MINISTRY OF POWER

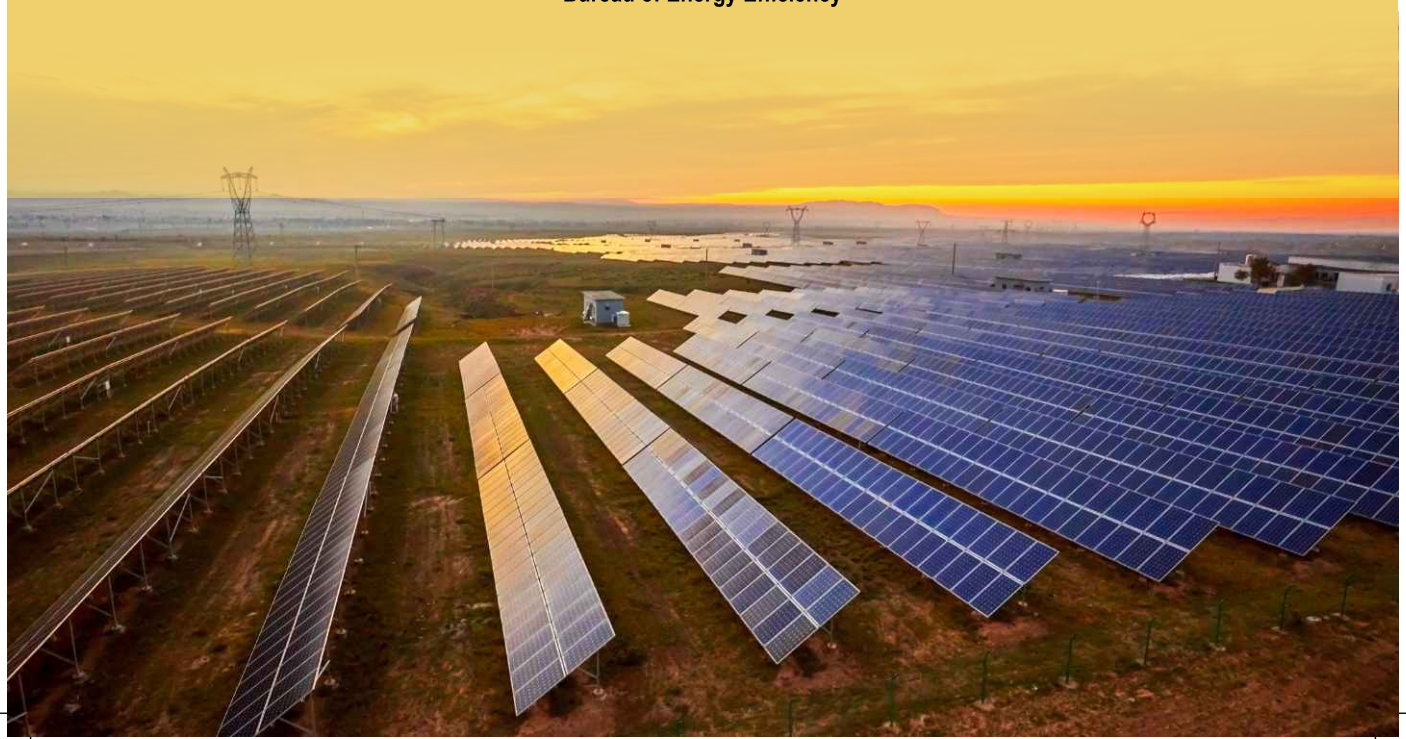
सत्यमेव जयते
GOVERNMENT OF INDIA

MINISTRY OF NEW
AND RENEWABLE ENERGY

MORE STARS MORE SAVINGS
POWER SAVINGS GUIDE

Star Rating Program
for
Solar Photovoltaic Module

Bureau of Energy Efficiency



Standards and Labelling Program

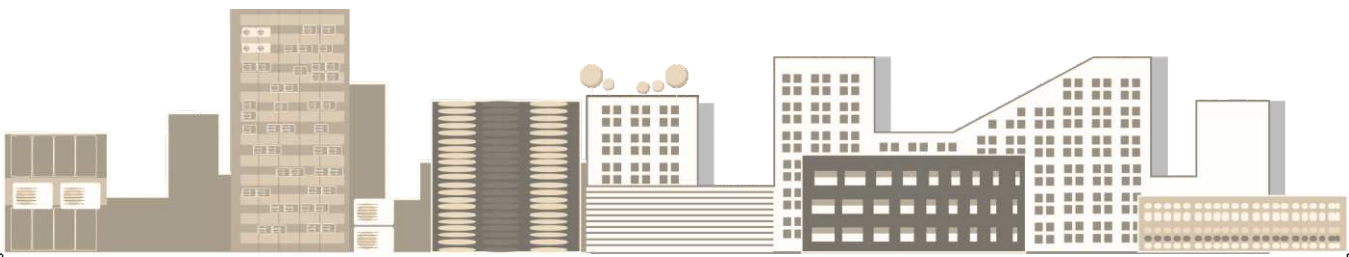
Standards and Labelling (S&L) program is one of the major thrust areas of BEE. This scheme was launched with the objective of providing the consumers an informed choice about the energy and cost-saving potential of the star labelled appliances/equipment being sold in the Indian market. The scheme involves laying down energy performance norms for appliances/equipment, rating its energy performance on a scale of 1 to 5, 5 star labelled appliance being the most energy-efficient one. The program presently covers 34 appliances out of which 15 appliances are under the mandatory regime while remaining 19 are under the voluntary regime. This scheme has resulted in overall electricity saving of 70.56 billion units translating to an abatement of 57.05 million ton of CO_2 emission in FY 2021-2022.

Electricity Saved
70.56 Billion Units

Cost Saving
42,340 Crores

Co_2 Emission Reduction
57.05 Million tons

S&L Program: Overall Savings



Background

India has embarked upon an ambitious program to achieve 40% of electric power installed capacity from renewable energy sources by 2030 which is one of the largest Renewable Energy (RE) capacity expansion program in the world and targets 100 GW of Solar Energy. Renewable Energy sector is bound to see exponential growth over the next few years. Among the various types of available RE technology solutions, solar PV has proved to be one of the most effective ways of energy generation. As more and more users are embracing solar PV, benchmarking the performance of Solar PV modules has become necessary.

The absence of performance standard for Solar PV has become a barrier before consumers in making an informed choice while purchasing this equipment. Also, there is an absence of a level playing field in terms of quality of the product against the cost-competitive substandard ones being sold in the Indian market causing it to be flooded with poor quality low-cost Solar PV modules.

BEE has introduced Standards & Labelling (S&L) program for Solar PV with the objective of promoting energy efficiency by highlighting the cost and energy savings from such initiative which are generally assured, and comparatively simple to quantify, but readily verifiable.

The objective of S&L for solar PV modules is to help the ***Indian customers*** to make an informed decision and contribute towards the ***Government of India's larger goal*** of enhancing the use of renewable sources thereby reducing the CO_2 emission.

SOLAR PV MARKET

Growth of Solar PV in India got a boost in the year 2010 after the launch of Jawaharlal Nehru National Solar Mission (JNNSM). In the year 2010 during the launch of the mission, it was targeted to achieve a total of 20GW from grid-connected solar PV plants and 2 GW from off-grid solar PV installations by FY 2021-2022. In the year 2015, the target was revised to 100GW out of which 60GW is to be achieved from grid-connected utility-scale projects and the remaining 40GW from rooftop solar PV projects. From FY 2014-15 to FY 2022-23 yearly solar PV installation in India has grown with a CAGR of 30%.

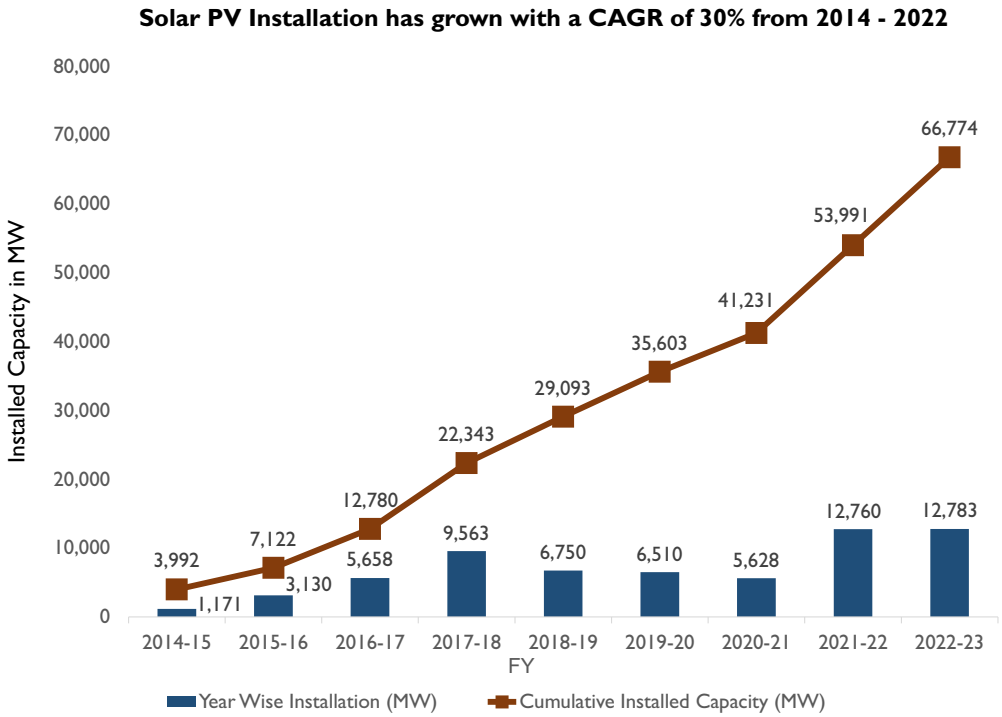


Figure-1: Yearly and cumulative solar PV installation

SOLAR PV MODULE

Solar PV modules can be categorized based on the capacity of the modules and on the type of cell technology. Solar PV modules range from 5W to 445W. India relies majorly on imports for meeting the solar PV demand.

PRE-QUALIFICATION CRITERIA FOR LABELLING:

It is mandatory to meet the general requirements of design qualification and type approval as per '*IS 14286:2010*' for crystalline PV modules and as per '*IS 16077:2013*' for thin-film PV modules. Also, it is mandatory to participate in the Compulsory Registration Scheme (CRS) of Bureau of Indian Standards (BIS). Additionally, to qualify for star labelling, the solar PV modules must meet the performance standards mentioned in Tabel-I.

Star Rating / Labelling Plan:

The star rating plan is based on effective efficiency $(\%\eta_{eff.})$ of the solar PV module. The performance levels are given in Table-1. The effective efficiency is calculated using equation-2

Star level	Effective Efficiency η_{eff} (%)
1 Star	>=17% & <=18%
2 Star	>18% & <=20%
3 Star	>20% & <=21%
4 Star	>21% & <=22%
5 Star	>22%

Table-1: Star labelling scheme for PV modules (from 1st January 2024 to 31st December 2025)

Significance of Effective Efficiency

Presently, the Solar (Photovoltaic) PV modules are rated at Standard Test Conditions (STC) and Nominal Operating Cell Temperatures (NOCT). The ratings mentioned at STC are extremely optimistic when compared with the climatic conditions of India. Whereas the ratings mentioned against the NOCT conditions convey close to the field performance. However, the actual performance of the PV modules for a geographical location can be diligently determined only after accounting for the local climatic conditions.

The effective efficiency is formulated such that it helps to rate the performance of the PV module based on both efficiency as well as thermal performance. Moreover, weight factors (0.14, 0.62 & 0.24) used in effective efficiency formula (equation-2) are representative of the Indian climate. These weight factors represent the percentage of total sunshine hours a PV module shall be exposed to the respective ambient temperature. The weights have been determined by analyzing the weather data of thirty-three Indian cities across five climatic zones.

Symbol	Description
$\eta_{max,t°C}$ (%)	Module Efficiency at t°C (Calculated as per equation-1).
I (Wm^{-2})	Total Irradiance incident on the module
A (m^2)	Area of the module
$P_{max,t°C}$ (W)	The maximum power output of the PV module at 't°C' & an irradiance of 1000 Wm^{-2} when tested as per the clause 8 of IS16170 part 1:2015

The maximum efficiency of the module is calculated by equation-1, and the values of maximum power output ($P_{max,t°C}$) at different temperatures from Table-2 are used to calculate the maximum efficiency ($\eta_{max,t°C}$).

$$\eta_{max,t°C} = \frac{P_{max,t°C}}{I \times A} \times 100 \quad \ldots\ldots \quad \text{Equation 1}$$

Irradiance (Wm^{-2})	Spectrum	Module temperature		
		25°C	50°C	75°C
1000	AM 1.5	$P_{max,25°C}$	$P_{max,50°C}$	$P_{max,75°C}$

Table-2: Power output of PV modules at different module temperatures

$$\eta_{eff} = (0.14 \times \eta_{max,25°C}) + (0.62 \times \eta_{max,50°C}) + (0.24 \times \eta_{max,75°C}) \quad \ldots\ldots \quad \text{Equation 2}$$

Energy Savings and Greenhouse Gas Abatement Potential

Due to the introduction of S&L program for Solar PV, it is assumed that the Solar PV module efficiency will enhance by 2% over its existing levels. Owing to performance improvement, the electricity generation shall increase by 33GWh/year and this will offset ~27,000 tons of CO_2 emission per annum.

Schedule 35

Standards and Labelling of Solar Photovoltaic Modules

1. Scope

This schedule specifies the energy-labelling requirement for Solar Photovoltaic (PV) modules imported or sold in India for electricity generation and similar use.The schedule covers all types and sizes/capacity of Solar Photovoltaic Modules.

For this schedule, the star rating shall be based on SPV module's conversion efficiency as per Appendix -A of this schedule.

This schedule does not apply to:

- Concentrator Photovoltaic (CPV) Modules
- Photovoltaic Thermal (PVT) hybrid solar collectors

2. Normative References

This schedule shall be read in conjunction with the following standards with all amendments, for the purpose of star labelling

Number	Standard
1.	IS 14286: 2010 Crystalline Silicon terrestrial photovoltaic (PV) modules-Design qualification and type approval
2.	IS 16077:2013 Thin film terrestrial photovoltaic (PV)- Design qualification and type approval
3.	IS 16170 part1:2015 Photovoltaic (PV) Module Performance Testing and Energy Rating; Irradiance and Temperature Performance Measurements and Power Rating
4.	IS 12834: 2013 Photovoltaic Energy Systems – Terms, Definitions and Symbols

3. Terminology

For this schedule, the following definitions shall apply. However, in case of dispute, the definitions given in *'IS 12834 :2013 Solar Photovoltaic Energy Systems – Terms, Definitions and Symbols*' may be referred.

3.1 Photovoltaic cell/ Solar Photovoltaic Cell / Solar Cell
Most elementary photovoltaic device.

3.1.1 Crystalline silicon PV cell: PV cells made of crystalline silicon.

- **3.1.1.1 Crystalline silicon:** General category of silicon materials exhibiting a crystalline structure, i.e., showing long range ordering of the silicon atoms.

3.1.2 Thin film PV cell: A photovoltaic cell is made of thin layers of semiconductor material

3.2 Photovoltaic Device
Component that exhibits the photovoltaic effect

3.3 Photovoltaic effect
Production of DC voltage by the absorption of photons.

3.4 PV module
Complete and environmentally protected assembly of interconnected photovoltaic cells.

3.5 PV Module efficiency
Ratio of the electric power generated by a PV module to its incident irradiance as measured under standard test conditions (STC).

4. Testing Guidelines and Requirements

For star labelling, it is required to determine the maximum power ($P_{max,t°C}$) of the PV module at an irradiance value of 1000 Wm^{-2} at 25°C, 50°C and 75°C of module temperatures as per the clause 8 of IS16170 part-1:2015. The power output values need to be noted in Table 2 given in appendix A. The maximum efficiency ($\eta_{max,t°C}$) of the module at 't°C' is calculated by equation-1 given in Appendix-A

4.1 Test report:
The results of the test shall be reported in the prescribed format as given in Appendix-B of this schedule. Test report from laboratories that are either BIS recognized / NABL accredited or signatories of ILAC or APAC accredited as per the standards mentioned above.

4.2 Tolerance limit:
There is no negative tolerance for star rating band; the products tested must be at par or better than the star rating band minimum threshold. The scope for manufacturing and testing tolerance and other variations shall be accounted for as per relevant IS standards to be used when determining the Star Rating. Effective efficiency of solar PV module will be rounded off to nearest two decimal place as per IS 2:1960.

5. Rating Plan / Labelling Plan

The rating plan is based on effective efficiency ($\%\boldsymbol{\eta}_{eff.}$). The performance levels are given in Table-3. The effective efficiency is calculated using equation-2 given in Appendix-A.

5.1 Qualification Criteria for Labelling:

It is mandatory to meet the general requirements of design qualification and type approval as per '*IS 14286: 2010*' for crystalline PV modules and as per '*IS 16077: 2013*' for thin film PV modules. Additionally, it is mandatory to comply with all BIS or equivalent IEC standard required as per the Compulsory Registration Scheme (CRS) of BIS (Bureau of Indian Standards). In addition, to qualify for star labelling the PV modules must meet the performance standards on effective efficiency mentioned in Table-3 as follow:

Star level	Effective Efficiency η_{eff} (%)
1 Star	>=17% & <=18%
2 Star	>18% & <=20%
3 Star	>20% & <=21%
4 Star	>21% & <=22%
5 Star	>22%

Table-3: Star labelling scheme for PV (from 1st January 2024 to 31st December 2025)

The program will be voluntary for two years and will be reviewed thereafter, to make it mandatory.

5.2 Check Testing

The samples will be picked up by Bureau of Energy Efficiency (BEE) or its designated agency for testing as per the following sampling plan:

- Testing for compliance of PV modules covered under the S&L scheme with respect to BEE performance standards will be carried out in laboratories that are either BIS recognized / NABL accredited Laboratories.
- The samples will be picked up by Bureau of Energy Efficiency (BEE) or its designated agency for testing as per the following sampling plan:
    - One sample will be picked up at random from the market.
    - If the first sample fails only then second check testing will be done.
    - Two samples will be picked up at random from the market for second check testing, and both samples must pass the test.
    - Even if one sample fails during second check testing, the PV module will be in non-compliance with prescribed BEE standards.
    - In case of non-compliance as per manufacturer's declaration, the manufacturer has to again submit a fresh application with derated effective efficiency for the respective basic model groups.

6. Fees

The applicant shall deposit a security fee of INR 1,00,000 for each registration as security deposit. However, applicants registered as small scale industries (SSI units), shall deposit INR 25,000, provided they submit the valid SSI registration certificate.

6.1 Application fee payable on application for assignment of the authority to affix label is INR2000/- (Rupees Two thousand only)

6.2 No application fee is payable on application for renewal of permission to affix label on model.

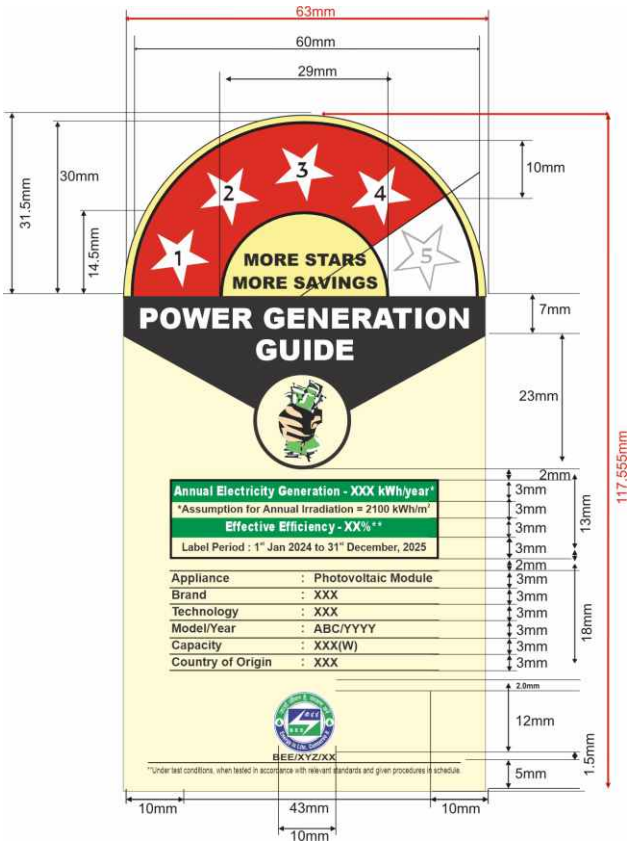
6.3 Labelling fee for affixation of label on each unit of Solar PV module is INR 0.02/W /- (2 Paisa per Watt only)

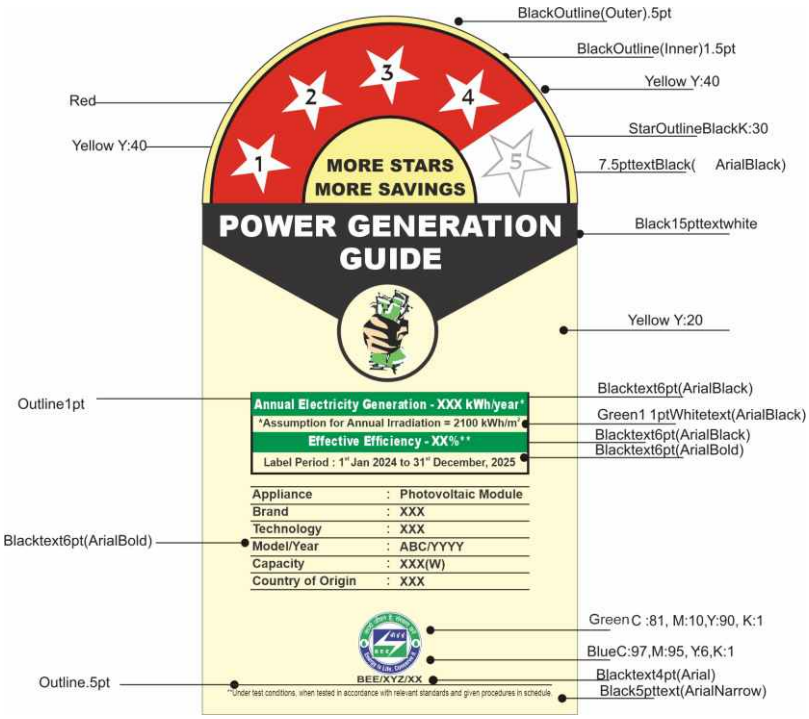
6.4 Labelling fees will be waived off for 4 and 5 star rated solar PV modules till 31st December 2025.

7. Label Design and Manner of Display

7.1 Placement: All PV panels must display the label. The label shall be displayed on the backside of the panel. The label shall also be displayed on the packaging.

7.2 Material, Dimension and Shape: The label shall be of durable material and printed as per the dimensions mentioned below:





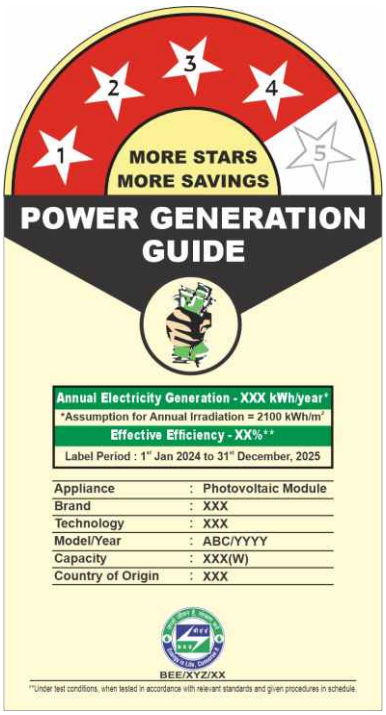


Figure-2: Label design for Solar PV Module

APPENDIX - A

Symbol	Description
$\eta_{max,t°C}$ (%)	Module Efficiency at t°C (Calculated as per equation 1).
I (Wm^{-2})	Total Irradiance incident on the module
A (m^2)	Area of the module
$P_{max,t°C}$ (W)	The maximum power output of the PV module at 't°C' & an irradiance of 1000 Wm^{-2} when tested as per the clause 8 of IS16170 part 1:2015

The maximum efficiency of the module is calculated by equation 1, and the values of maximum power output ($P_{max,t°C}$) at different temperatures from Table 2 are used to calculate the maximum efficiency ($\eta_{max,t°C}$).

$$\eta_{max,t°C} = \frac{P_{max,t°C}}{I \times A} \times 100 \quad \ldots\ldots \quad \text{Equation 1}$$

Irradiance (Wm^{-2})	Spectrum	Module temperature		
		25°C	50°C	75°C
1000	AM 1.5	$P_{max,25°C}$	$P_{max,50°C}$	$P_{max,75°C}$

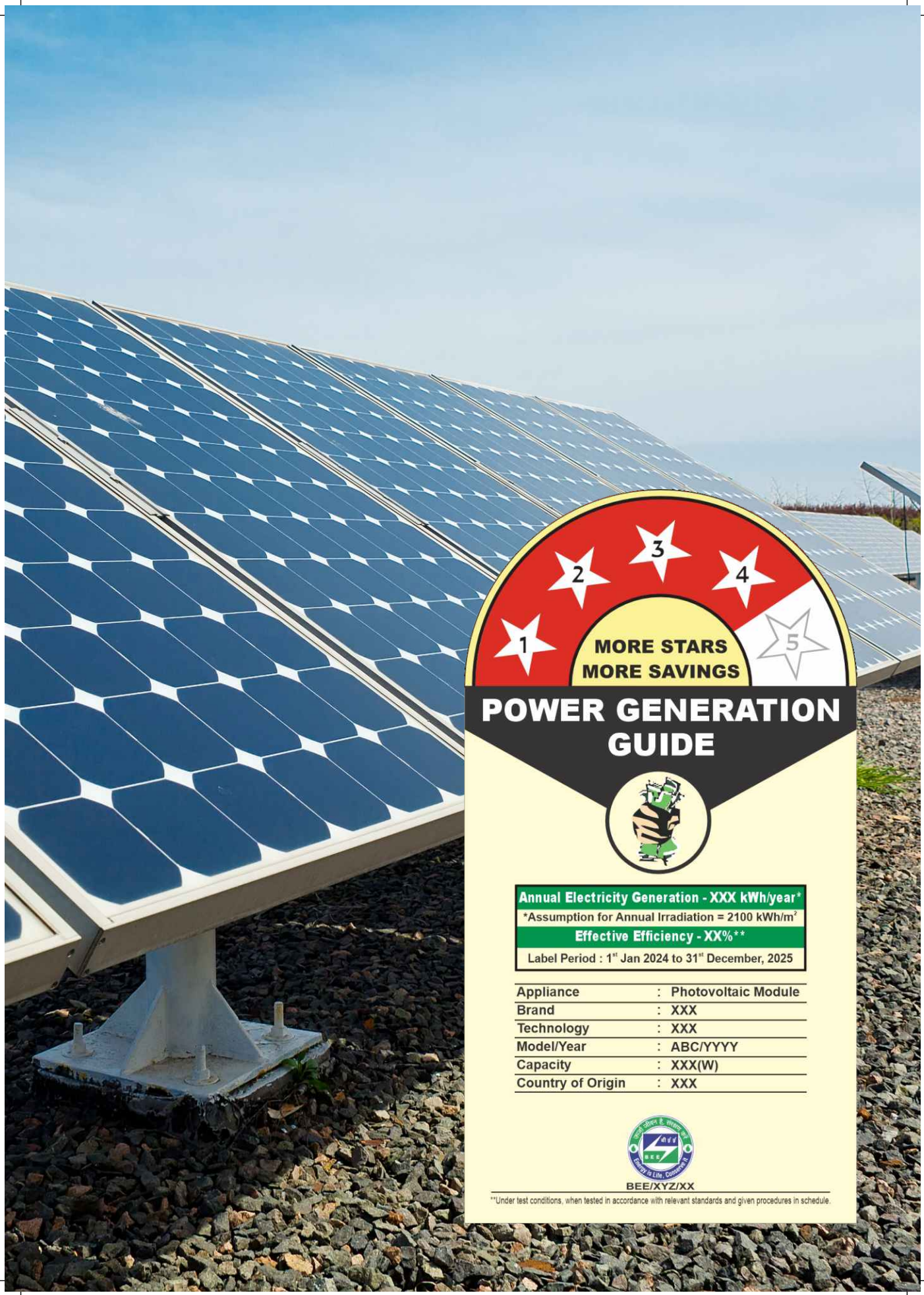
Table-4: Power output of PV modules at different module temperatures

$$\eta_{eff} = (0.14 \times \eta_{max,25°C}) + (0.62 \times \eta_{max,50°C}) + (0.24 \times \eta_{max,75°C}) \quad \ldots\ldots \quad \text{Equation 2}$$

APPENDIX - B

Laboratory Name	Values
Address	
Date of receipt	
Test report No.	
Tested by	
Date of testing	
Reviewed by	
Brand name	
Model name / number	
Serial number	
Year of manufacture	
Nameplate capacity of the PV panel	
BIS certificate for CRS	
Effective Efficiency (%η_{eff})	

Table-5: Information to be submitted by manufacturer to BEE



POWER GENERATION GUIDE

Annual Electricity Generation - XXX kWh/year*

*Assumption for Annual Irradiation = 2100 kWh/m^2

Effective Efficiency - XX%**

Label Period : 1st Jan 2024 to 31st December, 2025

Appliance	:	Photovoltaic Module
Brand	:	XXX
Technology	:	XXX
Model/Year	:	ABC/YYYY
Capacity	:	XXX(W)
Country of Origin	:	XXX

BEE/XYZ/XX

**Under test conditions, when tested in accordance with relevant standards and given procedures in schedule.

BEE's Key Endeavours

Standards & Labeling Program (S&L)

Demand Side Management (DSM)

Energy Conservation Building Code (ECBC)

National Mission for Enhanced Energy Efficiency (NMEEE))

Energy Efficiency in Micro Small and Medium Enterprises

Electric Vehicle Energy Efficiency

BUREAU OF ENERGY EFFICIENCY (BEE)
Ministry of Power, Govt. of India
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi - 110066 (INDIA)
www.beeindia.gov.in beeindiadigital beeindiadigital

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