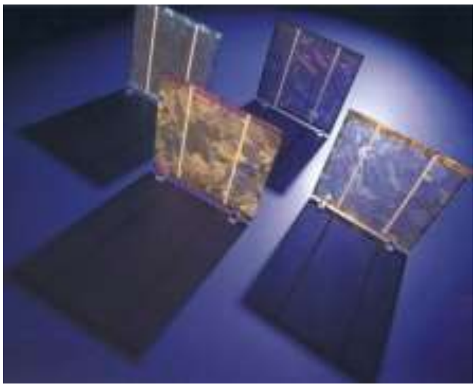
Ministry of Energy, Water & Communications

11.88 kWp BIPV SYSTEM INSTALLATION AT PUTRAJAYA PERDANA BERHAD HEADQUARTERS, PRECINCT 16, PUTRAJAYA.

Prepared by:
Malaysia Building Integrated Photovoltaic (MBIPV) Project



MILESTONE REPORT

for

11.88 kWp BIPV System Installation at Putrajaya Perdana Berhad HQ, P16, Putrajaya.

Malaysia Building Integrated Photovoltaic (MBIPV) Project

UNDP Project No.	MAL/04/G31 (Project ID: 42090)
Project Task	Component 2 (Sub-activity 2.6)
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CASE STUDY FOR 11.88 kWp PUTRAJAYA PERDANA BERHAD HQ, PUTRAJAYA, MALAYSIA.
"The IEA PVPS Task 10 (Malaysia)"

1. General information

Name of the project	: '11.88 kWp BIPV System at Commercial Building'
Location	: Putrajaya, Malaysia
Project type	: Building Integrated PV (BIPV)
Peak power installed	: 11.88kWp
Start of operation	: 7th August 2007

2. Added value

The installation of 11.88 kWp BIPV system was initiated by Senandung Budiman Sdn Bhd, a subsidiary of Putrajaya Perdana Bhd (PPB). Putrajaya Perdana Bhd is a public-listed company on the Main Board of Bursa Malaysia and of late, the company has positioned itself to be a lead property developer in Malaysia, in developing energy-efficient and BIPV office buildings and residential homes. One of the renowned EE-BIPV projects undertaken is the construction of Malaysia Energy Centre's (Pusat Tenaga Malaysia) new office, "Zero Energy Office", also dubbed as PTM ZEO which has 92 kWp BIPV systems integrated in the building.

PPB is one of the keystone developers in the development of Putrajaya, the Administrative Capital City of Malaysia. In the process, PPB has developed a niche in designing and constructing of energy-efficient buildings. The application of energy-efficient concept was reflected in residential homes, the company has launched a housing project in Precinct 16 of Putrajaya comprising 19 bungalows that will be fitted with BIPV systems to support the theme of truly sustainable homes.

Hence, the recent installation of the BIPV system at the office of PPB was an indication of the company's commitment to walk the talk on CSR and a statement of leadership in developing BIPV homes and office buildings.

3. Economic issues

The BIPV system installed by PPB in their office received financial and technical support from Malaysia Energy Centre (PTM) under the Malaysia Building Integrated Photovoltaic (MBIPV) Project. In addition, PPB also received assistance from the MBIPV project for their BIPV system to interconnect to the national grid (Tenaga Nasional Berhad) on net-metering basis.

The system price for this 11.88 kWp system is shown in Table 1 on the following page.

Table 1: BIPV system price (in Malaysian Ringgit).

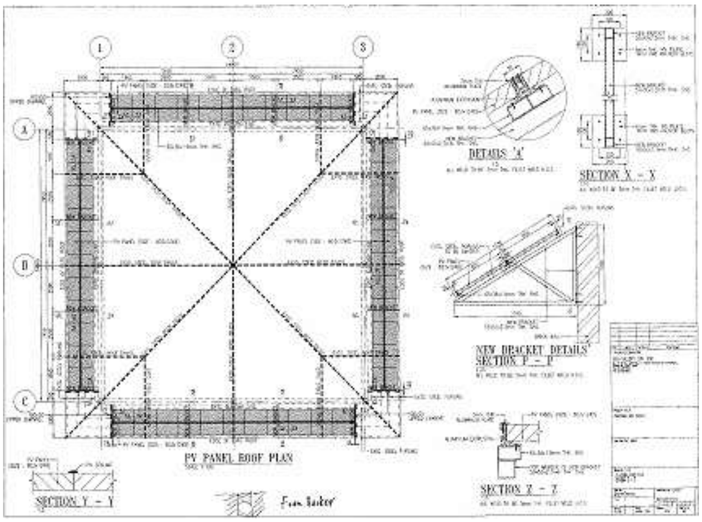
Item	Unit price (RM)	Qty	Total price (RM)	%
PV modules (135Wp each)	2,487.40	88 units	218,890	62
Inverter (Fronius IG30)	12,300	4 units	49,200	14
Mounting structures & roof modification	-	1 lot	27,400	8
Electrical components, design and installation	-	1 lot	24,640	7
Labour	-	1 lot	22,500	6
Others (consultation, transportation)	-	1 lot	17,348	5
Less (discount)	-	-	8,000	-
System price (11.88 kWp)			**351,978**	**100**
Price per kWp system			29,627	-

Note: 1USD is equivalent to RM3.4715 (as at 1st August 2007 from www.bnm.gov.my)

This project received financial assistance equivalent to RM 93,139.20 which is approximately 26.5% of the total system price in addition to the technical assistance from the MBIPV project.

4. Architecture

The BIPV systems were retrofitted into existing polycarbonate structure. The polycarbonate roof was cut to ensure the PV modules are aligned to the overall structure.



Roof plan.

PV modules are nicely integrated into the existing polycarbonate roof.

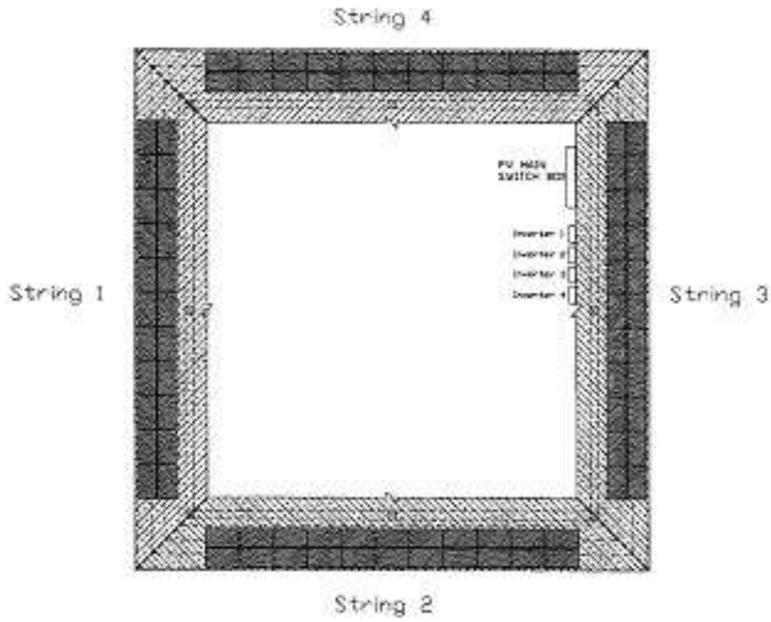
5. Energy calculations

The expected electricity production is shown as follows:

- Total number of PV modules installed : 88 units (135 Wp each)
- Total PV capacity installed : 11.88 kWp
- Expected annual energy yield : 11,971 kWh/year
- Expected daily energy production : 32.8 kWh/day

Please refer to **Annex 1** for detail calculation.

The PV modules (four systems of 2.97kWp each) are located at different orientation and give different output depending on the sun position as shown by the below picture.



6. Solar modules and inverter

i) PV modules

A total of 88 units of poly-crystalline PV modules each having capacity of 135 Wp were used to cover an area of about 88 m^2 as shown in Figure 1.

The technical specifications are as follow:

Manufacturer/model: Mitsubishi PVMF135EA4 (135 Wp)-standard

- Power rating: 135 Wp
- Type: poly-crystalline with frame
- Dimension (L×W×D): 1248×803×46 mm
- Weight: 12.5 kg
- Certifications: IEC 61215
- Bypass diode: included

Figure 1: PV modules.

ii) Grid connected inverter

The BIPV system consisted of four units of grid connect inverter rated at 3,600 W as shown in Figure 2 with the technical specifications as stated below.

Manufacturer/model: Fronius IG30

- MPP range: 150 to 400 Vdc
- Max input voltage: 500 Vdc
- Nominal power output: 2500 Wac
- Max power output: 2650 Wac
- Cooling: Control forced air cooling
- Dimension (L×W×D): 500×435×225 mm
- Weight: 12 kg
- Certifications: EN 50081, EN 50082, EN 61000-3-2, EN 50178

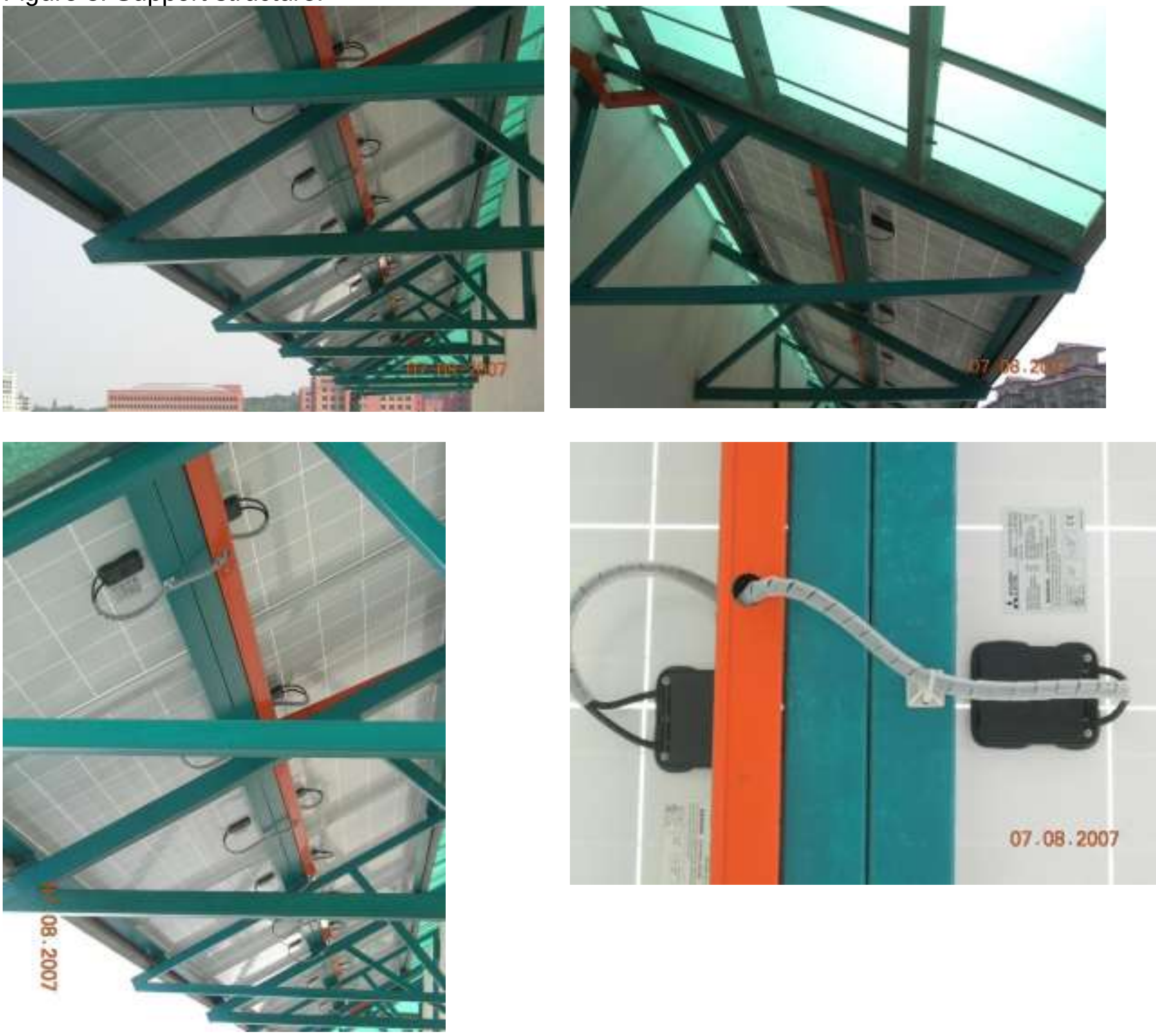
Figure 2: Inverters.

DC/AC combiner box.

7. Mounting Structure

The PV modules were inclined at 30 degrees and were integrated as part of the polycarbonate roof. The existing polycarbornate roof was cut and replaced by the 88 units of PV modules with 22 units on each pyramidal side. Water proofing is not a critical issue as the PV modules formed external overhanging roof. As a result of the overhanging roof structure, the installation of PV modules was made much easier due to ease of accessibility. The PV modules were supported by galvanized steel coated with green paint.

Figure 3: Support structure.

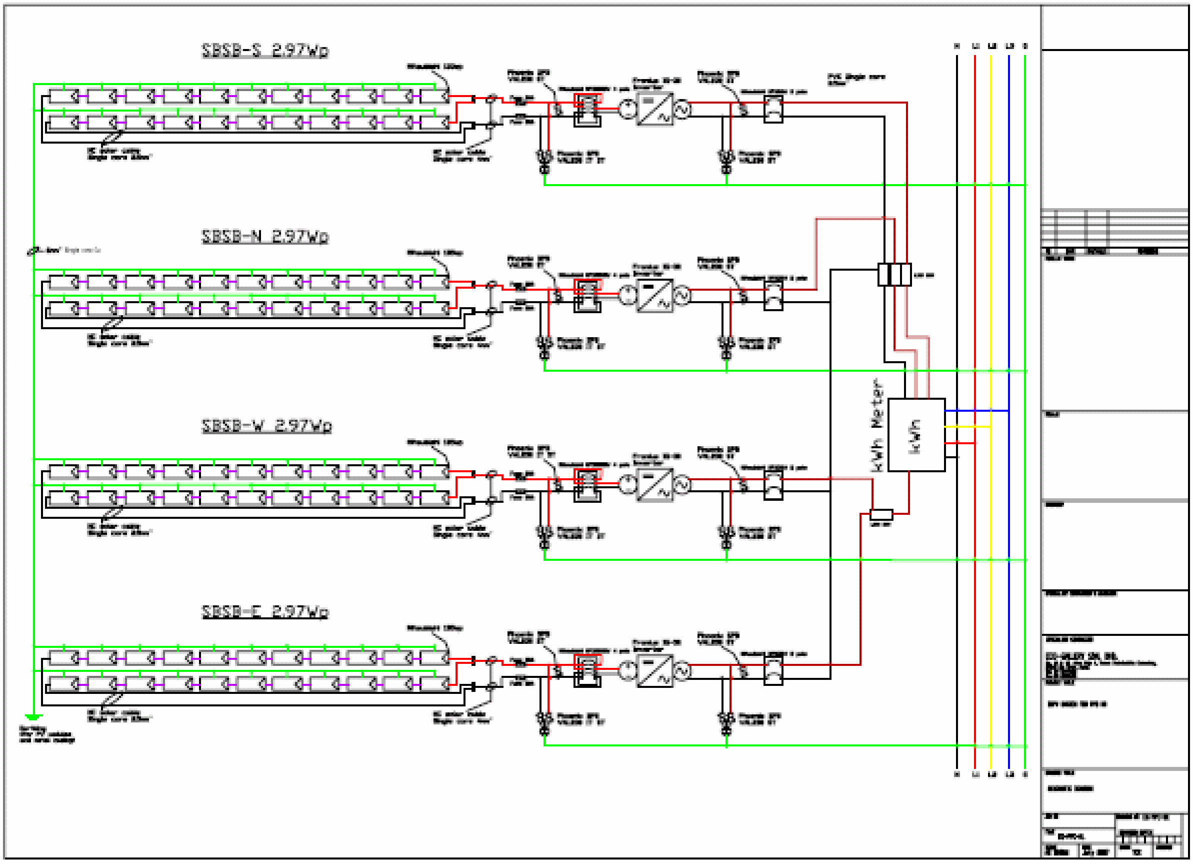


8. Electrical design

Each sub array is connected with 11 modules in series and 2 strings in parallel. The BIPV system is interconnected through in-direct feed method where the output is fed back to the main distribution board (MDB) of the building to cater for internal load.

The system installation and commissioning was supervised by the MBIPV technical expert. The schematic diagram is shown in Figure 4.

Figure 4: Schematic diagram of the BIPV system installed.



9. Tendering

The tender was carried out by the system owner according to their procurement procedure.

10. Grid-connection

Output of the inverter was fed to the consumer's main distribution board of the building (indirect feed). An import-export meter was installed to monitor the energy generated and the meter was located beside the main utility's (TNB) supply meter at the customer's incoming supply point.

Currently in Malaysia, interconnection to the grid is only limited to net-metering basis. The net-metering for billing in this case is the difference between the electricity supplied to the customer through the TNB meter measurement in the import mode, and the surplus PV generated electricity exported to the TNB grid which is recorded by the TNB meter in the export mode. The PV meter records the electricity generated by the PV system.

Recognizing the importance of feed-in tariff (FiT) mechanism in driving the local PV market, one of MBIPV Project's target is to convince the Government of Malaysia to put in place the FiT by the end of the Project which will be in year 2010. Thus, the infrastructure for grid-connected BIPV systems under the MBIPV Project is FiT-ready for the ease of implementation of FiT in the near future.

Figure 5: PV meter is located inside the main switch board room next to the TNB meter.

TNB meter.

PV meter.

11. Monitoring

The system is being monitored by a PV monitoring centre since the commissioning of the BIPV system. The energy output since the system commissioning on 7 August 2007 is shown in the table.

Date	PV meter reading	kWh	kWh/kWp
7 August 2007	286	-	-
10 September 2007	1,587	1,163 *(normalised to 30 days)*	98

The company assumes ownership and responsibility of the BIPV system. PPB monitors the system very closely as the performance of the invested BIPV system is in their interest. This is due to the number of BIPV systems they have installed in office and residential homes, any lessons learnt would be invaluable for future BIPV installation improvement.

12. Maintenance

System maintenance required is very minimal. As Malaysia is located near to the equator with heavy rainfalls, the PV modules need no regular cleaning. A regular check on cable tightness and connection on a scheduled interval is encouraged.

13. Hightlights and lessons learned

Nil.

14. Standards, regulations, recommendations, grid connection, links & references

The Malaysian Standard (MS 1837: 2005) for installation of grid-connected photovoltaic (PV) system was officially published and available from September, 2005. This standard provides guidelines on BIPV installation and electrical safety requirements.

Annex 1: Calculation of expected annual energy yield of the system.

- Array is rated at 11.88 kWp
- Inverter efficiency: Fronius IG30 is about 94.3%
- Average daily maximum ambient temperature of 35 °C
- Allow 5% for manufacturers tolerance and mismatch
- Dirt derating of 3%
- Total voltage drop of 2%

Step 1: The derating of the PV array can be calculated by the following formula:

$P_{array} = P_{a.stc} \times f_{mm} \times f_{temp} \times f_{dirt}$

$P_{a.stc}$ = 11.88 kWp
f_{mm} = 0.95 (5%)
f_{dirt} = 0.97 (3%)

$f_{temp} = 1 - (\gamma \times (T_{cell.eff} - T_{stc}))$ (γ is taken as 0.4%)
= 1 - (0.4/100 x ((35 + 25) -25)) ($T_{cell\text{-}eff} = T_{a.day} + 25^0$ C)
= 0.86

$P_{array} = P_{a.stc} \times f_{mm} \times f_{temp} \times f_{dirt}$
= 11.88 x 0.95 x 0.86 x 0.97
= 9.4 kWp

Step 2: The average yearly energy output of the PV array is calculated as follows:

$E_{pv} = P_{array} \times H_{tilt}$

P_{array} = 9.4 kWp
H_{tilt} = 1,368 kWh/m^2 (irradiance at Bandar Baru Bangi, tilted at 30 degrees)

$E_{pv} = P_{array} \times H_{tilt}$
= 9.4 x 1,368
= 12,859 kWh per annum

Step 3: The sub-system efficiency can be calculated from the following formula:

$\eta_{pvss} = \eta_{pv\text{-}inv} \times \eta_{inv}$
η_{pvinv} = 98% (2% voltage drop)
η_{inv} = 95%

$\eta_{pvss} = \eta_{pv\text{-}inv} \times \eta_{inv}$
= 98% x 95%
= 93.1%

Step 4: The average yearly real energy yield of the PV system is calculated as follows:

$E_{real} = E_{pv} \times \eta_{pvss}$
= 12,859 x 0.931
= 11,971 kWh per annum
= 32.8 kWh per day