



Building Integrated Photovoltaic System (BiPV)

(Solar Panel + Metal Deck Roof + Inverter & Monitoring) 3-in-1 Building Materials

13 January 2021

Contact: info@pvfoundry.com
Website: www.pvfoundry.com

**Enterprise
Singapore**



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Photovoltaic Foundry Pte. Ltd. (PvFoundry®) is an Invent-and-Build solar technology company headquartered in Singapore since 2016. PvFoundry® specialises in solar module design & customization, offer full suite of turnkey solutions which includes project design, engineering, supply, installation, maintenance & asset management for rooftop solar system as well as mass scale solar asset development.

PvFoundry® leverages its self-proprietary patented technologies and capabilities into solar asset development to achieve client's objectives and to attain higher-than-average project returns of investment. Our innovations are designed and engineered in Singapore. Among our product portfolio is the High-Power Density low-glare module (GMD series), 3-in-1 Building-Integrated solar roof materials (BiPV series), Bi-Facial double glass Fire Test Class A modules (DG series), and Ultra-lightweight bendable flexible module (FLEX series).

PvFoundry® has established market presence in Singapore, Malaysia, Hongkong, Sri Lanka and is determined to promote Singapore Brand abroad as a regional solar tech-based asset developer, which is in-line with our institutional investor Enterprise Singapore (ESG) vision.

**Enterprise
Singapore**



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Block 81, Ayer Rajah Crescent #02-48,
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Sri Lanka Office:

7th Floor, No.456, R. A. De Mel Mawatha,
Colombo 03, Sri Lanka

Contact: info@pvfoundry.com

Website: www.pvfoundry.com

What is BiPV (Building Integrated Photovoltaic System)?

Conventional Solar Panel



Conventional Solar Panel is physically another separate component that put on top of existing rooftop surface.

Usually it is mounted in the middle of the rooftop for ease & safety of construction reason. A big portion of rooftop surfaces will be left vacant, utilization rate usually **~70% only**.

Conventional solar panel product requires to passed **IEC61215 & IEC61730** test specification, in order to meet photovoltaic product certification standard.

BiPV Solar Roof Building Materials



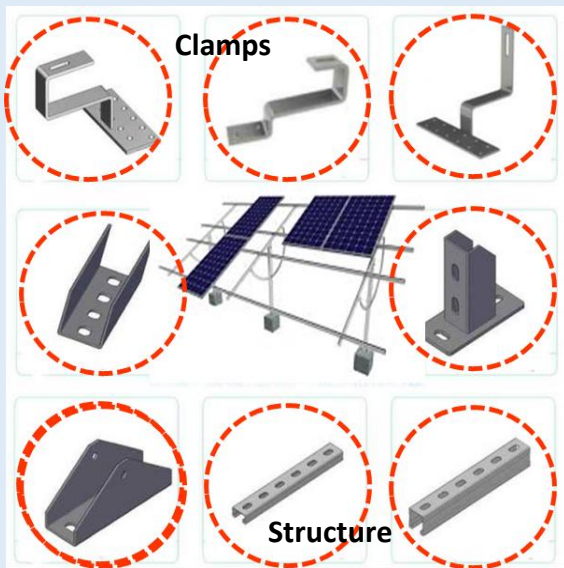
BiPV is a 2-in-1 technology which combine (Solar Panel + Metal Roof Building Material) together and mounted on building purlins as part of the building itself.

BiPV due to its building materials nature, mount tightly to purlins as part of the building, it can cover the full roof space, therefore roof space utilization rate can be often **>90% (+20% higher)**.

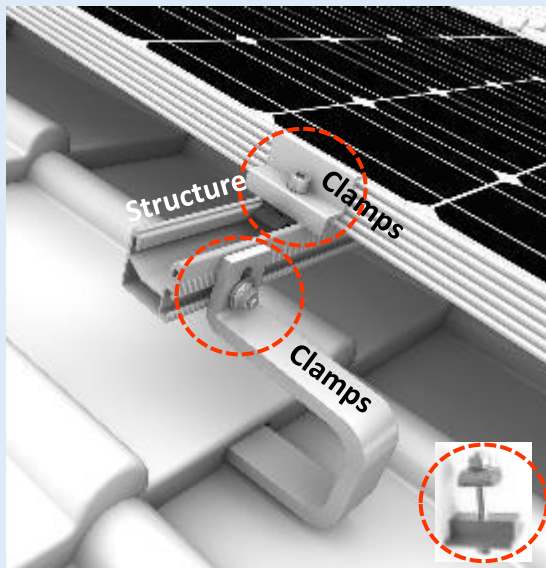
BiPV passed both **IEC61215** solar test specification, as well as **GB50345-2014** Building Material test specifications.

PvFoundry® BiPV Solar System Versatility

Conventional Solar System

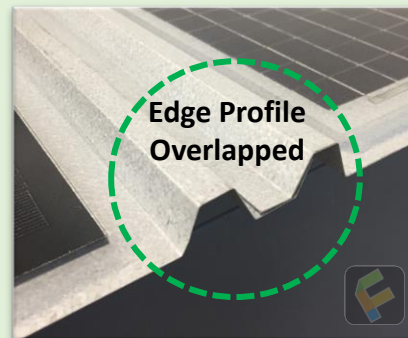


Mounting Structure

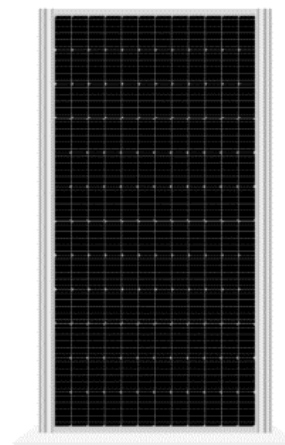


Mounting Clamp

BiPV Solar Roof Building Materials



✗ Installation Complexity: Installation requires at least 7 different clamps, rails, screws. This adds material cost, labor cost, and weight load on roof structure
(total approx. 28.3kg/m² include entire PV System & metal deck)

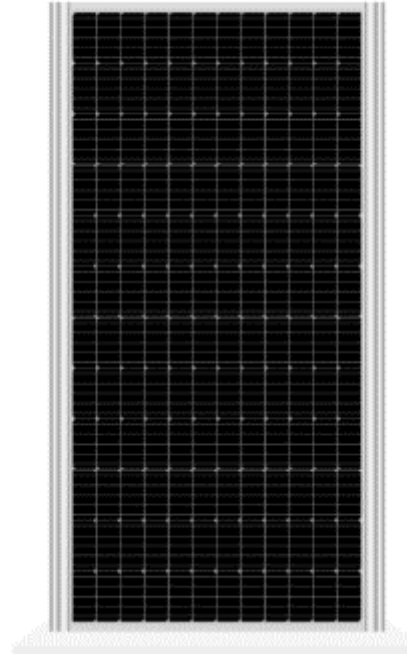


✓ Robust Installation: BiPV solar roof is installed in a similar manner as metal deck roof installation
✓ Material and labor cost reduced
✓ Weight on roof reduced **(10.7kg/m², or -62% less weight on roof)**

PvFoundry® BiPV Solar Building Materials



PvFoundry BiPV Solar Panels are mounted straight into the structure purlin. These 2-in-1 panels forms the roof sheet of the structure and later connected to generate power



Each panel delivers a maximum output power of 360 Watts

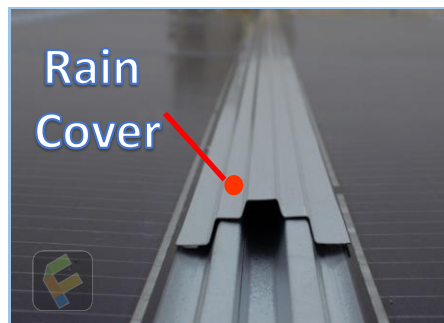
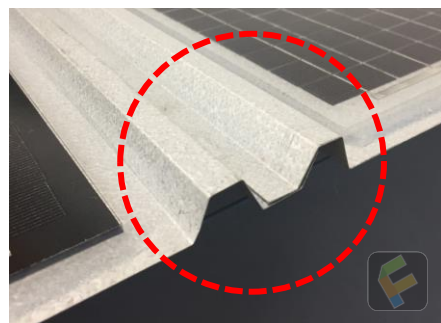


Installation is as simple as bolting a M8 self tapping screw onto the roof purlins. The BiPV Solar Panels are designed to overlap above each other to provide water tightness

✓ **Building Integrated System :** BiPV Solar Panels forms the roof structure itself, therefore lesser materials required to be transported to site. The gap between panels and roof is also eliminated, preventing the panel “fly-off” issue

✓ **Safety & Security :** BiPV Solar Panels as part of the building structure have lesser tendency of being stolen or vandalized compared to conventional bolt-on solar systems

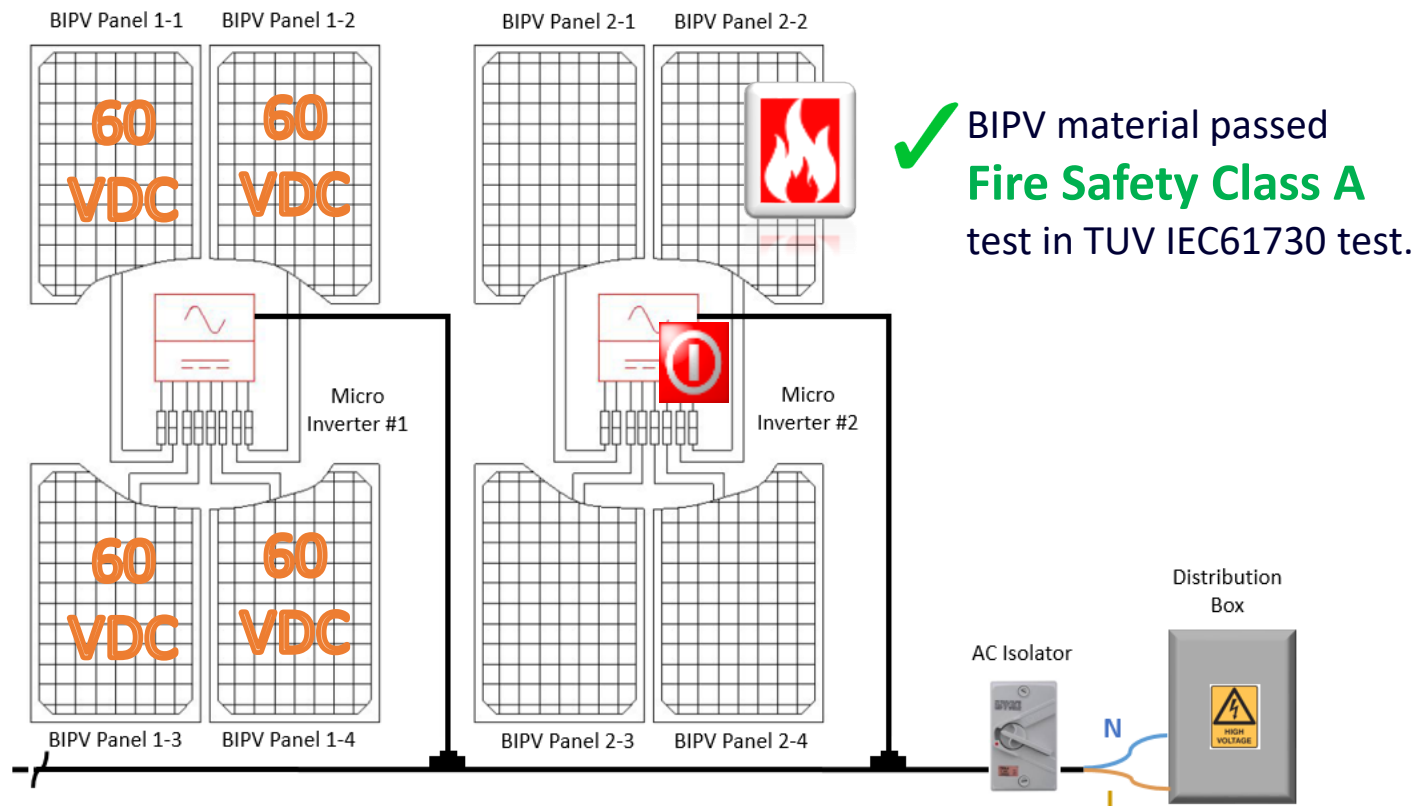
Mechanical Safety & Reliability



Rain
Cover

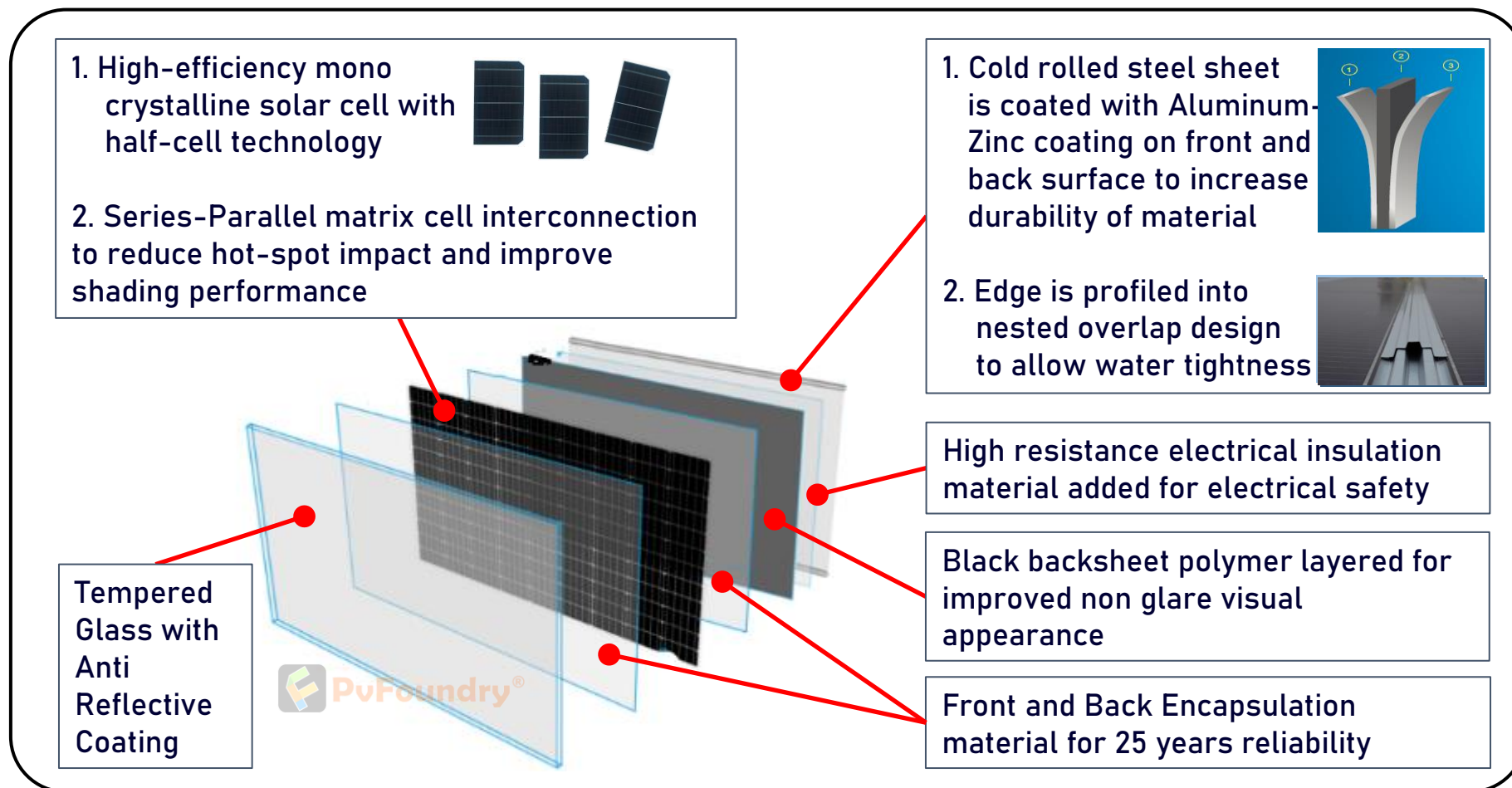
- ✓ Nested overlapping design, similar to conventional metal deck roofing construction is incorporated. The joints are further protected by using a rain cover. Static Load Capacity is **70kg/m²**

Electrical Safety, Fire Safety & Protection



- ✓ Low DC Operating voltage (**<60VDC**), compared to conventional solar systems (600 to 1000VDC). Low risk of personnel injury and arcing fire.
- ✓ Built-in Auto shutdown features at inverter (**>85 degC**), in case of fire.

PvFoundry® BiPV Solar Roof Materials Architecture



✓ **Excellent Durability & Strength :** BiPV Solar Panel uses steel sheet on rear side of panel compared to polymer backsheet used on conventional solar panels available in the market

✓ **Tested & Certified :** BiPV Solar Panel is tested for mechanical and electrical reliability and passed Class A fire test. Certified by Photovoltaic Standards (IEC 61215/61730) and Building Material Standards (GB 50345-2014)

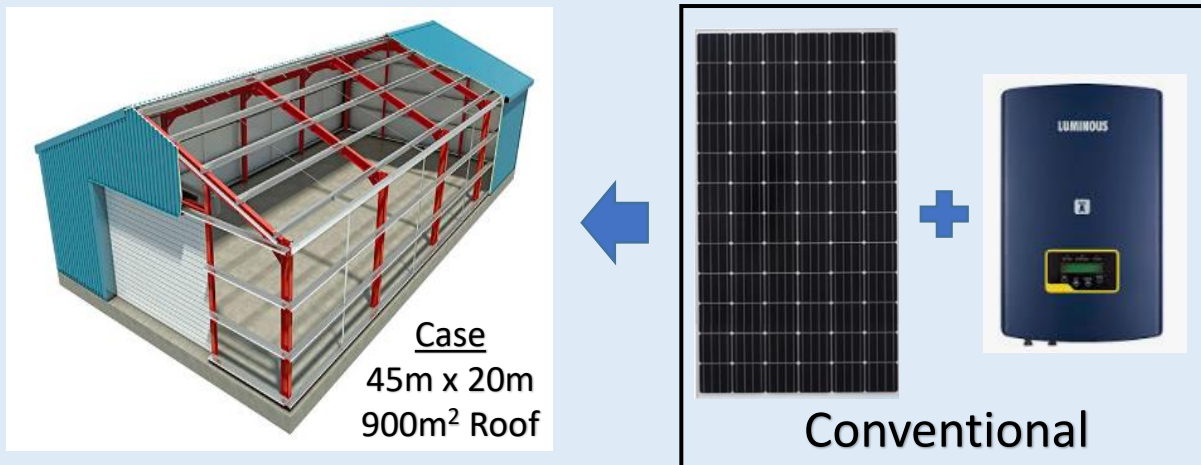
PvFoundry® BiPV System User Performance Monitoring



✓ Web-based monitoring, App based monitoring available to study the system performance and trigger for maintenance if necessary. Dedicated EMA cloud servers holds present and historical data

BiPV System Benefits: More Capacity & Energy per square meter

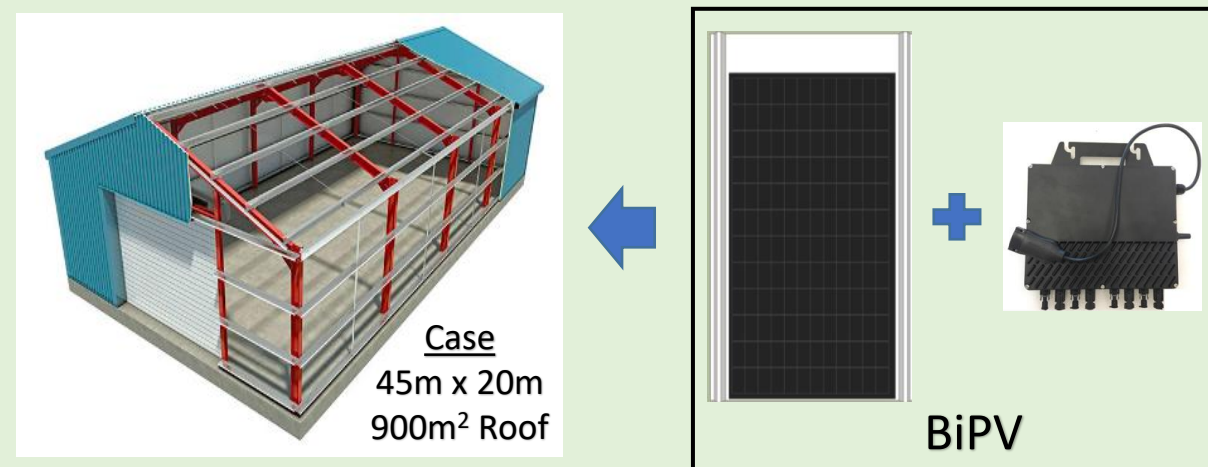
Conventional Solar Panel



Capacity : **114kWp installed** @ 317 panels
Power density: 126.7 Watts per sqm
System Efficiency : 80.5%
Roof Utilization: 71%
Energy : 144MWh per year*

* Annual irradiation 1572kWh/m²

BiPV Solar Roof Building Materials



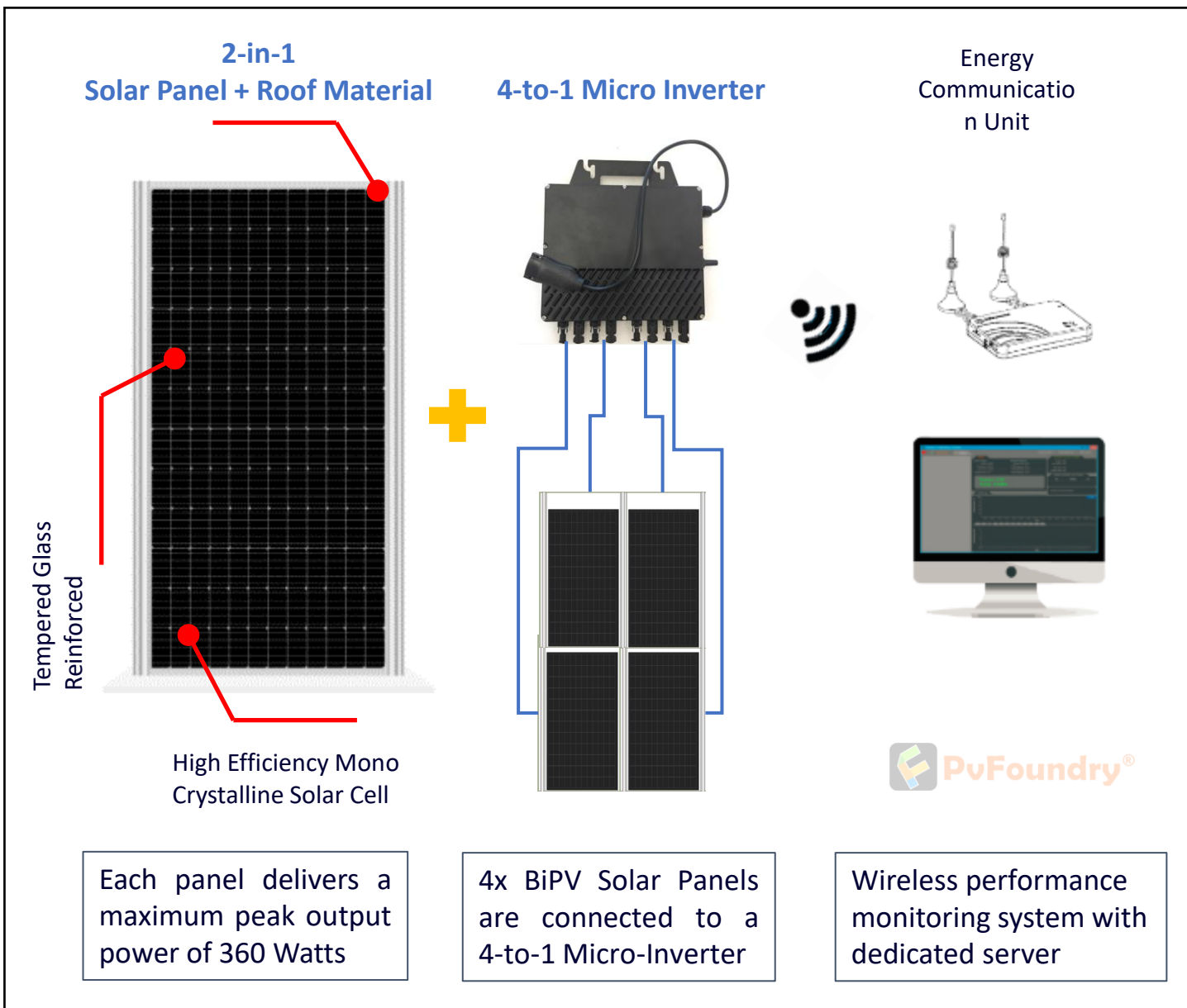
Capacity : **140kWp installed** @ 390 panels (+22% capacity)
Power density: 155.8 Watts per sqm (+29W/sqm)
System Efficiency : 84.0% (+3.5%)
Roof Utilization: 93% (+22%)
Energy : 185MWh per year* (+41MWh/yr)

28%
Energy
Harvest

✓ With BiPV System, roof utilization is maximized, resulting in 28% more energy harvest

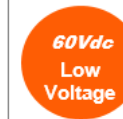
* Annual irradiation 1572kWh/m²

PvFoundry® BiPV System Architecture Overview



Building Integrated PV

- **PvFoundry's BiPV rooftop panel** combines solar panel with traditional Aluminum plated Zinc roofing materials to provide 2-in-1 solar roof solutions for green field buildings and rooftop upgrade projects
- **Lower Cost:** With BiPV panels, the need for roof materials, racking and mounting structures can be eliminated. Labor cost is reduced
- **Versatility:** The system is easily adaptable to existing building structures and applicable to old building renovations and roof replacements



Safety Features

- **Electrical Safety:** Low DC operating voltage (60Vdc) compared to conventional rooftop system (600-1000Vdc) minimizes the risk of DC-arc to installers and home owners. Combined with Auto Shutdown features, this system is safer in the event of fire
- **Fire Safety:** BiPV System complies with fire code requirements. The rear side is constructed with metal or other non-combustible material and pass GB 8624-2012 Test (GB/T 14402-2007, GB/T 20284-2006); Building Material Fire Test Grade A2



Reliability

- **Dual Certification:** BiPV module is designed and certified to meet both Building Materials Standard (GB50345-2014) and Photovoltaic Module Standard (IEC61215/IEC61730). Meets 25 years product service life requirements of steel structure roof. The system has watertightness and heat-insulating properties
- Excellent mechanical load strength, capable of withstanding weight load of personnel (installer, maintenance crew)



Technology

- **Advanced Bypass Technology:** BiPV Module circuitry combines both series-parallel string layout. This provides multiple circuit bypass routes for optimal shading performance & minimize hotspot impact
- **Wireless & Long Range Application:** PvFoundry BiPV system incorporates wireless communication method between multiple systems and central communication unit. The system can be monitored from long range

PvFoundry® BiPV System Module Specifications



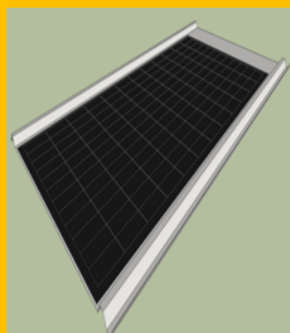
PHOTOVOLTAIC FOUNDRY PTE. LTD. (Reg. 201610251G)
Block 81 Ayer Rajah Crescent, #02-48 Singapore 139967
Email: info@pvfoundry.com
Website: www.pvfoundry.com

Material Specifications

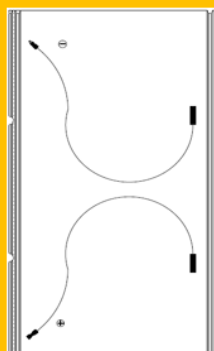
External Dimension (L x W)	2100mm x 1140mm
Effective Overlapped Dimension	2000mm x 1100mm
Total Thickness	3.70mm
Effective Area	2.14m ²
Weight	23Kg Total, 9.7kg/sqm
DC Cable	1x 4.0mm ² , 2000mm
DC Module Connector	MC4 Compatible
Solar Cell Type	Mono Crystalline PERC
Front Surface Material	Tempered glass
Backplane Material	0.5mm Aluminium-Zinc Coated Steel
Frame	BIPV Profile
Colour	Black / Silver
Mounting Accessories	ST6.3 self tapping, Cover Plate
Fire Safety Class	CLASS A (IEC)
Fire Resistance Rating	A2 grade non-combustible material
Waterproof Level	II class (GB50345-2014)
Load Capacity	3600Pa Max

Product Drawing

Isometric View



Rear View



Electrical Performance Parameter [STC]

Product Model: HBH144	345M	350M	355M	360M
Maximum Power (P _{max} /W)	345	350	355	360
Maximum Power Voltage (V _{mp} /V)	25.7	25.8	25.9	26.1
Maximum Power Current (I _{mp} /A)	13.42	13.57	13.71	13.83
Open Circuit Voltage (V _{oc} /V)	31.6	31.7	31.9	32.1
Short Circuit Current (I _{sc} /A)	14.36	14.52	14.64	14.75
Module Efficiency (%)	16.1%	16.3%	16.5%	16.7%

STC: 1000W/m², Temp 25°C, AM1.5

Working Parameter

Operating Temperature	- 40~+85°C
Application Class	CLASS A (IEC)
Power Tolerance	0~+5W
NOCT	45±2°C

Temperature Coefficient [STC]

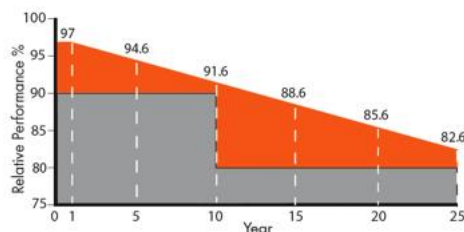
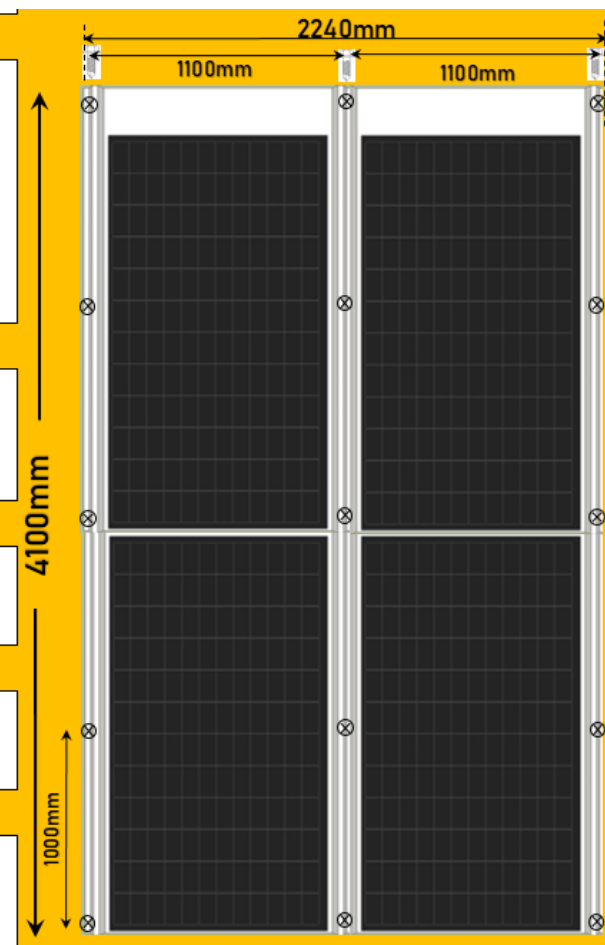
Temperature Coefficient of I _{sc}	+0.05%/°C
Temperature Coefficient of V _{oc}	-0.29%/°C
Temperature Coefficient of P _{max}	-0.39%/°C

Load Capacity

Max. Static Load, Front	3600Pa
Max. Static Load, Back	1600Pa
Passed Hail Test (25mm diameter, acceleration 23m/s)	

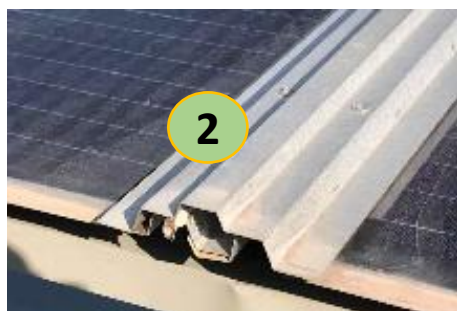
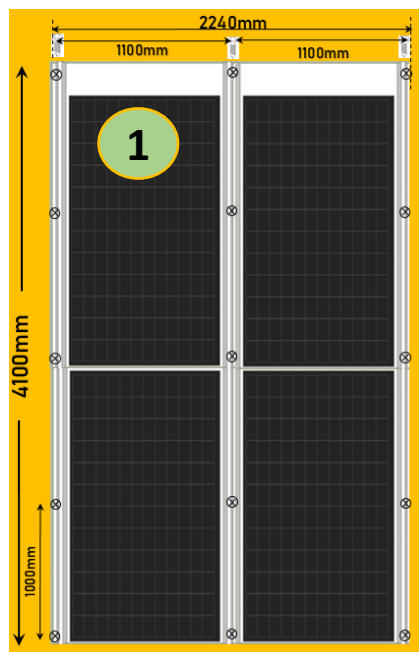
PvFoundry Warranty

10 year limited warranty for materials and workmanship
25 year linear power warranty at STC:
+ Year 1: < 3% of rated power
+ After Year 1: < 0.6% rated power degradation per year



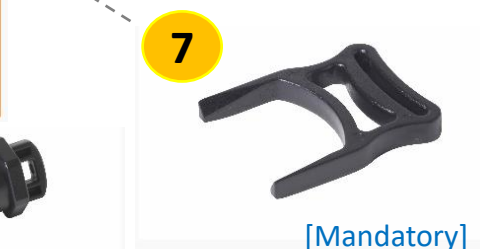
PvFoundry® BiPV System – Components Standard Package

	Items	Std Package
1	BiPV Module HBH144360M (360W Monocrystalline Metal Deck BiPV)	4
2	BiPV Rain Cover	6
3	M8 Self Tapping Screw with rubber Gasket	33
4	Double Sided Foam Tape (1m/roll)	8
5	APS QS1 Micro Inverter	1
6	QS1 Y2 AC Bus cable with connector	1
7	QS1 AC Connector Unlock Tool	1
8	QS1 AC Bus Cable End Cap (Tail)	0.33
Option	QS1 Bus Y-Conn Cap	0
Option	ECU-R (Power socket 3-pin type)	0



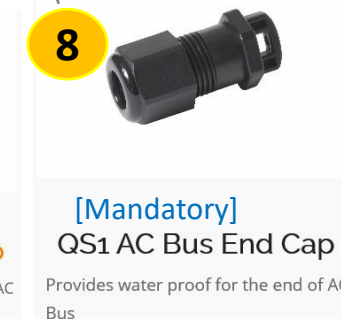
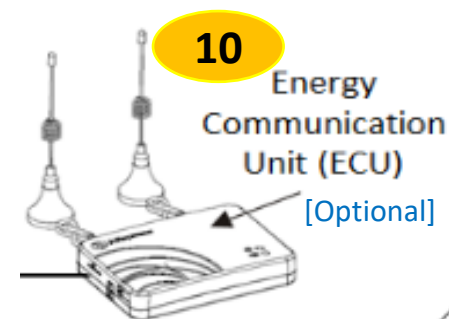
QS1 AC Bus

Provides the junction of the inverter's AC output side and grid connection
 CSA/TUV certified
 2,5mm² (12AWG), U-1000-RO2V (TC-ER)
 3-wire (includes internal ground)
 Drop length: 2M or 4M options



QS1 AC Connector Unlock Tool

Unlocks the inverter and AC Bus



Energy Communication Unit (ECU)

[Optional]



[Optional]

Protects the unused Y-CONN on the AC Bus



[Mandatory]

QS1 AC Bus End Cap

Provides water proof for the end of AC Bus

PvFoundry® BiPV Product TUV Certifications



TÜV NORD CERT GmbH
herewith declares that

Photovoltaic Foundry Pte. Ltd.
Block 81, Ayer Rajah Crescent, #02-48
Singapore 139967

is authorized to provide the product mentioned below with the mark as illustrated:

Description of product (details see Annex 2):

PV Modules with Half-cut 6" Mono-crystalline Silicon Solar Cells



Valid from: 2019-07-17
Valid until: 2023-08-06

Tested according to: IEC 61215-1:2016;
IEC 61215-1-1:2016;
IEC 61215-2:2016;
IEC 61730-1:2016;
IEC 61730-2:2016.
Registered No.: 44 780 19 406749 - 213
Manufacturer: see Annex 1
Test Report No.: 492011260.001
File No.: SHV07045/19

Reinhold

TÜV NORD CERT GmbH
Certification Body
Consumer Products

Please also pay attention to the information stated overleaf.

TÜV NORD CERT GmbH

Langemarkstr. 20
Fon +49 (0)201 825 5120

45141 Essen
Fax +49 (0)201 825 3209

www.tuev-nord-cert.de
prodcert@tuev-nord.de



Essen, 2019-07-17

Anlage 2 zum Zertifikat Nr.: / Annex 2 to Certificate No.: 44 780 19 406749 - 213

Aktenzeichen: / File reference: SHV07045/19

Description of product(s):

Module types: PV Modules with Half-cut 6" Mono-crystalline Silicon Solar Cells:
144 cells: HPH144xxxM (xxx = 345, 350, 355, 360)
144 cells: HPV144xxxM (xxx = 345, 350, 355, 360)

Maximum system voltage: 52V
Fuse rating: 15A
Electrical protection class: Class II
Pollution degree: 2
Material group: I
Design load: 2400Pa (positive and negative)
Safety factors: 1.5
Fire safety class: Class C

Module types: PV Modules with Half-cut 6" Mono-crystalline Silicon Solar Cells:
144 cells: HBH144xxxM (xxx = 345, 350, 355, 360)
144 cells: HBV144xxxM (xxx = 345, 350, 355, 360)

Maximum system voltage: 52V
Fuse rating: 15A
Electrical protection class: Class II
Pollution degree: 2
Material group: I
Design load: 3600Pa (positive) / 1600Pa (negative)
Safety factors: 1.5
Fire safety class: Class A

Remark:

For detailed product information, please refer to CDF (Constructional Data Form) in Annex 1 of test report.

Reinhold

TÜV NORD CERT GmbH
Certification Body
Consumer Products

Langemarkstr. 20 • 45141 Essen • Fon +49 (0)201 825 5120 • Fax +49 (0)201 825 3209 • Email: prodcert@tuev-nord.de



PvFoundry®
Block 81 Ayer Rajah Crescent,
#02-48, Singapore 139967
www.pvfoundry.com

HBH144360M
BiPV Building Integrated Photovoltaic

Pmax	Impp	Vmpp	Isc	Voc
360	13.83	26.1	14.75	32.0

All Specifications at STC: 25°C, 1000W/m2, AM1.5
Product Tolerance at 0W to +5W with +/- 3% Measurement Uncertainty

Application Class : Class A (IEC)
Fire Safety Class : Class A (IEC)
Fuse Rating : 15 A
Max. System Voltage : 52 VDC (IEC)
Electrical Protection Class : Class II
Dimension : 2100mm x 1140mm x 3.9mm
Weight : 23.0 Kg



Warning - Electrical Hazard

High Voltage under Sunlight - Authorized Personnel Only.

Engineered in Singapore. Made in China.

PvFoundry® BiPV Product MyHijau Certifications

MyHIJAU • MARK



This is to certify that

PHOTOVOLTAIC FOUNDRY (M) SDN. BHD. (1315737K)

No 30, 1st Floor
Jalan S2 B17, Biz Ave Seremban 2
70300 Seremban
Negeri Sembilan

has the rights to use the MyHIJAU Mark on the following item:

(Refer to Schedule Page for more details)

Compliance Category:

Performance Standard Compliance

Certification Scheme:

Solar Photovoltaic Panels Systems (TUV Nord Germany)

Certificate no.: MyHP00194/19

Issue Date: 14-08-2019

Expiry Date: 12-08-2022



Malaysian Green Technology Corporation
(462237-T)

No 2, Jalan 9/10, Persiaran Usahawan
Seksyen 9, 43650 Bandar Baru Bangi
Selangor Darul Ehsan
Malaysia

T : 603-8921 0800
F : 603-8921 0801

www.myhijau.my
www.greentechmalaysia.my

This is a computer generated certificate hence no signature is required.

This certificate is granted subject to the Terms and Condition of usage of MyHIJAU Mark certificate and label.



Certificate No. : MyHP00194/19
Issue Date : 14-08-2019
Expiry Date : 12-08-2022

SCHEDULE PAGE

Item #	Item Name	Brand	Model	Sector
MyHP00194/19-E001	Mono-Crystalline Building Integrated Photovoltaic (BiPV) Modules	PvFoundry	HBH144360M	Energy
MyHP00194/19-E002	Mono-Crystalline Building Integrated Photovoltaic (BiPV) Modules	PvFoundry	HBH144355M	Energy
MyHP00194/19-E003	Mono-Crystalline Building Integrated Photovoltaic (BiPV) Modules	PvFoundry	HBH144350M	Energy
MyHP00194/19-E004	Mono-Crystalline Building Integrated Photovoltaic (BiPV) Modules	PvFoundry	HBH144345M	Energy

END PAGE



HBH144360M

Building Integrated Photovoltaic
Block 81 Ayer Rajah Crescent,
#02-48, Singapore 139967
www.pvfoundry.com

BiPV

Pmax	Impp	Vmpp	Isc	Voc
360	13.83	26.1	14.75	32.0

All Specifications at STC: 25°C, 1000W/m², AM1.5
Product Tolerance at 0W to +5W with +/- 3% Measurement Uncertainty

Application Class : Class A (IEC)
Fire Safety Class : Class A (IEC)
Fuse Rating : 15 A
Max. System Voltage : 52 VDC (IEC)
Electrical Protection Class : Class II
Dimension : 2100mm x 1140mm x 3.9mm
Weight : 23.0 Kg



Warning - Electrical Hazard

High Voltage under Sunlight - Authorized Personnel Only.

Engineered in Singapore. Made in China.

[PvFoundry® BiPV Product Launching] MBS, Singapore



PvFoundry BIPV Product Launch @ SWITCH 2018

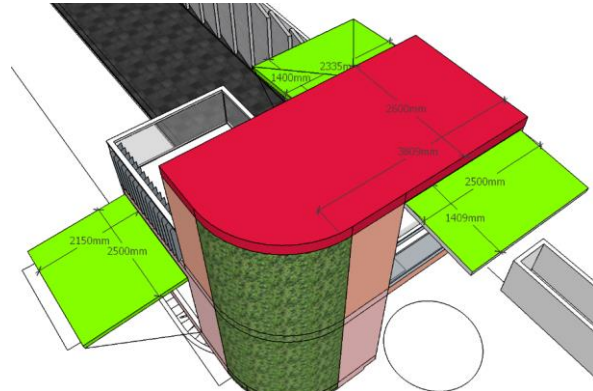
- BIPV product launched / market entry into Singapore during Singapore Week of Innovation and Technology (SWITCH 2018) on 17-September 2018

<http://www.switchsg.org/exhibitors>

PvFoundry is now ready to offer BIPV product to:

- ✓ Construction companies
- ✓ Solar EPCC companies
- ✓ Property & Solar asset developers / owners
- ✓ Solar-Agricultural & Solar-Aquaculture industry
- ✓ Special project collaboration & JV partnership

National Design Center, Singapore



Monomer House I

Location : National Design Center lobby, Middle Rd, Singapore

Purpose : Demo showcase of modular house concept

System : 230VAC, 1.4kWp Hybrid System (Solar + City Grid)

Business Case : A collective of Singapore companies are putting in joint effort and know-how to establish a new **Modular House Concept** industrial standard, where BiPV product is used to spec-in architectural requirement. The BiPV product enables hybrid power system for modular structures and scalable for future deployments.



The GymPod, Singapore



The GymPod

Location : Alexandra Technopark, Alexandra Rd, Singapore
Purpose : First prototype of Modular Structure Gymnasium
System : 230VAC, 1.4kWp Hybrid System (Solar + City Grid)

Business Case : The first prototype of Hybrid (Solar + City Grid) powered modular Gymnasium concept has been rolled out. The GymPod concept will be scaled up in phases according to client demands. Two pod variants have been identified;

1] Grid-tied pod: 4x BiPV panels are used as part of the pod's roof structure. The 4x BiPV panels produces 1.4kWp and AC coupled to city grid via micro-inverter.

2] Zero Emission standalone pod: The pod's roof structure will be extended in all 4 directions to form a shelter/canopy. A total of 24 BiPV panels @ 8.4kWp will be used to construct the canopy, along with hybrid inverters and battery system to ensure a Zero Emission solution is achieved.

BiPV Car Porch, Upper Jurong Factory (*Demo of Shading Scenario)



Factory premises car park, Upper Jurong, Singapore



10am



12pm



2pm



4pm

- Module Technology

Project Type

System Design

Location

Year Commissioned

System Size
- : Building Integrated Photovoltaic (BiPV)

: BiPV Car Porch: 2 parking lots, scalable in size

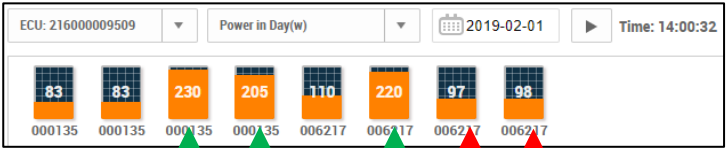
: 4 MPPT Micro Inverter, movable structure

: Upper Jurong, Singapore

: Nov 2018

: 2.88 kWp

Site is heavily shaded from am to pm. To prevent entire array energy loss, BiPV panels are paired with 4 MPPT micro inverter



Output maxed out Shaded modules

BiPV Car Porch, Kranji Fish Farm



Module Technology	: Building Integrated Photovoltaic (BiPV)
Project Type	: BiPV Car Porch: 2 parking lots, scalable in size
System Design	: 4 MPPT Micro Inverter, light weight structure
Location	: Neo Tiew Crescent, Kranji, Singapore
Year Commissioned	: July 2019
System Size	: 2.88 kWp

BiPV Car Porch, Bahau Residential



Module Technology

Project Type

System Design

Location

Year Commissioned

System Size

: Building Integrated Photovoltaic (BiPV)

: BiPV Car Porch: 4 parking lots, scalable in size

: 4 MPPT Micro Inverter, RC footing, RC slab, I-Beam structure

: Bahau, N.Sembilan, Malaysia

: November 2020

: 14.04 kWp



BiPV Rooftop, Marine Aquaculture Floating Barge



Module Technology	: Building Integrated Photovoltaic (BiPV)
Project Type	: BiPV Roof on Aquaculture Floating Barge
System Design	: 4 MPPT Micro Inverter, Customized Natural Light Panels
Location	: Pulau Ubin, Singapore
Year Commissioned	: November 2019
System Size	: 93.6 kWp

BiPV Rooftop, Expandable House, Indonesia



Rubah Batam

Location : Kg Tua Melayu, Batam, Indonesia. July 2019 launch.

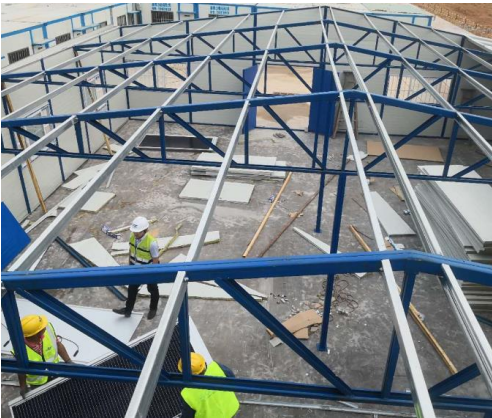
Purpose : Prototype demo unit of expandable and sustainable smart homes to cater for rapid population growth across Asian cities

System : 230VAC, 1.3kWp Hybrid System (Solar + City Grid)

Business Case : This collaboration project between Singapore and Zurich based architects along with Indonesian Universities is aimed to spec in a demo prototype house with the concept of sustainability living. Upon successful launch, scale up and larger deployment is next in schedule



BiPV Warehouse Rooftop, China



Warehouse Building Rooftop

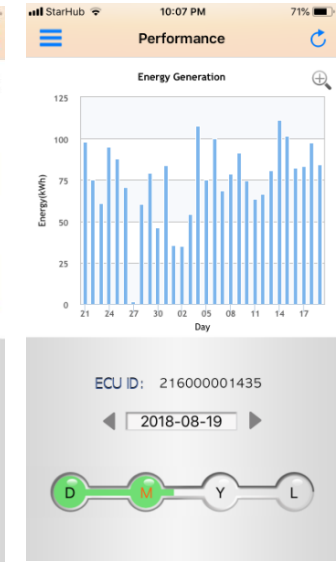
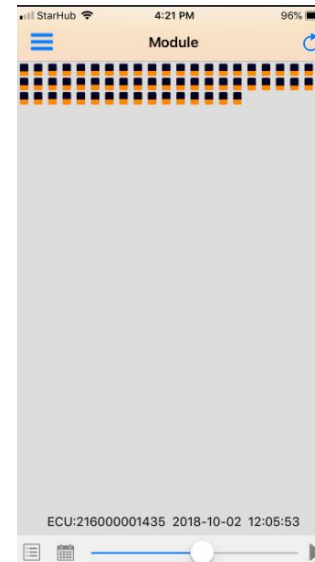
Location : Zhejiang, China

Purpose : New building construction (green field)

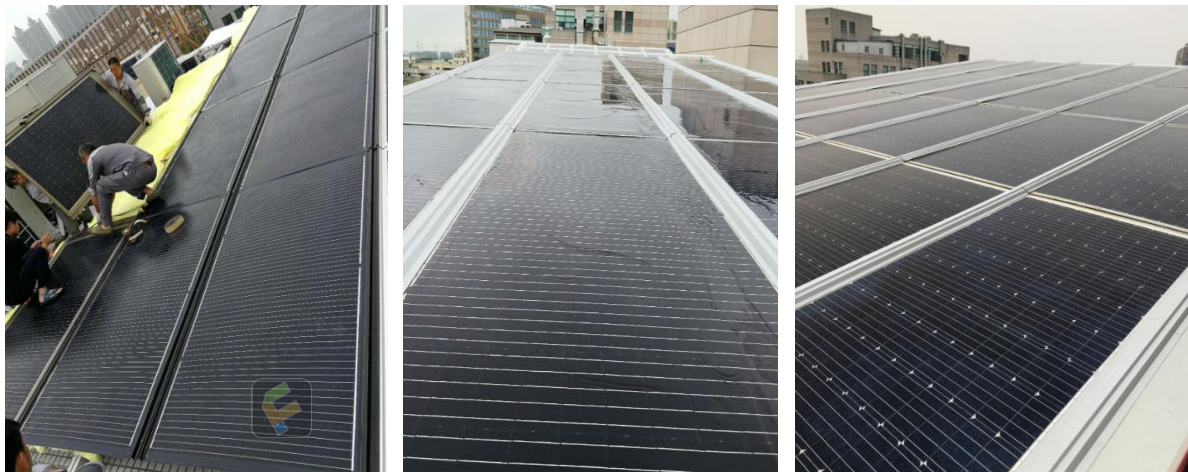
System : 32.4kWp Hybrid System (Solar + City Grid)

Business Case : BiPV product was used as part of new building construction material. System turn-on date on July'2018. Energy generation for 2018'YTD @ 4500kWh is used for own consumption & offset utility bills

Snapshot of system performance



BiPV Industrial Building Rooftop, China



Industrial Building

Location : Shanghai, China

Purpose : Rooftop replacement / retrofit system

System : 17kWp Hybrid System (Solar + City Grid)

Business Case : BiPV product was used to replace traditional zinc roof that is due for replacement. System turn on date on April'2018. Energy generation for 2018'YTD @ 7500kWh is used for own consumption & offset utility bills

Snapshot of system performance

