Chapter 4
Case studies

Case study: Malabar HQ, Kozhikode. 2017

The project constituted of more than 180 highest quality PERC solar panels installed as canopy over the building. The solar power plant installed at the site helps to produce about 89,000 kWh per year and thus annually saving around Rs 7,12,480. The solar power plant helps to reduce around 44 tons of carbon dioxide and also helps to save around 2,013 trees. The installation of the solar power plant required a completion time of two weeks.

Building typology	-	Administrative
Technological system	-	Canopy
Active cladding surface	ft^2	4,500
Orientation	°	South
Tilt	°	8
Nominal power	kWp	60
System power density	Wp/ft^2	13.3

Tab. 4.16 System features.

Fig. 4.14 General view. Source: Sunsenz.

Tab. 4.17 Product features.

BIPV technology	-	Semi-transparent glass/glass modules (325Wp per module)
PV technology	-	PERC, bifacial modules
Degradation rate yr 0	%	0.70
Degradation rate yr >0	%	0.70
Customization in size	-	No
Customization in colour	-	No

Tab. 4.18 Energetic features.

Energy production	kWh/yr	89,060
Average yearly yield	kWh/kWp	1,460
Self-consumption	%	NA
Self-sufficiency	%	NA
Business model	-	NA
Subsidies	-	No
Payback time	Year	NA

Fig. 4.15 Canopy, interior view. Source: Stapati.

Case study: Sierra E-Facility HQ, Coimbatore. 2018

The facade of the building in Coimbatore is fitted with amorphous silicon BIPV modules that produce solar power energy in conditions of low light. The curtain wall facade combines transparent photovoltaic glass with conventional glass, achieving an aesthetic and functional result. Has been calculated that the yearly energy production is about 1,200 kWh. The PV glazing solution is a laminated safety glass with modules used in standard size (4.1x6.1ft^2) with medium transparency. The solar capacity of the building has been completed with further PV installation in the roof. The Sierra E-Facility uses environmentally friendly building materials and high-performance glass. It scored 103 points in the LEED-NC rating system.

Tab. 4.1 System features. Source: Onyx Solar.

Building typology	-	Commercial
Technological system	-	Curtain wall
Active cladding surface	ft^2	580
Orientation	°	East
Tilt	°	90
Nominal power	kWp	4.3
System power density	Wp/ft^2	7.4

Fig. 4.1 Curtain wall. Source: Onyx Solar.

Tab. 4.2 Product features. Source: Onyx Solar.

BIPV technology	-	Transparent glass modules (medium transparency)
PV technology	-	a-Si PV
Degradation rate yr 0	%	NA
Degradation rate yr >0	%	NA
Customization rate	-	100% customized in shape, thickness, colour, transparency-degree, size and finishes

Tab. 4.3 Energetic features. Source: Onyx Solar.

Energy production	kWh/yr	1,476
Average yearly yield	kWh/kWp	343
Self-consumption	%	100
Self-sufficiency	%	NA
Business model	-	NA
Subsidies	-	NA
Payback time	Year	<16

Fig. 4.2 a-Si BIPV glazed facade. Source: Onyx Solar.

Case study: Desai Brothers Ltd, Sahakarnagar. 2019

Discontinuous roof covered by BIPV tiles. The solar roof of the following commercial activity produces about 6,000 kWh per year being oriented towards South, West, East, Southwest and Southeast. The installation of the tile is very simple and doesn't require the use of sealant. In the following case study, the shading losses are lowered due to the installation of bypass diodes for each tile. The rooftop is installed in Sahakarnagar, Bangalore and the payback time of the solar investment is assessed in 5-6 years.

Tab. 4.13 System features.

Building typology	-	Commercial
Technological system	-	Discontinuous roof
Active cladding surface	ft^2	387
Orientation	°	S, W, E, SW, SE
Tilt	°	25
Nominal power	kWp	5
System power density	Wp/ft^2	12.9

Fig. 4.12 Rooftop installation. Source: Anu Solar Power.

Tab. 4.14 Product features.

BIPV technology	-	BIPV roof tiles
PV technology	-	c-Si
Degradation rate yr 0	%	0.7
Degradation rate yr >0	%	0.7
Customization rate	-	Flexible and easy installation. No need of sealant application

Tab. 4.15 Energetic features.

Energy production	kWh/yr	6,300
Average yearly yield	kWh/kWp	1,260
Self-consumption	%	NA
Self-sufficiency	%	NA
Business model	-	CAPEX
Subsidies	-	40% tax depreciation
Payback time	Year	5-6

Fig. 4.13 Rooftop detail. Source: Anu Solar Power.

Case study: CTRLS Datacenter, Maharashtra. 2020

The CTRLS Datacenter was renewed in 2020 with the installation of BIPV glazed modules installed on all four facades. The installation is realized by U-Solar, a Clean Energy Eneterprise with PAN India and neighboring country installations. The center located in Mumbai is the largest building integrated vertical solar PV system in India. The solar installation allowed to transform the building in a solar power plant and drastically reduced its energetic impact. The mono c-Si PV frameless modules cover a vertical surface of about 51,505 ft^2 with a system capacity of 863 kWp. The active facade area is about 7-8 times of that available on the roof (this is assuming all the roof is empty - which is not).

The glazed PV modules have been installed on the top of the previous opaque facade, by creating a ventilated airgap between the thermal insulation and the PV panels. Indeed, the technological system is rainscreen.

The solar system is configured accordingly to four orientations: NW (252 kWp), SW (261 kWp), SE (290 kWp) and NE (60 kWp). The PV modules utilized are 2,466 per 350 Wp.

The energy production has been measured in more than 590 MWh per year, corresponding with an average yield of almost 700 kWh/kWp. The actual energy production corresponds with an increase by 7% of those expected.

Considering the high energy demand of the datacenter, the self-consumption rate is 100%, which means that the total amount of energy produced by the solar system is used outright. However, only 2% of the energy demand is supplied with renewable energy.

Building typology	-	Commercial
Technological system	-	Rainscreen
Active cladding surface	ft^2	51,505
Orientation	°	NW, SW, SE, NE
Tilt	°	90
Nominal power	kWp	863
System power density	Wp/ ft^2	17

Tab. 4.4 System features.

BIPV technology	-	Opaque glazed BIPV solution without thermal properties
PV technology	-	Mono c-Si
Degradation rate yr 0	%	0.70
Degradation rate yr >0	%	0.70
Customization in size	-	No
Customization in colour	-	No

Tab. 4.5 Product features.

Fig. 4.3 CTRLS during the BIPV facade construction phase. Source: U-Solar.

Energetic and economic evaluation

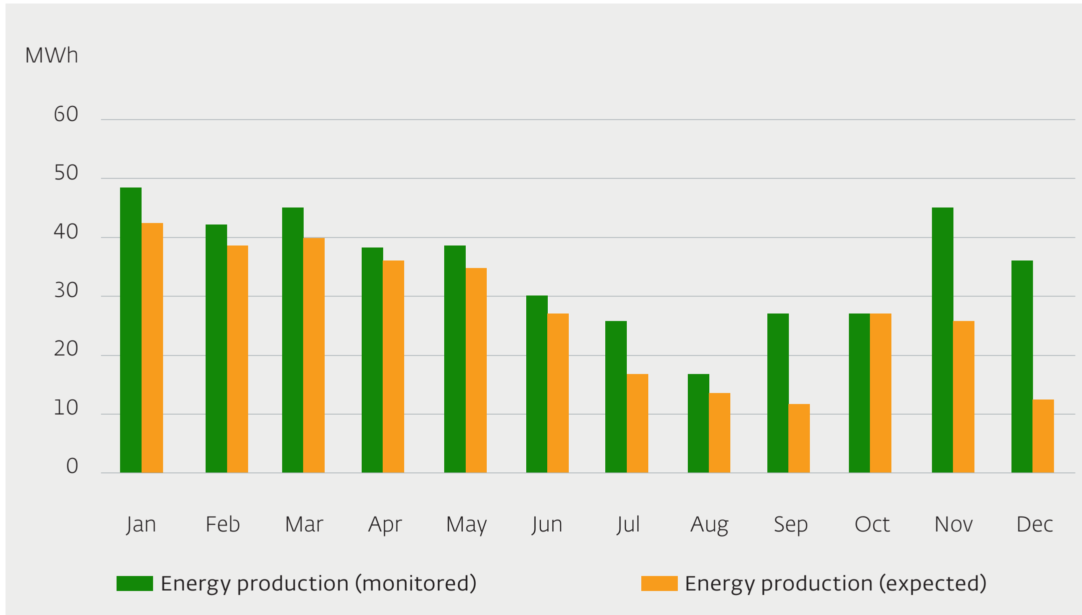
Energy production	kWh/yr	593,014
Average yearly yield	kWh/kWp	687
Self-consumption	%	100
Self-sufficiency	%	2
Business model	-	CAPEX
Subsidies	-	40% tax depreciation
Payback time	Year	4.3

Tab. 4.6 Energetic features.

The system energy payback time, calculated by U-Solar, is less than 5 years by assuming a total cost of about 650 Rs/ft^2, subsidies corresponding with a 40% accelerated tax depreciation. The business model is CAPEX.

Fig. 4.4 CTRLS BPV facade. Source: U-Solar.

Fig. 4.5 Energy production (expected vs monitored-2020), variation over the year due to weather. Source: U-Solar.



Case study: Ponnore Group (Aqua Star), Kerala. 2020

This administrative building is covered with high efficiency mono PERC double glass semi-transparent BIPV facade facing the south and west orientation. The solar power plant transforms the Ponnore Group Construction in a low energy building. Indeed, the energy production, estimated in about 17,000 kWh/yr, generates 50% of the energy requirement of the building. Considering the high yearly solar horizontal irradiation of the location (about 2,000 kWh/m²/yr) and according with the calculation of the facade manufacturer, the payback time of the investment in the solar power plant is only 4.3 years by including a 40% tax depreciation.

Building typology	-	Administrative
Technological system	-	Curtain wall
Active cladding surface	ft²	1,000
Orientation	°	S, E
Tilt	°	90
Nominal power	kWp	12.2
System power density	Wp/ft²	12.2

Tab. 4.10 System features.

Fig. 4.10 Rendering of the curtain wall. Source: TopSun.

Tab. 4.11 Product features.

BIPV technology	-	Semi-transparent BIPV laminated glazing
PV technology	-	Mono PERC
Degradation rate yr 0	%	0.70
Degradation rate yr >0	%	0.70
Customization in size	-	No
Customization in colour	-	No

Tab. 4.12 Energetic features.

Energy production	kWh/yr	17,000
Average yearly yield	kWh/kWp	1,398
Self-consumption	%	NA
Self-sufficiency	%	50
Business model	-	CAPEX
Subsidies	-	40% tax depreciation
Payback time	Year	4.3

Fig. 4.11 Curtain wall under construction. Source: TopSun

Case study: BIPV Rupa Renaissance, Mumbai. 2021

Aelius Turbina is proud to have commissioned one of India's Highest Rooftop BIPV Solar Installation at Rupa Renaissance, Mumbai - an A+ grade commercial office campus.
This 300 KW Solar plant has been installed with Mono PERC cells that offer 21.2% high efficiency resulting in more energy generation and the space below the plant continues to be utilised fully.
Key Benefits & Features:

- 40% extra energy yield in the same space.
- Solar panel as a Roof. Savings on Metal Roofing.
- Integrated roofing with daylighting.
- More economical than metal roofing + solar.
- Savings on Solar module mounting structure.
- Eligible for GST Input Tax Credit

Building typology	-	Commercial
Technological system	-	Canopy
Active cladding surface	ft²	15,400
Orientation	°	East, West
Tilt	°	3
Nominal power	kWp	300
System power density	Wp/ft²	19.5

Tab. 4.19 System features.

Fig. 4.16 Building view. Source: Aelius Turbina.

Tab. 4.20 Product features.

BIPV technology	-	BIPV roof
PV technology	-	540 Wp Mono PERC
Degradation rate yr 0	%	2
Degradation rate yr >0	%	0.55
Customization in size	-	No
Customization in colour	-	No

Tab. 4.21 Energetic features.

Energy production	kWh/yr	405,000
Average yearly yield	kWh/kWp	1,350
Self-consumption	%	100
Self-sufficiency	%	5
Business model	-	CAPEX
Subsidies	-	40% tax depreciation
Payback time	Year	3

Fig. 4.17 Canopy. Source: Aelius Turbina.

Case study: Residential villa project, Bengaluru. 2022

Renewable energy pioneer SunEdison launched their new integrated solar roofing range, called the 'ARKA collection', developed in partnership with ARKA Energy, a Silicon Valley-based startup. The ARKA collection consists of aesthetic BIPV solutions with Mono-PERC dual glass PV tiles as the base along with a false ceiling and the option of a gazebo structure.
The case study is a duplex villa in a luxury complex project in an upcoming locality in Bengaluru. The rooftop area was already fitted with a 280 ft^2 hexagonal metal gazebo structure with a fibrocement board, meant to be used as a recreational or garden space. SunEdison saw this opportunity to install the ARKA PowerRoof – which consisted of a BIPV solution with a customized false ceiling, an inverter & necessary safety and electrical peripherals. The client wanted the hexagonal structure to remain intact but requested for a wooden finish matching the building architecture. A PowerRoof solution with a DC capacity of 4 kWp was proposed for the location.
The solar tiles used in the solution are homogeneously black and frameless, ensuring a picture-perfect minimalist look from the top. Below the hexagonal structure, one can see the wooden false ceiling fit seamlessly with the gazebo. The perforated metal cage covering the inverter and switchgear is custom made to match the overall structure.
Tested as per BIS / IEC standards, the system can withstand winds of up to 160 km/hr. The customer was given app access allowing the monitoring of system performance.

Building typology	-	Residential
Technological system	-	Canopy
Active cladding surface	ft^2	280
Orientation	°	South
Tilt	°	10
Nominal power	kWp	4
System power density	Wp/ ft^2	14

Tab. 4.7 System features.

BIPV technology	-	Opaque dual glass BIPV solution with false ceiling
PV technology	-	Mono Perc MBB
Degradation rate yr 1-5	%	5.00
Degradation rate yr >5	%	0.60
Customization in size	-	Yes
Customization in colour	-	No

Tab. 4.8 Product features.

Fig. 4.6 Close-up of the PowerRoof. Source: SunEdison

Fig. 4.7 . Aerial view of the PowerRoof. Source: SunEdison

Energetic evaluation

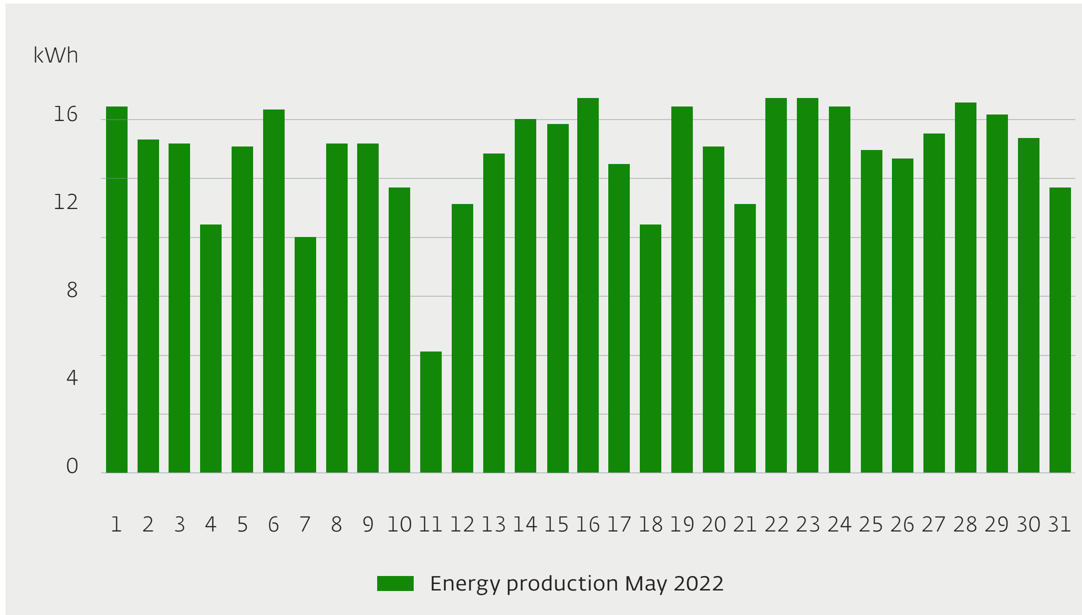
The first aim of the ARKA PowerRoof is to provide an aesthetic, durable & reliable roof that acts as a solar investment for the future. The tiles are wired such that the impact of nearby shadows are minimized, and shaded tiles are isolated in a different string with minimal impact to system performance.
The southern oriented PowerRoof produces a large amount of electricity to satisfy the energy needs during peak summer.
This will continue to produce optimum energy during winter months, where energy generation is boosted by the lower temperatures.
Energy performance on sunny days largely mirrors the performance of regular PV systems; however, the impact of shading and soiling is reduced due to the usage of modular tiles.
The rest of the system is designed from a safety perspective; lightning protection, suitable earthing as per IS standards, and protective equipment on the DC and AC side ensure low downtime.

Fig. 4.8 View of the PowerRoof. Source: SunEdison.

Energy production (May 2022)	kWh	428.31

Tab. 4.9 Energetic features.

Fig. 4.9 PV energy production on May 2022 (monitored).



Summary and Outlook

Within the existing framework of the Indian PV sector, the essentiality of BIPV sectoral evolution is indispensable for the coming decades of the Country's green energy uprisal. However, the Indian BIPV sector needs multi-stakeholder involvement as frontline participants for its growth. Hence, the requirement of awareness of the present state of the Indian BIPV sector is essential to conceptualize the factors and ideas for the future and initialize a roadmap. The " Indian BIPV Report 2022: Status and Roadmap" essentially conducts the same in consideration with the future of the Indian BIPV sector. The Indian solar market potential, perspectives, and financial schemes presented in the first chapter draw the main traits for penetration (BI)PV in the Country. The chapter also documents and exhibits the historical development of the Indian PV sector with the recollection of government policies and regulations and landmarks architectures developed in the Country. The financial schemes that support conventional solar installations in India need to find the jumping-off point to create specific support for BIPV, which represents a building component combining energy production, multifunctionality and aesthetics. The second chapter focuses on the technical aspects of BIPV as a building element and its potential in Indian demography. The chapter also provides a precise cut categorization of BIPV products, as it is currently needed, especially for India, where the ambiguity on BIPV definition prevails. The Indian BIPV roadmap, analysed in the last chapter, is presented as a discussion through five factual contemplation levels that represent the resume of the report and are aimed at opening future actions. From a roadmap perspective, the last chapter is expected to encourage actions among the various stakeholders of the Indian BIPV scenario towards collaboration among the construction and solar sectors for solid and prosperous development.

In the coming years, India will be called upon to make a great effort to implement the development strategies according to the international agreements, including COP26. The long-term global goal of limiting the temperature rise to 1.5°C above pre-industrial levels has been reaffirmed. In the pact, the signatories also emphasized the effort to accelerate the energy transition. The prime minister of India announced the climate neutrality goal by 2070, setting a 50% of renewable energy share by 2030. Considering the importance of the goal, India provides an excellent opportunity for contributions to the Country's energy transformation, especially in the expanding building and construction sector.

To date, India is one of the world's nations that appears to be more attractive in terms of solar investments, considering the potential for cost-effectiveness and the high value of solar irradiation. Despite the availability of an extensive real estate portfolio, planned urban growth and very high solar energy potential, BIPV is still in the experimental age in India. This report discussed and presented many opportunities to move in the BIPV direction and have already experimented with globally.

Further, the year 2030 also marked globally for achieving United Nations' Sustainable Development Goals (SDGs), also known as the Global Goals. All United Nations Member States adopts sDGs as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. In this regard, the global community has committed to fast-track progress for those furthest behind first through the pledge to "Leave No One Behind" by ensuring a time-bounded fulfilment of the SDGs objectives. According to the NITI Aayog's 2020 SDG Index, India has achieved remarkable progress in the SDGs related to clean energy, urban development and health. This shows the Country's commitment to achieving energy security, a prerequisite for socio-economic development, ensuring SDG 7 ("Ensure access to affordable, reliable, sustainable and modern energy for all"). By 2030, the SDG 7 target will be to substantially increase the share of renewable energy in the global energy mix and double the global rate of improvement in energy efficiency.

As reported by IEA India Energy Outlook 2021, over the period to 2040, an estimated 270 million people are likely to be added to India's urban population, the equivalent of adding a new city the size of Los Angeles every year. Most of the buildings in India in 2040 have yet to be built. Urbanization underpins a massive increase in total residential floor space from less than 20 billion square meters today to more than 50 billion in two decades. This prompts enormous growth in demand for energy-intensive building materials. Demand for steel more than doubles to 2040, and demand for cement nearly triples. Urbanization is also a spur for the transition of household energy use away from solid biomass and towards electricity [1]. The SDGs go further toward improving efficiency and the use of low-carbon technologies. The rapid growth in the building stock and other infrastructures will demand a range of construction materials. Also the Indian electricity sector is on a solar-powered revolution with the rise of utility-scale renewable projects. The scope for solar to meet India's energy and building needs, as it can happen in BIPV, is a key challenge to match the construction and solar sectoral growth in the upcoming solar urbanization of the Country. The world's progress in meeting the SDGs largely depends on India's progress. In the battle against climate change, India's optimistic movement supporting green energy will be favourable for future generations to conduct a healthier and more sustainable ecosystem.

We strongly hope that India's sun will shape its buildings for years to come!

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SUMMARY AND OUTLOOK

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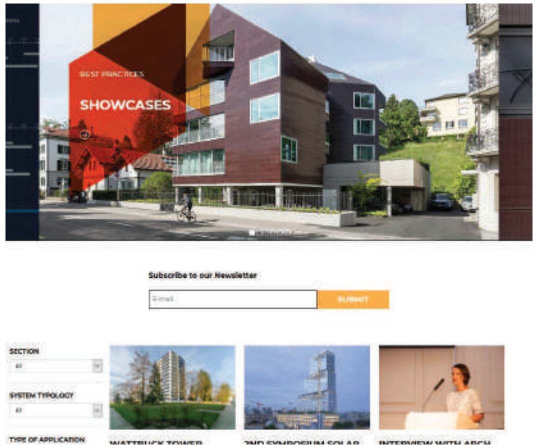
Contacts:

ISAAC-SUPSI
Campus Mendrisio
Via Flora Ruchat-Roncati 15
CH-6850 Mendrisio
T +41 (0)58 666 63 51
info@bipv.ch

CSIR-NIIST
Thiruvananthapuram
695 019, India
T +91 471 2515326
contact@niist.res.in



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Editor
SUPSI, University of Applied Sciences and Arts of Southern Switzerland

Authors
Paolo Corti
Pierluigi Bonomo
SUPSI, University of Applied Sciences and Arts of Southern Switzerland
Swiss BIPV Competence Centre, Institute for Applied Sustainability to the Built Environment

Animesh M Ramachandran
Adersh Asok
Photosciences and Photonics Section
CSIR-National Institute for Interdisciplinary Science and Technology

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Info at
Swiss BIPV Competence Centre Institute for Applied Sustainability to the Built Environment
Campus Mendrisio
Via Flora Ruchat-Roncati 15
CH-6850 Mendrisio
T +41 (0)58 666 63 51
F +41 (0)58 666 63 49
info@bipv.ch