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Original Article

Net Zero Energy Buildings in India - A Case Study

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Abstract - *Energy serves man and machine to work in terms of human comfort, considering the environmental aspects to achieve human comfort. Energy can come in any form or source, such as solar, wind, geothermal, etc. However, the application of energy depends on user requirements, energy converters, source of energy, and, most importantly, energy conversion and energy recovery systems. The main idea discussed in this study is how buildings can meet all their energy demands from these cheaper, easily available, and clean, renewable sources. This research paper primarily shows how an existing building can be converted to zero net energy with a systematic approach to building energy consumption profiles. The paper demonstrates an innovative approach to highlight the systematic thought on the factors affecting energy performances of non-energy efficient buildings. The study was conducted for all buildings of Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune. The analysis assessed various factors affecting a building's energy demand in a well-engineered way focused on the energy demand profile. Some methods of integrating energy-efficient analysis techniques into the different milestones of construction, namely Planning, detailed designing, erecting and actual operation of buildings, were studied to upgrade the human lifestyle and optimise the efficiency of existing premises. The study results show that users can significantly reduce the energy consumption of low-performance buildings.*

Keywords - *Zero Energy Buildings, Coefficient of performance, Variable air volume, Green building, Solar power.*

1. Introduction

Cities with Universities, high-rise residential buildings, and commercial business bays have become legendary symbols and icons of growth and development for any country worldwide. Day-to-day increases in electrical demand will create the need to generate more electrical energy, focusing on reducing the natural resources used to convert electrical energy. Buildings are, nowadays, considered the primary energy demand consumers, and in well-developed countries such as the United States, they record 33% of global carbon dioxide emissions assessed yearly. The energy usage of the building sector is increasing at a very fast rate. As a paper approach, the buildings designed and executed in the earlier few decades were not considered for an energy-efficient design approach because of many factors at that time. However, nowadays, older buildings consume more energy than modern Energy-efficient buildings. The paper gives some approaches to highlight the systematic thought on the factors affecting the energy performance of non-energy-efficient buildings. Until buildings are designed to produce enough energy per their daily demands and become sustainable, the annual energy demand will be produced in-house throughout the demand. With the increase in energy prices, and more importantly, because of the increasing effects of climate change, it has become increasingly urgent to decrease energy consumption, and one way of doing so is to target building energy use. This could also help to decrease the dependence on energy derived from non-renewable fuels. The main idea is that buildings can be made to meet all their energy demands from these cheaper, easily available, and clean, renewable sources. However, advancements in construction technologies and renewable energy systems are making Net Zero Energy buildings more and more achievable.

2. Brief Literature Review

The current energy demand from a larger, increased population globally will lead to increased infrastructure requirements, which are highly noticeable. The larger infrastructure requirements will lead to higher energy demand per capita, which is a very noticeable case nowadays. The upcoming new buildings are modern, and energy efficiency is taken care of. The research article gives us an idea about the energy demand for older buildings that were constructed a few decades ago. The analysis shows how older buildings can be assessed from an energy efficiency approach and converted to a net-zero building. The analysis gives an idea about how old buildings serving society can be looked at as net-zero energy-efficient Buildings. There is a vast scope available in society to save energy in non-energy-efficient buildings, which has not been focused on so far. Institutional, Banking, Offices, and Hospitals in old buildings can be converted into net-zero Buildings with a case-to-case study. Thus, Net-zero buildings in India are gaining attention as the country aims to reduce its carbon footprint and 0% carbon discharge by 2060. The article suggests initiating an energy-saving approach for older buildings.

The case study gives us a brief idea about the NZE initiative for Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, India, the academic building where the detailed audit has been carried out. The research analysis shows a systematic approach to identifying the causes of energy wastage by doing various activities throughout the year. The analysis also shows a brief comparison of existing utility equipment and proposed replacement of energy-efficient equipment, which will identify the optimal energy need for the complete academic year. By replacing existing non-energy efficient equipment and doing some modifications, we can save 45% of the energy of total annual demand, which is a basic requirement from the Indian Green Building Committee, which can certify the building as a green building, which will help to get the carbon credits and relief from government taxes. The report will help to become a sustainable building that is not dependent on energy needs for utility supply company services.

An analysis and detailed survey of the college campus will be conducted to identify the locations where the on-site electrical generation by solar PV is carried out. The research paper shows how older buildings can be converted to ZEB without compromising human comfort and electrical safety. The paper gives an idea about the different focus areas where energy efficiency can be improved, which helps energy auditors to focus on the following areas and utility components to reduce maximum demand and electrical energy consumption.

3. Zero-Net Energy Building

The Zero Net Energy Building (ZNE) is a building that has zero energy consumption during its use. This means that the Building uses renewable energy, which is created onsite, and this energy is roughly equal to the total energy used by the Building annually. For this type of Building, one unit of energy must be generated for each unit of energy consumed by the Building over a year. Most of these buildings are still connected to the utility grid. This is done so that the Building can use Electricity from the grid if the renewable energy generation is not enough to meet the electrical load of the Building. However, when the generation of the energy onsite energy exceeds the load, the excess energy should be sent back to the electric grid. The excess energy is then used in case of peak demands. This is why the energy consumption is said to be net zero.

3.1. Types of Zero Energy Buildings

Zero energy building can be divided into different categories. These categories are listed below:

1. Net zero Building energy: - The amount of energy produced at the same Building should meet the energy demands of the Building.
2. Net zero source energy: the energy produced at the source should meet the demands of the Building in terms of energy.
3. Net zero energy costs: - In a cost ZEB, the cost of energy purchase equals the amount of money received for the sales of excess Electricity to the supply company.
4. Net zero energy emissions: - The amount of energy produced from pollution-producing energy sources is almost equal to the emissions-free renewable energy it produces.

Table 1. Energy generation options (on and off Site)

S.No	Location	Description	Remark
1	Onsite Generation	Use of Renewable Energy available within Buildings	PV, Solar Hot Water, Wind Energy
2		Use Renewable Energy Sources available at the Site	PV, Solar Hot Water, Wind Energy, Low Impact Hydro, Wind Mills
3	Off-Site Generation	Use Renewable Energy Sources available. Site the Project	Biomass, Wood Pallets, Ethanol/Bio Diesel, and West Stream can Produce Electricity.
4		Purchase Off-Site Renewable Energy Generation	Utility-based wind, solar PV, emission panels, green purchase options, and hydroelectric generation off-site.

3.1.1. Net Zero Site Energy

This type of ZEB produces energy that it needs on Site. The energy generated is mostly from Photovoltaic panels mounted on the roof and on other surfaces such as at the parking, solar hot water collector, small-scale wind power and, in some rare cases, impact hydropower.

3.1.2. Net Zero Source Energy

Source energy accounts for both the energy demand of the Building and the energy required to transport the energy to the Building. It takes into consideration the losses that occur during electrical transmission. The imported and exported energy should be multiplied by the required site-to-source conversion factors to obtain the Building's total source energy.

3.1.3. Net Zero Energy Costs

The energy purchase cost equals the amount received to sell excess Electricity to the grid. This occurs when the Building has more energy than required; hence, it can sell the excess energy produced to the grid, which may be a challenge in future. Generally, in a drive to promote renewables worldwide, Government utilities offer higher costs for energy exported to the grid than that supplied from the grid.

However, such a revolution in India might be the next fold. Hence, in a building with onsite renewable power generation, selling power to the utility grid fetches more than imports from the grid. The net annual costs between power sold to the grid and consumed directly from the grid come to zero or +ve.

3.1.4. Net Zero Energy Emissions

Carbon emission from onsite or off-site fossil fuel use almost equals onsite renewable energy production. For example, suppose a building uses hydroelectric or wind power sources. In that case, emissions are already zero, and there is no need for any onsite renewable energy generation to balance the emissions. However, if that Building requires natural gas for heating, it will have to balance emissions by producing and exporting enough emissions-free renewable energy. Onsite measurements are used to check the adequacy of a site ZEB, whereas source energy or emissions ZEBs cannot be measured as easily since site-to-source factors are involved.

4. Factors Affecting on Building's Energy Use

For a new building, the most profitable way to obtain a reduction in the energy consumed usually occurs during the conceptual design process.Various factors alter the energy demands in a building.

These can be divided into three main categories: non-design and design factors. The design factors can be further divided into the passive design factors and the active system design.

Non-design factors are those affected by;

- Occupancy and management,
- Environmental Standards and
- Climate and Building application.

Passive design can be further divided into

The use of the Building's location and Site to reduce the Building's energy profile and the design of the Building itself, such as

- Size and shape,
- Orientation,
- Thermal mass,
- Daylighting,
- Passive cooling and heating and,
- Solar thermal Collector.
- Location of Project.
- Energy Use Profile.
- Operation Cycle of Building

5. Active System Design

This involves mechanical and electrical use to decrease the Building's energy demand. Some examples of mechanical systems include HVAC, extraction systems, Lifts and escalators, pumps, etc. The electrical systems include luminaires, motors and equipment used in the Building, such as computers, servers, UPS, printers, etc.

6. Energy Efficient Design

The figure below gives an account of the amount of energy consumed by a building in terms of lighting, electric heat, gas heat, Air conditioning, Exhaust fans, HVAC fans and other internal loads. Figure 1 shows the amount of energy a building consumes for various applications.

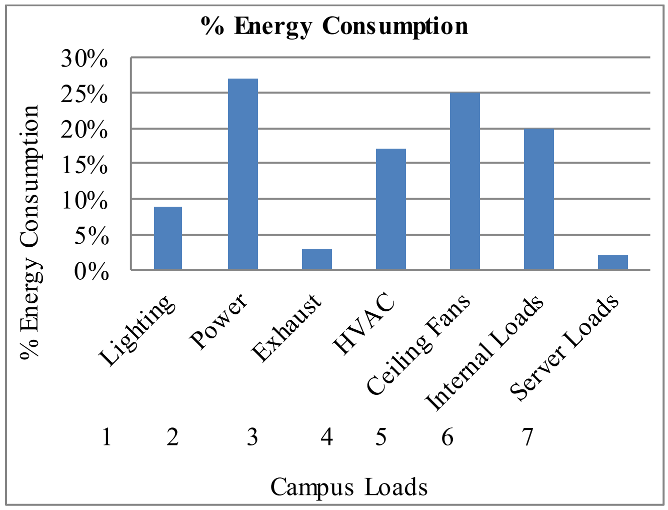

Fig. 1 Amount of energy consumed

7. Passive Design

This section will be concerned with the different factors involved in the passive design.

7.1. Size and Structure

The shape and structure of the Building are vital as they determine the amount of solar energy it receives, which affects its total energy requirements. Solar radiation can increase energy requirements by up to 25%. The surface exposed to the outside also determines the energy losses. Ideally, the ratio between the outer surface and the volume of the Building is related to a building's capacity to store or lose heat. The ratio between the outer surface and the volume should be small to prevent heat loss or heat gain. The shape also defines the percentage of the Building exposed at each cardinal point. A building in the Northern Hemisphere, with less wall surface facing the South, requires 8.2% more energy for heating.

7.2. Building Orientation

The orientation of a building is measured using the meters. GPS is a way of measuring the angle of a surface from the true north. Orientation, generally in the East-West direction, with the shortest lengths facing East and West, would be ideal to:

- Maximise natural daylighting and solar passive heating in cold climate countries
- Maximise natural daylighting and minimise the air conditioning loads in hot climate countries

Some benefits of having optimal building orientation are:

- Less capital investment can be planned at the detailed design stage of the property.
- Reduces energy demand.
- Reduces the need for complex passive systems.
- Increases the amount of daylight, reducing demand for artificial lighting and, therefore, reducing the contribution to internal heat gain on the premises.
- Advances performance of solar panels.

Overheating and glare can be mitigated by knowing how the sun will interact with the Building in the summer or winter.

7.3. Thermal Radiation Mass

It is the property of a building material to take heat inside and retain it in it. Two main parameters, heavy-weight and lightweight, describe buildings with different thermal absorption abilities. Buildings constructed with heavy-weight materials tend to take the heat in and retain it in them. Many cooling cycles are required to deduce the temperature of high-density materials like RCC, bricks, glass façades and tiles. They are called high thermal mass. Wood or Ply is a lightweight, low-density material with less thermal mass. A building with high thermal heat gain will intake, retain, and radiate heat to the internal interior or exterior, whichever way is the thermal driver. Thus, in a hot country, this will impact the internal comfort air conditioning cooling load; in a cold country, it will impact the heating load. Hence, in hot countries, buildings should be more open and lightweight. In cold climates, buildings should have high insulation and little exposed thermal mass. When used properly, a combination of passive solar PV design and appropriate thermal mass can reduce energy use in active systems. It is important, therefore, for the architect to be well aware of the properties of the materials that will go into the construction of the Building as well as insulation levels, as this will help to reduce energy consumption or the need for heating or cooling systems.

7.4. Day Lighting

Natural external daylight intensity varies from 400 Lux at sunrise/sunset to about 120,000 Lux during bright sunlight. Normally, an internal lighting level of 300 Lux is more than adequate for general office work. So, if ways and means could be found to maximise natural daylight inside a building, this would reduce the need for artificial lighting and electrical power. Artificial light can take up to 35% of a building's cost. So, the use of natural daylight should help reduce these costs. During the conceptual design of the Building, this criterion has to be considered. A building laid out in the East and West orientation with glazing along the longer North and South façades would allow daylight with minimum sunlight on either the North or South façades depending on which hemisphere the Building is located. The architect can also use other means to shield the glazing from direct sunlight, such as fixed or adjustable architectural sunshings on the façades or even special tinted glazing that would allow daylight into the room while preventing heat transmission into the occupied space.

7.5. Passive Cooling and Heating

This type of cooling or heating uses a natural process to remove or absorb heat. Summer cooling and winter heating are important in a building. Unwanted summer heat includes direct solar impact on buildings, heat transfer and infiltration of outside air through structure elements, and internal heat produced by lighting, equipment, and appliances. The Project should be planned in such a well-engineered way that sunlight striking the external surfaces is minimised. Painting the external surfaces with light colours, e.g. white, would reduce heat absorption by reflecting direct sunlight on the surface. The heat from surrounding outside areas should also be prevented from re-radiating and reflecting back into the Building. The laws of nature are used to carry out passive cooling: hot air is less dense and rises naturally, so this natural principle could be used in a building with external air entry at a lower level and extraction of warmer air at roof level. Many of the techniques used for passive cooling, such as insulation of the walls, will also prevent heat loss in winter.

7.6. Solar Thermal Collector

Solar water tubes are passive heat absorption which collect beaming heat from the sun to heat water circulated through tubes in the Collector for use as canteen or domestic hot water in the Building and as pre-heated water for general heating in cold countries. Solar thermal collectors are usually located on the roof to the inclination as necessary. An efficient solar thermal collection, a green energy source, can help considerably reduce utility bills in a building.

8. Active Design

This section will be concerned with the different electrical and mechanical systems involved in the active design.

8.1. Cooling System

For the general comfort of the occupants in a building, a cool and clean internal environment is required, Which is the key to employees' satisfaction, good health, happiness, and maximum productivity. To achieve such internal comfort conditions, it is generally required to treat, cool and circulate the air supplied to the occupied areas mechanically using Air Conditioning systems, which may include Central water chillers, air handling units, air supply and return ducts, Variable Air Volume (VAV) terminals, fan coil units, split air conditioning units, supply fans, return fans etc.

These mechanical components usually run on electrical power. In a building, it has been found that the air conditioning power load is more than 50% of the total electrical power consumption. Hence, reducing electrical power consumption is important for buildings to achieve a Net Zero Energy status.

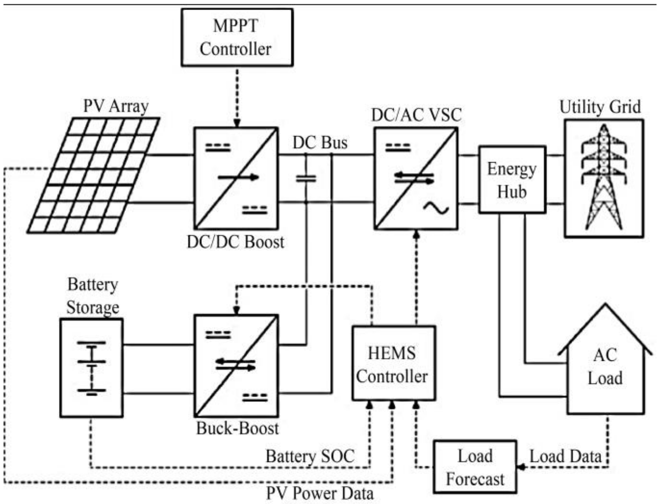

Fig. 2 Grid-connected residential Photovoltaic (PV) system with SEMS

A few Methods to reduce the energy consumption of HVAC in a building are as follows: -

- Use of star-rated water chillers with a high Coefficient of Performance (COP), variable speed condensing fans, the ability to modulate their cooling capacity as per the demand in the Building, etc.
- Use variable speed pumps in the circuit so that the chilled water flow varies as per cooling load requirements.
- Use highly efficient Variable Refrigerant Flow (VRF) systems for mini central systems.
- Use high-efficiency inverter-type air conditioners with high COP's and very low power consumption.
- Use highly efficient variable speed fans for air supply, return, and extraction.
- Balancing the peak electrical loads.

As mentioned above, the air conditioning power load, which adds to the general power load during the day, is shifted to the night. In this way, the electrical power consumed in the Building remains balanced at a low average. It does not have peaks, which would penalise the user over an extended period regarding electricity tariffs. Shifting the air conditioning electrical load to nighttime may also be beneficial if the electricity cost is lower at night.

This is the case in many countries, such as the USA and other well-developed countries. A highly Intelligent Computer Control system for the air conditioning system could provide the required exact cooling at any time by controlling each element, thus avoiding any wastage.

8.2. Lighting System

Lights in a building consume about 20% of the overall electrical power consumed in the Building. Therefore, Finding ways and means to minimise this load without compromising the lighting levels required for the different tasks being carried out in the Building has become crucial. LEDs are light-emitting Diodes, also called LEDs. LED performs at the atomic level to emit light energy photons source after getting a supply of Electricity. A simple 100-watt incandescent lamp can be replaced by a 36-watt Compact Fluorescent or 18-watt LED Bulb.

The LED lamp will not produce too much heat; comparatively, the air conditioning system has a very low load. Also, LED lights have an operation period of 30,000 burning hours in a lifetime, compared to 10,000 burning hours for CFL lamps and 1000 burning hours for normal incandescent lamps. In the technological revolution of today's lifestyle, advances in ID lighting are automated with computer-controlled smart, intelligent dimming LED lighting with human sensors within lamps.

These add to dim the outer natural daylight luma output in the workplace, generally set to 300 – 400 Lux, also got off when no movement in the premises, i.e. the male movement is absent. This system is generally wired to a Building Management System (BMS). Actual differences between different types of lighting bulbs used in various applications are to be evaluated during lighting design. As per the current trend and technological revolution, LED lights with the highest Luman outputs are more popular and have lesser wattages than other lights.

8.3. Photo Voltaic (PV) Electricity Generation

These are flat plate photon collectors (PV) placed at roof level to convert the light from the sun into electrical energy. Several PV panels can be installed on the roof at the required inclination for maximum solar exposure and solar thermal collectors for hot water production. PV collectors also come as architectural panels, which can be placed on the façade in the direction of the sun as sun blinds, where they act as both sun blinds to prevent direct sunlight through the windows and electricity generators. A further improvement in the inclination of the PV collectors is to have them automatically oriented always to be perpendicular to the sun's rays so that they get the maximum power from the sun. With all the energy savings features incorporated in a building, the power produced by the PV panels could meet the demand of the Building or even be in excess so that it can be exported back to the mains grid.

If the Building is connected to the grid, then the excess power produced by all the PV panels can be exported to the grid during the day, while Electricity is obtained from the grid at night. The required solar PV connection details are in the image below, Figure 3. Thus, with careful yearly monitoring, the balance on an annual basis can become zero. The daytime energy consumptions are fed through the solar PV to the internal electrical network. At the same time, the access solar PV-generated electrical energy will be stored in Battery Banks. The stored energy will be utilised during nighttime through batteries.

9. Proposed Zero Net Energy Building Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, as Case Study

In India, commercial and residential buildings use up to 48% of the Electricity generated. Many Buildings in India nowadays are zero-energy buildings and have been operating efficiently for many years. The Net Zero buildings cost 20 to 30 percent more than a normal building. This zero-net energy building was designed to improve energy efficiency in building design and use.

Clean, renewable energy generation and extensive energy efficiency strategies achieved zero energy-related costs. Some of the energy-saving strategies include double panel windows to reduce heat gain. At the same time, it provides natural light, high-efficiency pumps and fans, office equipment that requires less energy, and harvesting rainwater to provide for its water needs, such as gardening or cooling the condenser. All these analyses helped to present the energy usage of the Building by 45% compared to a conventional Indian institutional office building. The proposed Building is the Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, India. The academic engineering Building has more potential to reduce the energy demand and conserve energy. The energy saving report and the scope/ energy saving are given in the summary below, and the calculations are in Table 2. The table below shows the actual comparison between existing unit energy consumption and the estimated unit consumption of each application after replacing the equipment with star-rated BEE-certified equipment. Drastic reductions in energy use without compromising on human comfort can be achieved.

Table 2. Comparison between existing installation vs Enerfy efficient equipments

Energy Statement for Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, India Acamadic Building for Net Zero Building						
Sl. No.	Description	Conventional		Energy Saving Method		% of Energy Saving / Day
		Units / Day	Cost (Rs. 7.5 / Unit)	Units / Day (kWh/ Day)	Energy Cost Saving / Day (Rs/Day)	
1	Building Block 01	600.1	4500.7	347.2	2604.0	42.1
2	Building Block 02	600.1	4500.7	347.2	2604.0	42.1
3	Energy Saving for Ceiling Fans	108.8	816.1	40.2	301.3	63.1
4	External Lighting Loads	14.0	105.0	8.6	64.8	38.3
5	Plumbing Loads	24.0	180.0	21.6	162.0	10.0
6	HVAC LOAD By replacing Star Rated Outdoor Units	80.0	600.0	24.0	180.0	70.0
	Total	1427.00		788.81		
	Units Saved/Day	638.19	kWh			45%
	Total No of units Savings / Year	159547.30	kWh			
	Required No of Units per year	42000.00	kWh			
	Units Generation Savings with Solar PV per Year	50400.00	kWh			
	Proposed SOLR PV Rating	120.00	kWp			

Energy-saving opportunities are mostly through energy-efficient LED lighting, which has an efficacy of more than 120 Lumen per watt. Replacement of conventional ceiling fans with Brushless DC Fans, which are available at 25 to 32 watts and replace 80 watts (1200mm) Fans. The speed control can be achieved through remote control, so fan regulators are not required. External street lights are proposed to be replaced with 48-watt LED lamps at the required colour temperature. The existing government offices, old institutional buildings, private offices, malls, and theatres are major sources of electrical energy consumption recorded. The systematic approach of energy use profile, quality of electrical supply, and identification of the non-energy efficient electrical and mechanical equipment consistently used must be identified to know the actual energy gap of Required V/S Available, which must be a future necessity. The current trend of energy-efficient upcoming new installations abides with green building requirements, which are to be followed by IGBC guidelines. However, reviewing and reassigning the energy profile of older, non-efficient buildings is necessary.

The above case study is assessed based on the necessity of converting older non-energy efficient buildings into partially efficient buildings as an initiative towards utilising natural resources and reducing energy use to create a sustainable environment for human beings in the future. The energy consumption readings were taken during the peak energy demand at the main incoming source to identify the peak demand. Also, the maximum Peak demand is verified through utility company bills; the maximum recorded peak demand is considered for assessments.

The available Natural LUX levels in different areas are measured during the daytime and Nighttime through LUX meters. The Luman Output of each recommended light fitting was referred to from the Photogoni Meter Curve given in the IES datasheet the manufacturer declared. The above assessment is done in March 2023, April 2023, and May 2023, during which the maximum peak demand data can be recorded, and the peak HVAC requirements are utilised. The maximum solar heat gain and solar radiation are recorded during peak solar days.

Table 3. Electrical energy consumption comparision existing and proposed for NEB

Sr No	Billing Month	Existing Energy Consumption in kWh	Recorded MD in Wyatt	Proposed Energy Consumption in kWh (After Renovation)	Energy Max Demand after NZB	Required Solar PV Generation in kWh per Year
1	Apr-24	14791	49.2	9614.15	34.44	10575.565
2	May-24	4635	37	3012.75	25.9	3314.025
3	Jun-24	3790	22.4	2463.5	15.68	2709.85
4	Jul-24	18606	33.32	12093.9	23.324	13303.29
5	Aug-24	16118	33.92	10476.7	23.744	11524.37
6	Sep-24	10014	169	6509.1	118.3	7160.01
7	Oct-24	16503	167	10726.95	116.9	11799.645
8	Nov-24	4646	16.44	3019.9	11.508	3321.89
9	Dec-24	5261	76	3419.65	53.2	3761.615
10	Jan-25	5005	76	3253.25	53.2	3578.575
11	Feb-25	8938	76	5809.7	53.2	6390.67
12	Mar-25	8536	29.28	5548.4	20.496	6103.24
	Total	**116843**		**75947.95**		**83542.745**

Below, Fraphs shows the actual impact before and after NZB. The energy consumption profiles also assessed from April 2024 to March 25 are carried out so that the minimum energy demand of the academic Building can be recorded, and the available natural resources are also reviewed. The assessment readings are very attractive and lowest from August 24 to November 25. Month-even building services utilisations are top requirements. All the classes and lab equipment are utilised to conduct various study experiments on class days. As per the above-collected data, the solar PV capacity of 150 kWp shall be enough for the above-said Building to convert the existing academic Building into a net-zero building. These types of buildings are, therefore, becoming more realistic nowadays.

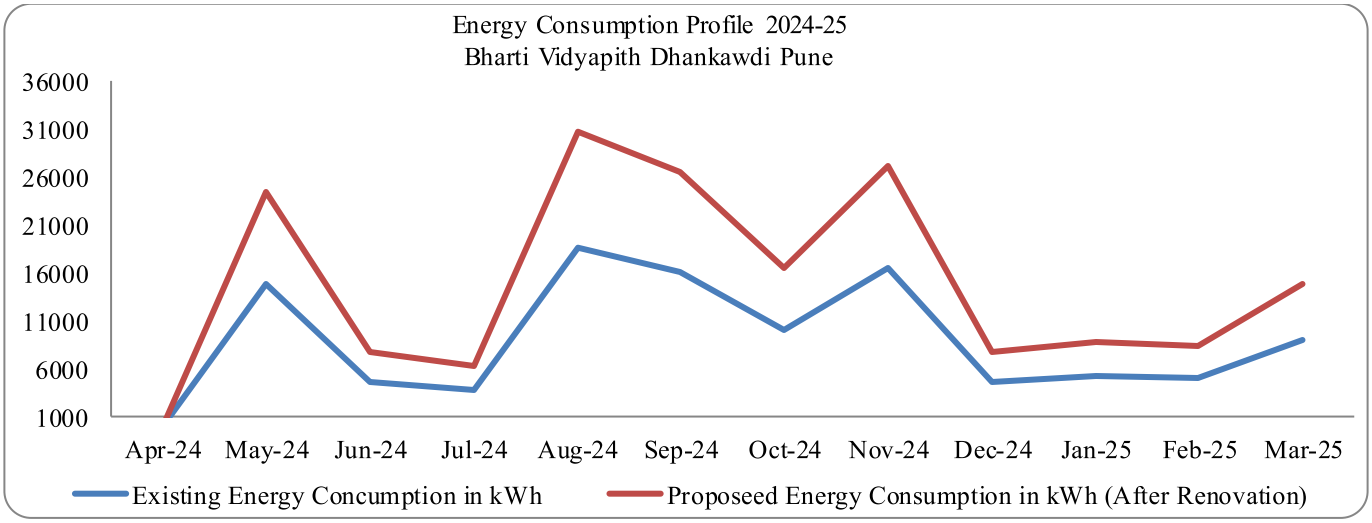

Fig. 3 Energy consumption profile

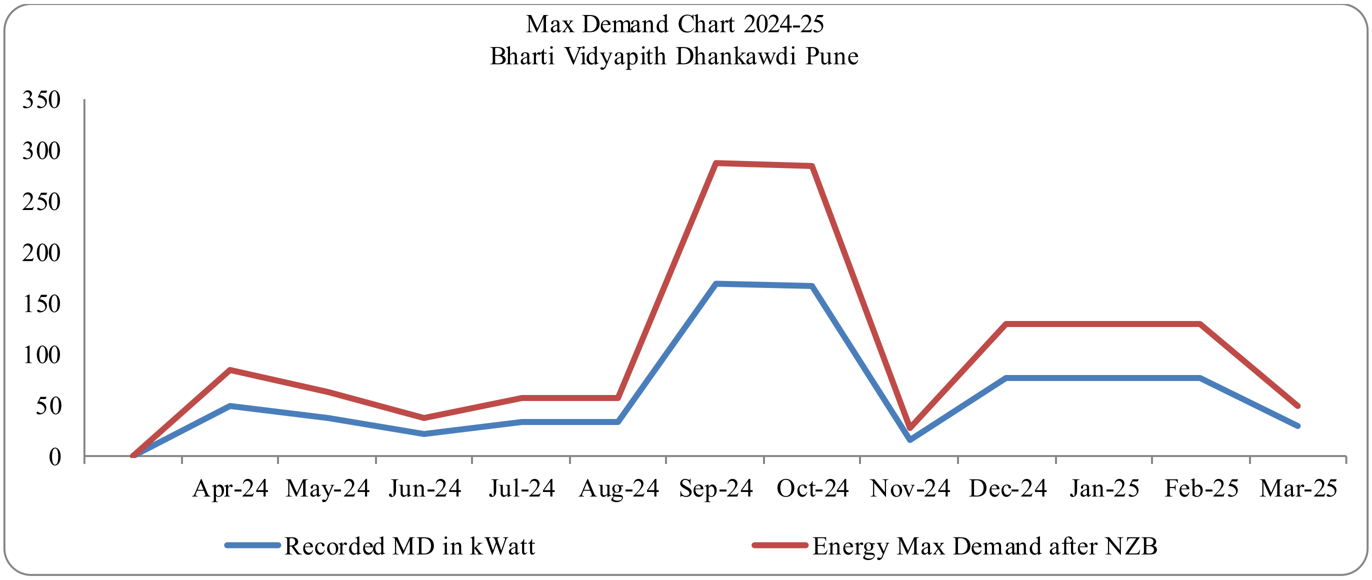

Fig. 4 Maximum demand reduction before and after NEB

10. Methodology Used

To assess the above research papers, a preliminary energy audit of the engineering block is carried out using different methods of data collection and simulation software.

1. Energy consumption readings of different applications through digital energy meters and Fluck Clamp Meter.
2. Identifying maximum peak demand reached throughout the year based on data collected from utility companies.
3. HVAC requirements and HEAT load analysis in the air-conditioned area are done with calculation and temp readings.
4. Lux level available and actual requirements in class through LUX Meter.
5. Data collection from existing Lab equipment and its operational frequency to identify the simultinity factor of lab equipment.
6. Solar PV Capacity requirements and sizing of Solar Panels by Manual calculations.
7. Auto CADD was used to analyse the classroom and lab sizes.

11. Conclusion

The academic engineering building of Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune, India, has been operational for many decades and has the highest energy demand. A systematic review and research of energy utilisation surveys have been carried out, and it was found that the Building has more potential to become grid-free from supply utility buildings. Further, a detailed study has been conducted, and it was found that the energy survey and retrofitting of energy-efficient equipment will drastically reduce energy demand without compromising human comfort. The study highlights the significance of energy-saving potential and converting existing Buildings to NEB by replacing non-efficient building accessories with star-rated fan lamps and implementing solar PVs and accessories. Considering the present scenario, the entire campus can be free with an external energy supply, and the Building can be a 100% net zero self-energy dependent institute. Also, the campus has the in-house capability to generate electrical energy using solar PV, making the Building self-sustainable and a Net Zero Building. The total energy saving can be done upto 45% of existing demand, and the Building can become self-sustainable. Further, Green Building certification can be done after this study. Also, onsite energy demand can be fulfilled with the help of the idea proposed in this study research work. This case study building could be the first Project converted into a Net Zero institute in India.

11.1. Future Scope

Based on the above assessment method and collected data, a similar assessment can be done for the medical college building, hospital building, architectural department building, and the entire campus, including common centralised utility equipment. The centralised STP, ETP, groundwater tank, and transfer pumps can be assessed. The optimum energy use awareness drive to complete campus staff can be carried out.

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