

## **Sustainable Homes: Potential of BIPV to reshape India's urban architecture**

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India's urban areas are expected to house about 600 million people by 2031 and 850 million people by 2051, as per the Handbook of Urban Statistics (2016) by the Ministry of Housing and Urban Affairs. However, as per an estimate by the World Bank, about 70 per cent of the urban infrastructure needed by 2047 is yet to be built. Given this massive impending growth and infrastructure requirement, there is an urgent need for energy-efficient and sustainable building-integrated photovoltaic (BIPV) solutions.

### **What is BIPV and what are its benefits?**

BIPV represents an innovative approach to renewable energy integration in which solar panels are seamlessly blended into building elements such as facades, windows and roofs. Unlike traditional rooftop solar systems that are installed on building roofs, BIPV systems are embedded into the very fabric of buildings. BIPV systems serve a dual purpose – as a building material and a power generator. The integration of BIPV in Indian cities can have transformative effects, particularly in metropolitan areas, where skyscrapers dominate the skyline, and in rapidly developing Tier II cities.

BIPV technology has gradually been gaining traction globally, by offering economic, environmental and aesthetic benefits as listed below.

**Energy efficiency and cost savings:** BIPV can significantly reduce energy consumption from the grid by generating electricity at the point of use. This decentralised power generation eliminates transmission and distribution losses, while enhancing the overall energy efficiency and conservation. In commercial and office buildings, the extensive use of glass facades traps the heat inside, akin to the greenhouse effect. This is counterproductive in most Indian climatic zones, leading to higher cooling loads and, therefore, higher electricity consumption. BIPV can address this problem by replacing glass facades, thereby lowering the overall energy demand for cooling. Although BIPV panels might cost marginally more than traditional glass facades, they offer the added benefit of electricity generation, thereby reducing energy bills. Eventually, these savings can offset the initial investment, making BIPV a cost-effective solution.

**Aesthetic and architectural benefits:** Integration of BIPV systems with building materials can preserve and even enhance the architectural integrity of structures. Such buildings also align well with the vision of smart cities and solar cities in India.

**Environmental impact:** By reducing fossil fuel dependency, BIPV can help lower greenhouse gas emissions and combat air pollution. The adoption of BIPV can also help India meet its international climate commitments such as the targets set under the Paris Agreement, by reducing carbon emissions from the building sector.

**Energy security:** BIPV systems enhance energy security by diversifying energy sources and reducing dependence on external energy supplies. This is particularly important for the rapidly growing Indian economy, which faces increasing energy demands.

Urban centres with high population densities and industrial activities are prone to energy shortages and power cuts. BIPV can mitigate these issues by providing a reliable, stable and local source of electricity. This decentralisation of power generation can make cities more resilient to natural disasters and other disruptions that might affect the centralised power grid.

**Job creation and economic growth:** The deployment of BIPV can stimulate job creation in the renewable energy sector and contribute to the country's economic development. The growth in BIPV demand will also drive the expansion of related industries, creating a robust supply chain and fostering innovation.

**Public and private sector collaboration:** The successful implementation of BIPV in Indian cities requires strong collaboration between the public and private sectors. Government policies and incentives can play a crucial role in encouraging BIPV adoption, while private sector involvement, including building developers, architects and solar installers, is essential to drive innovation and ensure high quality installations. Public-private partnerships can facilitate the development of large-scale BIPV projects and exchange of best practices and help attract investments, accelerating the adoption of this technology.

### **Current status of BIPV in India and globally**

BIPV is becoming increasingly popular as countries strive to meet their ambitious renewable energy targets and reduce greenhouse gas emissions. In Europe and North America, the rise in BIPV installations is driven by supportive policies and technological advancements. For example, the European Performance Building Directive mandates zero emission and fully decarbonised building stock by 2050, promoting BIPV adoption. Countries including Germany, China, Japan and Switzerland are leading the charge with extensive BIPV projects in urban settings, enhancing the sustainability of cities. At present, the world's largest BIPV system (120 MW) has been installed at a ceramic manufacturing facility in China's Jiangxi province.

In India, BIPV adoption is still at a nascent stage. India's ambitious targets of achieving 500 GW of renewable energy capacity (including 300 GW solar) by 2030 and net zero by 2070 cannot be met only by scaling up utility solar and rooftop solar. It is imperative to explore innovative applications such as BIPV that do not require additional land for installation.

The inclusion of BIPV in the PM Surya Ghar Muft Bijli Yojana, which aims to promote rooftop solar installations across India, is a significant step forward in promoting BIPV implementation in the country. This move recognises the technology's potential to transform urban architecture. Under this scheme, BIPV systems in the residential segment are eligible to receive subsidies similar to rooftop solar systems. However, creating awareness about BIPV in the residential segment will be crucial.

### **Potential of BIPV in India's existing and upcoming buildings**

India's rapid urbanisation creates challenges and opportunities for sustainable development. This expansion in urban areas significantly affects the environment, population and economy at both local and global scales. To overcome such challenges associated with rapid urbanisation, renewable energy technologies such as BIPV offer a promising solution.

India's vast potential for BIPV lies in both its existing building stock and numerous new constructions planned in urban areas. The existing building stock in India alone is estimated to have a BIPV potential of over 300 GW, according to the Solar Technology and Application Atlas of India. Retrofitting this building stock with BIPV systems can enhance their energy efficiency and sustainability without compromising their structural integrity or aesthetic value. For new buildings, incorporating BIPV at the design stage can lead to more integrated and efficient energy solutions. India's urban centres are experiencing a surge in commercial, industrial and office buildings, presenting a unique opportunity for BIPV integration. These buildings, with their large glass facades and roofs, are an ideal case for BIPV installations.

The Vijayawada railway station in Andhra Pradesh, India's first BIPV-powered railway station, has deployed 130 kWp of BIPV over some of its platforms. BIPV solar roofs with integrated solar panels have been installed on these platforms without the use of galvanised sheets, generating electricity, while serving as a shelter for passengers. With over 7,000 railway stations across the country, the BIPV potential of India's railway stations will be substantial. This will also help Indian Railways become a net zero carbon emitter by 2030.

### **Challenges and the way forward**

BIPV faces several challenges in India such as high initial costs, lack of awareness and limited availability of BIPV materials and technology. Integrating BIPV into the existing building codes and standards requires regulatory adjustments and capacity building among architects and builders. The current infrastructure for BIPV is not as developed as the one for traditional PV systems, leading to higher costs and longer installation times. The maintenance and long-term performance of BIPV systems in India's diverse climatic conditions pose additional concerns. There is also a pressing need to develop comprehensive guidelines for BIPV in India to improve the understanding of both the technical and financial aspects of BIPV and push its adoption across various sectors.

To overcome these challenges, a multifaceted approach is needed. Government policies should continue to incentivise BIPV adoption through subsidies, tax benefits and streamlined approval processes. BIPV-friendly regulations should be integrated into building codes and urban planning guidelines. Developing comprehensive guidelines for BIPV can provide clear technical and financial frameworks that stakeholders can follow, facilitating smoother adoption. In terms of technical knowledge and design acumen, BIPV as a subject should be included in the curriculum of engineering and architecture courses in India. Collaboration among the industry, academia and the government can drive innovation and reduce costs through research and development.

Public awareness campaigns can educate building owners and developers about the benefits of BIPV, fostering greater acceptance and demand for the technology. Building developers, architects and solar installers need to be trained and equipped with the knowledge and skills to incorporate BIPV into their projects effectively. Encouraging partnerships between BIPV manufacturers and the construction industry can lead to more integrated and streamlined processes, reducing the overall costs and enhancing the quality of installations.

BIPV holds immense potential to reshape India's urban architecture. By integrating solar power into building elements, BIPV can transform urban centres into hubs of energy efficiency, environmental stewardship and economic growth.