

Building Integrated Photovoltaic (BIPV) Policy in China

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Executive Summary

Is Building Integrated Photovoltaics (BIPV) anticipating a sustainable future in China? From rural to urban, self-built houses to apartments and high-end villas, BIPV has gained significant attention worldwide in promoting renewable energy generation and enhancing buildings' energy efficiency. BIPV has emerged as a promising solution to meet the growing energy demands and environmental challenges. A global leader in both solar PV production and building construction, China harbors excellent potential for BIPV development. Yet, some important challenges remain to generalize and scale it up. This paper discusses China's BIPV development policy and analyzes the impact these policies exerted on China's BIPV practices. By examining policies, incentives, and regulations, this paper identifies the progress and issues in China's BIPV development, providing insights for policymakers, industry stakeholders, developers, and researchers for future BIPV development in China. This paper also discusses whether the current BIPV policy framework is financially sustainable, meaning that it can be maintained in coming decades until BIPV reaches its full potential.

This paper finds that China's position as a global leader in solar PV production and building construction makes it well-placed to advance sustainable BIPV integration. This paper advocates for continuous policy support, technological innovation, and stakeholder collaboration to reveal the full potential of BIPV in China's built environment.

Introduction

Building integrated Photovoltaics (BIPV) serves as the outer layer of a building and generates electricity simultaneously, offering sustainable and aesthetically pleasing electricity solutions. (GAIN Solar 2023). BIPV generates energy, saves cost, reduces carbon footprint, improves indoor comfort, optimizes resource, and is durable (Id.). As part of energy efficient buildings, BIPV not only reduce the carbon footprint, but also offer many benefits such as lower energy costs, better productivity, better health and a positive impact on the environment. Integrating sustainable practices into architecture is essential for sustainable future development. BIPV applied in individual properties is underdeveloped in China, largely because China has more apartment buildings than villa households, especially in urban and developed areas. According to Zhang Yifei, an engineer at YingLi Group who constructed over 50 BIPV buildings in China, most buildings in cities of China do not have enough roof space to accommodate large numbers of solar panels (CGTN 2021). Therefore, for these high-rise buildings, it would be more efficient for both the roof and walls to both contribute to generating electricity through BIPV.

A renewable energy technology solution that aims to integrate solar PV power generation products into buildings, BIPV integrates architecturally designed solar cells as PV modules, specifically PV tiles, PV glass, and other PV-integrated roof products, as functional, irremovable building components (Li 2010, pp. 71-72). BIPV integrates PV materials directly into windows, walls, or roofs, seamlessly blending renewable energy generation with architectural design (utilitiesone.com). The average efficiency of BIPV is around 5-10% (GAIN Solar 2023).

Traditionally, PV are retrofitted into buildings to generate energy. BIPV alleviates the concerns of traditional distributed PVs of aesthetics and integration in that BIPV is not attached to the building but integrated into the building from the design phase (Wild 2014). The difference between a BIPV project and a Building Applied Photovoltaic (BAPV) project is that BIPV projects seamlessly integrate modules into a building's skin, including façades, roofs, and windows, both functionally and aesthetically, providing weather and noise protection, thermal insulation, daylight illumination, and safety, by modifying the supplying material and construction element that focuses on incorporating with the building as a seamless whole and employing this process at any time from the start of the construction project to the end of its renovation. BAPV, although also making surfaces active, fits modules to existing building surfaces via superimposition after completing the construction (Government of Canada) (asca.com 2019).

According to Li in *365 Questions on Knowledge of New Energy*, BIPV can meet parts of buildings' energy demands at lower costs, reduce commercial energy consumption and building load, prevent later solar panel installation and the inconvenience and damage it may bring to users and the building structure, which is a downside of BAPV, and alleviate the contradiction between energy supply and demand (Id.). Since 2021, while the broader market price for solar PV has fallen, the stock prices of the above companies have shown an upward trend, significantly since the cooperation between Sente and LONGi Green Energy to expand the BIPV business. Their stock price has risen by more than 280%, and the price-earnings ratio is as high as 539.2 times, indicating that investors are optimistic

about the prospects of BIPV business (Interview No.2 2023). If China would install BIPV annually on 5% of the 4 billion square meters of buildings, it would create an installed power generation capacity of 20GW, equal to that of the Three Gorges Dam (Snowball 2021). But as the issues and challenges section in this paper later puts forward, it is difficult to apply BIPV in such large scale now.

In BIPV development, central and local policies working together form a complex strategic scheme, which overlap and complement each other to implement BIPV practices. This paper studies China's BIPV policies, uses qualitative document content analysis and legal analysis through books, articles, regulations, news reports, and graphics, uses extrapolation from foreign best practices, and conducts interviews with leading PV industry personnel and securities analysts. Such documents and communication are significant because of their authority and relevance, and they have the potential to answer the question of whether current policies grant a sustainable development for BIPV in China.

This paper describes of China's BIPV development history, including China's BIPV status quo, mentioning a few BIPV representative projects and stocks and provides a broad policy framework of current BIPV policies, regulations, and building codes in China, including governmental subsidies, tax and other financial incentives, and bank and state-owned enterprises guideline policies.

This paper's first section discusses the general development of BIPV in China, including China's BIPV development phases, the potential BIPV roof area of China, and a generalized introduction to leading BIPV projects and stocks. The second section reviews and analyzes the policy measures, including national and local policies and building codes. The third section analyses issues and challenges in BIPV development in China, including insufficient **Feed-in-Tariffs (FIT)** schemes, application issues, ownership of PV Modules, and other potential risks. The fourth section discusses future directions and recommendations, including a discussion of a public future BIPV development trend in China and recommendations and the deputy's view on the issue.

History of BIPV in China

Development Phases

The earliest application of BIPV goes back to satellites and the International Space Station, and the PV power generation structure on satellites was the earliest prototype of PV and structural integration (PV-Tech 2023). In the past, solar PV existed in northwest China with centralized power stations; with the promotion of PV projects to the densely populated eastern China, distributed PV, including BAPV and BIPV, continues to grow (Leqing 2022). The International Energy Agency (IEA) has produced draft guidelines for BIPV implementation as early as 2002, including those concerning building ownership issues: owner-occupant, owner-investor, and owner-developer. However, China still needs a parallel guideline so far.

The concept of BIPV entered China in 2006 (People's Information 2021). The first recorded building in China to try to apply BIPV technology was before 2008, when more than a dozen PV curtain wall products were installed in a commercial building supporting the Olympic Games (The Paper 2021). Pioneering projects include Baoding Power Valley International Hotel, which was completed in October 2008 and is the world's first five-star BIPV hotel with solar power generation

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system (People's Information 2021). The project was completed by GAIN Solar, with a PV curtain wall area of 4,111 square meters and a photovoltaic installed capacity of 0.3 megawatts in the first phase of the project (Id.). At the end of 2013, GAIN Solar provided PV modules, and the BIPV demonstration project of Power Valley Jinjiang Hotel invested and built by Baoding Yingli was completed, including 1.5MW of various BIPV products (Polaris Solar PV Network 2020). Baoding then built Asia's largest PV greenhouse park Low-Carbon Park and China's first PV building-integrated fire station in the following years, and there are as many as 11 BIPV buildings in Baoding (The Paper 2021). In 2022, Sungrow in Hefei, China supplied its inverters for the Jiangxi 120MW BIPV project, the world's largest BIPV project (Jacobo 2022).

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Potential BIPV Roof Area

The calculation of China's BIPV roof potential is as follows. A total roof area of 30,000 square kilometers multiplies the percentage of roofs suitable for BIPV 15-20% = 4,500 to 6,000 square kilometers (Sina Finance). Compared internationally, according to the IEA, the United States has a potential roof area for BIPV of 10096.26 square kilometers, Germany 1295.92, Japan 966.38, Canada 963.54, the UK 914.67, Italy 763.53, and other countries less (Pillai et al. 2022, p. 8).

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Financial Stocks and Projects

Leading BIPV concept stocks in China include Shenzhen Energy, Dongxu Blue Sky, and Southeast Grid.

Global leading BIPV projects include the Pompeu Fabra Library in Spain, the refurbishment project at King's Cross railway station in London by John McAsian+Partners, the first phase of the Freiburg City Hall in Germany, designed by Ingenhoven architects, and the NEW-Blauhaus designed by architect Kadawittfeldarchitektur in Mönchengladbach (FORCITIS 2023).

Several BIPV applications in China have also achieved significant results. There has been progress in applying exterior walls, roofs, shading, curtain walls, and skylights. For example, the T3 terminal of Beijing Daxing International Airport uses a solar PV glass curtain wall to achieve self-sufficiency in electricity. Risen Energy, a well-known PV module manufacturer, launched several new BIPV products in May 2023, upgrading technology and matching the market, including single super energy tiles, concentrated energy tops, and empowerment tops (PV-Tech 2023).

Sinopec's first BIPV gas station, Shandong Junan Gas Station BIPV Power Generation Shed, is equipped with 72.36KW installed capacity and a yearly power generation capacity of 81,600 kWh, which is equivalent to a yearly reduction of 81.39 tons of carbon dioxide and a decrease of 32.65 tons of greenhouse gases produced by coal combustion (GAIN BIPV). The world's first colorful 100-meter high-rise BIPV project, the Dalian International Triumph building, was connected to the grid for power generation in 2022 (Shanghai Jiaotong University 2023). Regarding technological aspects, PV-House's "consummate" BIPV bracket system adopts super corrosion-resistant and self-healing magnesium-aluminum-zinc plated material, creating a risk-free installation and assembly fixation at

the bottom, which is labor-saving and more ornamental in construction and maintenance (PV-House 2023).

LONGi Green Energy (601012) and SENT (603098) released the world's first BIPV product equipped with a Back Contact (BC) battery (while conventional PV cells have grid lines on both sides, BC cells transfer the front metal grid lines to the back of the cell), the absolute mainstream in crystalline silicon cells in the coming 5 to 6 years, Longding 4.0 (Jiang 2023). The product is said to achieve high-efficiency power conversion capacity with astounding power generation efficiency of more than 86.9% in 30 years, conversion efficiency of 22.6%, and output power reached 580W, prolonging power generation time and continuously breaking the efficiency limit, and providing customers with 25 years of safe, stable, and reliable income protection, with anti-rust components (Starry Sky Wealth 2023) (Xinhuanet 2023). The product is Class A non-combustible standards, with waterproof performance reaching the highest standards in the industry (Id.). The product also effectively resists Category 17 typhoons and can cover 99.9% of China's areas, focusing on China's coastal regions (Id.).

River Group (601886) undertook BIPV projects of about 950 million yuan in the first half of 2023 (Id.). Yongqing Environmental Protection (300187. SZ) signed a contract with Hunan Yongxin Environmental Protection Technology Co., Ltd. to construct a distributed rooftop PV power station (Hunan Yongqing Environmental Technology Industry Group Co., Ltd. 2023). Collida (603828.SH) announced that the company set up a BIPV team to carry out BIPV pilot work, taking BIPV as a breakthrough and cutting into the field of new energy (Collida 2023). Henan's first large-scale BIPV PV storage project was also recently used (Starry Sky Wealth 2023). Skyworth Solar launched BIPV household PV power station products such as "Xiaoyang Courtyard," "Xiangyang Courtyard," and "Yueyang Courtyard" that integrate multiple value functions such as power generation, spatial interaction, and national style artistic appearance (Life Daily 2023). "Yueyang Pavilion" is the leader in pulsating health PV power stations, the industry's first combination of smart wearable watch and PV power station, which provides users with Bluetooth call, all-weather heart rate monitoring, and many other functions to protect the stability of the power station and the well-being of users (Life Daily 2023).

Policy Measures

Review and Analysis of National PV Policies

BIPV is part of sustainable building integration. There are policies focused on PV in general or on distributed solar and those specifically on BIPV, presented as follows. Regarding Chinese laws and regulations on the PV industry in general, the "*Renewable Energy Law*" (enforced 2010) stipulates the state's policies to support of renewable energy development, including renewable energy power generation, heat supply, hydrogen production, and biomass energy utilization. The "*Law on Energy Conservation*" (enforced 1998) stipulates policies to save energy, improve energy efficiency, and promote renewable energy development. The "*Building Law*" (amended 2019) stipulates policy measures for building energy conservation. The "*Electricity Law*" (enforced 1996) stipulates policy measures for producing, supplying, and using electricity. The 14th Five Year Plan's "*Science and*

Technology Innovation in the Energy Field,” *“Modern Energy System*,” and *“Renewable Energy Development”* set clear phased development goals for building a new energy system. *“Building Energy Conservation and Development of Green Buildings”* proposed to urged integration of solar PV in new buildings and investment in public buildings to strengthen the application (China Business Intelligence Network 2023).

Regarding policies on PV development, on March 26, 2009, the Ministry of Finance, Housing, and Urban-Rural Development (MOHURD) promulgated the *“Interim Measures for Financial Subsidy Funds for Application of Solar PV Buildings.”* The Ministry of Finance issued a policy interpretation supporting the quickening of the application of solar PV buildings in April 2009 (Ministry of Finance 2009).

In October 2021, the promulgation of the full-text mandatory standard *“General Code for Building Energy Conservation and for Utilization of Renewable Energy”* required that new buildings be equipped with solar energy systems from April 1, 2022. In July 2022, the Ministry of Industry and Information Technology, the National Development and Reform Commission (NDRC), and the Ministry of Ecology and Environment issued the *“Implementation Plan for Carbon Peak in the Industrial Sector,”* guiding enterprises and parks to quicken the development and operation of distributed PV (Sobi Consulting, 2022).

BIPV Policies

Specifically for BIPV, in December 2011, MOHURD announced (No. 1229) the issuance of the *“Industry Standard Code for the Operation and Maintenance of BIPV Systems”* to approve the *“Code for the Operation and Maintenance of BIPV Systems”* as an industry standard, numbered JGJ/T264-2012, implemented since May 1, 2012 (internationally, around the 2010s is also when the European policy fostered renewable energy use in buildings and set goals through Energy Performance Building Directive 2010/31/EU (Meturi L. and Adami J. 2018). Through the Renewable Energy Sources (RES) Directive 2009/28/CE requiring a minimum level of RES use in all new buildings, China is within this trend of BIPV policy development) (MOHURD) (Tongwei Media et al., 2022, pp. 579-588) (Id.). The Chinese standard, compared to the EU one, does not include an absolute goal, but speaks directly to the overall trend, implying China’s building industry’s efforts of integrating with international standards.

China’s dual-carbon policy has clear goals, and the construction industry has a large room for carbon reduction; green buildings have become a significant trend to reduce carbon in the construction industry. Many places in China have introduced BIPV development policies, with several documents supporting BIPV (or distributed solar) and green buildings, and vigorously promoted the accelerated growth of the PV construction industry, among which distributed PV power generation is especially encouraged by policies because of its flexibility (Interview No.1, 2023) (Zhang et al., 2019). National and local policies for BIPV encourage architects, developers, and stakeholders to incorporate solar energy generation as an integral part of the built environment. The NDRC strongly supports the

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intelligent PV industry’s innovation, upgrading, and characteristic applications (China Business Intelligence Network 2023).

Once the “*Opinions on Strengthening Green and Low-carbon Construction of Counties*” got issued on May 25, 2021, the country demonstrated its readiness to execute its plan in sustainable built environment, as the *Opinions* wrote “improve... the implementation of BIPV development reduce the proportion of traditional fossil energy in building energy” (Opinions 2021). MOHURD and NDRC’s “*Implementation Plan for Carbon Peak in the Field of Urban and Rural Construction*” promoted BIPV projects for new and existing buildings (Sobi Consulting, 2022). Although not an adopted policy, Two Sessions Deputy Peng, in his “*Proposal on Improving the Policy System to Accelerate BIPV Development*,” put forward the necessity to amend the “*Construction Law of the People’s Republic of China*,” “*Energy Conservation Law of the People’s Republic of China*,” and the “*Circular Economy Promotion Law of the People’s Republic of China*” among others, to stipulate that BIPV should be required from the planning and design stage of new construction, to require the mandatory use of PV material products in new building planning, and clarify that at least 1/4 or the same amount of area of the building façade should achieve PV coverage, or that new buildings should achieve more than 20% of energy self-sufficiency, and stipulating the subject, period, procedures, and legal responsibilities (Liu 2022). BIPV can promote the transformation of buildings from energy-consuming and energy-saving to capacity-based and become the best solution for building green buildings; in response, in January 2023, MOHURD issued a “*Response to Recommendation No. 2254 of the Fifth Session of the 13th National People’s Congress*” mentioning that the rapid decline in PV costs has laid the necessary foundation for the large-scale development of BIPV (Shui Yao, 2021) (MOHURD reply to Recommendation No. 2254 2023). Thus, the country supports BIPV development at the national level. Still, these national policies lack specific guidelines regarding BIPV implementations.

Economic Incentives

F_iTs provide guaranteed pricing for solar electricity generated from BIPV systems. Renewable energy subsidy F_iTs are ubiquitous in Europe and North America; since April 2010, the British government has introduced the F_iTs (Specified Maximum Capacity and Functions) Order 2010 for rooftop PV, including (1) the installation scale is less than 5MW; (2) incentives are given according to the power generation of rooftop PV, and there are additional incentives if connected to the grid; (3) the award period is 25 years (applied before August 2012) or 20 years after grid connection (Solarbe, 2023).

In China, F_iT subsidies for PV include the Generation tariff, which determines the revenue based on the amount of electricity generated, and the Export tariff, which determines the revenue based on the amount of electricity on the grid (Id.). In the context of the lack of widespread intelligent meters, it is assumed that the self-consumption ratio is 50%, and the electricity bill savings are reduced; that is, by using the electricity generated by the own rooftop PV system, less electricity is purchased from the energy company, thereby reducing the electricity bill (Id.). In 2020, China’s F_iT for distributed

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rooftop solar PV was around 0.07 Yuan/kWh, which serves as a reference for FiT for BIPV projects (Yuki 2020).

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Domestic BIPV projects can also enjoy some tax incentives. Specifically, enterprises engaged in new solar power generation projects that fall under the “Preferential Catalogue of Enterprise Income Tax for Public Infrastructure Projects,” which apply to some BIPV cases, in the “*Implementation Regulations of the Enterprise Income Tax Law of the People’s Republic of China*” enjoys the preferential policy that includes three exemptions as well as three halves of enterprise income tax (Tax Tai, 2022).

People’s Bank of China issued the “*Notice on Matters Concerning the Establishment of Support Tools for Carbon Emission Reduction*” in November 2021; according to this policy document, financial institutions should strengthen innovation in department settings, resource allocation, incentive assessment, product design, and information disclosure, as well as leverage more social funds to promote carbon emission reduction (China Business Intelligence Network, 2023). The *Tools* guide banks in using carbon emission reduction support tools such as carbon offsetting tools to issue about 5 billion yuan in loans to BIPV projects (MOHURD 2023). In addition, financial institutions can provide low-interest loans, guarantees, and other support for BIPV projects (Interview No.2 2023).

In addition, according to the “*Notice of the State Administration of Taxation of the Ministry of Finance on the Preferential Policy of Enterprise Income Tax for Special Equipment for Energy Conservation and Environmental Protection*,” enterprises investing in energy conservation can enjoy enterprise income tax credit policy, which reduces the cost of BIPV projects and promotes application of BIPV (River Flows 2023).

Analysis of Local Subsidies for the implementation of BIPV projects

At the provincial level, Jiangxi, Liaoning, Hunan, Inner Mongolia, and Sichuan specifically enacted policies to promote BIPV projects (Sobi Consulting 2022). Connected to the distribution networks of Guangdong, Guangxi, and Hainan Provinces of China Southern Power Grid Corporation, BIPV is treated similarly to distributed solar PV projects.

An article published by China Economic Review, “Analysis and Forecast of the Development Trend of China’s BIPV Industry,” indicated that the realization of BIPV is an essential driving force for the successful completion of the dual carbon goal. At present, 31 provinces and cities in China issued relevant policies for BIPV, and the paper collected the stock data and established a moving average model of the “BIPV sector index” for reference through graphic presentation, which is not included in this paper but is a reference for those interested (Huang et al. 2023).

The table in annex 1 provides an overview of selected local government BIPV subsidies in China. In summary, governmental support is limited and depends on the scale of specific BIPV projects, while different regions have different subsidy methods per their characteristics. Longgang district in Shenzhen stipulates rules through “*Shenzhen Longgang District Housing and Construction Bureau 2022 Special Application Guide to Support the High-quality Development of Modern Construction Industry*” (China Power Grid 2023). In Bengbu, Anhui, the BIPV demonstration building roof project,

which is a pilot project that was similar to an actual BIPV project, will be subsidized according to the standard of 200 yuan/kW, the BIPV façade project will be subsidized according to the standard of 300 yuan/kW, and the standard of energy storage will be subsidized according to the standard of 200 yuan/kW, ultra-low energy consumption, near-zero energy consumption demonstration projects will be rewarded according to the standard of 500 yuan/square meter. The subsidies for a single BIPV demonstration project will be within 300,000 yuan (Id.). The Chaoyang District of Beijing released the 2021 application guidelines for remarkable energy conservation and carbon reduction funds that green buildings and Leadership in Energy and Environmental Design (LEED) certified projects can apply for special funds for energy conservation and carbon reduction, with a maximum grant of 5 million (PV Building 2021). On June 1, 2022, the People's Government of Qujiang District, Quzhou City, Zhejiang Province, announced a detailed rule; the document clarified that within the scope of Qujiang District, except Qujiang Economic Development Zone, BIPV and industrial and commercial PV projects subsidies are 0.8 yuan/watt, with a maximum subsidy of 1 million (PV Energy Circle 2022).

In Chongqing, BIPV subsidies are for specific projects. Chongqing Municipal Urban and Rural Construction Commission and Municipal Bureau of Finance will provide subsidy funds of 25 yuan/square meter and 40 yuan/square meter, respectively, according to the construction area of the project for BIPV projects that have obtained the gold and platinum green building labels and adjust them promptly according to technological progress and cost changes (Id.). Among them, subsidies of 10 yuan/square meter and 15 yuan/square meter will be given to projects that only obtain the completion mark of Chongqing Gold and Platinum green buildings (Id.). While reducing the cost of BIPV projects and promoting BIPV application, the subsidies are not sufficient for a prosperous BIPV development.

The fourth is government procurement, and at present, domestic government procurement also tends to choose to use BIPV products or services. For example, in public buildings, industrial plants, and other fields, government procurement will prioritize the use of BIPV products or services, promoting application of BIPV and provide a sales channel for enterprises. These mechanisms can effectively reduce cost and promote BIPV application (Interview No.3 2023).

Building Codes

It is significant to consider building codes for BIPV development these codes serve as guidelines and restrictions for the building industry. Regarding building codes, grid interconnection regulations, certification systems, and alignments between existing regulations and BIPV technologies and safety, quality, and reliability of BIPV systems, “*Green Building Evaluation Standards*” and the “*Design Standards for Energy Efficiency for Residential Buildings*” are two fundamental regulatory frameworks that require the incorporation of renewable energy systems into buildings, setting minimum requirements for BIPV installation, and ensuring its inclusion in the overall building design process.

The National Energy Administration cooperated with the “*Technical Standards for the Application of BIPV Systems*” issued by the National Standards Commission. It put forward technical

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requirements for all aspects of BIPV power generation, showing that the country attaches high value to BIPV development.

The government approval process is an essential link to the integration of PV buildings. The procedure is as follows for general reference. The first step for the developer is to understand relevant policies and regulations, including the “Renewable Energy Law,” the “Regulatory Conditions for the PV Manufacturing Industry,” and the “Regulations on Quality Management of Construction Projects.” The second step is to apply for project implementation. The third step is to get approval for access to the power grid. The fourth step is to get approval for the environmental impact assessment. The fifth step is planning permit application. The sixth step is to get a construction permit application (Id.).

Issues and Challenges

There are numerous issues regarding market failures, implementation gaps, technological constraints, and stakeholder engagement in China’s BIPV development. BIPV is still in the early stages of application, so the market operation mechanism could be better, and there are many pain points in the promotion process. For the construction party, despite subsidies, the payback period is long, and the construction standards such as “Regulations on Quality Management of Construction Projects” are not sufficiently clear or precise, which is prone to cause problems such as acceptance issues by the construction party (Interview No.3 2023). For the user, BIPV incurs extra costs, reducing the user’s enthusiasm; for operators, the operation and maintenance cycles are longer and more sensitive to the stability of the enterprise. (Huibao Intelligent Investment Research).

In a BIPV project, the cost of BIPV modules accounts for more than 50%. However, current methods of improving the power generation efficiency of PV modules and reducing their production costs are still in the preliminary stage (Starry Sky Wealth 2023). The lack of BIPV-specific standards exacerbates the situation. BIPV modules require a longer service life and are waterproof, safe, firm, beautiful, and easy to clean over time building supplies (Id.).

Insufficient Policies

Although some argue China’s laws and regulations provide legal support and guarantee for the development of BIPV and also put forward requirements for technical standards, design, construction, acceptance, and other aspects of BIPV, many of these regulations such as the Renewable Energy Law are already outdated and demand immediate revision to provide further specific guidance and support for renewable energy development and innovative solutions such as BIPV to synchronize with the Party’s call on greener economic growth and with the international community’s development paces.

By studying other countries’ practices, China can incentivize property owners to invest in solar integration and provide tax incentives such as income tax reductions and exemptions and FiT to encourage BIPV adoption. The FiT for residential BIPV in China is 1.09 RMB, while the electricity tariff supplied by the network is 0.59 RMB (Gholami et al. 2019). The policy term is 20 years according to NDRC, and the payback time of the initial cost considering FiT of residential renewable energy was obtained in 6.52 years (Id.). Because of BIPV’s significant contribution to sustainable building

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development, there should be a **more detailed national FiT than the current policy, which is insufficient considering BIPV's higher cost than traditional rooftop PV.** If these incentives are correctly implemented, **there will be a more economically viable choice for BIPV developers** (Solarbe, 2023).

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Bank Issues

Despite the commitments by the Bank of China for BIPV projects mentioned above, the high credit requirements for electricity enterprises (whether the preferential loan policies are sufficiently generous for BIPV projects to obtain the capital they need) renders BIPV, which is a type of electricity enterprise as it generates solar electricity, slow to progress (Environmental Investment 2017).

Insufficient Industry Engagement

BIPV is within a category of “building-integrated renewable technologies,” a part of international, regulatory building rating systems. With specific reference to green building rating systems (GBRS), energy efficiency and carbon emission reduction, renewable energy credits are considered a top priority when it comes to the energy category” ... “[T]hree points can be earned under LEED for 10% renewable energy generation and a maximum of three points for 30% contribution under BREEAM ... eight points can be earned under Estidama for 20% renewable energy generation” (Attoye & Aoul 2020). The International Energy Agency PV Power System Task 15 Subtask E 2019 report extensively development prospects of BIPV regarding dissemination, business modeling, and regulatory and environmental issues, but China still needs to keep up with much international BIPV information (PVPS Report IEA-PVPS T15-07: 2019).

Hope Shares (301024. SZ), an architectural design consultant, will increase its capital by 45 million yuan to Epoch ESS, and the two parties will jointly develop the building PV energy storage and charging (PV storage and charging) market, actively promote the BIPV layout, create a new profit growth segment of the company, further enhance the company’s growth and competitiveness, and lay the foundation for the company’s gradual transformation and long-term development. However, at this juncture, Jiang Yunfeng of the Middle Index Research Institute analyzed that the current domestic BIPV has not been on a scale or in terms of integration, that the building and the PV are detached, the cost is immense, and there are stability and durability deficiencies, the owner might consider that the economic gain of BIPV installation is not worth the loss, therefore, the market size is limited (Silver Persimmon Finance 2022). In general, BIPV projects also face the problem of prioritizing aesthetics or maximum power output requirement, which usually achieved by opaque solar panels.

Although the Chinese government has given specific policy support for BIPV, this support still needs improvement. Lack of policy uncertainty in stipulating BIPV-specific rules can lead to a lack of confidence in BIPV among investors and manufacturers, limiting the development of the field. PV and construction industries intersect less in terms of technology and market, which limits the development of BIPV. The differences in technology and aesthetics between architects and PV engineers make combining the two industries difficult.

Another concern is the route of building energy conservation development. The energy-saving idea of reducing heating consumption in buildings conflicts with BIPV. The fact that energy-saving and storage are not synchronized restrains BIPV development (Jia, 2021). The regulatory support in the construction sector is also insufficient. In addition, inconsistency of business models is also a reason for the slow development of BIPV in China.

Ownership of PV Modules

In BIPV projects, the ownership of PV modules is a controversial issue. The mechanism that is in place here is the following. The developer might install solar panels on the roof of the building (rooftop PV, which is different from BIPV) and sign a contract with the owner that the developer would have ownership of the panels for 20 years and would be responsible for maintenance and upkeep. However, after the contract expires, the developer might refuse to return ownership of the panels to the owner and demand the owner pay for maintenance. The owner should have ownership of the panels, and the developer must return the panels and pay the corresponding compensation costs.

The roof service life of BIPV is more than 25 years, but the stability of business owners is more consistent, reducing investment enthusiasm. BIPV from construction to operation involves investors, builders, users, and other parties, and most of the enterprises are leasing wide houses; after the installation of PV roofs, it is necessary to ensure stable function of the enterprise in the payback period of the power station, that is, 5-8 years, otherwise, it will involve the ownership of property rights disputes (Id.).

Other Risks

Construction angle, replacement cost, installation difficulty, lack of experience, unclear standards, owner operation, property rights issues, financing, power generation efficiency, building modeling, and other conflicts of interest also interfere with BIPV development sustainability (Id.) (Xiaohan 2022). For example, the life of metal color steel tiles for roofing is 10-15 years, and PV is installed after a long period of use; if replaced together with the damaged roof, the high cost of building installation leads to a decline in investors' willingness to invest in dense urban buildings, plus some buildings cannot install solar roofs (Interview No.3 2023) (Id.). BIPV should only consider power generation capacity after meeting the requirements, such as building materials, and traditional PV companies need more construction design capabilities and building construction capabilities. BIPV is a unique building material product, and despite current standards, there is currently no unified national standard that authority the picture, which may lead to quality issues. Other issues concern unethical enterprises, whose practices include slow to settle electricity bills or paying electricity bills by goods, thus interfering with standard business procedures (Id.).

Predictions of BIPV Development by Industry Experts

BIPV is still underdeveloped in China, yet there are considerable governmental subsidies and technological progress so that BIPV is likely to develop solidly in the future (China Business

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Intelligence Network, 2023). Different sources predicted different financial values for BIPV's future development, reflecting estimation disparity. According to MOHURD and China Business Industry Research Institute, the installed capacity of BIPV in China will increase from 1.1GW to 30.2GW from 2021-2025 (Wallet Thickness Actuary 2021). It is estimated that in 2024, China's BIPV installed capacity (GW) will reach 16, its penetration rate in distributed PV will reach 43.5%, in 2025, BIPV installed capacity (GW) will reach 30.2, and its penetration rate in distributed PV will reach 74.5% (Interview No.2 2023). The general trend reads an accelerating BIPV integration with the integration of energy storage systems, innovative grid technologies, and advanced technology and innovation with BIPV (Wang Q., 2023).

According to Grand View Research, BIPV global market size will reach \$32.2 billion projected by 2026 (utilitiesone.com). In China, the total completed area of the construction industry in 2021 is approximately 3.889 billion square meters. In 2020, the BIPV installed capacity of major enterprises is 702MW. It is estimated that the actual new market space for BIPV market space will reach 76.6-billion-yuan, accounting for more than 30% of the PV building market in 2024-2025. The market space corresponding to BIPV from 2022 to 2025 is 20/43/73/10 billion yuan, respectively (Mumeng Group 2022). BIPV may have a tenfold expansion space from 2022 to 2025, with a compound growth rate of 81% (Northeast Securities 2022). The combination of BIPV and buildings is flexible, and the application scenarios are diverse; it can be composed of building roofs, curtain walls, and other components (Id.). In addition to the function of power generation, BIPV also has the performance necessary for building envelopes, such as wind pressure resistance, water tightness, air tightness, sound insulation, heat preservation, and sunshade (Id.). While providing protection, building energy saving, solar energy utilization, and other functions, it also guarantees aesthetics, safety, comfort, and other functions to achieve perfect cooperation with the building (Cao 2022). According to Tianfeng Securities, the market space for PV curtain walls will reach 10.9 billion yuan and 13.8 billion yuan, respectively, from 2024 to 2025, and the new market space for BIPV roofs will reach 16.1 billion yuan and 30.2 billion yuan, respectively (Interview No.2 2023). According to the China Academy of Building Research, the market space for BIPV roof renovation will reach 75 billion yuan and 103.8 billion yuan, respectively, from 2024 to 2025 (Id.). According to the forecast of Guotai Junan Securities, by 2025, the new installed capacity of the rooftop stock market will be 2.78GW, and the market size will reach 11.532 billion yuan (Id.). National Bureau of Statistics shows that by 2025, the Chinese market size of new BIPV façades will be about 40.495 billion yuan, with an installed capacity of 8.78GW (Id.). These estimations are quite impartial because they are not from inside the PV industry but from relatively neutral consulting firms, but they don't provide sufficient considerations to policy gaps and potential policy support. In fact, more predictions are interested in BIPV concept stocks and their individual developments such as Arctech Solar and Canlon.

Regarding technology, the latest research on BIPV modules shows that since February 2023, the increase in irradiance over time and irradiance has led to an increase in ambient temperature and PV module back surface temperature (Interview No.2 2023). The technological innovation of N-TOPCon modules will significantly increase the effectiveness of the solar PV power-generating process. The

lower attenuation and better operating temperature of the N-type TOPCon module increased its single-watt generation gain compared to the P-PERC module from 1.26% in February to 3.68% in June (Id.). Since the beginning of 2023, the cost price of PV modules fell rapidly; current cost of purchasing PV modules is not more than 1.4 yuan / W plus, the traditional stock transformation brings about market increment, the new market space of BIPV in the next three years will be 37.5 billion yuan, and the potential increase of BIPV roof will be 55.5 billion yuan (Starry Sky Wealth 2023).

Policy Recommendations

It is necessary to strengthen work to remove barriers for BIPV from the following aspects. The government should increase policy support for the BIPV sector, including more financial subsidies and tax incentives. There should be more innovative business models such as PV leasing and corresponding regulations should provide guidelines for such practices and regulate the development of the BIPV industry specifically instead of the PV industry in general (Interview No. 3 2023). The government should encourage the strengthening of exchanges and cooperation between the PV and construction industries, as well as jointly developing new technologies and processes to improve the feasibility and aesthetics of BIPV. Architects and PV engineers should be encouraged to learn and communicate across industries to cultivate more comprehensive talents (Interview No.2 2023). As the primary power mode of renewable energy, the state encourages and supports PV, including BIPV (Jingrui 2023). However, existing BIPV policies still need to be improved for a broader application of the technology.

In addition, local media should cooperate with the solar industry to enhance awareness of BIPV usage and organize educational campaigns in neighborhoods and communities (Id.). Driven by the mission of building carbon neutrality, building investment, and building design will gradually become the two main driving forces for BIPV applications to help buildings' carbon reduction, and more new buildings will take PV applications as an essential part of them and gradually achieve the deep integration of PV and buildings. Correspondingly, with the decline of PV power generation costs, its application scenarios and application modes are becoming more diversified, accelerating coordinated development of the PV industry (Sihan Industrial Research Institute 2022).

Conclusion

This paper provides a general analysis of China's BIPV development policy context. By examining major policy initiatives, regulations, and incentives, China established a favorable environment for BIPV development. The paper highlights the achievements and challenges associated with BIPV integration, showcasing successful case studies that demonstrate the potential of BIPV. Furthermore, this paper provides recommendations for prospects for sustainable future development of BIPV. This paper advocates for continuous policy support, technological innovation, and stakeholder collaboration to reveal the full potential of BIPV in China's built environment. The paper suggests policy loopholes for further research and policy development to enhance BIPV deployment and contribute to China's sustainable energy transition. China's policy context for BIPV integration demonstrates the government's commitment to promoting renewable energy and sustainable building

practices. Despite existing challenges, this paper concludes that China's position as a global leader in solar PV production and building construction makes it well-placed to advance sustainable BIPV integration.

Attachment

City	Guiding Document	Amount	Subsidy Content
Beijing	Beijing Municipal Development and Reform Commission issued the <i>“Notice on Further Supporting the Promotion and Application of PV Power Generation Systems”</i>	0.4 yuan/kWh	“From 2021 to 2025, for projects with integrated PV applications (PV modules as building components), the subsidy standard is 0.4 yuan per kWh (with tax) for three-star green building operation label project, and the subsidy period of each project is 3 years, and the standard is 80 yuan / square meter for two-star green building operation label project, and the subsidy period of each project is 3 years, and the standard is 50 yuan / square meter. Schools, social welfare places, and projects that all realize BIPV can receive a subsidy of 0.4 yuan per kWh.”
Shanghai	<i>“Shanghai Renewable Energy and New Energy Development Special Fund Support Measures”</i>	0.3 yuan/kWh	“The project investor will be given a kWh incentive for a period of 5 years. PV subsidy generally continues the 2021 incentive standard, and gives greater support to BIPV projects.”
Shenzhen	The Shenzhen Municipal Development and Reform Commission issued <i>“Several Measures on Vigorously Promoting Distributed PV Power Generation (Draft)”</i> and the <i>“Operation Guidelines for the Management of Distributed PV Power Generation Projects in Shenzhen (Draft)”</i> <i>“Shenzhen Longgang District Housing and Construction Bureau 2022 Special Application Guide to Support the High-quality Development of Modern Construction Industry”</i>	Max for BIPV is 0.36 yuan/kWh Longgang and Futian – 0.3 yuan/kWh	“From 2022 to 2026, the municipal finance will subsidize the power generation included in the scope of subsidies, including benchmark conventional PV projects. the subsidy standard for grid-connected power generation projects in 2024 and 2025 is 0.2 yuan/kWh, and the subsidy standard for grid-connected power generation projects in 2026 is 0.1 yuan/kWh; BIPV projects subsidy standard is 1.2 times that of the benchmark conventional PV project. The document promoted the large-scale application of distributed PV in accordance with local conditions in accordance with the principle of “build as much as possible,” and vigorously promote BIPV. Thin-film PV demonstration projects built between January 1, 2022 and December 31, 2025 in Shenzhen and metered by the grid will be within the scope of subsidies. The document also encouraged the exploration of innovative financial products, flexible credit support, and the provision of integrated financial leasing services. <i>Several Measures</i> strengthened the guidance of urban planning layout,

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			and clearly supported the application of BIPV in urban new construction and renewal, which brings benefits to the near-zero carbon demonstration construction implemented by Shenzhen. Centex BIPV ushered in opportunities under the circumstances. Regarding Longgang district, support will be given according to the actual power generation of the previous year, and the support for the same project shall not exceed 20% of the actual construction investment of the project and shall not exceed 1 million yuan.”
Changzhou	“Policies and Measures for Promoting the Construction of a New Energy City in Changzhou City”	BIPV subsidy of 0.3 yuan/watt to give a one-time construction reward	“Accelerate the application of PV in public institutions. Improve the level of PV application and demonstration functions of public institutions in the city. By 2025, the new buildings of public institutions can install PV roof areas and strive to achieve a PV coverage rate of 50%. For completed PV projects of public institutions that are connected to the grid during the period, the investor will be given a one-time construction reward according to the standard of 0.3 yuan/watt. Power grid companies further simplify the grid-connection process to ensure that the supporting grid and PV projects are completed and put into operation at the same time. Many places issued subsidy policies for BIPV, up to 300 yuan/kW.”
Chongqing	“Special Policy for Supporting the Development of New Energy Storage in Chongqing Liangjiang New Area” “Notice on Improving the Matters Related to the Financial Subsidy for Chongqing Green Building Projects”	BIPV subsidy is 200 yuan/kW, with a max of 5 million yuan; green buildings in general up to 40 yuan/m ²	“Encourage the demonstration of new energy storage applications. For projects such as user-side energy storage, distributed PV storage, charging and swapping integration projects that have been filed in the new area and completed and put into operation, if the energy storage configuration time is not less than 2 hours, 200 yuan/kWh will be given according to the installed capacity of the energy storage facilities. The maximum subsidy for a single project shall not exceed 5 million yuan. For independent energy storage projects that have been filed in the new area, completed and put into operation, and participate in power grid dispatching, support will be provided

			<p>according to “one case, one discussion.” Since 2017, projects with gold green building labels will still be subsidized according to the standard of 25 yuan / square meter of project construction area, total not more than 4 million yuan. Among them, projects that only obtain the city’s gold-level green building completion mark are still subsidized according to the standard of 10 yuan / square meter of project construction area, but the total subsidy funds at this stage do not exceed 1.6 million yuan. The subsidy limit for each of the above phases is not included in the indoor garage of the project. Chongqing Municipal Urban and Rural Construction Commission and Municipal Bureau of Finance will provide subsidy funds of 25 yuan / square meter and 40 yuan / square meter respectively according to the construction area of the project for projects that have obtained the gold and platinum green building labels and adjust them in a timely manner according to technological progress and cost changes. Among them, subsidies of 10 yuan per square meter and 15 yuan per square meter will be given to projects that only obtain the completion mark of Chongqing Gold and Platinum green buildings.”</p>
Xuancheng	Xuancheng Housing and Urban-Rural Development Bureau “ <i>Xuancheng BIPV Demonstration Project Construction Management Measures (Draft)</i> ” and “ <i>Xuancheng BIPV City Pilot Special Fund Use Measures (Draft)</i> ”	BIPV30 yuan/kW, roof 20 yuan/kW	<p>“From 2022 to 2023, Building roof PV projects will be given construction subsidies according to the standard of 20 yuan / kW; building façade BIPV projects will be given construction subsidies according to the standard of 30 yuan / kW.”</p>
Hefei	“ <i>Hefei Further Promotes the High-Quality Development of the PV Industry, Several Policy Implementation Rules</i> ”	0.4yuan/W	<p>“For rooftop PV and BIPV projects with an installed capacity of 100 kW or more, a one-time subsidy of not more than 0.2 yuan / watt and 0.4 yuan / watt will be given to the investment entity, and the maximum for the same project shall not exceed 100,000 yuan.”</p>

Bengbu	<p><i>“Administrative Measures for the Use of Special Funds for Pilot Cities of BIPV in Bengbu City”</i></p>	<p>BIPV subsidy 200 yuan/kW, building façade PV subsidy 300 yuan/kW</p>	<p>“The construction area of new BIPV demonstration projects is not less than 5,000 square meters, and the construction area of ultra-low energy consumption demonstration projects is not less than 500 square meters. The construction area of existing building energy-saving renovation demonstration projects is not less than 10,000 square meters, and the installed capacity of the energy storage demonstration project is not less than 1MW. BIPV demonstration building roof project will be rewarded according to the standard of 200 yuan/kW, the BIPV façade project will be rewarded according to the standard of 300 yuan/kW, and the standard of energy storage will be rewarded according to the standard of 200 yuan/kW, ultra-low energy consumption demonstration projects will be rewarded according to the standard of 500 yuan/square meter; the reward and subsidies for a single demonstration project will be within 300,000 yuan.”</p>
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