Building-Integrated Photovoltaics: converting buildings into solar assets

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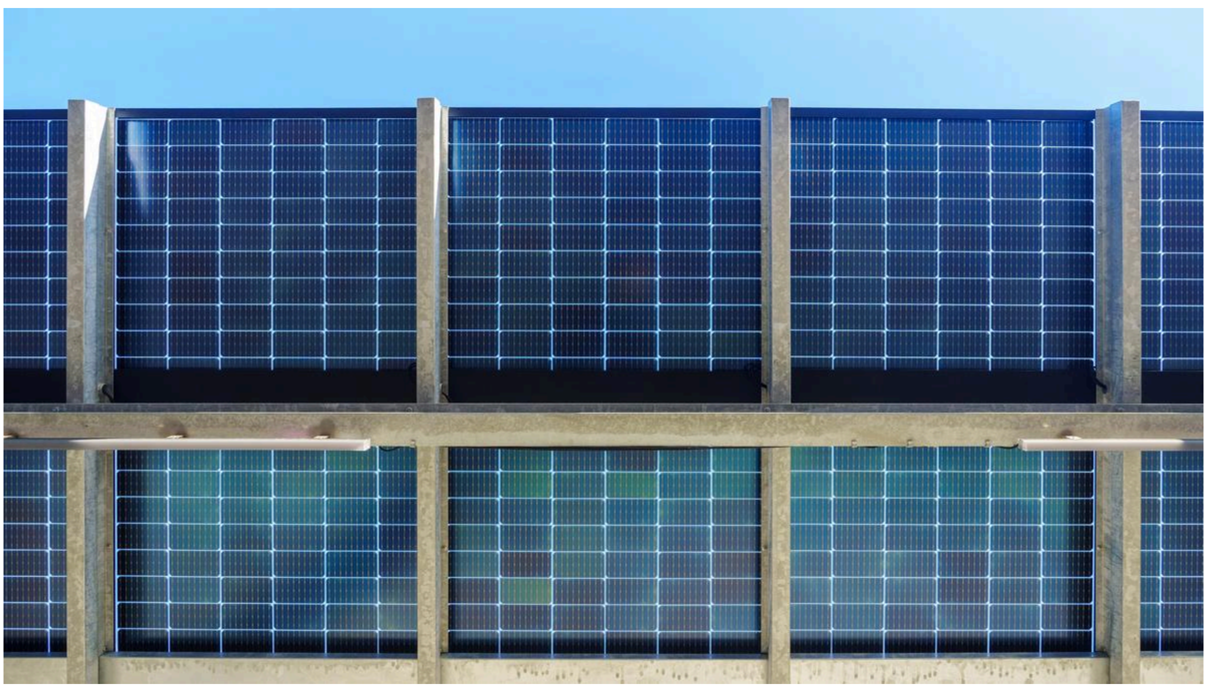

For representative purposes. | Photo Credit: Getty Images

With an installed capacity of over 17 GW as of April 30, rooftop solar (RTS) is starting to play a significant role in India's renewable energy transition, especially in urban areas. However, its scalability is constrained by the limited availability of shadow-free rooftop spaces. Boosting solar adoption in densely populated cities therefore requires us to look beyond traditional rooftop-mounted solar systems and towards Building-Integrated Photovoltaics (BIPV).

What is BIPV?

BIPV can turn entire buildings into power generators by integrating solar elements directly into architectural elements.

It has two purposes: generating electricity and working as a structural part of a building. Unlike RTS systems, which are added to rooftops, BIPV systems are embedded into the building's architectural fabric, like in façades (the front exterior of a building), roofs, windows, and railings. They replace conventional construction materials such as glass, tiles, and cladding with solar alternatives.

While the initial costs may be high, by transforming conventional building components into energy-generating surfaces, BIPV can deliver long-term savings that help offset the capital costs.

How can BIPVs be incorporated?

Façades can host semi-transparent BIPV panels that serve as curtain walls or cladding, generating electricity while reducing entry of heat. Traditional roofing materials can be replaced with BIPV panels, allowing power generation without altering the building's structure.

Windows and skylights can also feature transparent or semi-transparent BIPV panels that allow natural light to enter while producing clean energy. Even balconies, canopies, atriums, and shading devices can be designed to house solar elements, utilising structural features for energy generation without occupying additional space.

Because of their "stay out of sight" design, BIPVs can be used in residential apartments and commercial buildings as well as in public infrastructure such as railway stations, airports, and educational institutions. Their transparency, colours, sizes, and shapes can also be customised to suit particular aesthetic requirements.

BIPVs for India

The need for BIPVs stem from space constraints and the pressing obligation to pursue sustainable urban development. According to the 2016 Handbook of Urban Statistics published by the Ministry of Housing and Urban Affairs, India's urban population is projected to reach approximately 600 million by 2031 and 850 million by 2051.

In the high-rise buildings of India's populous cities, rooftop space is often insufficient to install RTS systems. Since BIPV can be integrated into various parts of a building's envelope, it can use available surfaces more efficiently.

For example, a 16-storey building with a 4,000 sq. ft rooftop and 15,000 sq. ft of façade area on each side can support an RTS system of only about 40 kW-peak (kWp) — but BIPV panels on just the south-facing façade could produce around 150 kWp.

Beyond high-rises, BIPVs can also be integrated into independent houses and in the balconies of homes whose residents don't have rooftop access.

The latter is already popular in Germany, where solar panels have been installed on nearly 15 lakh balconies and manufacturers have estimated that a typical participating household could save up to 30% on its electricity bill.

What is the status of BIPVs in India?

The steady decline in solar technology prices and a growing interest in sustainable and energy-efficient architecture is allowing BIPVs to gain momentum.

Today's India has some impressive BIPV installations. The CtrlS Datacenters building in Navi Mumbai has an 863-kWp system on its four façades. The Renewable Energy Museum in Kolkata, inaugurated in 2024, features a solar-powered dome made from over 2,000 integrated solar panels. The Jindal Steel & Power Ltd. facility in Angul, Odisha, hosts one of the largest BIPV installations in India. They have also been incorporated into the Vijayawada Railway and the Sahibabad Railway Stations.

These examples indicate BIPVs' ability to scale across public, commercial, and institutional buildings.

How can BIPV uptake be scaled up?

BIPV adoption in India has been limited by high initial costs, policy gaps, inadequate technical capacity, and reliance on imports.

Low awareness, lack of dedicated incentives, and absence of clear standards also push BIPV out of early building-design considerations.

In this milieu, Seoul's dedicated incentive scheme is instructive: it subsidises up to 80% of installation costs, allowing BIPV into mainstream urban construction. India could look at expanding the existing solar schemes to offer higher incentives for BIPV, especially in space-constrained urban areas. In 2024, the Ministry of New and Renewable Energy issued operational guidelines for the PM Surya Ghar Muft Bijli Yojana, a scheme to install RTS systems in one crore households. The guidelines included BIPV in the scheme, allowing consumers to opt for it in case of limited rooftop space. BIPV installations in a residential segment qualify for a subsidy akin to that available for RTS systems: up to ₹78,000 for a 3-KW solar system. Similar schemes are required for commercial and industrial segments.

Likewise, Europe's Energy Performance of Buildings Directive mandates the increased use of solar technologies in all new buildings and encourages innovative solutions like BIPV through clear regulatory guidance and minimum performance standards. India too can consider embedding BIPV provisions in its National Building Code, the Energy Conservation Building Code, and the Eco Niwas Samhita.

Demonstrating BIPV through pilot projects in public infrastructure (via public-private partnerships) can improve visibility and catalyse wider acceptance. Boosting indigenous manufacturing through production-linked incentive schemes and targeted R&D alongside awareness programmes for architects, planners, and building developers will further strengthen the ecosystem.

Financial arrangements such as the Renewable Energy Service Company model and long-term power purchase agreements can help enhance project reliability and enable large-scale BIPV deployment.

India can't rely solely on ground-mounted and rooftop systems to meet its goal to install 300 GW of solar capacity by 2030. Land-neutral solutions like BIPV need to be prioritised. The potential of BIPV for India's existing building stock is estimated to be 309 GW. According to the World Bank, nearly 70% of urban infrastructure needed for India to become a developed country by 2047 is yet to be built.

While this underscores the immense potential of BIPV to accelerate the nation's clean energy transition, actualising it demands robust policy support, design innovation, and a strong market push.

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