	Type 4 Quarters	3131.12
5	Type 5 Quarters	2984.68
6	Health Centre	1000
7	Guest House	414.46
8	Vice Chancellor Residence	250
	TOTAL	11341.83

Table 3.2 Residential (faculty housing) area of DTU

Hostel Area

S.No	Description Of Building	Area In Square Meter
1	Boys Hostels	15750
2	Girls Hostels	1700
3	Transit Hostel	573
4	PG Hostel	1500
5	Warden's Flat	2000
	Total	21523

Table 3.3 Hostel area of DTU

Academic Area

S.No	Description Of Building	Area In Square Meter
1	Administration Block	2250
2	Library	3200
3	B.R.Ambedkar Hall	3000
4	Computer Centre	1800
5	Department of Civil and Environment/Computer Science and Information Technology/Electronics and Electrical Engineering	14815
6	Department of Mechanical and Production Engineering/Biotechnology Engineering/ Delhi School of Management/ Mechanical Workshop	12856
7	Science block	3378
8	Canteen	1000
	Total	42299

Table 3.4 Academic area of DTU

Calculations : Area in which Solar panels are installed = 39099 square meter

- Total combined area of all zones = 75163.83 square meter.
- Percentage of area installed with solar panels = (39099 / 75163.83) * 100 = 52.018 %
- Hence, percentage of area installed with solar panels are more than 50 % , therefore the points secured in this criterion are 4 Points.

3.1.4 Criterion 4: Site Imperviousness

Rapid runoff of rainwater is a result of high imperviousness which reduces the urban rainwater recharge and leads to urban flooding. Ensure that the project is designed in such a way that it assist in reducing the total site imperviousness factor.

Maximum Point awarded in this criterion is 1 Point.

Appraisal: Not more than 25 % of the project area can come under the paved area of the site such as parking, roads or any other use:- 1Point

Observation:

S.No	Description of paved and unpaved area	Total area in square meter
1	Residential Zone (Faculty housing / Hostels)	47988.86
2	Academic zone	59117
3	Sports and cultural zone	4750
4	Area under roads and parking	91360.5
5	Area under green and open spaces	459942
	Total area of DTU	663158.362 (163.87 acre)

Table 3.5 Description of paved and unpaved area of DTU

Calculations :

- Total paved area of DTU :- 203216.36 square meter
- Total area of DTU :- 663158.362 square meter (163.87 acre)
- Percentage of paved area in DTU :- (203216.36 / 663158.362) * 100 = 30.64 square meter.
- Hence the percentage of net paved area under parking , roads, paths or any other use are exceeding the given limit of 25% ,therefore No points are awarded in this criterion.

3.2 SECTION 2 : CONSTRUCTION MANAGEMENT

3.2.1 Criterion 5 : Air And Water Pollution Control

Adopt certain strategies that can reduce air and water pollution from the site at the time of construction period.

Maximum point awarded in this criterion is 1 Point.

Appraisal :

A. Water Pollution Control Plan:

- Introduction and implementation of a spill prevention plan on site during the construction period in order to control the harmful effects of spill from hazardous materials such as diesel, bitumen etc) :- 1 point
- Two cases are made in order to give points in this criterion.

Case 1	Case 2
Spill Prevention plan was developed and implemented at the time of construction of project.	No spill prevention plan was developed and implemented at the time of construction of project.
Points secured : 1	Points Secured : 0

Table 3.6 Cases of water control pollution plan

B. Air Pollution Control Plan:

- At least 3 measures are to be adopted on the site of the project in order to restrain air pollution inside the campus during construction period.
  - No points are to be awarded in this appraisal.
  - Two cases are taken in order to full fill the criterion of this appraisal.

Case 1	Case 2
✓ Facility of wheel washing was provided at the main vehicular entrance of the DTU campus. ✓ Fine aggregates and the excavated earth were covered with plastic or geo textile sheets on the site. ✓ Water was regularly sprinkled on fine aggregate such as sand and on the excavated earth.	No measures were adopted on site of the project in order to restrain air pollution inside the campus during construction period.

Table 3.7 Cases in air pollution control plan

3.2.2 Criterion 6 : Protect And Preserve Landscape During Construction

Make sure that the mature trees and the fertile top soil are preserved in order to minimize the effect of the construction activities on the existing landscape.

Appraisals :

- The total number of trees on the site of the project are increased by 25% above the construction phase of the site :- 2 Points
- The top soil of the site is preserved during construction and its fertility is maintained during the construction phase. :- 2 Points

Observation :

- Prior to the construction of DTU campus in Shahbad Daulatpur Delhi , this land was used by farmers as the agricultural land to grow crops. Government of Delhi acquired this land from them and then the construction of this campus took place.
- DTU has 459942 square meter of area out of total 663158.362 square meter under green spaces which is about 69.356% of the total 100% of the area. So, therefore thousands of trees are planted at the time of construction of DTU and after that.
- Points secured in this part of criterion are 2 Points.
- Second appraisal that deals with the fertility of soil at the time of the construction of DTU campus are given in following cases:

Case 1	Case 2
The topsoil of the DTU campus at the time of construction was fertile and all the essential major nutrients such as nitrogen, phosphorus, potassium were present in the top soil.	The topsoil of the DTU campus at the time of construction was not fertile and all the essential major nutrients like nitrogen, phosphorus, potassium were absent in the top soil.
Points Secured : 2 Points	Points Secured : 0 Points

Table 3.8 Cases on information of topsoil

Figure 3.23 Trees inside Civil and Environmental Engineering Department .

Figure 3.24 Trees inside Computer Science and Information Technology Engineering Department

Figure 3.25 Trees outside microbiology lab of Environmental Engineering Department

Figure 3.26 Trees in Computer Science and Information Technology Parking

Figure 3.27 Trees outside Administration building

Figure 3.28 Trees outside Civil and Environmental Engineering Department (View from the roof of Environmental Engineering Department

3.2.3 Criterion 7: Construction Management Practices

Make sure that the good construction practices are adopted on site.

Maximum Points awarded in this criterion are 4 points.

Appraisals:

- Staging is to be adopted on site during construction period.:- 1 Point
- Strategies have to be adopted in order to prevent or reduce the movement of soil outside the site of the project. :- 1 Point
- In order to manage water, at least three strategies should be adopted during construction on site.:- 1 Point
- In order to segregate the construction wastes, a construction management plan has to be developed and implemented in order to safe storage of waste and its on-site or off-site recycling. – 1 Point

  Following cases are made in this appraisal:

Case 1	Case 2
Staging was adopted during construction on site.	Staging was not adopted during construction on site.
Strategies were adopted to prevent movement of soil outside the site	No strategies were adopted to prevent movement of soil outside the site.
To manage water, certain strategies were adopted during construction on site. • Gunny bags were used for curing. • Monitoring was done in order to avoid wastage of water due to leaks. • Additives were used in order to reduce water requirement at the time of curing.	No strategies were adopted to manage water during construction on site.
A construction waste management plan was developed and implemented to segregate the construction waste on site or off site for recycling.	No construction waste management plan was adopted to segregate the construction waste on site or off-site for recycling.
Points Secured :- 4 Points	Points Secured :- 0 Points.

Table 3.9 Cases in construction management practices

3.3 Section 3 : Energy

3.3.1 Criterion 8 : Energy Efficiency

Determine the energy efficiency of the project.

Maximum points to be awarded in this criterion are 13 Points.

Appraisals :

- Demonstrate that the 100% of the outdoor lighting of the project site meet the luminous efficacy requirements of GRIHA i.e all the outdoor lighting must be of at least 75 lumens/watt. : 3 Points
- Some additional points will be awarded if there is a reduction in Energy Performance Index as mentioned below :

Reduction from Energy Performance Index Benchmark	Points
10%	2
20%	3
30%	5
40%	7
50%	10

Table 3.10 Reduction from energy performance index benchmark

Energy Performance Benchmark is given below :

Energy Performance Index Benchmark (EPI) – (kWh/m²/year)		
Climate Classification	Day time occupancy	24 hours occupancy
	5 Days a week	7 Days a week
Commercial/ Academic/Institutional/Hospital Buildings		
Composite/ Warm and humid/ Hot and dry	90	300
Residential buildings/Hostels		
Composite / Warm and humid / Hot and dry	70 (7 days a week)	

Table 3.11 Energy performance benchmark (EPI)

Observation :

There are different types of lamps that are used as the outdoor lightning in the DTU campus . These are Sodium vapour 250 watt lamp, Metal halide 400 watt lamp, Sodium Vapour 70 watt lamp , Metal halide 250 watt lamp, Metal halide 150 watt lamp.

Description of area	Number of Sodium vapour 250 watt lamp	Number of Metal-halide 400 watt lamp	Number of Sodium vapour 70watt lamp	Number of Metal-Halide 250 watt lamp	Number of Metal-halide 150 watt lamp
Science Block	12				
Computer Centre	12				
Civil and Environmental Engineering Block	34	6			
Mechanical and Production Engineering Block	13	6			
Administrative Building	10	4			
Type 1-4 Quarters	17				
Library	11				
Workshop				12	
Nursery			1		
Wind Tunel	09				2
VC residence	06				
Multi purpose Hall				12	
Boys Hostel	36	14			
Kalpana Chawla Girls Hostel			2		
Sister Nivedita Girls Hostel	2		21	6	
Transit Hostel	04				
Type-3 Girls Hostel	08				
Guest House	05				
Aryabhatt Hostel	18		03		

Table 3.12 Different types of lamp used in DTU campus

Luminous efficacy table:

S.No.	Light type	Typical luminous efficacy (lumens/watt)
1	Tungsten incandescent light bulb	12.5 – 17.5
2	Halogen lamp	16-24
3	Fluorescent lamp	45-75
4	LED lamp	30-90
5	Metal halide lamp	85-115
6	High pressure sodium vapour lamp	85-150
7	Low pressure sodium vapour lamp	100-200
8	Mercury vapour lamp	35-65

Table 3.13 Luminous efficacy table

Calculations :

1. Sodium vapour 250 watt lamp

- Power results in watt = 250 watt
- Light source : High pressure sodium vapour lamp
- Average Luminous efficacy in lumens/watt = 117.5 lumens/watt
- Luminous flux in lumens = (117.5*250) = 29375 lumens

2. Metal halide 400 watt lamp :

- Power results in watt = 400 watt
- Light source :- Metal halide lamp
- Average luminous efficacy in lumens/watt = 90 lumens/watt
- Luminous flux in lumens = (400*90) = 36000 lumens

3. Sodium vapour 70 watt lamp :

- Power results in watt = 70 watt
- Light source :- Low pressure sodium vapour lamp
- Average Luminous efficacy in lumens/watt = 150 lumens/watt
- Luminous flux in lumens = (70*150) = 10500 lumens

4. Metal halide 250 watt lamp

- Power results in watt = 250 watt
- Light source :- Metal halide lamp
- Average luminous efficacy in lumens/watt = 90 Lumens/watt
- Luminous flux in lumens = (250*90) = 22500 lumens

5. Metal halide 150 watt lamp

- Power results in watt = 150 watt
- Light source :- Metal halide lamp
- Average luminous efficacy in lumens/watt = 90 lumens/watt
- Luminous flux in lumens = (150*90) = 13500 lumens

- Hence 100% of the lamps that are used in the DTU campus as outside lighting have atleast 75 lumens/watt as luminous efficacy.
- Points secured in this appraisal are 3 points

Energy Performance Index of DTU

- Since DTU consists of both Academic/Institutional buildings and residential buildings. Average of both is calculated in order to get Energy performance index of DTU.
- Category 1 Building is calculated of academic area - 5 days a week ,8 hours a day.
- Category 2 Building is calculated of residential area – 7 days a week, 18 hours a day.

Category 1 building - Academic Building of DTU	
Initial GRIHA benchmark	90 kWh/sqm/annum
Conditions	1. Total number of operational hours cannot be greater than 16 hours per day. 2. Total number of occupied days cannot be more than 6 days.
Academic hours of DTU	1. Working hours of academic section of DTU are 9 a.m - 5 p.m and the working days are Monday to Friday . 2. The total number of operational hours per day is 8 hours and the total occupied days in a week are 5 days. 3. The GRIHA benchmark of the academic area of the project is : (90 * 1.6) = 144 kWh/sqm/annum.
Total academic area of DTU (in square meter)	59117 square meter

Table 3.14 GRIHA benchmark for academic area of DTU

Category 2 building – Residential area of DTU (faculty housing , hostels)	
Initial GRIHA benchmark	70 kWh/sqm/annum
Conditions	1. Total number of operational hours cannot be less than 14 hours per day 2. Total number of occupied days must be 7 days.
Total hours in which energy is consumed in Residential area of DTU (Faculty housing, Hostels)	1. The total number of operational hours per day is 18 hours and total occupied days in week are 7 days. 2. The GRIHA benchmark of the residential area of the project is : (70 * 2.57) = 180 kWh/sqm/annum.
Total area of residential buildings of DTU (in square meter)	47988.86 square meter

Table 3.15 GRIHA benchmark for residential area of DTU

Total energy consumption of DTU in a year

Purchased Electrical Energy trend in DTU campus 2015-2016					
Month and year	Total energy consumption kWh	MD charge / Rs. Kva	Energy charge Rs kWh	Power Factor	Total bill cost Rs./kWh
17-March 2015	380580	1032	8.4	0.88	3898380
16-April 2015	395100	1116	8.4	0.89	4030820
19-May 2015	498780	1500	8.4	0.92	5055960

14-Jun 2015	561900	1866	8.4	0.92	5689390
14-July 2015	430560	1602	8.4	0.92	4545110
16-August 2015	533100	1586	8.75	0.92	5602000
14-September 2015	591263	2332	8.75	0.92	5689390
14-October 2015	553157	2303	8.75	0.92	4545110
16-November 2015	408243	953	8.75	0.92	5602000
14 December 2015	341079	834	8.75	0.86	3640670
14 January 2016	553157	756	8.75	0.86	3734310
16 February 2016	417604	1062	8.75	0.92	4425470
	Total: 5664523				Total: 56458610

Table 3.16 Total energy consumption of DTU in a year

Calculation of Energy performance index of DTU

- Total energy consumption (kWh) in DTU in a year (March 2015- February 2016) is 5664523 kWh.
- Total academic area of DTU : 59117 square meter.
- Total residential area of DTU :- 47988.96 square meter.
- Energy performance index (kWh/sqm/annum) =
  (Total energy consumption in a year (kWh/annum)
  Total academic and residential area of DTU (sqm)
- EPI of DTU = (5664523 / 107105.86)
- EPI of DTU = 52.887 kWh/sqm/annum
- GRIHA benchmark of the academic area of DTU :- 144 kWh/sqm/annum and the GRIHA benchmark of the residential rea of DTU :- 180 kWh/sqm/annum. Taking average of both the benchmarks of academic area and residential area in order to get the GRIHA benchmark of DTU.
- GRIHA benchmark of DTU :- { (GRIHA Benchmark of academic area + GRIHA Benchmark of residential area) / 2 } = { (144+180) / 2} = 162 kWh/sqm/annum .
- Reduction from EPI GRIHA benchmark of DTU :-
  Energy performance index of GRIHA benchmark of DTU – Energy performance index of DTU * 100
  Energy performance index of GRIHA benchmark of DTU
- Reduction from EPI GRIHA benchmark of DTU(in %)= [{ (162 – 52.887) / 162 } * 100] = 67.354 %.
- Since the reduction from EPI GRIHA benchmark of DTU is more than 50% , therefore 10 Points are awarded in this appraisal.

3.3.2 Criterion 9: Renewable Energy Utilisation

Ensure that the renewable energy sources are provided in the project area.

Maximum points awarded in this criterion are 8 points.

Appraisals : In order to offset the annual energy consumption of internal artificial lighting, certain renewable energy system are installed in the project site.

Daytime Buildings of the project area	Points
5%	1
10%	2
15%	4
20%	5
25%	7
30%	8

Table 3.17 Reduction in energy consumption in percentage by renewable energy system

Observations :

- In DTU, recently solar panels have been installed in the academic area of DTU as a renewable source of energy in order to reduce the total energy consumption of internal artificial lighting.
- 432 KW per day of power are being generated by the solar panels in DTU in order to reduce the usage of consumption of energy.
- The name of the project is "432 KWp Grid Connected Solar Photovoltaic Power Plant at Delhi Technological University , Rohini, Delhi'.
- There are three buildings of DTU in which solar panels are installed.
- Electronic Building (Civil and Environmental Engineering Department, Computer Science and Information Technology Department, Electronics and Communication Engineering Department, Electrical Engineering Department.) which generates 174 KWp per day.
- Mechanical building (Mechanical and Production Engineering Department, Biotechnology Engineering Department, Delhi School of Management) which generates 150 KWp per day .
- Science Block (Applied Physics Engineering Department , Applied Chemistry Engineering Department, Applied Mathematics Engineering Department) which generates 108 KWp per day.Total power generation by solar panels in a year = (432 * 365) = 157680 KW

- Total energy consumption by buildings of DTU in a year = 5664523 kWh.

- Total number of operational hours of academic area of DTU is 8 hours/day and the total number of operational hours of residential areas of DTU is 18 hours/day.
- Average operational hours of DTU campus ={(8+18) / 2} =13hours/day
- Total power used by buildings of DTU in a year (in KW) =
  (5664523 kWh / 13 hours) = 435732.538 KW
- Reduction in annual energy consumption of internal artificial lighting (in %) =
  Total power generation by solar panels in a year * 100 =
  Total power generation by solar panels in a year
  Percentage = { (435732.538 / 157680) * 100 } = 36.187 %

- Hence, using solar panels as a renewable energy source, the annual energy consumption by internal artificial lighting is reduced by 36.187 % which is more than 30 %. Therefore 8 points are awarded in this criterion.

3.3.3 Criterion 10 : Low ODP Materials

Ensure that the equipments that are used in buildings such as refrigerators and fire fighting systems have to be with low ozone depleting potential.

No points are to be awarded in this criterion.

Appraisal:

- All the refrigerant equipments used in the project site should be CFC's free – Mandatory
- All the fire extinguishers installed in the building are halons free. – Mandatory.

Observations :-

All the refrigerators and fire extinguishers that are used in DTU be it either in hostels, canteen, labs or residential areas are CFC free , as CFC comes under ozone depleting substances and Government of India have banned the use of equipments or materials that produces CFC under "Ozone Depleting Substance (Regulation and Control) Rules,2000".

Figure 3.29 A CFC free Lg GL-528YTX4 refrigerator is used in microbiology lab of Environmental Engineering Department

Figure 3.30 Fire extinguisher used in Computer science and I.T Engineering Department

Figure 3.31 Fire extinguisher used in Electrical Engineering Department

3.4 SECTION 4: OCCUPANT COMFORT AND WELL BEING

3.4.1 Criterion 11 : Noise Level

Ensure that the noise level of the project area is within limits so as not to cause harmful effects to the staff members of the project.

Appraisal : The noise level of the project area should be within the acceptable limits of NBC 2005. :-2 Points

Observation :

CPCB has installed 10 noise monitoring stations in Delhi (to monitor and measure noise level of that area) in which one station is at DTU. The noise monitoring station installed at DTU is outside the administration building. Constant monitoring of noise level is done at these stations and data are available on CPCB website in real time basis. Data are available on the basis of hourly average and daily average.

Figure 3.32 Noise level monitoring station installed at DTU.

The noise level of the DTU is taken as the average of noise level of 10 days (i.e 1st May to 10th May)

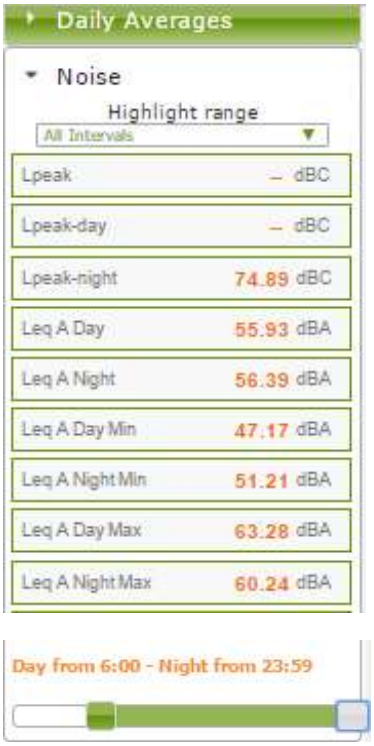

Figure 3.33 Daily average noise level of DTU (1st may 2017)

Figure 3.34 Daily average noise level of DTU (2nd May 2017)

Average noise level of DTU of 10 days (From 1st May 2017 – 10th May 2017)

Type of zone	Limits in dB(A) Leq as specified by CPCB		Leq A in dB Day (DTU)	Leq A in dB Night (DTU)
	Day time	Night time		
Silent zone	50	40	56.45	55.21

Table 3.18 Average noise level of DTU in 10 days

Since the day and night noise level limits of DTU are exceeding than the standard specified by CPCB .

Hence , the points awarded in this criterion are zero.

3.4.2 Criterion 12 : Maintaining Good Air Quality

Ensure that the good air quality of the project site is maintained as it is related with the healthy living conditions of the building users.

Appraisals :

- The air quality of the project area should meet the minimum requirement of the CPCB National Ambient Air Quality (NAAQS) :- 3 points
- Monitoring of temperature, relative humidity is carried out on the project site :- 1 point

Observation:

CPCB has installed 13 air monitoring stations in Delhi (to monitor the ambient air quality) in which one station is at DTU. The monitoring station installed at DTU is outside the administration building. Constant monitoring of air quality is done and data is available on the CPCB website in real time basis (on a time lag of 15 minutes). Data available in 15 minute, 30 minute, 1 hour, 4 hours, 8 hours, 24 hours and annual average basis. Several parameters are calculated such as , nitrogen Dioxide (NO_2), $PM_{2.5}$, ammonia (NH_3), relative humidity (RH), temperature, wind speed and direction etc.

Figure 3.35 Ambient air quality monitoring station at DTU installed by CPCB, Delhi

Concentration of pollutants as measured by the monitoring station at DTU are as follows:

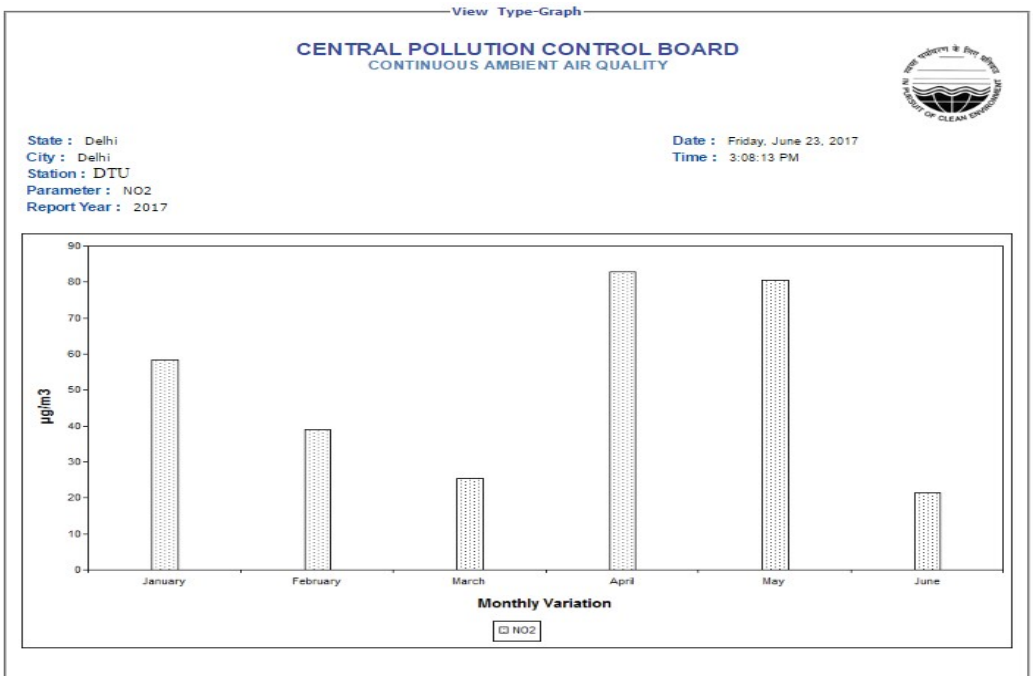

Figure 3.36 Concentration of Nitrogen Dioxide (24 hours) by CPCB monitoring station at DTU from 1st January 2017 to 20th June 2017

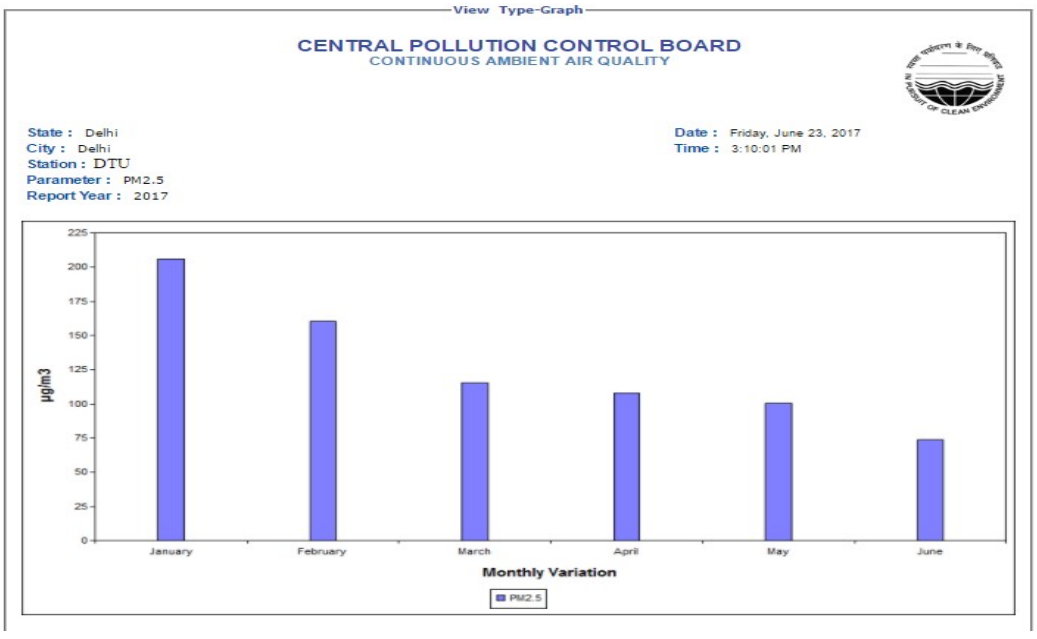

Figure 3.37 Concentration of PM2.5 (24 hours)by CPCB monitoring station at DTU from 1st January 2017 to 20th June 2017

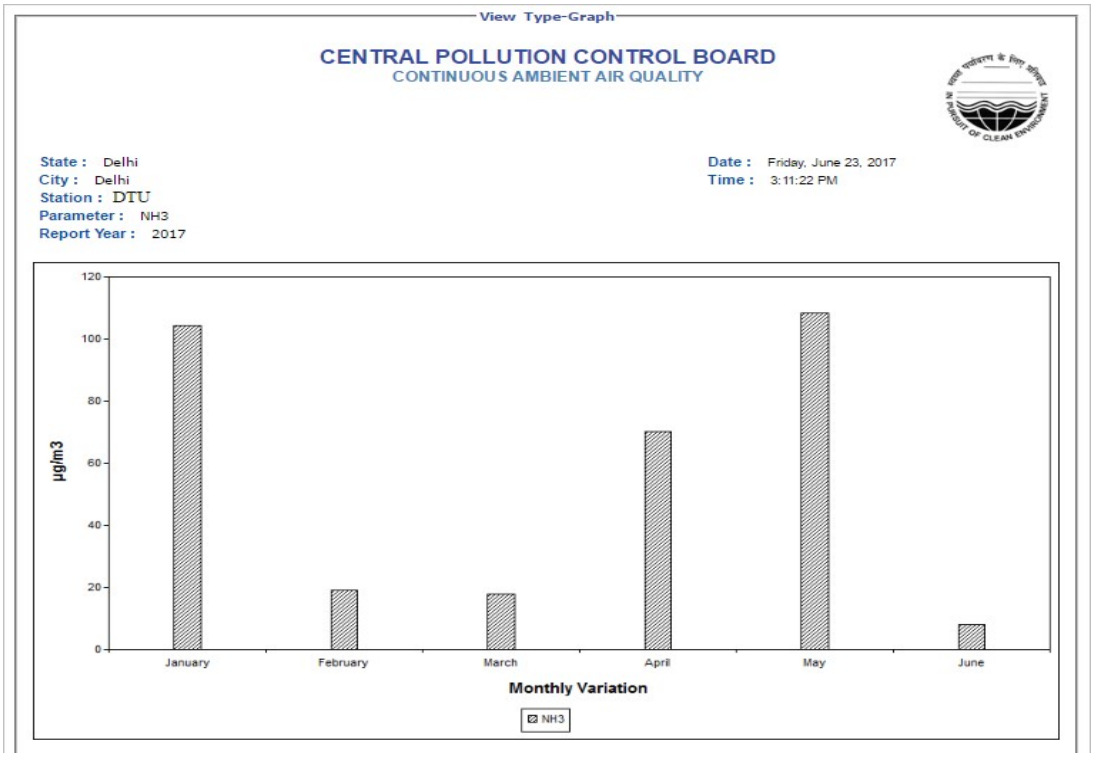

Figure 3.38 Concentration of NH_3 (24 hours) by CPCB monitoring station at DTU from 1st January 2017 to 20th June 2017

Average concentration of ambient air in DTU (1st January 2017 - 20th May 2017)

Pollutant	Time weighted average	NAAQS standards (2009): Concentration of ambient air in Industrial/residential/rural areas and other areas.	Concentration of ambient air at DTU
NH3 (ug/m³)	24 hours	400	52.50
NO2 (ug/m³)	24 hours	80	50.15
PM2.5 (ug/m³)	24 hours	60	133.08

Table 3.19 Concentration of pollutants in ambient air of DTU

The concentration of NH3 and NO2 are under prescribed limit of NAAQS 2009 but there is an inconsiderable amount of increase in PM2.5. Hence the points awarded in this part of the criterion are 2 points.

Monitoring station of CPCB at DTU also calculate temperature and relative humidity.

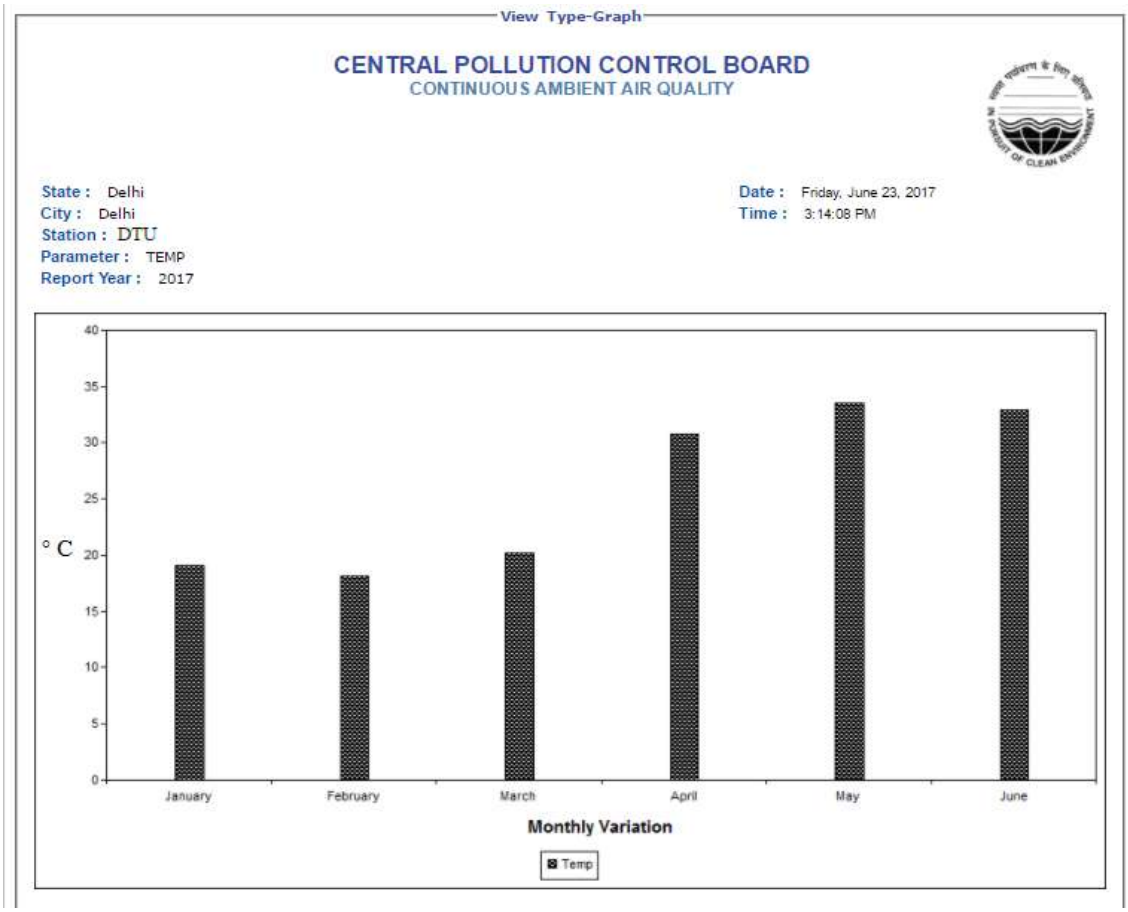

Figure 3.39 Temperature (°C) by CPCB monitoring station at DTU (1st January 2017 - 20th June 2017)

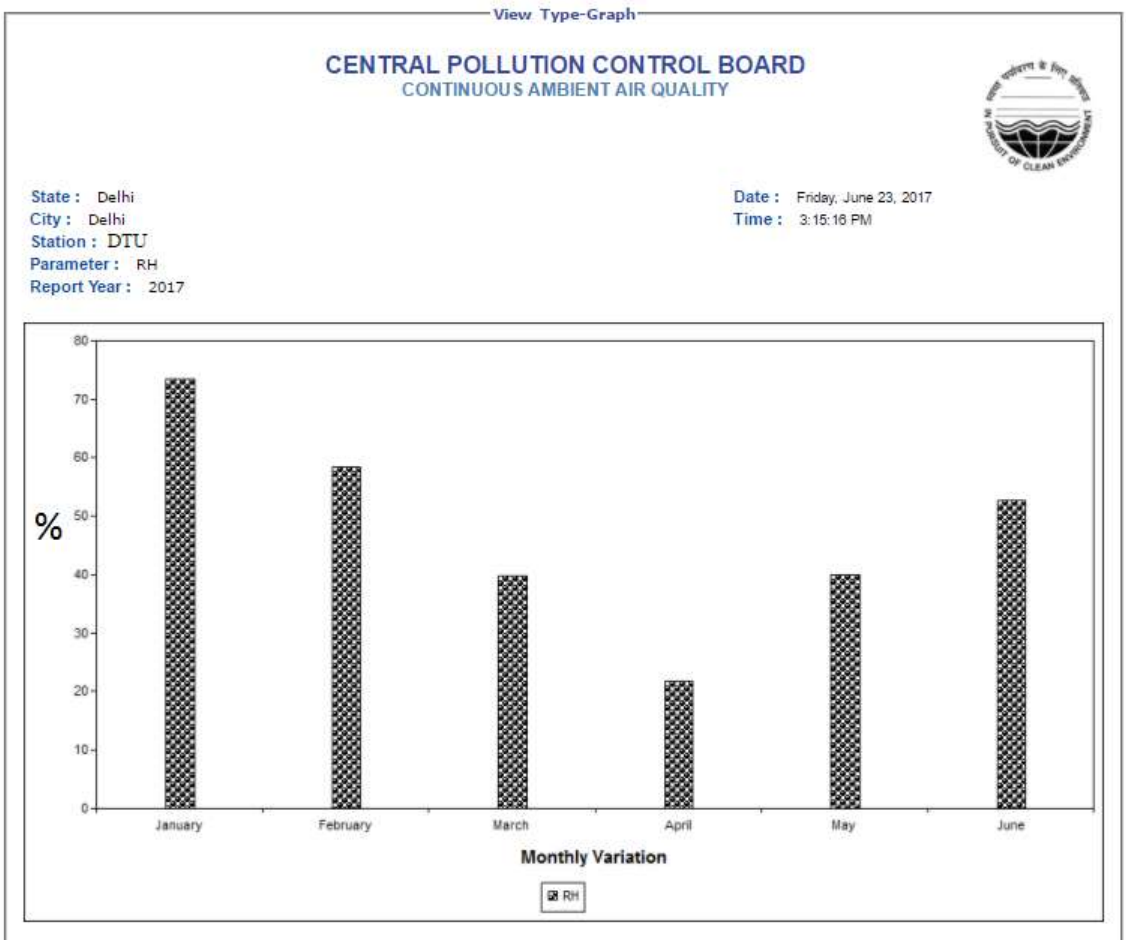

Figure 3.40 Relative humidity (%) by CPCB monitoring station at DTU from 1st January to 20th June 2017

- The average temperature of DTU as calculated by CPCB monitoring station from 1st January 2017 to 20th June 2017 = 25.01 °C.
- The average relative humidity of DTU as calculated by CPCB monitoring station from 1st January 2017 to 20th June 2017 = 46.90 %
- Hence the points awarded in this part of the criterion is 1 point.
- Total points secured in this criterion are 3 points.

3.4.3 Criterion 13: Use of Low -VOC Paints

Promote paints which have low volatile organic compounds (VOC) and are lead free and does not contain any harmful substances in it.

Appraisal : Ensure that all the paints that are used in the project whether they are interior paints or exterior paints are of low volatile organic compounds (VOC) i.e there VOC content should be less than 50 gram per litre of paint and lead free.:- 2 points

Observation : The various types of paints that are used in DTU are:

- Interior Paint :
- Oil bound distemper :- Oil bound distemper offers a smooth finish on the walls. It is non flammable and environment friendly paint as it does not contain lead or any petrochemical dependent components. It can be used on plaster and even on the brick walls. It is very helpful in decorating the walls and ceilings.This type of paint is perfect for interior use.
- Plastic emulsion paint (Asian tractor emulsion):- Asian tractor emulsion is a flat topcoat product type and according to the guidelines of international GS-11 (Green Seal) standard , this type of paint have a very low Volatile organic compound (VOC) of less than 50 gram per litre. The exact VOC level of asian tractor emulsion as measured by an external laboratory by a test method (ASTM D 6886) specified by the standard is 12.7 grams per litre with certificate date 03-12-2016.

- Exterior Paint :
- Asian ace advanced emulsion :- It is a water based exterior paint . It is a flat topcoat product type whose value of volatile organic compound (VOC) as measured by an external laboratory by a test method (ASTM D 6886) specified by a standard is 20.28 gram per litre with certificate date 29-01-2016 and is also a lead free paint.

Hence the points secured in this criterion are 2 points.

3.5 Section 5: Water

3.5.1 Criterion 14 : Use of low-flow fixtures and system

Make sure that the water consumption in the operational period of the project is sufficiently reduced through the use of low flow fixtures.

Maximum points awarded in this criterion are 4 points.

Appraisals:

- Water demand of the project is to be reduced through selection of low flow fixtures by 50% of the total amount of consumption of water :- 2 points
- Water demand of the project is to be reduced through selection of low flow fixtures by 70% of the total amount of consumption of water :- 4 points

Observation :-

Low flow fixtures are very useful as it reduces the amount of water released per minute. They use half the amount of water as compared to traditional fixtures. They save water and provide equal rate of flow of water as they uses the technique of high pressure and uses less amount of water whereas the traditional fixtures uses a large amount of water. Water efficient toilets and bathrooms not only save water but it also saves a lot of amount of money on our monthly water bill. These low flow fixture facilities are neither use or promoted in the DTU campus. This may be due to the free costing of water that DTU get as the entire amount of water that is being used in the DTU campus are groundwater which comes from various tube wells that are installed in different places of the campus which gives 10-12 lacs (approximately) litre of water daily to the entire DTU campus and because of no monthly bill of water is to be paid, there is no record of the amount of consumption of water used by the people in the campus.

Hence the no points are awarded in this criterion.

3.5.2 Criterion 15 : Reducing Landscape Water Demand.

Promote the use the water efficient irrigation system in order to reduce the water demand of plants/trees.

Maximum points awarded in this criterion are 4 points

Appraisals:

- Reduce the water demand that are required by the plants/trees by atleast 30% from the earlier water consumption. :- 1 point
- Reduce the water demand that are required by the plants/trees by atleast 40% from the earlier water consumption. :- 2 points
- Reduce the water demand that are required by the plants/trees by atleast 50% from the earlier water consumption. :- 4 points

Observation :

Prior to the construction of DTU, the project area was an agricultural land. After acquiring the area from the farmers by the Government of Delhi this campus was made. So no mature trees are there prior to construction of DTU but thousand of trees are being planted since then. The water used in growing those trees are groundwater which are extracted from the ground with the help of tubewells installed at various different places in the campus whose record is not calculated and maintained. So no efficient irrigation system is used in the DTU campus in order to reduce the demand of plants/trees.

No points are secured in this criterion.

3.5.3 Criterion 16 : Water Quality

Ensure the quality of water used for various purposes. This ensuring of water quality during project operation is important for two main reasons : To ensure the overall hygiene of the project users and the durability of the plumbing systems that are installed in the project site. It is also important to make that the water that are discharged of from the project site should meet the required disposal limits and the water used in the project area meets the required national standards.

Maximum Points awarded in this criterion are 2 points.

Appraisal: Water that is being used in the project site for various purposes shall meet the Bureau of Indian Standards . :- 2 Points

Observations: DTU mostly uses the groundwater that are extracted from tube wells that are installed at different places in the campus. Around 10-12 lacs (Approximately) litre of water are extracted daily for various purposes such as drinking, cooking ,bathing etc are distributed in the academic, residential and hostel area of the campus. Tap water is taken as the water sample in order to test the water quality of the DTU.

Water quality results of DTU

S.No.	Characteristic	Requirement (Acceptable limit) as per IS 10500:2012	Permissible limit	Observed value
1.	pH	6.5-8.5	No relaxation	8
2.	Turbidity NTU	1	5	4
2.	Total dissolved solids (mg/l)	500	2000	233
3.	Total suspended solids (mg/l)	-	-	112
4.	Total solids (mg/l)	-	-	345
5	Chlorides (mg/l)	250	1000	96
6.	Calcium hardness (mg/l)	75	200	38
7.	Total hardness (mg/l)	200	600	164
8.	Alkalinity (mg/l)	200	600	84
9.	Acidity (mg/l)	-	-	23
10.	Dissolved oxygen (mg/l)	-	-	5.7
11.	COD (mg/l)	-	-	8.2
12.	BOD (mg/l)	-	-	1.2

Table 3.20 Water quality results of DTU

All the characteristics of water are under the acceptable limit specified by Indian Standard Drinking Water Specification (IS 10500:2012). Hence the points awarded in this criterion are 2 Points.

3.5.4 Criterion 17 : On-Site Water Reuse

Make sure that certain strategies are used to recycle and use of wastewater and to capture the rainwater in order to meet the demand required by the project, thus reducing the water required from local municipal supply or groundwater aquifers.

Maximum points awarded in this criterion are 5 points.

Appraisal : Develop strategies in order to reduce the water required from local municipal supply or from groundwater aquifers for its annual water requirements for building use, domestic and other utilities and meet the water reuse requirements through on site recycle and reuse of wastewater or from rain water harvesting. :-

On site water reuse	Points
20%	1
40%	2
60%	4
80%	5

Table 3.21 On site water reuse

Observation : DTU doesn't require water from local municipal supply as it uses groundwater extracted by tube wells to meet the water demand for domestic use, buildings and other utilities. It neither adopt any strategies to reuse the wastewater. There is no rainwater harvesting system used in the campus to reuse the rain water for various purposes as the ground water table is high in this region so the rainwater harvesting is not at all recommended in DTU campus.

Hence no points are awarded in this criterion

3.5.5 Criterion 18 : Rainwater Recharge

Promote such strategies which help in the recharge of groundwater aquifers.

Maximum points that are to be awarded in this criterion are 2 points.

Appraisal : Appropriate filtration measures to be used in order to recharge of surplus rainwater into aquifer. :-2 points.

Observation :

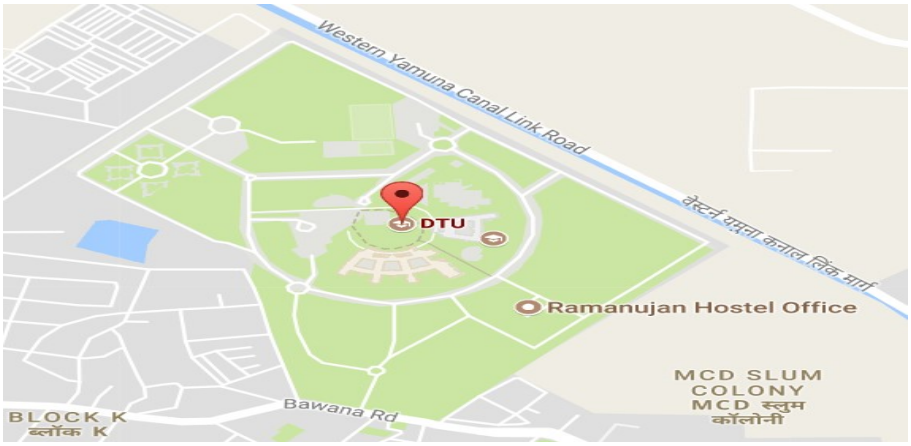

Figure 3.41 Map showing western Yamuna canal adjacent to DTU

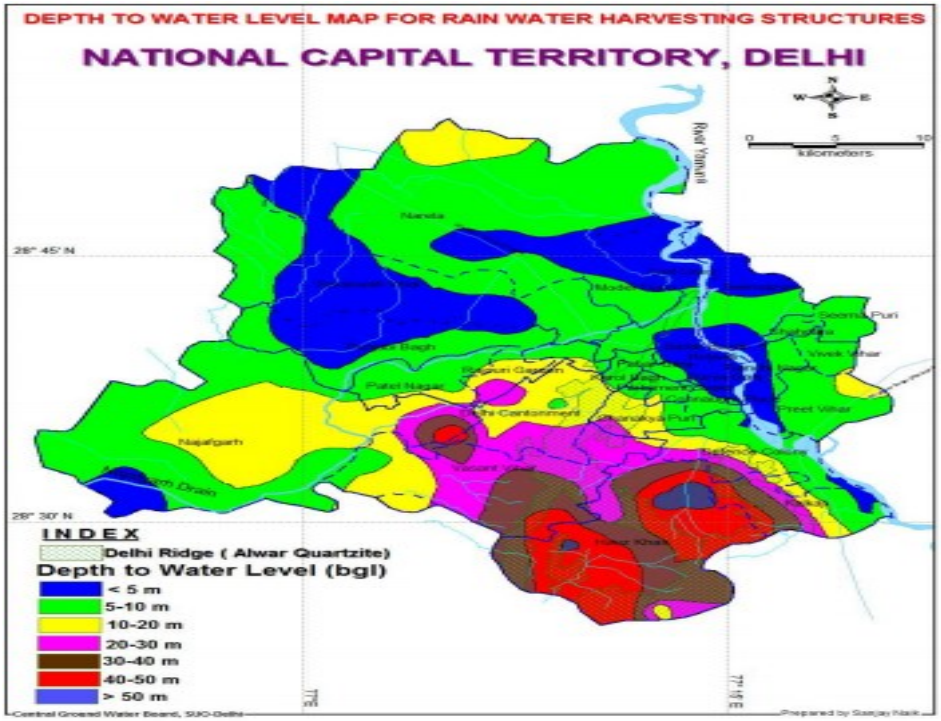

Figure 3.42 Depth to water level map for rain water harvesting structures, Delhi Central Ground Water Board

The water table of the DTU campus is high as western Yamuna canal flows adjacent to the campus. The depth to water level at DTU is less than 5 meter, therefore the collection of the surplus rainwater water through installation of rainwater harvesting structures are not recommended for DTU by Central Ground Water Board, Delhi. Hence no filtration measures are used in the campus to collect rainwater and reuse it. Therefore the no points are awarded in this criterion.

3.6 SECTION 6 : SUSTAINABLE BUILDING MATERIALS

3.6.1 Criterion 19 : Utilisation Of Waste Materials In Building Structure As Recommended By BIS

Promote the use of wastes that are recommended by BIS such as fly ash which have similar properties to conventional construction materials for building construction. These are low embodied energy materials and are waste products in order to reduce the need of virgin materials in the building construction which will ultimately help in diverting these substances from landfills.

The maximum points awarded in the criterion are 6 points.

Appraisals:

- Replacement of Ordinary Portland cement with fly ash by at least 15 % of the weight of cement that is used in the construction of the building. :- 1 point and if replacement is more than 25% :- 2 points.
- At least 40 % of the bricks are to be made by fly ash for load bearing and non load bearing masonry walls. :- 2 points
- Replacement of Ordinary Portland cement with fly ash by at least 15% in preparation of mortar :- 1 point and if replacement is more than 25%:- 2points.

Observation :-

J.K. Ordinary Portland cement of 43 grade was used in the construction of the DTU campus. Fly ash being an environmental friendly solution was mixed upto 25-30% by weight in the mixture replacing the ordinary Portland cement which ultimately increases the strength of the construction over time. This replacement of OPC with fly ash was also done in the preparation of mortar as it reduces bleeding which decreases the porosity and chances of the chemical attack. It also improved the paste to aggregate contact which resulted in enhanced bond strengths. Aggregate used in the preparation of mortar were of size 10mm and 20mm. Points awarded in these parts of the criterion are 4 points.

Burnt clay Fly ash(modular) bricks of not less than 7.5 N/mm² were used in the construction of DTU. Composition of the building blocks involved 40-45% of fly ash by volume in order to increase the compressive strength of the brick as the compressive strength of the bricks that uses fly ash increases with addition of fly ash percentage of up to 40-50% and thereafter the compressive strength of the bricks decreases. Hence the points secured in this part of the criterion are 2 points.

3.6.2 Criterion 20 : Reduction In Embodied Energy Of Building Structure.

Develop strategies in order to reduce the embodied energy of the building.

Maximum points awarded in this criterion are 4 points.

Appraisals :

- Develop strategies that reduce the embodied energy of load bearing structure and masonry walls by at least 20% below the base case. :- 2 points
- Develop strategies that reduce the embodied energy of load bearing structure and masonry walls by at least 30% below the base case. :- 4 points
  Base case :- RCC structure with burnt clay brick masonry. The live load, equipment load and span between the spans and the base case should be same and even the total length of the masonry wall should be same in both the cases i.e design case and base case of GRIHA.

Observation :

Embodied energy is an accounting method to find the total energy consumed in a life cycle of the product. It is the total energy consumed related to direct and indirect processes that are associated with the project or services.

Following cases are made in this criterion.

Case 1	Case 2
Strategies were developed which reduces the embodied energy of load bearing structure and masonry walls by at least 30 % below the base case .	No strategies were developed to reduce the embodied energy of load bearing structure and masonry walls below the base case.
Points awarded in this criterion are 4points	No points are awarded in this criterion.

Table 3.22 Cases in calculation of embodied energy of the building

3.6.3 Criterion 21 : Use Of Low-Environmental Impact Materials In Building Interior

Make sure that the certain low-environmental impact materials are used in the interiors of the building

Maximum points awarded in this criterion are 4 points

Appraisals:

- Demonstrate that a minimum of 50% of all materials used in the interiors of the building meets the criterion of GRIHA of materials that have low impact on the environment :- 2 points.
- Demonstrate that a minimum of 75% of all materials used in the interiors of the building meets the criterion of GRIHA of materials that have low impact on the environment :- 4 points.

The Materials that have generally less impact on the environment are:

- Stones that are manufactured in India
- Products can be made from composite wood.
- Products that have a minimum of at least 5% recycled content.

Observations: In order to make necessary information on the use of low environmental impact materials, following two cases are made :

Case 1	Case 2
At least 75% of all the materials used for the interior of the building meets the GRIHA criterion of low-environmental impact material requirements.	Materials used for the interior of the building does not meet the GRIHA criterion of low-environmental impact material requirements.
Points secured in this criterion are 4 points	No points are awarded in this criterion

Table 3.23 Cases on use of low environmental impact materials in building interior

3.7 SECTION 7 : SOLID WASTE MANAGEMENT

3.7.1 Criterion 22 : Avoided Post-Construction Landfill

Provide adequate infrastructure to the future users of the project so that they can manage the generated on-site solid waste during the operational phase of the project.

Maximum points awarded in this criterion is 4 Points.

Appraisals:

- Infrastructure is to provided to various building users such as multi coloured dustbins or/and different garbage chutes to make sure that the segregation of the solid waste takes place at source. :- 2 Points
- Proper hygienic storage spaces has to be provided in the project area to store different solid wastes before treatment or recycling. :- 2 Points

Observations:

- Various multicoloured dustbins such as green coloured dustbins for biodegradable waste (paper, paper boxes, paper clips, vegetable, tree leaves) and blue coloured dustbins for non-biodegradable waste (plastic, glass, bottles, metal cans, chemicals) are used to collect solid waste in the DTU campus which are placed at every 20-25 metre of distance.
- 3 hygienic storage places are provided in the campus such as :
  - One, at a distance of 25 metre from State Bank of India (in which all the residential solid wastes that are generated in the campus are dumped)
  - Second, at the adjacent to sister nivedita girls hostel (in which all the academic area's and girls hostels' solid wastes are dumped)
  - Third is in the boys hostel area near bhaskaracharya and varahmihira hostel (in which the solid wastes generated in all the boys hostel are dumped).
- Hence 4 Points are awarded in this criterion.

Figure 3.43 Dustbins outside Nescafe

Figure 3.44 Dustbins outside Civil and Environmental Engineering Department

Figure 3.45 Dustbins outside Mechanical and Production Engineering Department

Figure 3.46 Storage spaces of solid wastes near State Bank of India

Figure 3.47 Storage space of solid wastes adjacent to sister nivedita girls hostel

3.7.2 Criterion 23 : Treat Organic Waste On Site

Promote strategies of recycling and reuse of the organic waste that is generated on the project site.

Maximum Points awarded in this criterion are 2 Points.

Non applicability : If the total solid waste generation on the project site is less than 100kg/day, then the project is exempted from this criterion.

Appraisals : Develop and implement strategies to treat the organic waste such as kitchen waste that are generated on the project site and to convert it into a useful resource such as manure, biogas etc.:-2 points.

Observations :

- Two trolleys which can accommodate 500 kgs of wastes are used to collect the daily generated biodegradable and non- biodegradable wastes of DTU .
- Approximately 1000 kgs of wastes are generated in the DTU campus daily out of which 500 kgs are biodegradable wastes and 500 kgs are non biodegradable wastes.
- The wastes are collected from both the green and blue dustbins (which are used for biodegradable and non-biodegradable wastes) in the separate trolleys and the non-biodegradable solid wastes are then taken to the dumping sites to dump it into them.
- Rocket biogas plan is a further specific strategy that is adopted in the DTU to recycle and reuse the organic waste (and to convert it into a useful resource as biogas) that are generated in the DTU campus.
- This rocket biogas plant is situated adjacent to the canteen.
- Hence, 2 points are awarded in this criterion.

Figure 3.48 Rocket Biogas Plant to treat organic wastes generated in the DTU into biogas.

3.8 SECTION 8: SOCIO-ECONOMIC STRATEGIES

3.8.1 Criterion 24 : Labour safety and sanitation

Make sure that healthy, hygienic working and living conditions are provided for the construction workers working in the project site at the time of construction .

Maximum points awarded in this project are 1 point.

Appraisals : Provide proper drinking water facilities, hygienic working and living conditions, sanitary facilities for the workers in the project area at the time of construction. :- 1 point

Observations : Proper drinking facilities, hygienic working and living conditions, sanitation facilities are provided for the building occupants in the DTU. To ensure that these facilities were provided to the construction workers also at the time of construction of DTU, following cases are made :-

Case 1	Case 2
Proper drinking water, hygienic working and living conditions, sanitary facilities were provided for the construction workers at the time of construction of DTU.	No proper drinking water, hygienic working and living conditions, sanitary facilities were provided for the construction workers at the time of construction of DTU.
1 Point is awarded in this criterion	No points are awarded in this criterion.

Table 3.24 Cases on labour safety and sanitation

3.8.2 Criterion 25: Design for Universal Accessibility

Develop and implement such useful measures in the project in order to make it universally accessible.

Maximum points awarded in this criterion are 2 Points.

Appraisals :

Develop and implement various strategies on requirements for planning of public buildings meant to be used by physically challenged. :- 2 Points

Observations :

- Several ramps are provided for the physically challenged people in the academic area such as while accessing the Civil and Environmental Engineering department from the main gate of the department , accessing to microbiology lab from civil and environmental engineering department parking ,mechanical and production engineering department, canteen, while going to electrical engineering department from nescafe.
- No such ramps for physically challenged people are provided in the faculty housing or in boys/girls hostel.
- One lift is provided in the academic area which is in Electronics and communication department but no lift is provided in residential area including boys/girls hostel.
- No special parking and washrooms are made available for the physically challenged people.
- Only some areas of campus has the accessibility to the physically challenged people. Hence, the points secured in this criterion is 1 point.

Figure 3.49 Ramps in canteen to make it accessible for physically challenged people

Figure 3.50 Ramp in Civil and Environmental Engineering Department

Figure 3.51 Ramp in Electrical Engineering Department

Figure 3.52 Ramp outside Microbiology Lab in Environmental Engineering Department

Figure 3.53 Lift provided in Electronics and Communication Engineering Department

3.8.3 Criterion 26 : Dedicated Facilities For Service Staff

Ensure that there are adequate facilities of toilets provided for project service staff.

Maximum points awarded in this criterion are 4 points.

Appraisals : Toilet facilities are provided for the service staff that work on the project site. :- 4 Points

Guidance for estimation	
Fixtures	Population
WC's and L.C's	1 per 25
Washbasins	1 per 25
Urinals	Nil upto 6 1 for 7-20 2 for 21-46 3 for 46-70 4 for 71-100 and so on.

Table 3.25 Guidance for estimating toilet facilities

Observation :

DTU sanitary item detail (Block Wise)						
S.No.	Department	Urinal pots (nos.)	W.C. (nos.)	L.C (nos.)	Washbasin (nos.)	Looking mirror (nos.)
1	Electrical Engineering	24	8	24	36	36
2	Computer Science and I.T. Engineering	8	0	8	8	8
3	Civil and Environmental Engineering	8	4	8	12	12
4	Administration Building	10	7	7	14	14
5	Auditorium	8	8	8	16	16
6	Library	4	3	5	8	8
7	Computer Centre	4	3	3	6	6
8	Mechanical Engineering	12	8	8	16	16
9	Workshop	6	2	6	8	8
10	Gymnasium	0	2	0	2	2
11	Applied Science	14	13	11	24	24
12	Wind tunnel	2	1	1	2	2
13	Canteen	2	2	0	4	4
14	Gate Complex	0	0	1	1	1
15	Type-1 Quarters (Block-1)	0	0	15	15	15
16	Type -2 Quarters (Block-2)	0	0	15	15	15
17	Type-1 Quarters (Block-3)	0	0	15	15	15
18	Type-1 Quarters (Block-4)	0	0	15	15	15
19	Type -2 Quarters (Block-1)	0	0	15	15	15
20	Type-2 Quarters (Block-2)	0	0	4	4	4
21	Type – 2 Quarters (Block-3)	0	0	5	5	5

22	Type-2 Quarters (Block-4)	0	0	4	4	4
23	Type-2 Quarters (Block-5)	0	0	4	4	4
24	Type-2 Quarters (Block-6)	0	0	3	3	3
25	Type-2 Quarters (Block-7)	0	0	2	2	2
26	Type-3 Quarters (Block-1)	0	0	10	10	10
27	Type-3 Quarters (Block-2)	0	0	12	12	12
28	Guest House	2	9	0	9	9
29	Transit Hostel	0	15	0	15	15
30	V.C.'s Residence	1	2	1	3	3
31	Health Centre	4	0	4	2	2
32	Boy's Hostel (All 5 blocks)	210	64	86	158	158
33	Girl's Hostel (All blocks)	0	15	0	30	30
34	P.G. Hostel	22	11	11	22	22
	Total	341	177	311	515	515

Table 3.26 DTU sanitary items detail

There are a total of 515 toilets that are provided in the DTU campus for the building users in all the areas (faculty housing, hostels, academic area) of DTU. DTU has a total population of about 10000 people (approximately) which includes about 8000 (approximately) students(day scholar and hostellers) and 2000 service staff, faculties and their families .

Calculations :

- Water closets and L.C's:
- Number of W.C's and L.C's to be provided per 25 persons = Total population / 25
- Nos. of W.C's and L.C's = 10000 / 25 = 400
- Total number of W.C's and L.C's provided in the DTU campus = (177+311) = 488

- Washbasins:
- Number of Washbasins to be provided per 25 persons = Total population / 25
- Nos. of Washbasins = 10000 / 25 = 400
- Total number of washbasins provided in the DTU campus = 515

- Urinal pots :
- Taking 70% of the total population of DTU as boys and men.
- Total number of boys and men in the campus:- 7000
- 4 urinal pots are required for 100 boys/men . Number of urinal pots required for 7000 boys/men = 280
- Total number of urinal pots provided in the DTU campus :- 341
  Hence the total number of W.C's, L.C's, washbasins and urinal pots provided in the DTU campus are more than what was required in the project site.
  Therefore 4 points are awarded in this criterion.

3.8.4 Criterion 27 : Increase In Environmental Awareness

Create environmental awareness on sustainability among the building users and visitors.

Maximum points awarded in this criterion are 2 points.

Appraisal : Develop strategies to create environmental awareness. :- 2 points

Observation : The importance of environmental awareness is increasing day by day as the man made resources create a lot of environmental imbalance and hence it increases the importance of use of natural resources as much as possible in our daily lives.

In DTU, several major strategies are adopted in order to create environmental awareness.

- The most important and by far the largest strategy adopted in the DTU is the use of solar panels as the consumption of energy by the internal artificial lightning. Since the solar energy are abundant in quantity and is easily available so it reduces a large amount of use of annual energy consumption by internal artificial lightning. More than 35% of the consumption of the energy per year will now be reduced after the installation of solar panels in DTU this year .
- Planting more and more trees during and after the construction of DTU has also proved to be a great strategy in creating environmental awareness as the amount of carbon dioxide generated in the campus can be significantly reduced.
- Recycling and reuse of the organic wastes that are generated in the DTU campus in order to form biogas is also a great strategy in creating environmental awareness as this will reduce the dumping quantity of the wastes and results in the formation of biogas which is a useful resource.

  Hence the 2 points is awarded in this criterion

3.9.1 Criterion 28 : Smart Metering And Monitoring.

Promote smart metering and monitoring of energy consumed and the consumption of water on the project site and to analyze the performance of the building.

Maximum points that are to be awarded in this criterion are 4 points.

Appraisals: Ensure the regular monitoring of the project's energy consumption by installing meters in the project site.:- 2 points.

Ensure the regular monitoring of the project's water consumption by installing meters in the project site.:- 2 points

Observation :

- Regular monitoring of the DTU campus's energy consumption is done and meters are installed in the electricity room which is adjacent to the college temple which is at a distance of 50 meters from the main entrance of the DTU campus.
- Since water consumed in the DTU campus are groundwater extracted by tube wells and is not supplied by the municipal supply. Therefore no meters are installed in order to do regular monitoring of the water consumption of DTU.
- Hence 2 points are awarded for installation of meters to monitor energy consumption in the campus.

3.9.2 Criterion 29 : Performance And Assessment For Final Rating

Validate the performance of the energy, water and comfort conditions of the buildings in the project site during the design and development period.

No points are awarded in this criterion.

Appraisals : Several management systems of the building that are designed to reduce the consumption of energy, water and generation of solid waste are to be ensured that they are working properly as predicted at the time of award of GRIHA rating to the project

Observations : GRIHA rating of DTU is calculated in the operational phase of the project and hence the energy systems, water systems and solid waste management systems of the building are performing as per the information provided in the evaluation of GRIHA rating.

3.9.3 Criterion 30 : Innovation

Ensure that certain innovative strategies are adopted and implemented in the sustainability of the project.

Maximum points awarded in this criterion are 4 points.

Appraisals : 1 point is awarded to each of the innovation strategy that is implemented in the project area.

Examples of innovation are :

- A GRIHA certified trainer is included in the assessment of the rating of the project from start to end.
- Technology of green building is done in the country for the first time.
- Recycling of electronic waste are done in the project area.
- The total consumption of energy by indoor and outdoor lightning in the project is provided by the renewable sources in order to reduced the energy consumed by them.

Observation :

- No GRIHA certified trainer was include in assessment of the rating of the DTU.
- Installation of solar panels and rocket biogas plant are certain technologies that are used in the DTU campus but these technologies are being used in India for more than 10 years.
- Only organic wastes are recycled and reused in the DTU campus and no resusing of Electronic waste is done.
- Only 35 % of the energy consumption by internal artificial lightning are replaced by the solar energy that are generated from the solar panels .
- No points are awarded in this criterion.

CHAPTER- 4

RESULTS AND DISCUSSION

Out of 100 points assigned to 30 criterions in GRIHA Rating System for green buildings. Delhi Technological University secured the points awarded to them in two different cases.

Case 1	Case 2
The total points scored in this case of the project in which all the essential measures were taken at the time of construction of the DTU campus = 76 points	The total number of points secured in this case of the project where all the measures were not taken/avoided at the time of construction of DTU campus = 60 points.

Table 4.1 Cases in final estimation of GRIHA rating

Following ratings are assigned by the GRIHA rating on the basis of points secured by the project.

Points Secured	GRIHA RATING
25-40	1 star
41-55	2 star
56-70	3 star
71-85	4 star
86 or more	5 star

Table 4.2 GRIHA Rating System

- On the basis of points secured in both the cases, the GRIHA Rating of Delhi Technological University for green building are as follows.
- 4 star rating in Case 1
- 3 star rating in Case 2

CHAPTER-5

CONCLUSION

There are 2 GRIHA ratings that are being calculated for DTU. Case 1, in which all the measures and strategies were adopted in the DTU project site area at the time of construction and Case 2 in which none of the measures and strategies were adopted in the DTU project site area at the time of construction.

On the basis of 9 sections (which comprises of 30 criterions) that were considered in calculating the GRIHA rating of DTU, Case 1 secured 76 points out of total 100 points and is awarded with 4 star rating whereas Case 2 secured 60 points out of total 100 points and is awarded with a 3 star rating.

On the basis of these rating we can conclude that various measures and strategies are adopted in the DTU campus in order to make the buildings of DTU campus more green and environment friendly.

In order to improve its rating in near future, various more measures and strategies can be adopted to promote green building technology in the campus area and promotion of this green building technology should be done in the nearby areas in order to make a healthy environment for living beings

CHAPTER-6

SUGGESTIONS

The green building technology is widely used in the campus of Delhi Technological University. There are certain points in which better technologies can be used in order to make the DTU campus greener.

- Adoption of several waste water techniques to recycle and reuse it as for domestic purposes.
- Reduce the use of water by building occupants by using low flow fixtures, automatic flushing.
- Landscape water demand can be used by adopting various strategies used in irrigation engineering such as sprinkler irrigation method can be adopted in order to reduce water required in watering the plants and trees.
- Solar panels that are installed in the academic area, the same should be installed in the faculty housing and the hostel area in order to reduce the energy consumption by internal artificial lightning.
- More and more ramps should be made in the academic area and as well as in the residence areas so that the campus can be made fully accessible to the physically challenged people.
- Plant more and more trees in order to reduce the impacts of the harmful gases present in the atmosphere.

ANNEXURES

Annexure 1 : Campus Map of Delhi Technological University, Delhi

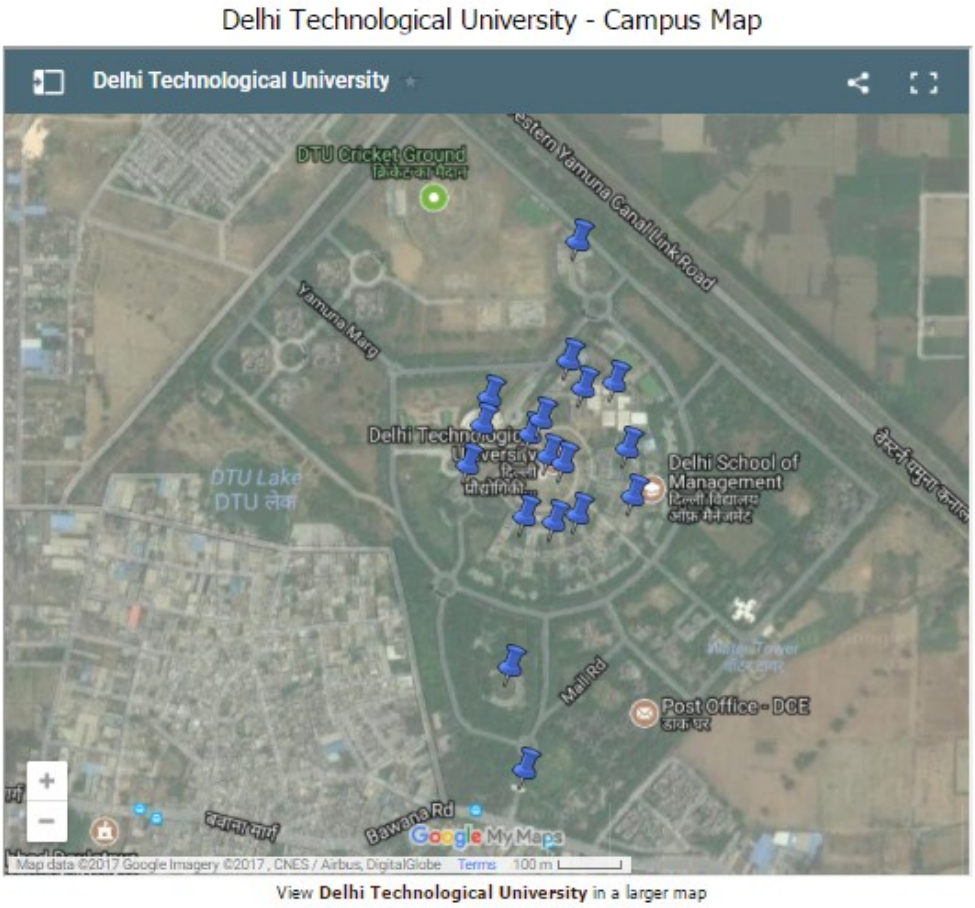

Figure I Campus map of Delhi Technological University, Delhi

Annexure 2 : Bureau Of Indian Standards For Drinking Water Specifications As Per IS 10500: 2012

Characteristic	Requirement (Acceptable limit)	Permissible Limit in the absence of alternate source
pH	6.5 - 8.5	No Relaxation
Turbidity (NTU)	1	5
Total dissolved solids (mg/l)	500	2000
Chloride (mg/l)	250	1000
Calcium (mg/l)	75	200
Total hardness (mg/l)	200	600
Alkalinity (mg/l)	200	600

Table I BIS for drinking water specifications as per IS 10500 : 2012

Annexure 3 : National Ambient Air Quality Standards (2009) By CPCB, Delhi

Pollutant	Time weighted Average	Concentration in Ambient Air	
		Industrial, Residential, Rural and other areas	Ecologically Sensitive Areas
SO2 (Ug/m³)	Annual	50	20
	24 hours	80	80
NO2 (Ug/m³)	Annual	40	30
	24 hours	80	80
Particulate Matter (PM10) (Ug/m³)	Annual	60	60
	24 hours	100	100
Particulate Matter (PM2.5) (Ug/m³)	Annual	40	40
	24 hours	60	60
Ozone (O3) (Ug/m³)	8hours	100	100
	1hour	180	180
Lead (Pb) (Ug/m³)	Annual	0.50	0.50
	24 hours	1	1
NH3 (Ug/m³)	Annual	100	100
	24 hours	400	400
CO (Ug/m³)	8hours	2	2
	1hours	4	4

Table II National Ambient Air Quality Standards by CPCB, Delhi

Annexure 4 : Ambient Air Quality Standards In Respect Of Noise As Per THE NOISE POLLUTION (REGULATION AND CONTROL) RULES, 2000

Category of Area	Limits in dB(A) Leq	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Area	50	40

Table III Ambient air quality standards in respect of noise by CPCB, Delhi

BIBLIOGRAPHY

[1] Adarsh, GRIHA V 2015 manual, May 2016, http://www.grihaindia.org/files/GRIHA_V2015_May2016.pdf

[2] Adarsh, The little book of GRIHA Rating, September 2012, http://www.grihaindia.org/static/Griha%20Rating%20Booklet_Dec12.pdf

[3] Alex Zimmerman, A. A. & Kibbert, C. J. (2007) Informing LEED's next generation with the Natural Step. Building Research & Information, 35, 681-689

[4] Anon, 2012, Glass facade buildings lead to temperature rise, says NEERI study, Hindustan Times, January 12, http://www.hindustantimes.com/India-news/Mumbai/Glass-facade-buildings-lead-to-temperature-risesays-NEERI-study/Article1-798228.aspx

[5] Apoorv Vij, (2013) GRIHA, SVAGRAHA and Green Buildings in working studio on Building Smart Human Cities by IIA, Bhopal Chapter

[6] BEE, Energy Efficiency in Building Design and Construction, a report, 2010

[7] Birt and Newsham, 2009, Post-occupancy evaluation of energy and indoor environment quality in green buildings: a review, 3rd International Conference on Smart and Sustainable Built Environments, Delft, the Netherlands, June 15-19, 2009), pp. 1-7

[8] BIS (Bureau of Indian Standards). 2005a Building services In National Building Code of India 2005 New Delhi: BIS [Section 4: Acoustics, sound insulation, and noise control]

[9] BIS (Bureau of Indian Standards). 2005b Plumbing services In National Building Code of India 2005 New Delhi: BIS [Section 5: Installation of lifts and escalators, subsection 5.5.11.2.1]

[10] BIS (Bureau of Indian Standards). 2005c Constructional practices and safety In National Building Code of India 2005 New Delhi: BIS

[11] BIS (Bureau of Indian Standards). 2005d Building services In National Building Code of India 2005 New Delhi: BIS [Section 1: Lighting and ventilation]

[12] BIS (Bureau of Indian Standards). 2005e Building services In National Building Code of India 2005 New Delhi: BIS [Section 3: Air conditioning, heating, and mechanical ventilation]

[13] BIS (Bureau of Indian Standards). 2005f Development Control Rules and General Building Requirements In National Building Code of India 2005 New Delhi: BIS

[14] Bo Xia1; Jian Zuo2; Martin Skitmore3; Stephen Pullen4; and Qing Chen5 "Green Star Points Obtained by Australian Building Projects." Journal of Architectural Engineering, Vol. 19, No. 4, December 1, 2013. ©ASCE, ISSN 1076-0431/2013/4-302–308

[15] Building Momentum: National Trends and Prospects for High Performance Green Buildings‖ 2002.U.S. Green Building Council, Baltimore

[16] Clark Bisel and Peter Simmonds "Efficiency and Comfort: An Integrated Approach". Consulting Specifying Engineer, Jan 1998

[17] CPCB (Central Pollution Control Board). 1998 Pollution Control Acts, Rules, and Notifications issued thereunder, Vol. 1, pp. 311–312 New Delhi: CPCB, Ministry of Environment and Forests, Government of India. 501 pp.

[18] Devi T, Laxmi, Green Building – Market opportunities and challenges, 2012,

[19] Fangzhu Zhang & Philip Cooke, Green Buildings and Energy, 2010 Cardiff University, UK

[20] Gowri Krishna Newsletter on Green Building From Indian Green Building Council, September 2007 Issue 17., Green Building Rating Systems An Overview ASHRAE journal November 2004

[21] Green Building Council , LEED reference package version 2.0, US, , June 2001

[22] Hopkins Philip, 2010, Green buildings failed by follow-up, The Sydney Morning Herald, December 8, http://www.smh.com.au/business/property/green-buildings-failed-by-followup-20101207-18oeq.html

[23] ICAEN (Institut Català d'Energia). 2004a Efficient water management and waste water treatment techniques, pp. 35–46 In Design Manual: sustainable building, vol. 2, 301 pp. New Delhi: TERI

[24] ICAEN (Institut Català d'Energia). 2004b Site planning, pp. 17–34 In Design Manual: sustainable building, vol. 2, 301 pp. New Delhi: TERI

[25] Khanna Ninza, John Romankiewicz, Nan zhou and Wei feng " From platinum to three stars: Comparative analysis of U.S. and China green building rating programs" ACEEE summer study on energy efficiency in buildings. 2-402-414.

[26] Kevern J.T. , A.M.ASCE1 "Green Building and Sustainable Infrastructure: Sustainability Education for Civil Engineers." Journal of Professional Issues in Engineering Education and Practice, Vol. 137, No.2, April 1, 2011. ©ASCE, ISSN 1052-3928/2011/2-107–11

[27] Lee WL, Yik FWH. Regulatory and voluntary approaches for enhancing energy efficiency of buildings in Hong Kong. Applied Energy 2002; 71:251–74.

[28] Mckensey & company, Environmental and energy sustainability, an approach to India, 2009

[29] McManus Brandi, Green Buildings Certifications, an Overview and Strategic Guidance for Schneider Electric Employees .

[30] Navar Mireya, 2009, Some Buildings Not Living Up to Green Label, The New York Times, August 31, http://buildinginformationmanagement.wordpress.com/2009/09/08/leed-certified-buildings-notperforming/

[31] Peng wu1 and sui pheng low2 “Project Management and Green Buildings: Lessons from the Rating Systems.” Journal of Professional Issues in Engineering Education and Practice, Vol. 136, No. 2, April 1, 2010. ©ASCE, ISSN 1052-3928/2010/2-64–70

[32] Perez-Lombard, L., Ortiz, J., and Pout, S., ―A Review on Building Energy Consumption Information‖, Energy and Building, Vol. 40, pp. 394–398, 2008.

[33] Saigaonkar R.G., Pimplicar S.S, Aher P.D., “Unique rating system for green building; By compairing various existing rating ayatems” ISSN: 2248-9622, Vol. 4, Issue 1 (Version 2), Jan 2014, 197-206

[34] Shrinivas S, Green Building Movement In India By, Principal Counselor, CII - Sohrabji Godrej green Business Centre, 2005

[35] Singh D, Chhoker P K, and Pandey R N. 2000 Soil plant water analysis: a methods manual New Delhi: Indian Agricultural Research Institute, 160 pp.

[36] Tathagat T, Yadav P, Saheb Y, McNeil M, Datta B.Standards and Labelling in India: Roadmap for 2030. In: Sixth International Conference on Energy Efficiency in Domestic Appliances and Lighting, EEDAL. 2011

[38] Vyas Gayatri Sachin and Jha K. N. “ Comparative study of rating systems for green building in developing and developed countries” ICCIDC-III July 4-6,2012.

[39] WBDG Aesthetics subcommittee report, Engaging the integrated sign process 2012

[40] White Paper on Sustainability: Are Port on the Green Building Movement. 2003. Supplement To The Building Design & Construction, November.

[41] W. Radhika "Constructing Change: Energy Efficiency and India's Buildings Sector, The Hindu Business Line, January 2012