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Development of Primary Energy for the Nation

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ABSTRACT

The present research emphasizes upon the utilization of alternative renewable energy sources, mainly solar energy, to fulfil the energy demand in buildings. The article includes a review of the literature on the kinds of field data required, parameters for energy-efficient structures, estimate of solar energy production on buildings, techno-economic analysis, and viability of Building Integrated Photovoltaics (BIPV). The team's results in both instances indicate that retrofitting BIPV in an existing structure is costlier than designing a building with BIPV in mind. In addition, BIPV modules offered great architectural shape and enhanced the building's overall aesthetics. The BIPV has been shown to be cost efficient since it not only generates energy but also reduces the cost of the construction materials it replaces. We estimate the payback period for BIPV to be 60-180 months, depending on the kind of connection, the quantity of energy replaced by BIPV, as well as existing government policies regarding incentives.

Keywords

Building Integrated Photovoltaics (BIPV),Economic Payback, Primary Energy, Retrofitting, Self-Sufficient Building.

1. INTRODUCTION

Through a GDP growth rate of about 7.38percent, India emerged as the world's biggest energy user. Rendering to the Ministry of Statistics and Programme Implementation of the Government of India, energy consumption per capita increased almost fourfold between 1970 and 2010. However, India's yearly energy consumption has risen five-fold over the last three decades, from 1980 to 2010 (3.8 quadrillion Btu to 21.8 quadrillion Btu)[1]. This is due to better urban living standards and more sophisticated energy usage techniques in the home and industrial sectors. Buildings in India account for at least 29.8-39.8percent of total energy consumption, and this demand is increasing at an annual rate of 10.8-11.8percent, twice the mean annual growth rate of power in the country, that is 4.8-5.8percent[2].

Building in India is seldom designed to reduce energy from a macro viewpoint. Water conservation is getting increasingly fashionable. Despite this, the energy issue remains unresolved. On a global basis, building design for energy efficiency in India (Fig. 1) may be the most gifted option, since the building segment hold the largest potential for lowering GHG emissions[3].The economics besides dimension of the Photovoltaic array are influenced by the technological state. The system's grid-connectivity, i.e. whether it's off-grid or grid-connected, has an effect on the design[4].

For a self-energy sufficient building, we utilized solar passive design and BIPV while optimizing the claim for heating alongside day-lighting. As a consequence, integrating the two components not only opens the path for net-zero energy but also enhances energy efficient structures. Potential location, climatic circumstances, as well as the user's technical and socio-economic position, are all aspects taken into consideration while designing. It should be noted that a potential installation location is least impacted by shadowing as well as is one that gets the greatest solar irradiation throughout the day. It includes orientation, the prospective site's location, as well as size. Solar irradiation related to the site's tilt and azimuth are among the climatic conditions[5].

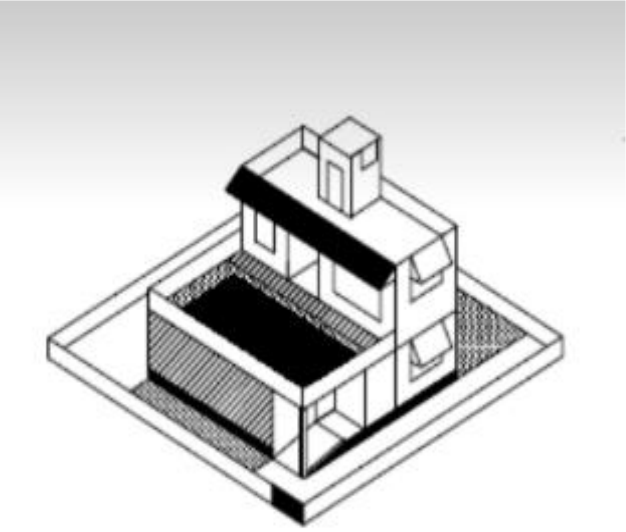

Figure 1: Three-Dimensional View (Isometric) Of Building (Proposed)

2. LITERATURE REVIEW

S Wittkopf et al submitted the business the first Zero-energy building of BIPV in Singapore. BIPV has established itself as a key foundation of power via excellent integration as a structural component. The submitted study addressed the development of BIPV prototypes, final design criteria, and tender assessments. The commissioning took place in the autumn of 2008, followed by a year of evaluation and fine-tuning. The rendering and efficiency estimates shown here may be used as a reference for the real performance until it is installed. A first energy balancing simulation comparing the monthly and daily energy demand with PV supply indicates that we are on pace to achieve the net-zero-energy goal. BIPV has been regarded not just as a technology for generating energy, but also as a building component intended at enhancing architectural aesthetics. At the Building Construction Authority in 2008, when the multifunctional behaviour of PV was examined, it gave recommendations for integration. They looked examined the viability of different installation locations, such as skywalks, walkways, and parking lots. When the projected Photovoltaic construction was equated to the claim, the findings are found to be promising[6].

S N Tabriz et al.Integrated architectural design via the BIPV scheme in a recent research study, proposing planning changes using BIPV as a consideration. Daylighting is the use of sunshine or skylight to illuminate the interiors of buildings, and it has been proven to enhance visual performance, lighting quality, fitness, human performance, and energy usage. Houses that offer insulation, ventilation, cooling, and natural heating and enhance human health, as well as BIPV system, have been emphasized. Sustainable building is one of the major topics of design throughout the globe these days since it is energy efficient. It is ideal when buildings be updated with Building-Integrated photovoltaic cells and collectors since it saves energy supply and maximises daylighting[7].

John Byrne et al. computed the PV value, cost, and payback time of polycrystalline as well as monocrystalline Photovoltaic modules in Shanghai, China. Rooftops and curtain walls have been explored for PV module installation in a research published in 2001. PV Planner, a programme developed by the Centre for Energy and Environmental Policy (CEEP) in partnership with the US National Renewable Energy Laboratory, offers simulation and financial analysis of BIPV for a range of infrastructure settings under various tools, policy, and financial circumstances. Thin film and polycrystalline PV modules are evaluated in a hypothetical site. BIPV multitasking is stressed, and the payback period is expected to be shorter than five years. The research produces different economic pricing for investments in the United States and China. We believe that the regulatory settings around grid-connected BIPV are mainly too responsible for this mismatch. Finally, the study discusses policies linked to BIPV development and offers suggestions for how China can make BIPV more economically appealing and promote broad use in large cities[8].

K. Kurokawa et al in the paper concerning grid-connected Photovoltaic system for experimentation upon industrial, commercial, and residential building. PV implementations in metropolitan settings are discussed in depth in this article. PV power may become extremely significant when a big number of PV systems are deployed in the region, and overall optimization for the entire area will be required. In terms of community PV system design and municipal energy delivery network. It concentrates on centralised connections, with a 0.8 Mega Watt Photovoltaic plant placed atop the rooftops of houses. Assuming these circumstances, current developments in suburban districts, commercial regions, and manufacturing uses are examined. The technical challenges for BIPV and electrical engineering are also summarised.[9].

Research Question:

- How to Development Primary Energy for the Nation?

3. METHODOLOGY

3.1. Design

3.1.1. Formulae for Calculating Energy Generation, Estimating Required Area, and Calculating Costs

The BIPV system is intended to meet the whole building's complete energy consumption. The three types of BIPV panels were chosen for their suitability as a construction material, with 15.348percent efficiency for Multi-crystalline C-Si panel with 249.8 Watt-peak, 9.8percent efficiency for Multi-crystalline BIPV module (Glass-to-Glass laminate) with 134.8 Watt-peak, besides 6.8percent efficiency. According to current market research, mounting, accessory, and labour expenses would amount for 24.8percent of the total cost. Other considerations include a Direct Current into Alternate Current DE rate factor of 0.68 (calculated using Indian conditions); a 29.8percentadministration funding up to 0.8 kW for housing installations as well as up to 99.8 kW for institutional and commercial installations; and a 29.8percent government subsidy up to 99.8 kW for commercial besides institutional installations[10].

Sample:

3.1.2. Calculating the amount of space needed for a PV installation

PV's area need was calculated in an iterative manner. First, based on the main construction survey, the maximum energy consumption is estimated/ projected, and the BIPV region is calculated using eq. (1). The required area for BIPV fitting was then linked to the actual area available upon the likely placement via an iterative procedure. Sunshade, skylight, rooftop, and finally façade have been the main exteriors accessible for solar fitting in decreasing way. When the desired area is equal to or less than the available space for BIPV, the iterative process will come to an end. IWEC offers the irradiance information used in the computation of region as well as the power production across various apparatuses.

$$A_{req} = D/(\eta \times I \times l) \quad \text{eq. (1)}$$

3.1.3. When the installation area is known, the projected energy generation can be calculated

Solar irradiances are used to estimate energy generation. As a result, the energy produced is given by

$$E = \eta \times I \times l \times A \quad \text{eq. (2)}$$

3.2. Instrument

3.2.1. BIPV Retrofit of the PDPU's SPT-1 Facility

On the PDPU campus, the SPT-1 building contains ten classrooms, nine laboratories, a library, a faculty wing, offices, and a welcome area. The study team performed a survey to collect construction drawings, current energy consumption, and physical features of the building. The home faces 298 degrees south of west; the façade wall's length was 98.2248 metres; façade wall faces east; wall gets 4.808 kilo Watt hour/meter2 solar irradiance upon its vertical exterior upon mean in the month of January at a 1/4-day exposure. During the examination, it was found that the building's longest side is 98.218 metres long and faces east.

3.2.2. Battery Size Calculation

As indicated in eq. (3), battery size was calculated based upon fitting capacity, length of battery procedure, as well as the available battery voltage. It's worth mentioning that size of the battery was usually raised by 19.8-24.8percent suitable notwithstanding anticipated future claim achievement.

$$\text{Size of the battery} = \frac{(Installedcapacity \times Hoursofoperation)}{Batteryvoltage} \quad \text{eq. (3)}$$

3.2.3. Payback Period Calculation

The time it takes to recover your investment is determined by the net cost, yearly savings, and annual profits. The cost of replacing building materials with the payback calculation for accelerated depreciation method as well as the BIPV panels are not included in this study.

Paybackfor depreciation = Net cost/ (Annual Earnings+ Annual Savings) eq. (4)

3.3. Data Collection

The average daily demand from July 2009 to May 2012 was collected from the PDPU Gandhi Nagar Amenities and Logistics Department. As shown in Fig. 2, the electricity usage has increased fourfold. The increase in tenancy and expanded use of large-voltage applications was to blame for the development. Furthermore, the figure indicates that energy consumption is lower in the months of November to January and higher in the months of March to September. The high power demand of the SPT-1 buildings requires the usage of renewable energy sources as a backup. The BIPV technique has been selected as an alternate power source to replace all before half of total consumption.

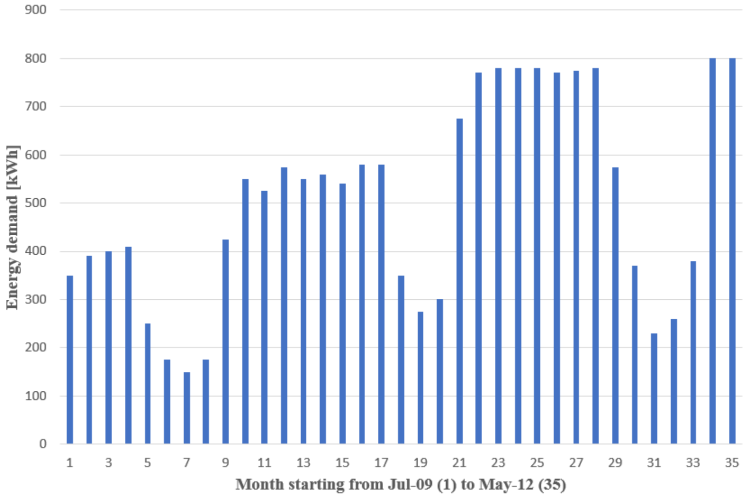

Figure 2: From July 2009 to May 2012, the SPT-1, 2 Building Had a High Energy Demand

3.4. Data Analysis

3.4.1. The cost was calculated using the current bazaar value of Photovoltaic panel besides BOS in the Indian bazaar

The prices of Battery (11.8V, 99.8Ah) of 9,998 per unit; Inverter (7.48/Watt-peak); Multi crystalline A-Si Thin film module 249.8 Watt-peak (44.8/Watt-peak);Multi crystalline C-Si module 249.8 Watt-peak (79.8/Watt-peak); and PV panels were originate to be BIPV module (Multi-crystalline) 134.8 Watt-peak (69.8 /Watt-peak), built upon a bazaar review conducted by the investigation crew.

Table 1: Characteristics of SPT-1 Construction Sites

Site	Mean irradiance [kilowatt hour/meter^2/day]	Position of installation	Area available [m^2]	Dimensions of panel [m]	Types of panel used
Sunshade	5.958	At 67^0 w.r.t., vertical	168.648	1.65 × 1	Multi-crystalline Carbon-Silicon 250
Adjacent fence	3.398	Vertical	280.58	1.65 × 1	Multi-crystalline Carbon-Silicon 250
Hole-in-the-wall	3.398	Vertical	314.438	2 × 1	Multi-crystalline BIPV 135

3.4.2. Calculation of electricity generation on the facade wall at different locations

Probable solar sites accessible upon the various apparatuses of the façade fence, such as sunshade, neighbouring fence, and holes-in-the-wall, have been suggested for fitting based on the area estimated from the building plan and elevation. For the purposes of this measurement, the energy consumption from July 2011 to June 2012 has been selected. Table 1 shows the installation's location, average irradiance, and panel type.

4. RESULT AND DISCUSSION

Table 2 shows overall usage on daily basis of the building throughout the course of many months. The lowest usage is 277.8 kWh in January, followed by 299.8 kWh in February, while the maximum consumption is 767.8 kWh in July and June, respectively. However, by incorporating Accelerated Depreciation (an incentive) in the calculation of the remuneration length, it is further reduced, demonstrating its feasibility. The BIPV technique produces excess throughout the year, yet the need in June is precisely fulfilled. The entire excess occurs from January through April, when all of the demand has been satisfied. The quantity of CO_2 emitted into the environment as a consequence of power consumption has been restricted to zero. eq. (3) is used to measure the size of the battery backup.

Table 2: SPT-1 Building Consumption on a Daily Basis

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Demand [kWh]	277.8	300	670.8	751	763.8	766	766	753	759	764.8	559	277.8

Table 3 shows the space required against the area available on the sunshade, surrounding walls, and glass, as computed using equation (1). The highest area available for BIPV installations was 46.78percent of the total installation space needed. As a consequence, BIPV installations are unable to satisfy the-total power demand. In column 2, it shows the remaining unfulfilled demand after each installation. It should be noted, however, that, while accounting for 36.168percent of total built-up area, the installation area substitutes 45.708percent of whole electricity consumption.

Table 3: Calculation for the Appropriate Region besidesthe Percentage of Demand Met by Locations

Size	Required installation area [meter^2]	Available installation area [meter^2]	Maximum demand unsatisfied [kWh]	Reduction potential [%]
Sunshade	1631.848	168.648	767.00	17.288
Adjacent wall	3420.218	280.58	683.548	16.428
Window	6884.728	314.438	627.468	11
Total		763.688		

Using eq. (2), the daily mean energy supplied by the BIPV onto a 763.668 meter^2 accessible area was measured. CO_2 emissions are estimated using www.carbonify.com's online calculator, which estimates saving a single kilo-Watt-hour of energy save 8.88 gram of carbon dioxide - was used to-establish the cost and payback date. The present system fulfils 45.708percent of the energy requirement.

Table 3 shows that the entire area underneath fitting was 763.688 meter^2, or 36.168percent of the total area on the facade, which replaces 45.708percent of demand.

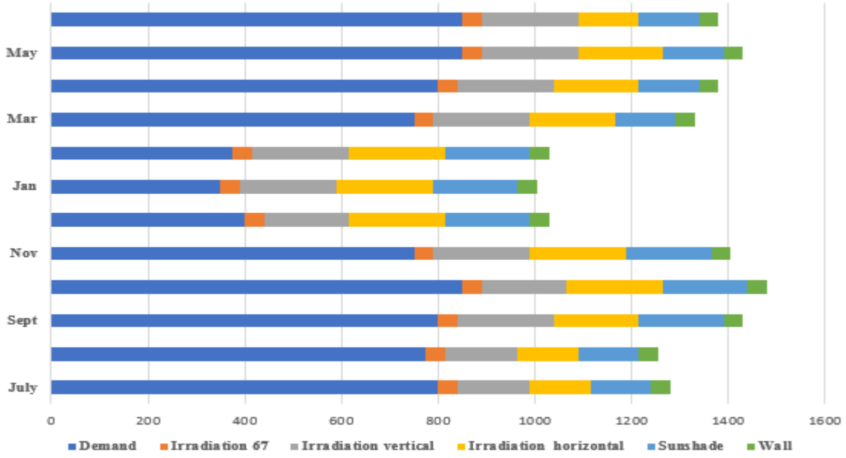

Figure 3: Demand for Electricity during the Year, Energy Supply for Various Sites, And CO_2 Emissions

Fig. 3 demonstrates that in January as well as February, generation outnumbers demand, resulting in surplus generation. Throughout the remaining months of a calendar, demands exceed supply. Because the period when solar power is accessible coincides with the generation is less than demand and peak demand for the majority of the yearly calendar, the generation is utilized at the site, reducing the need for a battery bank and decreasing the cost. The carbon dioxide emissions were reduced by 30.468percent, showing that BIPV is a feasible alternative for lowering GHG emissions from building energy consumption. On a macro level, the reduction of CO_2 emissions is found to be greatest. In December, the average drop is the lowest. In addition, the payback is calculated using eq. (4) based on the price of each component and the current government subsidies on clean energy installations.

4.1. BIPV as a consideration in the construction of a residential structure

For the construction of a hypothetical residential structure of 9.8m × 9.8 m in Gandhinagar, BIPV was considered as a pre-thought. The goal was to design a residential building that could satisfy the total energy requirement while also being visually appealing. The building orientation is one of the most essential things to consider (179 degree 58 minutes north); appropriate feature and opening placement to guarantee a pleasant building environment throughout the day It has been recommended that outside planting in the veranda reduce ground reflection, ensuring midday lighting via comfort in terms of enclosed temperature. BIPV has become a planned component for construction design to fulfil energy needs and to substitute certain building structures, reducing the cost of the building materials it would replace. Looking at the building, a few elements jump out as potential future installation sites, including the facade, the 1st floor sunshade, the skylight, and the roof.

The highlighted potions indicate the selected potential installation sites. The required area measurement is done using eq. (1) in the construction of a BIPV technique. It shows each site's potential for reduction (in percent) as well as the needs which remain unfulfilled after every fitting. Sunshade has an 80.838percent reduction potential, skylight has a 38.648percent reduction potential, roof has a 29.758percent reduction potential, and façade has a 35.398percent reduction potential. As a consequence of the construction on all of the selected locations, the energy demand is fully fulfilled while there is considerable excess. eq. (2) is used to measure monthly power output. The building is justified since needs are fulfilled throughout the yearly calendar then surplus power is produced, that is supplied into the grid reasons.

5. CONCLUSION

Two instances were compared in this study paper. One is BIPV retrofitting, while the other is building with BIV in mind. According to the results, it is better to design a building with BIPV in mind rather than retrofitting an existing structure. The latter was determined to be pricier since it restricts the number of potential places and how the panel would be positioned. A contemporary template, on the other hand, provides for proper building orientation, which is difficult to accomplish while retrofitting. For the measurement of the suitable area for BIPV installation, an energy production and optimization model were developed. Rooftop, skylight, sunshade, as well as the façade are prioritised in decreasing order for useable surfaces - was used to calculate the cost and payback date.

The solar energy plan was launched to be advantageous to installer and consumers, resulting in an increase in solar fitting throughout the nation. The solar approach has significantly reduced the payback period, which is currently less than 84 months for a dwelling construction as well as less than decade for an official structure without taking advantage of accelerated depreciation. Moreover, it was discovered that BIPV is the technology that it lowers carbon dioxide emission significantly. Finally, it is stated that BIPV was a gifted and hope-binding technology that has the potential to relieve the country's power crisis while also offering a justified method of decreasing CO_2 emissions and supporting long-term development.

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