Application categories

As mentioned in the previous paragraphs, the draft of the standard IEC 63092 [10] classified the BIPV applications into five main categories listed as “Application Categories” **(Tab. 2.1)**. It is applicable to different types of BIPV modules, and it is a classification according to the type of integration, slope and accessibility criteria, in particular:

- Integrated into the building envelope: yes/no
- Accessible from within the building: yes/no
- Sloped: yes/no

“Not accessible from within the building” means that another construction product still provides protection against mechanical impact within the building, even if the PV module has been damaged or removed. These categories are developed considering glass as a main substrate and material of the BIPV module retaining most of the mechanical properties.

System Categories

The classes of building skin systems can be identified as specialised construction units, and the categorisation is based on the main technological systems available for building envelopes. In conventional constructions, the definition of the main building skin construction systems can be grouped in:

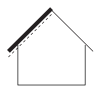
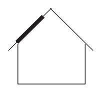
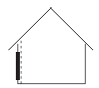
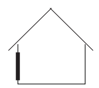
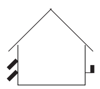
- *Roof*: A roof, in a traditional building construction with a top distinguishable by the facade, is the top covering providing protection and separating indoor and outdoor environments (application categories A and B).
- *Façade*: A façade, in a traditional building construction with parietal walls distinguishable by the roof, is the vertical (or tilted) exterior surface, which is the architectural showcase and separates indoor and outdoor environments. (Application categories C and D).
- *External integrated device*: Elements and systems of the building skin which are in contact only with the outdoor environment (application category E).

These groups can be categorised in sub-systems as shown in the following figures **Fig. 2.2** [9].

A specific definition of the sub-systems based on the IEA PVPS T15 [9] is presented below:

- *Discontinuous roof*: A “discontinuous roof” is typically a pitched/sloped opaque envelope part consisting of small elements (tiles, slates, shingles, etc.) with the primary function of water drainage. It is the part of the building envelope, where the PV transfer had its first successes due to the advantages of optimal orientation of pitches and the simplicity of installation. BIPV is typically part of the discrete elements composing the roof tiling, which form part of the roofing layer.
- *Continuous roof*: A “continuous roof”, a flat or curved roof, is characterised by a large uninterrupted layer with the primary function of being water-resistant. Usually, membranes are used as a water barrier. In the first applications in time, the PV was mainly placed on top of the roof (BAPV). Lightweight and self-bearing systems represent the second generation of PV applications (BIPV). Flexible membranes, solar flooring and other solutions can be used for integrating PV as a multifunctional part of the building envelope.
- *Skylight*: These are light-transmitting building elements that cover all or a part of the roof. They are typically (semi)transparent for daylighting purposes, with additional thermal, acoustic and/or waterproofing functions when protecting an indoor environment. Alternatively, they serve mainly as a shelter if protecting outdoor (non-heated) areas (atriums). They can be fixed or openable, and retractable. PV is typically part of the glazed layer, applying both crystalline or thin-film PV technologies, and with various possibilities for transparency degrees and visual appearance.
- *Curtain wall*: It is an external and continuous building skin fenestration system, totally or partially glazed, composed of panels supported by a substructure in which the outer components are non-structural. A curtain wall refers to its construction, since façade is hanging (just as a curtain) from the top perimeter of the building and is locally fixed to resist air and water infiltration, and is typically designed with extruded aluminium frames (but also steel, wood, etc.) filled with glass panes. The façade should satisfy multiple requirements, such as a load-bearing function, acoustic and thermal insulation, light transmission, waterproofing, etc. E.g., in the configuration of “warm façade” it directly divides, as a skin layer, outdoor and indoor environments. It can be realised according to different construction systems such as stick-system, unitised curtain wall, Structural Sealant Glazing (SSG), point-fixed or suspended façade. In their most basic form, they are windows, while in more complicated forms, they can be used to realise complex skin façades. PV is typically part of the outer cladding layer, in the form of glass-glass elements, with crystalline or thin-film technologies and various transparency

Tab. 2.1 List of Application Categories. Source: IEA.

Category A:	Sloping, roof-integrated, not accessible from within the building The BIPV modules are installed at a tilt angle between 0° and 75° from the horizontal plane [0°, 75°], with another building product installed underneath	
Category B:	Sloping, roof-integrated, accessible from within the building The BIPV modules are installed at a til angle between 0° and 75° from the horizontal plane [0°, 75°]	
Category C:	Non-sloping (vertically) envelope-integrated, not accessible from within the building The BIPV modules are installed at a tilt angle between 75° and 90° from the horizontal plane [75°, 90°], with another building product installed behind.	
Category D:	Non-sloping (vertically), envelope-integrated, accessible from within the building The BIPV modules are installed at a tilt angle between 75° and 90° from the horizontal plane [75°, 90°]	
Category E:	Externally-integrated, accessible or not accessible from within the building The BIPV modules are installed to from an additional functional layer that provides a building requirement. E.g. balcony balustrades, shutters, awnings, louvres, brise soleil, etc.	

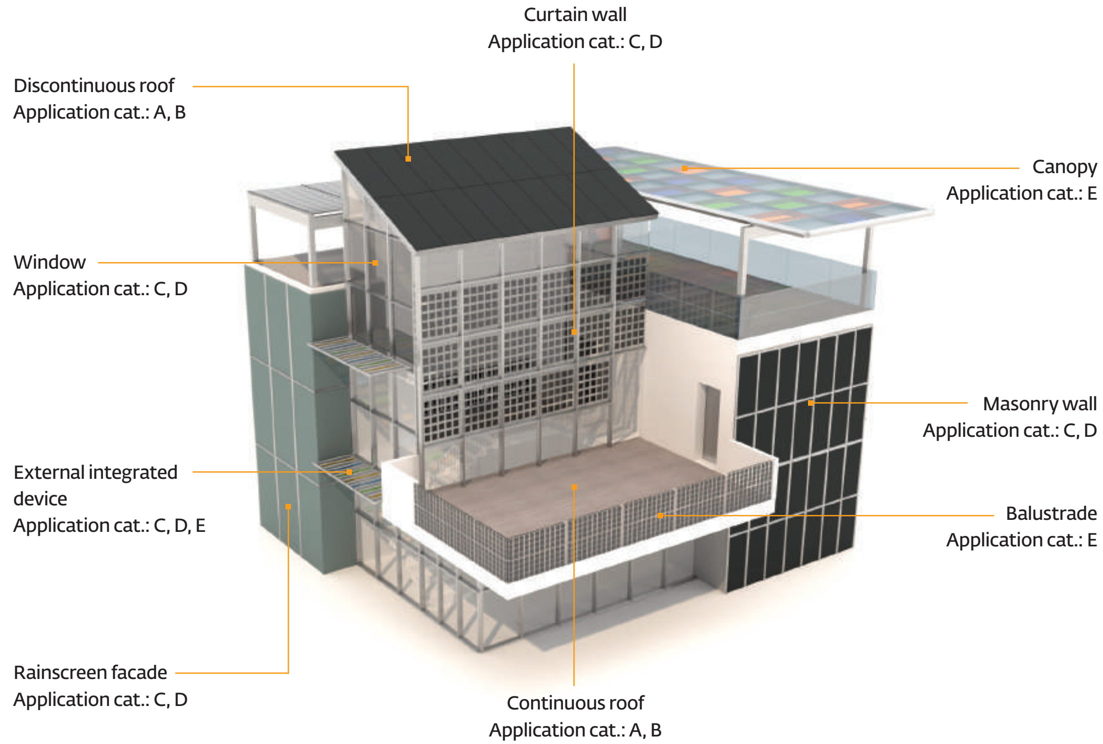


Fig. 2.2 System categories. Source: SUPSI.

degrees and visual appearance possibilities. Usually, the glass is an IGU (double or triple glazing) to ensure adequate thermal and acoustic insulation.

- *Rainscreen*: Well known as a "cold" or ventilated façade, it consists of a load-bearing substructure, an air gap and a cladding. In summer, heat from the sun is dissipated, thanks to the cavity that usually is naturally ventilated through bottom and top openings. A rainscreen is ideal for enhancing rear ventilation. It is typically categorised as "vented" with openings at the bottom; "ventilated" openings at both the bottom and top; and "pressure equalised" rainscreen with compartmentalisation in the air cavity. Many construction models and technological solutions are available on the market, also with various joints and fixing options. Usually, PV elements are integrated similarly to opaque, non-active building cladding panels and can assume many aesthetic configurations, especially through glass customisation (colours, textures, sizes, etc.).
- *Double skin façade*: It consists of two layers, usually two glazing elements wherein air flows through the intermediate cavity. This space (which can vary from 20 cm to a few meters) acts as insulation against extreme temperatures, winds, and sound, improving the building's thermal efficiency for both high and low temperatures. PV is applied similarly to a curtain wall even though the outer façade, in this case, does not require thermal insulation. Thus, it is often a glass laminate rather than an insulated glazing unit (IGU).
- *Window*: A window is a glazed wall opening to admit light and often air into the structure and to allow outside views. Windows, as a very ancient invention probably coincident with the development of fixed and enclosed constructions, are also strongly related with the building architecture, the space design, climatic conditions, functions, technologies and performance, etc. PV can be integrated into conventional PV glazing or also into some innovative applications.
- *Masonry wall*: A "barrier wall" or "mass wall" is an exterior wall assembly of bricks, stones or concrete that relies principally upon the weather-tight integrity of the outermost exterior wall surfaces and construction joints to resist bulk rainwater penetration and/or moisture ingress (e.g. precast concrete walls, exterior insulation and finish systems EIFS, etc.) or upon a combination of wall thickness, storage capacity, and (in masonry construction) bond intimacy between masonry units and mortar to effectively resist bulk rainwater penetration.
- *External integrated device*: These include 1) Transparent or opaque multi-functional and photovoltaic solar shading devices (Louvres or embedded venetian blinds) for façades or balustrades with the role of "fall protection" that are necessary for the safety of the building (e.g., in balconies, loggias, parapets);2) Transparent or opaque shading devices for roofs aimed to select the solar radiation; 3) Integrated canopies, greenhouses and veranda.
- *Canopy*: A canopy is an unenclosed roof or a structure over which a covering is attached, providing shade or shelter from weather conditions. Such canopies are supported by the building to which they are attached or also by a ground-mounting or stand-alone structure, such as a fabric-covered gazebo.

BIPV cladding properties

Cladding is referred to the external part of the technological system layering (e.g., façade cladding or roof tiling) together with the associated technological requirements (e.g., building covering, weather protection, safety, etc.). Today, BIPV claddings, namely the BIPV modules, can be tailored for almost every kind of building envelope resulting in a performing and high aesthetic solution. The customisation aspect includes colour, dimension, shape, thermal properties, material, etc. A categorisation of BIPV cladding, based on their properties and application, as defined in the framework of report D1.3 of the project H2020 BIPVBOOST project [13] is reported in Tab. 2.2. It offers to architects, building owners and other stakeholders of the BIPV value chain an overview of the possibilities offered by BIPV products:

Tab. 2.2 BIPV cladding properties. Source: IEA.

CLADDING	DESCRIPTION	SOURCE
MATERIAL	It represents the main material/s in which the solar cells are integrated or encapsulated in order to form the end BIPV product. Today, the most common material is glass, used as module backsheet and/or frontsheet. Glazed solution is suitable for semi-transparent and opaque solutions. Other supporting materials adopted for BIPV installations include polymer, metal, and cement-based materials. The features of the material establish the thermal, architectural and technical properties of the building envelope.	BIPVBOOST [13]
TRANSPARENCY	It permits to distinguish semi-transparent and opaque solutions. Semi-transparent solutions are suitable for curtain walls, double skin façades, warm façades, skylights, canopies, etc. The transparency value of BIPV modules allows architects and designers to increase the building's user comfort and energetic performance. The assessment of daylighting, glare and view out are additional parameters that can be set by adjusting the transparency performance of semi-transparent surfaces. Opaque solutions do not permit the light to pass through the building envelope. These solutions are suitable for rainscreen, prefab roof/façade, railings, louvres, curtain wall, flat or pitched roof solutions.	BIPVBOOST [13] IEA PVPS Task15 [9]
THERMAL INSULATION	It is referred to the module's thermal transmittance (U value). The thermal protection of the building is given by the materials that form the building skin. The minimum value required to overcome the energetic standard depends on the local regulations. The following solutions give the thermal insulation for the claddings: • Insulated glazed unit: Glazed solution normally used when thermal protection between two spaces is required (insulated glass unit, curtain walls or skylights, etc.); • Prefab solution: Composite solution where the cladding is one single element composed of a front-sheet, photovoltaic layer and a substrate. The front-sheet could be either glazed or not glazed. The substrate could be composed by different functional materials such as for thermal/acoustic or fire protective layers.	BIPVBOOST [13] IEA PVPS Task15 [9]
COLOURING	This framework represents one of the possible ways to customise and boost architecture. Today, several manufacturers offer coloured solutions, and the implementation of coloured modules is growing fast. In such a way, for example, PV cells can be camouflaged behind coloured patterns that completely dissimulate the original visuality of the PV cells. A shortlist of the colouring possibilities available in the today's market is presented below: • Products with coloured/patterned interlayers and/or with special solar filters • Products with coloured and/or semi-transparent PV-active layers (thin film, OPV) • Products with coloured polymer films (encapsulant, backsheet) • Products with coated, printed, specially finished or coloured front glass covers • Products with coloured anti-reflective coatings on solar cells (c-Si)	BIPV Status Report 2020 [7] IEA PVPS Task15 [8]
SIZE	The size parameter are distinguished as i) Large modules, when they exceed 2.6 m in any dimension or 2.1 m in both dimensions, ii) Less than 0.9 m in both dimensions for shingle, iii) Regular modules, when they do not fall under the categories of large or shingle [14].	IEA PVPS Task15 [9]

2.3 BIPV potential for buildings

To optimise the energy production from solar panels, one of the most investigated aspects is the relation between solar yield with orientation and inclination. The optimal inclination to exploit the maximum solar irradiation is mainly a matter of solar geometry; i.e., it depends on the location's latitude. However, for BIPV, the orientation possibilities need to be defined from the building design stage itself.

India has an extend of land from 8°4' to 37°6' North latitude and 68°7' to 97°25' East compiling 29 states and 6 union territories. In India, the Tropic of Cancer passes through eight states: Gujarat, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, West Bengal, Tripura and Mizoram. This specific feature of India does so that for locations to the north of Tropic of Cancer, solar radiations at peak time occur to be from South directions only for all the seasons. Moving from south to north of India, the optimal PV tilt angle for maximum energy generation, increases due to the decreased solar height. However, for the evaluation of BIPV potential based on application category in the Indian scenario, we need to consider the solar exploitation potential for different PV orientation and tilt angles. Herein, we have considered three locations in India for the study: 1. Thiruvananthapuram (Latitude 8.470865°; Longitude 76.991872°; Annual global irradiation on the horizontal plane 1945.3 kWh/m²); 2. Kutch ((Latitude 23.527348°; Longitude 70.785662°; Annual global irradiation 2050.5 kWh/m²); 3. Chandigarh (Latitude 30.7334421°; Longitude 76.7797143°; Annual global irradiation 1788.5 kWh/m²) (Irradiation data acquired from PV*SOL online tool). The locations are selected for the general solar pattern typology in India; Thiruvananthapuram for location south of Tropic of Cancer, Kutch for location passing through Tropic of Cancer, and Chandigarh for location north to Tropic of Cancer. The distinction in solar path of the three places is evident from the figure that for the southern location (Thiruvananthapuram) solar irradiation is coming from the North direction alone for more than one-third of the year, which will be reduced when moving towards north. The pattern will be evident up to the places of Tropic of Cancer (like Kutch), further moving towards north (like Chandigarh) will reduce the share of northern irradiation, particularly at the solar peak of a day.

To unlock the solar energy integration in the built environment, the assessment of the BIPV potential for existing urban areas represents a preliminary fundamental step. In fact, by knowing the BIPV potential, urban decision-makers can support the integration of PV in the urban environment with appropriate policies to achieve energy transition goals. Specifically, to assess the urban BIPV potential of façades, not only solar radiation analysis is required but also the identification of construction façade characteristics, which significantly affect the real BIPV exploitability. Many current urban BIPV façade cadastres generally do not consider specific building characteristics since the majority of them are based on 3D city models (e.g. LOD200-schematic design), meaning that the influence of architectural elements (such as windows, balconies, etc.) is not evaluated. Therefore, it is crucial to have a calculation method capable of matching existing solar radiation analysis with architectural characteristics of façades, through building typological indicators, in order to better estimate the urban BIPV potential, especially for façades, to improve the current estimations and create the framework to properly evaluate BIPV potential from the early design phases [15].

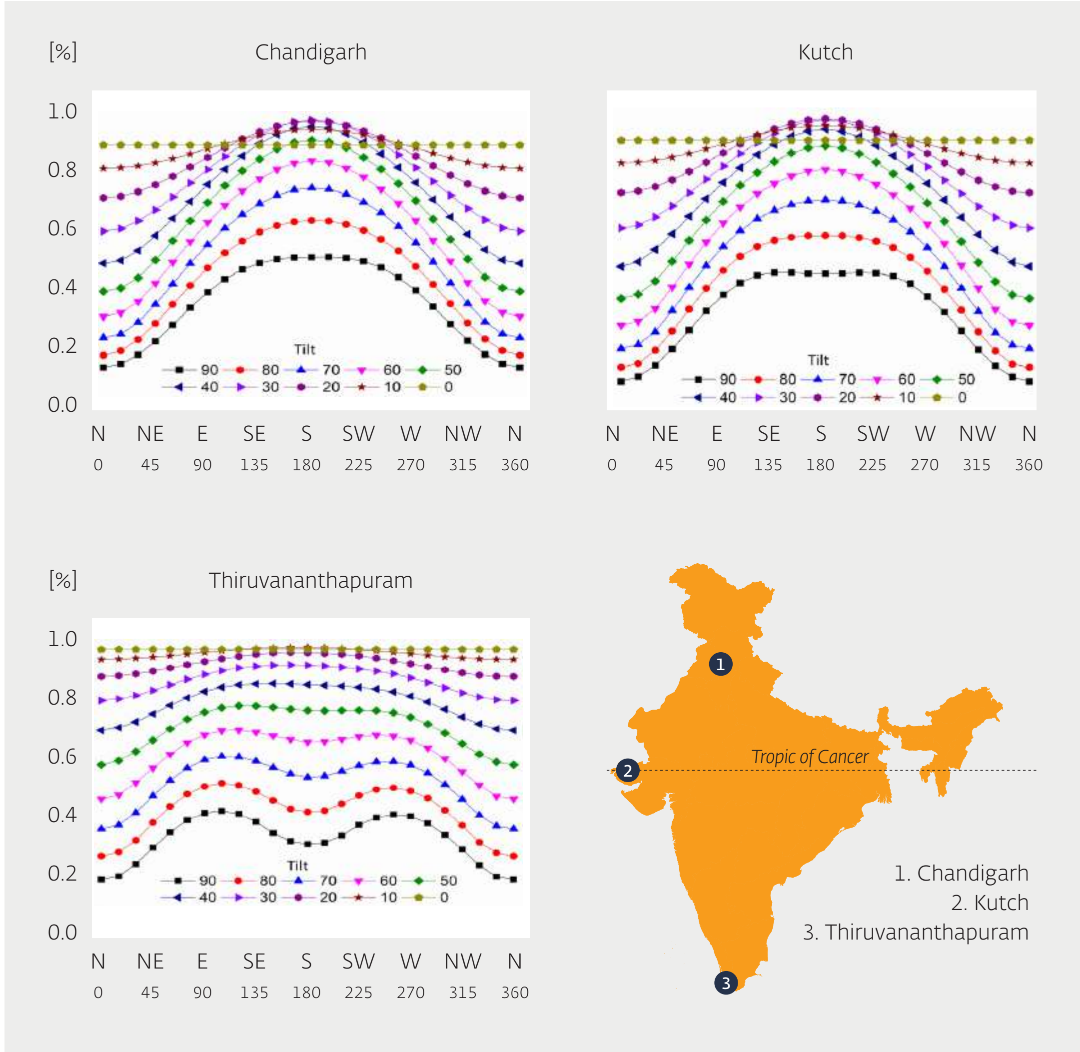
The following paragraphs present an in-depth analysis of the sun position in India and the related solar irradiation of the building envelope.

The solar potential study involved the data acquisition of energy generation from PV at the intended locations for different tilt and orientation of PV using PV*SOL online tool (Assumptions: Calculated for roof-mounted 300 Wp Si monocrystalline PV modules (18.1% efficiency) with zero considerations of diffuse light, shadowing and soiling loss). The data generated are used for a comparative study of the optimum tilt and orientation of PV at the specific locations, thus normalising the factor of annual global irradiance and the assumptions taken. The PV Energy Factor (ratio of energy that can be generated yearly for the specific tilt and orientation to the maximum possible energy generated at the optimum tilt and orientation for the same system at a specific location) of the location is plotted for the three locations with different tilt and orientations.

The optimum orientation is south for India, the tilt being higher in northern regions, as shown in the **Fig. 2.3** for Kutch and Chandigarh. This is due to the lower solar azimuth angle for northern regions compared to south. The optimum angle for Thiruvananthapuram, Kutch and Chandigarh is 8˚, 23˚ and 26˚ respectively.

The condition of southern states is thus more suitable for collecting irradiation with horizontally flat or small pitched PV systems (<10˚). Compared to Kutch and Chandigarh, the south state, Thiruvananthapuram shows a peculiar pattern of maximum energy factor around E-SE and W-SW orientations for vertically tilted PV systems. The formation of this pattern is due to the availability of irradiation from north for a considerable number of days in the southern locations. The pattern tends to diminish by decreasing the PV tilt. Also, the influence of irradiation from the north will reduce much when we travel from south to north of India, diminishing the pattern, thus the placement of vertical PV systems seems liberal in the northern region. As shown in the figure, Kutch and Chandigarh can utilise E-S-W orientations for vertical PV systems, offering a liberal vertical PV positioning.

Fig. 2.3 i) Top left: PV Energy Factor for Trivandrum; ii) Top right: PV Energy Factor for Kutch; iii) Bottom left: PV Energy Factor for Chandigarh. iv) Bottom right: Marking of selected locations in India. Source: NIIST.



For designing BIPV/BAPV integration in new or existing buildings, the necessity of mapping and valuing the solar potential of that building is crucial for efficient energy and economic optimisations. The BIPV potential of a building is associated with the factors like location, orientation and tilt of potential building surfaces, and other external factors (not considered here) like shading loss, soiling loss, hail loss, clouding loss, atmospheric pollution loss, etc. Herein, as an example, the representation for BIPV potential score (PV energy factor converted as score in 100 for easy adoption) is shown Fig. 2.4 indicatively for the three selected locations, and applicable for categories:

1. Sloping roof integrated (category A and B): Discontinuous and continuous roof, skylight, canopy. The BIPV score has been calculated with a minimum tilt angle of 0°.
2. Sloping roof integrated (category A and B): Discontinuous and continuous roof, skylight, canopy. The BIPV score has been calculated with a maximum tilt angle of 15°.
3. External integrated (category E): External integrated device and canopy. The BIPV score has been calculated with a tilt angle of 75°;
4. Non-sloping (vertically) envelope-integrated (category C and D): Rainscreen, curtain wall, double skin, window and masonry wall. The BIPV score has been calculated with a minimum tilt angle of 75°.
5. Non-sloping (vertically) envelope-integrated (category C and D): Rainscreen, curtain wall, double skin, window and masonry wall. The BIPV score has been calculated with a maximum tilt angle of 90° (refer BIPV application category).

In conclusion, the mapping of solar potential score for buildings (including the external losses) helps in identifying the utilisable surfaces and solutions for BIPV/BAPV integration for efficient investment. For new buildings, a score mapping according to the building design (including shade and utilisable surface analysis) can support the generation and modification of BIPV innovative designs for better energy and economic optimisation with efficient material utilisations.

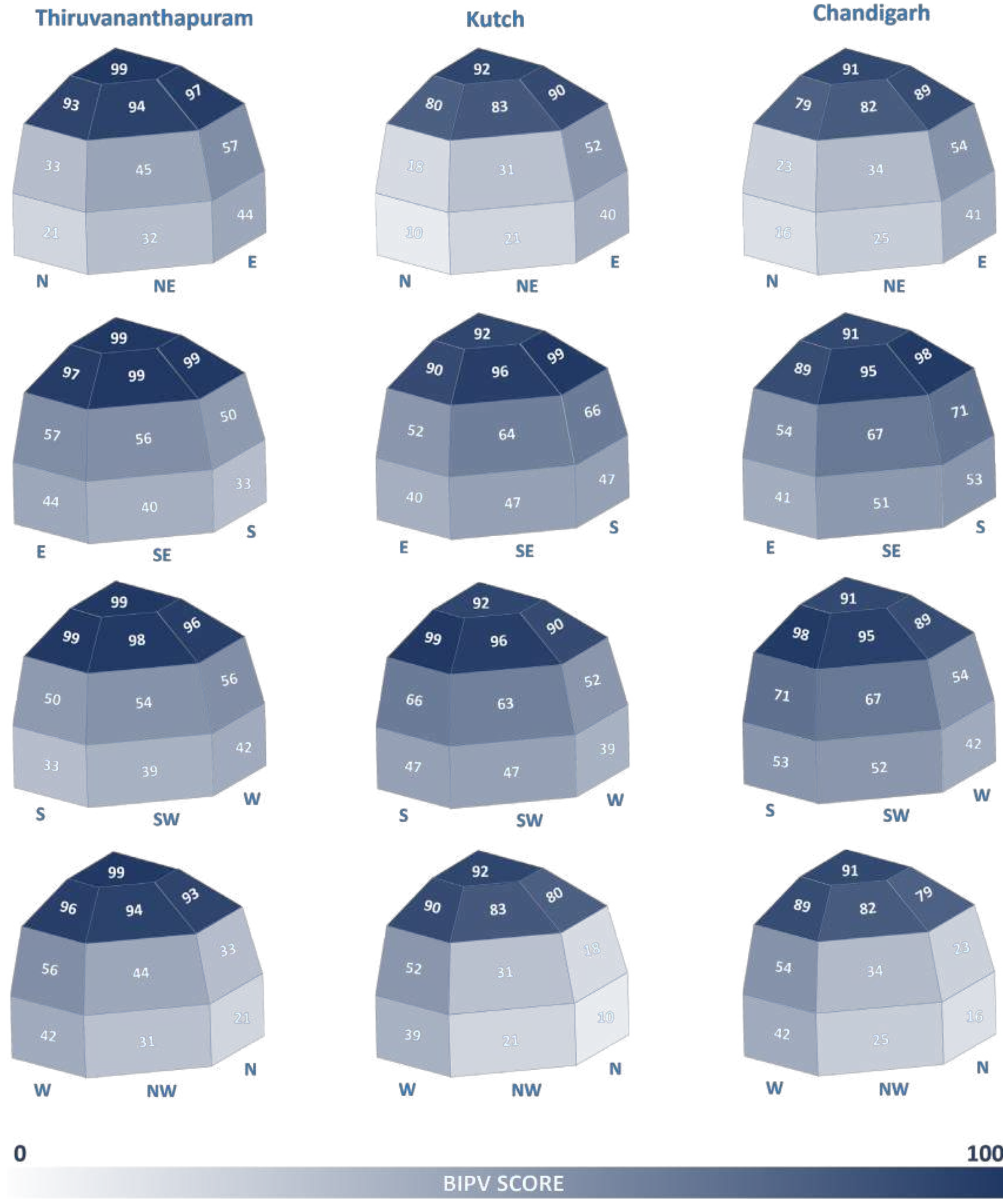


Fig. 2.4 BIPV Score: PV energy factor converted as score in 100 for easy adoption. Source: NIIST.

Aelius Turbina

www.aeliusturbina.com
renewables@aeliusturbina.com
+91 81690 58820 / +91 98202 45202

Introduction

Aelius Turbina was conceived in 2020 with a purpose of bringing green energy to the masses & trying to achieve the NetZero dream. We have won the **Best Green Energy Start-ups 2021** award and have been invited by the **Indian Consulate** to represent Innovation in the Solar sector for **Dubai Expo 2020.**
Aelius Turbina are the thought leaders, innovators & implementers of **BIPV** technology in India.

Our Innovation & USP:

- Our ultimate goal is to create a NetZero Carbon Building consisting of Aelius Turbina's innovative BIPVproducts.
- These BIPV products are a direct replacement of traditional building surfaces to maximise the potential of the Solar energy generation.
- While these BIPV products are independent solar energy products, they can be combined together to fulfil the energy requirements of any structure - flat to factories.
- Most of our BIPV Products have a ROI between 3-4 years*

a. Aelius BIPV roof (Roofing BIPV product)

The key features are:

- The Aelius BIPV Roof is a 5 in 1 integrated roof - shade, solar power, daylight, waterproofing and rainwater harvesting.
- There is no need for separate roofing costs. The Solar panels are the roof.
- Any solar panel can be converted into Aelius BIPV Roof. The BIPV roofing system is highly customizable.
- Economical than Metal Roofing + Solar.
- Accelerated depreciation benefits.
- Eligible Input Tax Credit.

Applicable for: Warehouses, Factories, Production Set-up, Manufacturing Plants, IT Parks, Hospitals, Hotel Chains, Bungalows, Houses/Flats.

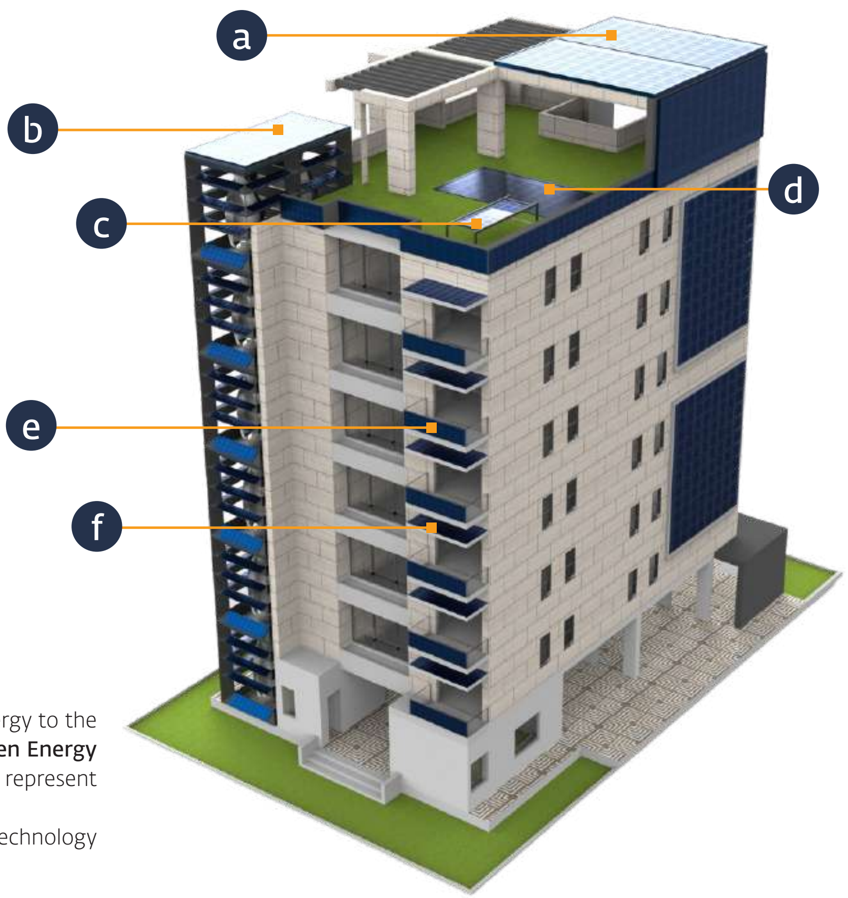


Fig. Aelius Turbina - BIPV Products & Services

b. Aelius Insulated Roof (Roofing BIPV product)

The key features are:

- This unique Roofing Panel is a combination of Metal Roof + Insulation + High SRI Cooling + Solar Panel all embedded into a single homogenous product.
- Perfect for factories and warehouses where high temperature is an issue.
- Provides Waterproofing as well.
- No separate installation mechanism.
- Modular, lightweight & durable.

Applicable for: High Temperature Regions - Warehouses, Factories, Production Set-up, Manufacturing Plants, Houses/Flats.

c. Aelius Solar Coffee Table (NetZero Individual product)

The key features are:

- Aelius Coffee Table is an aesthetically appealing, Solar Smart Table that allows you to charge your devices while enjoying your choice of drink.
- It is an all weather, outdoor friendly & light weight coffee table.
- It is equipped with 2 fast USB charging devices, ambient light, battery indicator & a 12AH battery backup that allows the table to be used even during the night.

Applicable for: Individual Home/Flat Owners, Hotel Chains, Cafes, Bungalow owners, Parks.

d. Aelius Solar Pavers (Building oriented BIPV)

The key features are:

- Single, modular solar pavers can be combined together.
- Direct replacement of tiles and multiple pavers.
- Waterproof, leakproof, tamper-proof, heat resistant & walk friendly.
- Easy maintenance.
- High energy yield.

Applicable for: IT Parks, Hospitals, Hotel Chains, Gardens, Pavements, Parks, Bungalows, Open public areas.

e. Aelius Solar Railings (Building oriented BIPV)

The key features are:

- A smart balcony railing that generates power from the sun.
- An aesthetically pleasing alternative to conventional glass panel railings.
- Seamless solar cell integration results in limitless design and colour options.
- Same sturdiness and protection of a traditional glass railing.

Applicable for: Architects, Builders, Houses/Flats, Hotel Chains, Residential Buildings.

f. Aelius Solar Awnings (Building oriented BIPV)

The key features are:

- Aelius Awnings acts as solar protection during the day thereby reducing the heat while generating energy for usage.
- Simple to set up, can be placed on the openings of the rooms or commercial premises as a single module or in series.
- Can be connected to an off-grid or on-grid stem, typically used for self-consumption.
- Modular, light-weight, easy to maintain.

Applicable for: Architects, Builders, Houses/Flats, Hotel Chains, Residential Buildings, Cafes.

Chapter 3
Indian BIPV roadmap

3.1 Roadmap for BIPV implementation

Unlike standalone PV utility systems and rooftop solar systems, the penetration of the BIPV sector in the market requires direct renewable energy policies integrated with other uninitiated policies and regulations in building energy and construction sectors. Building a roadmap for the Indian BIPV sector is challenging at the current state of non-uniform and expansive market, demographic distinction, stakeholder value and hierarchy, industrial inflexibility with the present state of affairs, and severe lack of awareness within every stakeholder level. To initiate and define a collective and concrete roadmap for BIPV implementation in India, this report focuses on five main factual contemplation levels;

1. Perspective: Government policies, Initiatives and Business models
2. Opportunities: Multifunctionality and cost reduction
3. BIPV Industrial Sphere: Technology readiness, Supply chain and Certification
4. Innovation landscape: Research projects & Engagement of international communities
5. Defining stakeholder involvement: Need for stakeholder awareness, extensive project planning & execution

(1) Perspective: Government policies, Initiatives and Business models

Scenario

Indian construction sector is expected to grow with an impressive trend, with a projection of ~45 billion square metres in floor area additions by 2060; among this, more than 80% of floor area accounts for residential buildings [1]. In this purview, India has a huge opportunity to build new renewable energy infrastructure in a more decentralised manner via the integration of solar energy systems in the built environment and also with the new building designs. To support sustainable renewable energy adoption, the Government of India (GoI) has developed many policies and initiated international alliances in the energy sector; this includes the handholding with International Solar Alliance for large scale solar adoption. Further, GoI has initiated many bilateral programs for attaining energy efficiency in the built environment, such as Indo-Swiss and Indo-US Building Energy Efficiency Projects (BEEP). In the similar line, national mission mode programs such as Smart Cities Mission and National Mission on Sustainable Habitat were initiated, where share for renewables is a major focus. Recently, GoI had released its National Action Plan on Climate Change, this is in line with the United Nations Sustainable Development Goals (UN SDG) and Mission Innovation (MI) launched during COP21. The MI is a global platform to foster and promote R&D for accelerated and affordable clean energy innovation, India and the EU are certain key members for this global initiative.

How can BIPV directly influence policies & regulations?

Replacing surfaces of building roofs and façades with active claddings, BIPV is a unique way to reduce the energetic impact of buildings, transforming them to nearly-zero energy or plus energy. Indeed, the multifunctionality of BIPV installations allows to produce on-site renewable electricity and to act for the performance as building skin with added functions of a building construction system. Moreover, as previously discussed, technology can be flexibly used for customising the architectural design of contemporary buildings. However, faster adoption of BIPV into the Indian building sector requires substantial efforts at the policy level. In this regard, Governments can pull two main levers: support the cost-effectiveness of BIPV products through the implementation of subsidies (similar to rooftop PV discussed in Chapter 1) or charge for the hidden costs of pollution and CO2 emissions in buildings. Ideally, any plan to address climate change via decentralised energy generation in buildings needs both. Implementing the right policies at the right time, especially in the construction sector, will open the possibilities to tap our most promising and sustainable landscape for sustainable design and decentralised renewable generation, extracted as "The building as energy generation nodes". To make this possible in the construction sector, Government could ensure that at least some of these carbon costs are paid by whoever is obligated and reduce the green premium, especially for multifunctional products that offer renewable integration into the buildings by exploiting already built surfaces. This would, in turn, create an incentive for building product manufacturers to come up with carbon-free alternatives, for example, building construction/ materials leading to sustainable solutions such as innovative BIPV products and their faster adoption in the construction sector.

Aside from that, governments, policy advisers and policymakers need to introduce new building energy policies and energy-efficient city planning. Even though