August 2018

# DETAILED PROJECT REPORT
# ON
# 150 kWp SOLAR ROOF-TOP PV SYSTEM

## M/s Shiv-Om Brass Industries–Jamnagar Brass Cluster

Submitted to
(Prepared under GEF-UNIDO-BEE Project)

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| | |
|---|---|
| **AC** | Alternate Current |
| **ANSI** | American National Standards Institute |
| **BEE** | Bureau of Energy Efficiency |
| **DC** | Direct Current |
| **DPR** | Detailed Project Report |
| **EE** | Energy Efficiency |
| **GEF** | Global Environmental Facility |
| **IRR** | Internal Rate of Return |
| **kW** | Kilo Watt |
| **LSP** | Local Service Provider |
| **MSME** | Micro and Medium Scale Industries |
| **NPV** | Net Present Value |
| **OEM** | Original Equipment Manufacturer |
| **PGVCL** | Paschim Gujarat Vij Company Ltd |
| **PV** | Photovoltaic |
| **RE** | Renewable Energy |
| **TOE** | Tonnes of Oil Equivalent |
| **UNIDO** | United Nation Development Organization |
| **Ghm** | Monthly sum of global irradiation [kWh/m2] |
| **Ghd** | Daily sum of global irradiation [kWh/m2] |
| **Dhd** | Daily sum of diffuse irradiation [kWh/m2] |
| **T24** | Daily (diurnal) air temperature [°C] |
| **Esm** | Monthly sum of specific electricity prod. [kWh/kWp] |
| **Esd** | Daily sum of specific electricity prod. [kWh/kWp] |
| **Etm** | Monthly sum of total electricity prod. [MWh] |
| **Eshare** | Percentile share of monthly electricity prod. [%] |
| **PR** | Performance ratio [%] |

# ACKNOWLEDGEMENT

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CII would also like to give special gratitude to Jamnagar Brass Factory Owners' Association for supporting CII for carrying out this project at Jamnagar Brass Cluster and for their constant support and coordination throughout the activity.

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Last but not least we are thankful to Shiv-Om Brass Industries, especially Mr. Nitin Donga, for showing keen interest in the implementation of this technology and providing their wholehearted support and cooperation for the preparation of this Detailed Project Report.

We would take this opportunity to express our appreciation to the Original Equipment Suppliers and Local Service Providers for their support in giving valuable inputs and ideas for the completion of the Detailed Project Report.

We would also like to mention that the valuable efforts being taken and the enthusiasm displayed towards energy conservation by the Jamnagar Brass Cluster is appreciable and admirable.

# 1. EXECUTIVE SUMMARY

Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India, in collaboration with United Nations Industrial Development Organization (UNIDO) is executing a Global Environment Facility (GEF) funded national project "Promoting energy efficiency and renewable energy in selected MSME clusters in India". The overall aim of the project is to develop and promote a market environment for introducing energy efficiency and enhanced use of renewable energy technologies in process applications in 12 selected energy-intensive MSME clusters across 5 sectors in India (with expansion to more clusters later). This will enable improvement in the productivity and competitiveness of units, as well as reduce overall carbon emissions and improve the local environment.

Key activities involved in the project are as follows:

- **LSP MAPPING:** Detailed Mapping of LSPs in the cluster.
- **TECHNOLOGY FEASIBILITY STUDIES:** Preparation of 10 bankable DPRs
- **TRAINING MATERIALS:** Development of 5 customized training material based on mapping
- **TRAINING PROGRAM:** Conduct 4 training programs in the cluster for the capacity building of local service providers.
- **LSP's AS LOCAL DISTRIBUTORS:** Mapping of LSPs and OEMs so that LSPs can become local dealers for major OEMs.

## 1.1 Brief Unit Profile

Table 1: Unit Details

| Particulars | Details |
|---|---|
| **Name of Plant** | Shiv-Om Brass Industries |
| **Name(s) of the Plant Head** | Mr. Nitin Donga |
| **Contact person** | Mr. Nitin Donga |
| **Constitution** | Private Company |
| **MSME Classification** | - |
| **Address:** | Plot No. 3690/3691, GIDC, Phase III, Dared, Jamnagar - 361004 |
| **Industry-sector** | Manufacturing |

## 1.2 Proposed EE Measure

During the plant visit it was observed that the plant has scope for renewable energy and after discussion with the plant team and technology supplier, it was proposed to implement 150kWp Grid connected rooftop solar PV based power generation project at Shiv-Om Brass Industries.

The expected electricity generation is 2,25,000 kWh per annum. The details of the proposed EE measure is given in below:

Table 2: Proposed EE Measure

| Sl No | EE Measure | Annual Energy Savings | | Monetary Savings (Rs. Lakhs) | Investment (Rs. Lakhs) | Payback (Months) | Annual GHG reduction (T $CO_2$) |
|---|---|---|---|---|---|---|---|
| | | kWh | TOE | | | | |
| 1 | Installation of 150 kWp Grid connected Solar Power Plant | 2,25,000 | 19.35 | 15.3 | 70.88 | 56 | 185 |

## 1.3 Means of Finance

The details of means of finance for the proposed EE measure is as under:

Table 3; Project Finance

| Sl. No. | Particulars | Unit | Value |
|---|---|---|---|
| i | Total Investment (Incl. of Tax) | Rs. Lakh | 70.88 |
| ii | Means of Finance | Self / Bank Finance | Bank Finance |
| Iii | IRR | % | 40.92 |
| Iv | NPV at 70 % Debt | Rs. Lakh | 130 |

# 2. INTRODUCTION ABOUT SHIV –OM BRASS INDUSTRIES

## 2.1 Unit Profile

Shiv-Om Brass Industries was established in 1992 and is a leading manufacturer precision turned brass components company in India. And well-known in the market for brass special fasteners, brass special components, brass pipe inserts, brass switchgear parts, brass assemblies, brass decorative parts, brass electrical plugins and electronic pins.

Shiv Om Brass Industries has gained recognition as a reputed manufacturer of high quality electrical products. The excellence in manufacturing, product designs and the performance over a decade has enabled the company to offer unique quality products and confirm to latest national & international standards.

Table 4: Unit Profile

| Particulars | Details |
|---|---|
| **Name of Plant** | Shiv-Om Brass Industries |
| **Name(s) of the Plant Head** | Mr. Nitin Donga |
| **Contact person** | Mr. Nitin Donga |
| **Contact Mail Id** | prajapatidevang1995@gmail.com; apatel@shivombrass.in |
| **Contact No** | +91-288-2573600 |
| **Constitution** | Private Company |
| **No. of years in operation** | 26 Years |
| **No of operating hrs./day** | 24 |
| **No of operating days/year** | 306 Days |
| **Address:** | Plot No. 3690/3691, GIDC, Phase III, Dared, Jamnagar - 361004 |
| **Industry-sector** | Manufacturing |
| **Type of Products manufactured** | Precision Brass components as per the customers drawing, design and requirement |

## 2.2 Production Details

The various products manufactured in Shiv-Om Brass are brass special fasteners, brass special components, brass pipe inserts, brass switchgear parts, brass assemblies, brass decorative parts, brass electrical plugins and electronic pins. Last year plant had an average final product production of 708.8Tonne per Annum[1]. The graph below shows the Brass produced during last one year

[1] Data provided by plant

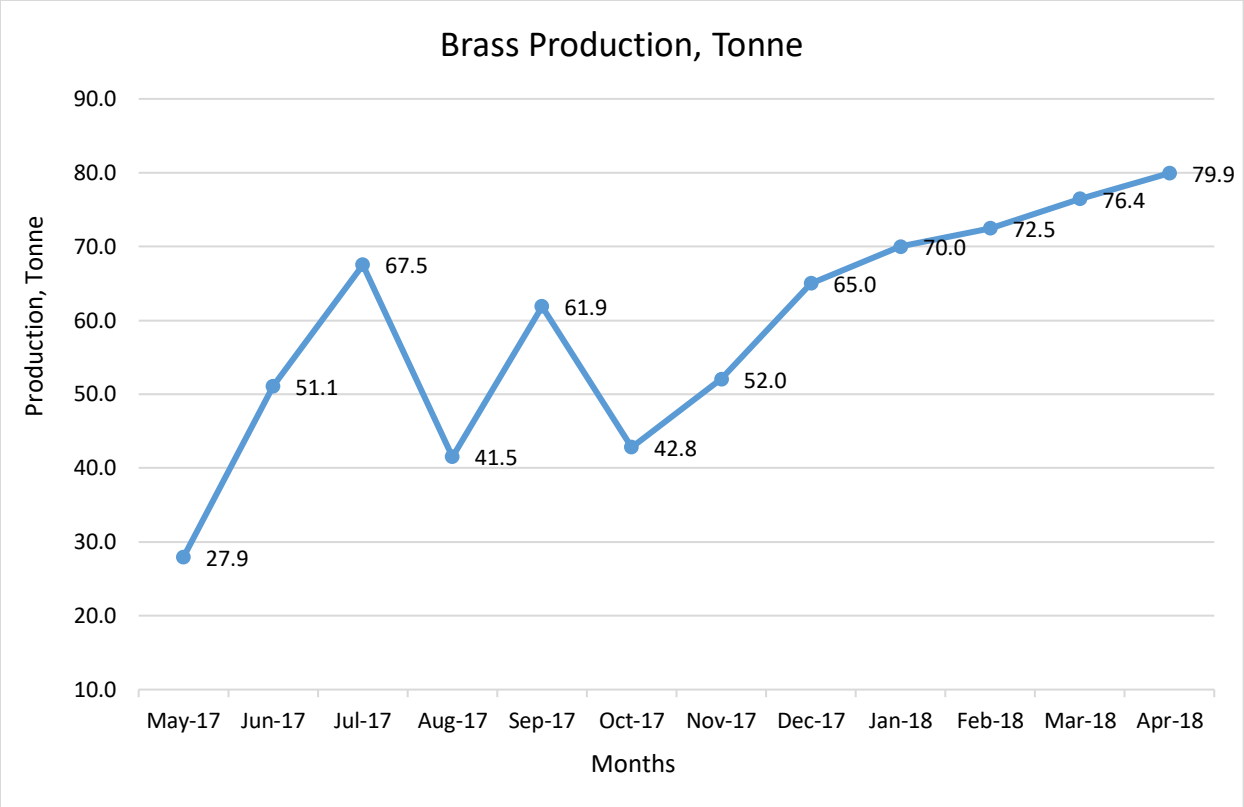



Figure 1: Production Details

## 2.3 Typical Brass Production Flow Diagram in Jamnagar

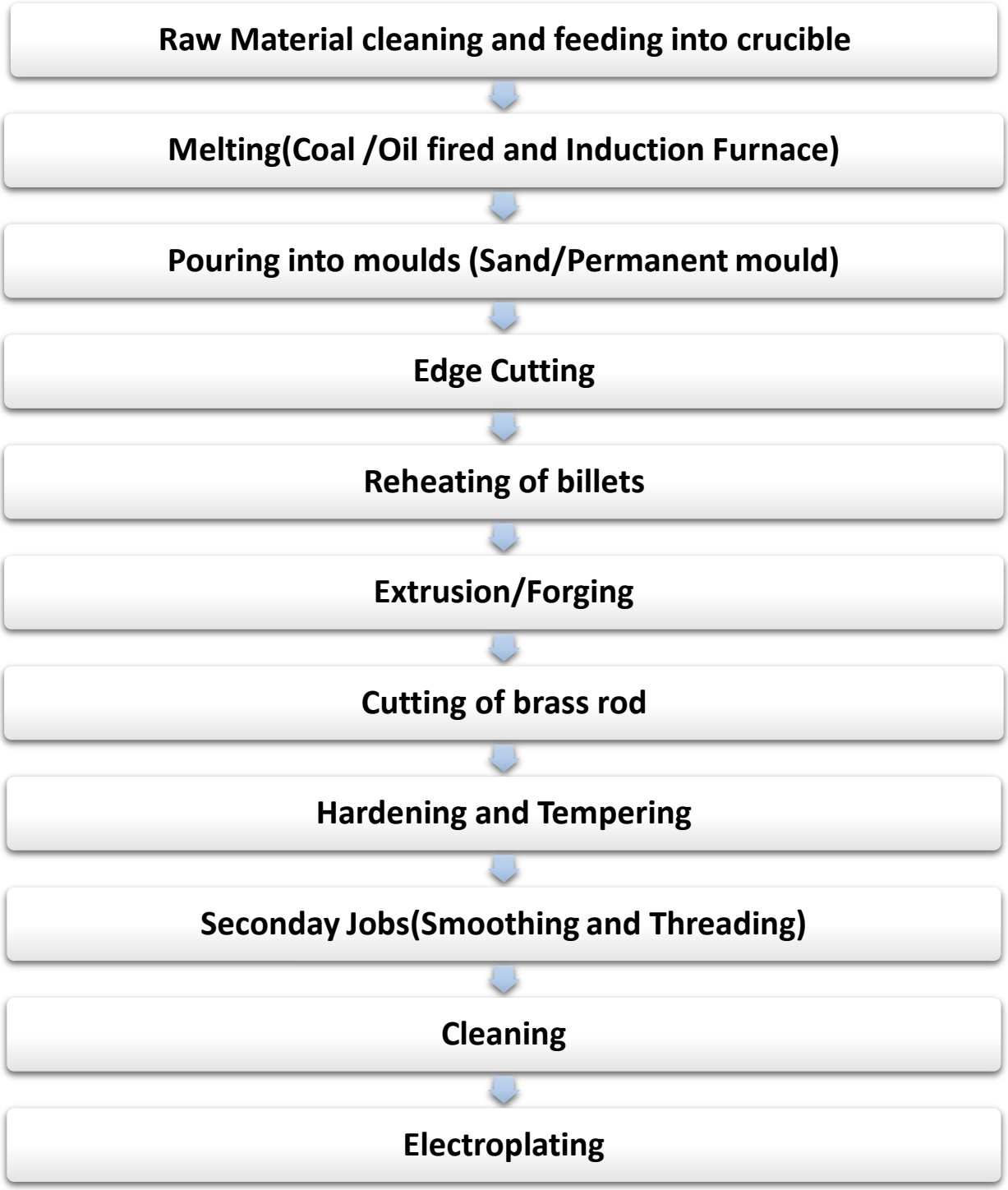


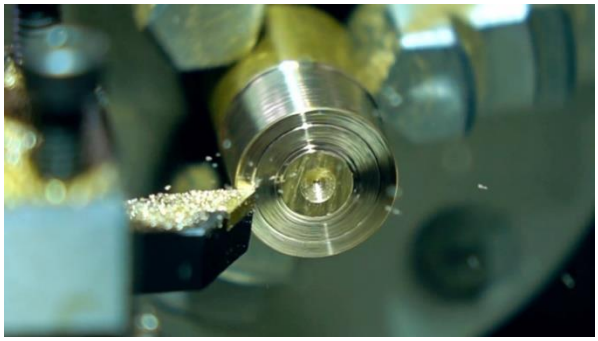

Figure 2: Typical Process Flow Chart

The production process mentioned in the above chart is almost similar to most of brass part manufacturing units in the cluster. However, depending on the final product, quality of final product and raw material properties, some of the stated process flow is altered to suit the requirement of industry. The major processes taking place at a typical Brass industry includes:

**Melting:** After separating the impurities form the brass scrap, the first step in making most of the products is melting the scarp in small furnace ranging from 100kg to 2000kg. Typically in Jamnagar pit type coal fired and induction melting furnaces are mainly used

**Casting**: After melting the next step involves casting molten brass in permanent mould or sand mould, depending upon the final product of the company. Sand moulding usually involves the preparing the consolidated sand mould around a pattern held within a supporting metal frame and removing the pattern to leave the mould cavity with cores. The liquid brass is poured into the cavity and allowed to solidify and when it does, the product is taken out of the mould cavity, trimmed and made to shape.

**Machining:** It is a broad term used to describe removal of material from a workpiece to get the desired shape and size of the material for further use. Machining is one of the key specialty of the products manufactured in Jamnagar clusters. Most of the plants are using traditional machines for grinding, grooving and other secondary jobs along with latest generation CNC machines for some specific jobs.



**Electroplating:** Is the process that is coating metals through reaction of the electrical conductive and chemical organics. The basic electroplating process consists of a plating bath filled with water containing a small amount of acid or alkali added to improve its conductivity.

- An anode (positive electrode) - either the plating metal or an inert electrode; this is expended as the process goes on and replenished periodically

- A cathode (negative electrode) - the item to be plated; these can be either hung inside the bath or placed in a barrel, which is rotated slowly to make the plating material deposited evenly

Usually, the bath is contained in metal container, lined with acid/alkali resistant membrane e.g. PVC sheet to make it insulated from electric circuit. The application of direct electric current across the bath solution causes the migration of positively charged particles (anions) towards the negative electrode (cathode) and negatively charged particles (cations) towards the positive electrodes (anode).

## 2.4 Energy Profile

The plant was using only electricity, imported from PGVCL grid supply with contract demand of 425kVA, for carrying out various activities in plant such as grinding , drilling ,profile cutting, machining etc. The plant has an average electricity consumption of 79,564kWh per month which costs Rs. 6.0 lakh per month for the last one year.

The table below shows the average monthly energy consumption of the plant along with the average production of the finished goods during the last 12 months:

Table 5: Energy Consumption and Finished product Details

| Month | Electricity Consumption (kWh) | Total Electricity Bill , Rs.(Lakhs) | Final Product, (Tonnes) |
|---|---|---|---|
| May-17 | 85938 | 5.23 | 27.94 |
| Jun-17 | 73242 | 5.62 | 51.12 |
| Jul-17 | 80484 | 6.09 | 67.54 |
| Aug-17 | 91236 | 6.67 | 41.52 |
| Sep-17 | 76854 | 5.77 | 61.90 |
| Oct-17 | 89418 | 6.60 | 42.84 |
| Nov-17 | 65718 | 5.04 | 52.04 |
| Dec-17 | 75186 | 5.65 | 65.03 |
| Jan-18 | 77352 | 5.80 | 70.00 |
| Feb-18 | 78750 | 5.79 | 72.49 |
| Mar-18 | 74028 | 5.55 | 76.44 |
| Apr-18 | 86562 | 6.38 | 79.94 |

# 3. PROPOSED EE MEASURE – INSTALL 150 kWp SOLAR PV POWER PLANT

## 3.1 Present System

The plant is presently using energy in the form of electricity and furnace oil. Electricity is used to operate electrical utilities and machines.

Figure 3: Plant Rooftop area

**Observation**

During the course of study, it was observed that plant has an effective 1,600 $m^2$ roof top area available which can be utilized to install solar PV panel to harness solar energy and generate electricity.

Table 6: Basic site details

| Parameters | |
|---|---|
| **Effective Rooftop available ,$m^2$** | 1,600 |
| **Location** | Latitude: - 22.25 degrees<br>Longitude: - 70.03 degrees |
| **Altitude above sea level, m** | 26 |

**Net Metering Business Model**

The net metering-based rooftop solar projects facilitate the self-consumption of electricity generated by the rooftop project and allows for feeding the surplus into the grid network of the distribution by licensee. The type of ownership structure for installation of such net metering based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. A rooftop photovoltaic power station, or rooftop PV system, is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop Industry building. The various components of such a system include photovoltaic modules, mounting systems, cables, solar inverters and other electrical accessories. Rooftop mounted systems are small compared to ground-mounted photovoltaic power stations with capacities in the megawatt range. A grid connected rooftop photovoltaic power station, the generated electricity can sometimes be sold to the servicing electric utility for use elsewhere in the grid. This arrangement provides payback for the investment of the installer. Many consumers from across the world are switching to this mechanism owing to the revenue yielded. A commission

usually sets the rate that the utility pays for this electricity, which could be at the retail rate or the lower wholesale rate, greatly affecting solar power payback and installation demand.

The global horizontal irradiation and air temperature; climate reference for Jamnagar is as follows[2]:

Table 7: Solar Irradiance Data

| Month | Ghm | Ghd | Dhd | T24 |
|---|---|---|---|---|
| **Jan** | 154.3 | 4.98 | 1.44 | 21.4 |
| **Feb** | 164 | 5.86 | 1.61 | 23.2 |
| **Mar** | 210.8 | 6.80 | 1.99 | 26.3 |
| **Apr** | 223.2 | 7.44 | 2.29 | 28.8 |
| **May** | 228.6 | 7.37 | 2.65 | 30.8 |
| **Jun** | 170.7 | 5.69 | 3.12 | 30.9 |
| **Jul** | 121.9 | 3.93 | 2.91 | 29.0 |
| **Aug** | 122.8 | 3.96 | 2.82 | 27.8 |
| **Sep** | 155.6 | 5.19 | 2.63 | 28.6 |
| **Oct** | 179.4 | 5.79 | 1.90 | 29.2 |
| **Nov** | 146.6 | 4.89 | 1.70 | 26.8 |
| **Dec** | 143.7 | 4.63 | 1.44 | 23.3 |
| **Year** | 2021.6 | 5.54 | 2.21 | 27.2 |

PV electricity production in the start-up is given as follows:

Table 8: Max. Electricity Generation

| Month | Esm | Esd | Etm | Eshare | PR |
|---|---|---|---|---|---|
| **Jan** | 164.8 | 5.32 | 37.1 | 9.9 | 78.0 |
| **Feb** | 157.1 | 5.61 | 35.3 | 9.4 | 76.7 |
| **Mar** | 174.3 | 5.62 | 39.2 | 10.5 | 75.1 |
| **Apr** | 161.8 | 5.39 | 36.4 | 9.7 | 74.2 |
| **May** | 149.9 | 4.84 | 33.7 | 9.0 | 73.9 |
| **Jun** | 110.1 | 3.67 | 24.8 | 6.6 | 74.4 |
| **Jul** | 81.8 | 2.64 | 18.4 | 4.9 | 75.1 |
| **Aug** | 86.8 | 2.80 | 19.5 | 5.2 | 75.8 |
| **Sep** | 120.9 | 4.03 | 27.2 | 7.3 | 75.6 |
| **Oct** | 158.3 | 5.11 | 35.6 | 9.5 | 74.8 |
| **Nov** | 145.4 | 4.85 | 32.7 | 8.7 | 76.1 |
| **Dec** | 155.8 | 5.03 | 35.1 | 9.3 | 77.6 |
| **Year** | 1667 | 4.57 | 375.1 | 100.0 | 75.7 |

[2] Detailed report is attached in the annexure

## 3.2 Recommendation

As per the site feasibility study it was found that plant can install a 150 kWp Solar PV power plant which will generate an average of around 2.25Lakhs electrical units annually. It is a grid connected net metering based rooftop solar system which is a new concept for MSME industries and in grid connected rooftop or small SPV system, the DC power generated from SPV panel is converted to AC power using power converter unit and is fed to the grid either of 33 kV/11 kV three phase lines or of 440V/220V three/single phase line depending on the local technical and legal requirements. These systems generate power during the day time which is utilized by powering captive loads and feed excess power to the grid. In case, when power generated is not sufficient, the captive loads are served by drawing power from the grid.

The net metering-based rooftop solar projects normally facilitates the self-consumption of electricity generated by the rooftop project and allows for feeding the surplus into the network of the distribution licensee. The type of ownership structure for installation of such net metering-based rooftop solar systems becomes an important parameter for defining the different rooftop solar models. In the international context, the rooftop solar projects have two distinct ownership arrangements.

The table below shows the advantages of using Solar PV Power

Table 9: Solar Power advantages

| Sl. No | Solar Power |
|---|---|
| 1 | Low gestation period |
| 2 | Lower transmission and distribution losses |
| 3 | Improvement in the tail-end grid voltages and reduction of system. |
| 4 | Loss mitigation by utilization of distribution network as a source of storage through net metering. |
| 5 | Long term energy and ecological security by reduction in carbon Emission |

## 3.3 Solar Panel Details

The technical specifications of solar PV system are given as follows:

Table 10: Technical Specifications of SPV system

| Description | Value |
|---|---|
| **Capacity of PV module, Wp** | 340 |
| **Output power, W** | 340 |
| **Voltage at Pmax.,V** | 36.70 |
| **Current at Pmax.,A** | 9.13 |
| **Open circuit voltage ,V** | 45.80 |
| **Short circuit current ,A** | 9.50 |

| | |
|---|---|
| **Module efficiency ,%** | 17.53% |
| **Maximum system voltage , V DC** | 100 |

## 3.4 Supplier Details

Table 11: Supplier Details

| Equipment Detail | 150 kWp Solar Power Systems |
|---|---|
| **Supplier Name 1** | Renesys Power Systems |
| **Address** | 1504 B 407 A, Mondeal Square, Prahlad Nagar,, Ahmedabad, Gujarat 380015 |
| **Contact Person** | J P Mehta |
| **Email Id** | info@renesys.in |
| **Supplier Name 2** | SM Renergy (P) Ltd. |
| **Address** | New Delhi |
| **Contact Person** | Samay Manalagiri |
| **Email Id** | Samay@smrenergy.in |
| **Supplier Name 3** | Topsun Energy Ltd. |
| **Address** | B-101 ,GIDC , Eltronic Zone , Sector 25,Ghandhinagar |
| **Contact Person** | Mohit Zala |
| **Email Id** | Project.exe3@topsunenergy.com |

## 3.4 Savings

The expected energy savings is around 21.8%[3] in overall energy bill of the plant which is equivalent to saving 2, 25,000 kWh/Year. The annual monetary saving for this project is Rs. 15.30 Lakhs with an investment of Rs. 70.88 Lakhs and payback for the project is 56 months.

Detailed savings calculations are given in below table

Table 12: Savings Calculation

| Parameters | Install of Solar Systems 150kWp Systems |
|---|---|
| **Proposed Roof top Solar installation, kWp** | 150 |
| **Average Annual units generation per kW of Solar PV, kWh/Annum** | 1500 |
| **Total Energy Generation Per Annum, kWh/Year** | 2,25,000 |
| **Cost Savings in Energy Bill per Annum, Rs. Lakhs/Year** | 15.30 |
| **Investment including GST @ 5 %, Rs.** | 70.88 |
| **Payback period, Months** | 55.6 |
| **Annual $CO_2$ Reduction, Tonne** | 185 |
| **Annual Energy Saving, TOE/Year** | 19.35 |

[3] Based on the total annual electricity bill of the plant

# 4. FINANCIAL ANALYSIS

## 4.1 Project Cost

Table 13: Project Cost

| Parameter | Amount in Rs Lakhs |
|---|---|
| **Install 150kWp Solar PV Power systems** | 67.50 |
| **GST @5%** | 3.37 |
| **Total Project Cost** | 70.88 |

## 4.2 Assumptions for Financial Analysis

- Cost of Debt (Interest rate) taken as 12%
- Yearly increase in fuel cost by 2% for cash flow analysis
- Depreciation method: Reducing balance method
- Depreciation rate: 40% [4]
- Life cycle of the project is taken as 7 years
- Three different Capital Structure considered
    - CS1 – 70:30 Debt Equity Ratio
    - CS2 – 50:50 Debt Equity Ratio
    - CS3 – 100 % Equity
- Return on equity is taken as 15 %
- Operation and Maintenance Cost taken as 5% of Initial investment
- For calculating weighted average cost of capital, the corporate tax rate is assumed as 30%

## 4.3 Cash Flow Analysis

Table 14: Cash flow of the project

| **Cash flow for the project** | | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
|---|---|---|---|---|---|---|---|---|
| | **Year 0** | **Year 1** | **Year 2** | **Year 3** | **Year 4** | **Year 5** | **Year 6** | **Year 7** |
| **Required Investment** | 70.9 | | | | | | | |
| **Energy Savings** | | 15.3 | 15.6 | 15.9 | 16.2 | 16.6 | **16.9** | **17.2** |
| **O&M Cost** | | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 |
| **Depreciation** | | 28.4 | 17.0 | 10.21 | 6.12 | 3.67 | 2.20 | 1.32 |
| **Net Cash Flow** | -70.9 | 42.2 | 31.2 | 24.7 | 20.9 | 18.8 | 17.7 | 17.1 |

[4] https://www.incometaxindia.gov.in/charts%20%20tables/depreciation%20rates.htm

| 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|
| Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 |
| | | | | | | | | |
| 17.6 | **17.9** | **18.3** | **18.7** | **19.0** | **19.4** | **19.8** | **20.2** | **20.6** |
| **-1.4** | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 |
| **0.79** | 0.48 | 0.29 | 0.17 | 0.10 | 0.06 | 0.04 | 0.02 | 0.01 |
| **17.0** | 17.0 | 17.2 | 17.4 | 17.7 | 18.0 | 18.4 | 18.8 | 19.2 |

| 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|
| Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | Year 23 | Year 24 | Year 25 |
| | | | | | | | | |
| 21.0 | **21.4** | **21.9** | **22.3** | **22.7** | **23.2** | **23.7** | **24.1** | **24.6** |
| **-1.4** | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 | -1.4 |
| **0.0** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **19.6** | 20.0 | 20.4 | 20.9 | 21.3 | 21.8 | 22.2 | 22.7 | 23.2 |

The table below shows the WACC at various capital structure assumed for the financial analysis

Table 15: Capital Structure

| Capital Structure | | | |
|---|---|---|---|
| **Particulars** | CS 1 | CS 2 | CS 3 |
| **Debt** | 70 | 50 | 0 |
| **Cost of Debt** | 0.12 | 0.12 | 0.12 |
| **Tax 30%** | 0.3 | 0.3 | 0.3 |
| **Equity** | 30 | 50 | 100 |
| **Sum of debt& Equity** | 100 | 100 | 100 |
| **Cost of Equity** | 0.15 | 0.15 | 0.15 |
| **WACC** | 10.38 | 11.7 | 15 |

Table 16: NPV Calculation

| NPV Calculation | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 |
|---|---|---|---|---|---|---|---|---|
| **NPV at CS 1 (70:30)** | -70.9 | 38.3 | 25.6 | 18.4 | 14.1 | 11.5 | 9.8 | 8.6 |
| **NPV at CS 2 (50:50)** | -70.9 | 37.8 | 25.0 | 17.7 | 13.5 | 10.8 | 9.1 | 7.9 |
| **NPV at CS 3 (100% Equity)** | -70.9 | 36.7 | 23.6 | 16.2 | 12.0 | 9.4 | 7.6 | 6.4 |

| Year 8 | Year 9 | Year 10 | Year 11 | Year 12 | Year 13 | Year 14 | Year 15 | Year 16 |
|---|---|---|---|---|---|---|---|---|
| 7.7 | 7.0 | 6.4 | 5.9 | 5.4 | 5.0 | 4.6 | 4.3 | 4.0 |
| 7.0 | 6.3 | 5.7 | 5.2 | 4.7 | 4.3 | 3.9 | 3.6 | 3.3 |
| 5.5 | 4.8 | 4.2 | 3.7 | 3.3 | 2.9 | 2.6 | 2.3 | 2.1 |

| Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | Year 23 | Year 24 | Year 25 | NPV |
|---|---|---|---|---|---|---|---|---|---|
| 3.7 | 3.4 | 3.1 | 2.9 | 2.7 | 2.5 | 2.3 | 2.1 | 2.0 | 130.1 |
| 3.0 | 2.7 | 2.5 | 2.3 | 2.1 | 1.9 | 1.7 | 1.6 | 1.5 | 114.1 |
| 1.8 | 1.6 | 1.4 | 1.3 | 1.1 | 1.0 | 0.9 | 0.8 | 0.7 | 83.3 |

## 4.4 Sensitivity Analysis

A sensitivity analysis has been carried out to ascertain how the project financials would behave in different situations such as

- Change in energy savings
- Change in operating hours
- Change in interest rate

The sensitivity analysis will help to estimate the impact of key project indicators on attractiveness of the project, thereby helping to understand the financial viability.

Table 17: Sensitivity analysis: based on energy savings

| Sensitivity analysis: based on energy savings | | | |
|---|---|---|---|
| | at 100% Savings | at 75% Savings | at 50% Savings |
| **IRR** | 40.9% | 33.4% | 25.1% |
| **NPV at CS 1 (D70:E30)** | 130.11 | 90.81 | 51.51 |
| **NPV at CS2 (D50:E50)** | 114.06 | 64.94 | 33.98 |
| **NPV at CS3 (D0:E100)** | 83.33 | 55.38 | 27.42 |

Table 18: Sensitivity analysis: change in operating hrs.

| Sensitivity analysis: based on operating hours | | | |
|---|---|---|---|
| | at 100% Operating hours | at 90% Operating hours | at 80% Operating hours |
| **IRR** | 40.9% | 38% | 35% |
| **NPV at CS 1 (D70:E30)** | 130.11 | 114.39 | 98.67 |
| **NPV at CS2 (D50:E50)** | 114.06 | 99.92 | 85.77 |
| **NPV at CS3 (D0:E100)** | 83.33 | 72.15 | 60.97 |

Table 19: Sensitivity analysis: change in interest rate

| Sensitivity analysis: change in interest rate | | | | | | |
|---|---|---|---|---|---|---|
| | at 9.5% Interest rate | at 10.05% Interest rate | at 11% Interest rate | at 12% Interest Rate | at 12.5% Interest Rate | at 13% Interest Rate |
| **NPV (70:30)** | 147.62 | 140.28 | 136.78 | 130.11 | 126.93 | 123.85 |

# 5. ENERGY EFFICIENCY FINANCING IN MSMEs

Financing plays a key role in facilitating procurement and implementation of energy efficient technologies and products in any industry. Government has given EE financing in MSMEs top priority since the sector contributes significantly towards India's economic growth. However, existing financing options are not sufficient to meet the financing requirement in the sector due to the large size of the sector. MSMEs using various financing schemes for technological up-gradation are still very less, as most of them use their own capital fund rather than making use of external financing models. Although financing models were very successful in some clusters, the scale-up of such activities is rather slow. This slow pace in implementation of energy efficiency financing in MSMEs is due to the various sector specific challenges in the sector.

Some of the key barriers to finance EE projects in the sector are: -

- Lack of available capital for investment as EE interventions being small may not get financed through FIs as they do not qualify as term loans
- Lack of clarity on financing schemes- repayment mechanism and complex procedural requirements
- Lack of availability of financing model that cater to the particular requirement of the MSME
- Lack of awareness among MSMEs with respect to benefits of implementing EE technologies
- FIs consider MSMEs as a high-risk category due to low credit flow to this sector. This is due to several factors such as poor book-keeping practices, weak balance sheets, poor credit history and smaller sizes of MSME loans.
- Collateral based lending, advocated by FIs, restricts MSMEs from availing loans
- No formal M&V procedure available to estimate the savings achieved by implementing EE measure
- Risks associated with repayment of loans which include technical, commercial and performance risks

## 5.1 FI Schemes in Gujarat

Table 20: FI schemes in Gujarat

| Sl.No | Name of Scheme | Purpose | Financial Details | Contact Address |
|---|---|---|---|---|
| 1 | **SIDBI Make in India Soft Loan Fund for Micro, Small & Medium Enterprises (SMILE)** | • The focus of the scheme is on technology upgradation which helps in reducing the impacts from process and operations as the reduction in resource consumption and productivity improvements are major outcome of technology upgradation<br>• The program aims to bridge the gap by providing financial support to the companies. | • Rate of interest is according to credit rating<br>• Interest rates for soft loans are from (8.90 % to 8.95 % pa) and term loans are in the range of (9.45% to 9.60% pa)<br>• Min loan amount: Rs 25 Lakhs<br>• Term Loan: 75% of the project cost as debt | Mr.Chandra Kant<br>SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008.<br>Contact no : 0288 275 3954<br>Mail id : chandrakant@sidbi.in |
| 2 | **4E scheme (End to End Energy Efficiency Financing scheme)** | • The 4E scheme promoted by SIDBI aims to assist the industries in implementation of energy efficiency and renewable energy projects.<br>• The scheme addresses all aspects of energy efficiency in a company from assessment and identification of energy efficiency interventions to facilitating implementation by providing technical and financial support | • Interest rate - 2.5% below market interest rate<br>• Min loan amount: Rs 10 Lakhs<br>• Max loan amount: Rs 150 Lakhs<br>• 90% of the project cost as debt | Mr.Chandra Kant<br>SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008.<br>Contact no : 0288 275 3954<br>Mail id : chandrakant@sidbi.in |

| | | | | |
|---|---|---|---|---|
| **3** | **Partial Risk Sharing Facility for Energy Efficiency project (PRSF)** | • The partial risk sharing facility aims at transforming the energy efficiency market in India and promotion of Energy Service Contracting Model for the Energy Efficiency.<br>• The scheme address barrier related to the financing aspects for energy efficiency | • Term Loan: 12%-15%<br>• Min loan amount: Rs 10 Lakhs<br>• Max loan amount: Rs 15 Cr<br>• Total Project funding of – USD 43 million<br>• Risk Sharing facility component of USD 37 million to be managed by SIDBI<br>• Technical assistance component of USD 6 billion to be managed by SIDBI and EESL | Mr Chandra Kant<br><br>SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008.<br>Contact no : 0288 275 3954<br>Mail id : chandrakant@sidbi.in |
| **4** | **Bank of Baroda's Scheme for Financing Energy Efficiency Projects** | All these Schemes from various banks (SBI, Bank of Baroda, Canara Bank) have their focus towards technology upgradation. Technology upgradation can lead to improvement in energy, productivity, and lower emission from the MSME company. As technology upgradation could be capital intensive most of the | • Loans of up to 75% of the total project cost, subject to maximum of Rs. 1 crore, will be provided. (Minimum amount of loan Rs. 5 Lakhs<br>• Collateral will be required for all loans. An interest rate of bank base rate + 4% will be applicable, to be paid back over a period of 5 years. | Bank of Baroda<br>Saru Section Road,Swastik Society,Park colony,Jamnagar,Gujarat,361008<br>Contact no : 0288 266 0779<br>Mail Id : Jamnag@bankofbaroda.com |
| **5** | **Canara Bank's Loan scheme for Energy Savings for SMEs** | | • The scheme covers up to 90% of project costs of up to INR 1 million (EUR 13,000).<br>• Max. loan: INR 10 million (EUR 130,000)<br>• Security: collateral free up to INR 5 million (EUR 65,000), beyond INR 5 million collateral required as determined by the bank<br>• Margin: 10% of project costs | Canara Bank, 1st Floor,New Super Market,Bedi Road,Jamnagar,Gujarat,361001<br>Ph no: 0288 267 6597 |

| | | | | |
|---|---|---|---|---|
| **6** | **SBI's Project Uptech for Energy Efficiency** | schemes from banking institutions aim at bridging the gaps for access to finance for MSME sector | • SBI identifies industrial clusters with potential for quick technology upgradation and a supporting environment. Based on studies in interested units, technology upgradation is undertaken if the same in viable.<br>• With a ceiling of INR 1 lakh, an amount equal to that invested by the unit is provided under this loan. There is a start-up period of 3 years, with a repayment period of 5-7 years, at zero interest. | SBI Regional Office<br>Junagadh Jamnagar Highway, Maheswari Nagar, Opp Anupam Cinema Hall, Kadiawad, Jamnagar, Gujarat 361001.<br>Ph no : 0288 2554026<br>Mail id : sbi.01816@sbi.co.in |
| **7** | **Solar Roof Top Financing Scheme IREDA** | The loan scheme is applicable to grid interactive, rooftop solar PV plants for industries, institutions and commercial establishments. Financing can be accessed for single or aggregated investments. | • Interest rate: 9.9% - 10.75%<br>• Max. repayment time: 9 years<br>• Minimum promoter's contribution: 30%<br>• The applicant's minimum capacity needs to be 1MW | IREDA Camp Office<br>603, Atlanta Towers<br>Near Panchvati Circle,<br>Gulabi Tekra<br>Ahmedabad<br>Ph No : 9811889805<br>Email Id : ashokyadav@ireda.in |

# 6. ENVIRONMENTAL AND SOCIAL BENEFIT

## 6.1 Environmental Benefit

A resource-efficient business demonstrates a responsibility towards the environment. Energy and the environment are so closely linked, that, in addition to saving energy and reducing utility expenses, there are additional and often unreported benefits from conserving energy, saving natural resources being an important benefit.

Energy efficiency plays a major role, even where company output is increased, energy efficiency improvements can contribute significantly in most cases to reducing the negative impact of energy consumption per unit of output. Any increase in pollutant emissions will thus be minimized. Significant environmental benefits gained by adopting energy efficient technologies and processes may include lowering the demand for natural resources, reducing the emission of air pollutants, improving water quality, reducing the accumulation of solid waste and also reducing climate change impacts. Improving energy conservation at the facility can improve the facility's overall efficiency, which leads to a cleaner environment.

**Reduction in Pollution Parameters**

The proposed RE measure of installing Solar PV system will result in reduction in electricity consumption by 2,25,000 kWh per annum. As the electricity consumption is reduced, the unit has to purchase lesser energy from grid thus resulting in fuel/coal savings at the utility thermal power plant and that there is a reduction of 19.4TOE per annum. The proposed EE measure will result in decrease of $CO_2$ emissions by 185 Tonnes of $CO_2$ annually, thus resulting in reduced GHG effect.

## 6.2 Social Benefit

**Work Environment**

The Factories Act, 1948 covers various aspects relating to working environment maintenance and improvement. The good maintenance practices, technology up gradation, efficient use of energy and resource conservation not only contribute to energy and pollutant reduction but also contributes in ensuring safe and clean working environment to the employees of the organization. Many units have also been doing review of safety process and have provided access to safe working environment to the workers. Basic facilities such as first aid kit, PPE gears and many others have been made available

**Skill Improvement**

Implementing energy efficiency measures requires mix of people and skills. It involves upskilling workers at all levels from the shop floor to the board room to understand how companies manage their energy use—and to identify, evaluate and implement opportunities to improve energy performance. As the project involved identifying energy saving projects, implementing and verifying the savings, the unit have understood how to estimate energy savings with respect to energy saving proposals and also energy wastage have been identified. The activity has been successful in bringing the awareness among workers on energy wastage reduction, technology up gradation possible, etc. Each new technology implemented in a brass unit will create an impact on the entire cluster as each unit can replicate the new technology and promote the concept of energy efficiency and renewable energy in entire Cluster and thus reduce the overall energy consumption of the cluster as a whole. Technical skills of persons will be definitely improved as the training provided by the OEMS' on latest technology will create awareness among the employees on new trends happening in market. The training also helps in improving the operational and maintenance skills of manpower required for efficient operation of the equipment.

# 7. CONCLUSION

Energy efficiency is an instrument to address the issue of energy crisis and also be employed as a cost-effective means to attain sustainability and business. Cost of energy is considered as a vital component for industries and warrant judicious use of energy. Amid spiraling power cost energy efficiency assumes at most importance for the sector to remain competitive.

The GEF, UNIDO and BEE project through its various engagements is able to demonstrate energy efficiency potential in Jamnagar Brass cluster. The project is able to promote the concept of energy efficiency and renewable energy in brass cluster through various capacity building programs for local service providers, technology feasibility studies in brass units, training programs on EE/RE technologies and also helped in penetrating new /latest technologies into the cluster.

The DPR on for installation of 150Kwp Solar Power Plant was prepared after the OEM came to the unit and done a detailed feasibility study. This measure will significantly reduce the dependency on electricity from the grid which will result in an annual energy savings of 2, 25,000 kWh with 185 Tonnes of $CO_2$ reduction.

The following table gives the overall summary of the savings achieved: -

Table 21: Proposed EE Measure

| Sl No | EE Measure | Annual Energy Savings | | Monetary Savings (Rs. Lakhs) | Investment (Rs. Lakhs) | Payback (Months) | Annual GHG reduction (T $CO_2$) |
|---|---|---|---|---|---|---|---|
| | | kWh | TOE | | | | |
| **1** | **Installation of 150 kWp Grid connected Solar Power Plant** | 2,25,000 | 19.35 | 15.3 | 70.88 | 56 | **1** |

The summary of financial analysis given in the below table clearly indicates that implementation of this project is economically and financially viable with an attractive payback period. So it is recommended to install 150kWp solar PV system.

Table 22: Financial Analysis

| Sl. No. | Particulars | Unit | Value |
|---|---|---|---|
| **i** | **Total Investment (Incl. of Tax)** | Rs. Lakh | 70.88 |
| **ii** | **Means of Finance** | Self / Bank Finance | Bank Finance |
| **Iii** | **IRR** | % | 40.92 |
| **Iv** | **NPV at 70 % Debt** | Rs. Lakh | 130 |

## 7.1 Replication Potential

Most of the units in Jamnagar brass cluster have an unutilized roof area. These units have a huge replication potential in the cluster. The implementation of this project will inspire other units to take up similar energy efficiency initiatives which eventually will lower the bottom line and increase the top line therefore the margin increases. Secondly, the very clear specifications on vendor and the cost base is already available which makes it easy for other units in the Jamnagar Brass cluster to access the technology and gives them a very good idea about the cost and benefits associated with the projects. Overall, the holistic approach adopted by the project will be extremely useful in achieving the goal of improving EE in the cluster.

# 8. ANNEXURE

## 8.1 Financial Quotation -01

SM Renergy (P) Ltd.

# Rooftop Solar PV Proposal for Shivom Brass, Jamnagar

Pre - Feasibility Report for a 150kWp rooftop solar PV project

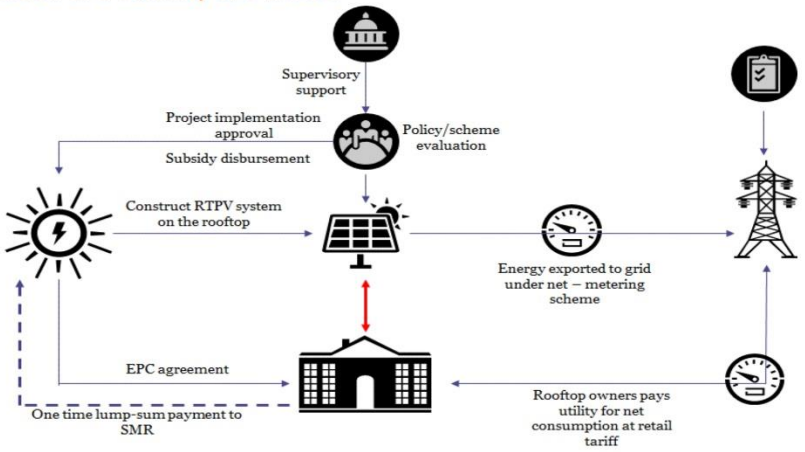
15th May, 2018

### Introduction

SMR proposes an installation of a grid connected rooftop solar PV system under **Turnkey EPC Model** on the available rooftop space of Shivom Brass to offset a majority of the energy consumption from the grid. SMR is one of the few companies in India which is able to offer a high quality solar PV plant at the most competitive cost.

### Project Details

### Explanation of a Turnkey EPC Model




**Key Highlights**

- One time capital investment to enjoy more economical and clean energy for 25 years
- One – stop – solution for client willing to adopt solar PV
- SMR will provide all relevant product guarantees and warranties
- SMR will assist in procuring all relevant permits and approvals

## Site Details

| Site | Shivom Brass |
|---|---|
| Location | Jamnagar |
| Latitude | 22°25'10.24" N |
| Longitude | 70°03'03.71" E |

*Figure 1 – Image of Shivom Brass*

The proposed site for installation of solar PV system has an annual Global Horizontal Irradiation (GHI) of 1,937 kWh/$m^2$ i.e 5.30 kWh/$m^2$/day[1], which is more than adequate for the viability of the project.

| Particulars | System Details | Comments |
|---|---|---|
| Project Size in DC (AC) | 150 kWp (150kWac) | Approx area requirement: Approx 5,000 sq feet |
| Module Technology | **Poly-Crystalline Modules**<br>330/350Wp: 74 nos | REC TwinPeak (Tier 1)<br>Trina (Tier 1) |
| Inverter Technology | **String Inverters**<br>50kW: 3nos | KACO<br>ABB |

[1] Data Source: Meteonorm 7

| | | |
|---|---|---|
| Annual Energy Yield P50 (1st year) | 2,36,700 kWh/year | Substantial Yield: 1,578kWh/kWp |
| Performance Ratio (1st Year) | 79.5% | As per Central Government guidelines (MNRE & SECI), RTPV plants are mandated to have 75% PR |
| Interconnection | 415V/11kV 3 phase, LT side | This will depend on DISCOM approval. |

## Sizing Consideration

- We have estimated the usable roof area for installation of PV modules after excluding 1.5 ft (minimum) from parapet/boundary walls of the superstructure for maintenance requirements and to avoid any detrimental shadow effect throughout the day.
- We have considered an area requirement of 10 $m^2$ per (1) kWp of installed capacity which takes into consideration tilt angle of the modules on the mounting structures, as well as array spacing as well as space required for cabling /maintenance requirements.
- Tilt angle of 20° has been considered for technical analysis.

## Solar PV System under Turnkey EPC Model

The following are the financials under the Turnkey EPC Model for Shivom Brass –

| Particulars | Without Subsidy[2] |
|---|---|
| Total Project Cost[3] | **67,50,000 + 5% GST** |
| Payable by Client | 70,87,500 (incl of all taxes) |
| Current Grid Tariff | INR 8.50/kWh[4] |
| **Project Cost/Wp (Premium Equipment)** | INR 45/Wp |
| Grid Tariff Escalation per annum (average) | 5% |
| Plant Life | 25 years |
| **Debt:Equity** | 50:50 |
| **Interest Rate** | 12% |
| **Tenure** | 12 years |
| **O&M** | 5 year workmanship maintenance<br>1 year cleaning maintenance free |
| Gross Savings over 25 years[5] | INR 820.29 Lakhs |
| Equity IRR | 39.05% |
| **Project IRR** | 27.44% |
| Solar LCOE | INR 3.52/kWh |
| Project Payback | 3.64 years |

[2] **Subsidy is not liable for imported equipment**
[3] **Excluding Taxes – as applicable**
[4] Based on information shared by Admin Staff
[5] Considering 5% escalation per year, although last 6 years CAGR shows approx 7.5% escalation per year

## 8.1 Financial Quotation -02

Topsun®

Proposal No. : TEL/Rooftop/18-1/GNR_019_154 Date: 17/05/2018

**To,**

**Shiv-Om Brass Industries**
**Plot No.3690 / 3691, GIDC Phase-3,**
**Road No.7, Near Pramukhswami Circle,**
**Dared, 361004, Jamnagar,**
**Gujarat 361004**

**Sub. : Basic Offer for 140 KW Solar Grid Connect Power Plant for Captive consumption.**

We, TOPSUN Energy Ltd. (TEL), are reputed manufacturer of Solar PV modules and have vast experience of over 20 years in the field of Solar PV. TEL provides turnkey solutions and single window support for Solar Rooftop Power plants for captive consumption including Design, Engineering, Manufacturing, Procurement, Installation, Testing, Commissioning, O&M, Monitoring and Training.

TEL also provides additional services for liaison with various Government departments such as DISCOMs, CEI, and GEDA for regularization of Solar Plants including necessary permissions, NOCs and REC accreditations as applicable.

TEL has installed more than 15 MW solar power plants with plant capacity from 10KW to 1MW single rooftop project running successfully since last 4 years with generation performance more than 17% PLF.

TEL at its fully automatic production line with annual production capacity of 150 MW manufactures SPV modules up to the range of 320Wp with highest efficiencies. SPV modules are certified by various test laboratories like TUV, Certisolis, SGS, UL, MNRE (SEC), and STQC.

We are herewith submitting our basic Techno-commercial offer for grid connect solar power plant with primary details of scope of works, brief financial analysis of IRR and paybacks for your kind perusal.

Hope this is in line with your requirements, if any queries please revert back to us. Feel free to contact us for any further details and information as required.

We look forward to your acknowledge and favorable consideration for the offer submitted.

Thanking you,
**For Topsun Energy ltd.**

**Mohit Zala**
**Sr.Exe-Marketing**
**project.exe3@ topsunenergy.com**

**Topsun Energy Ltd.**

B-101, GIDC, Electronic Zone, Sector-25,
Gandhinagar - 382 028. Gujarat. INDIA.
Phone / Fax : +91 79 23288804, 23288805
Email : info@topsunenergy.com

Website : www.topsunenergy.com

# *TECHNO-COMMERCIAL PROPOSAL*

*FOR ENGINEERING, PROCUREMENT AND CONSTRUCTION OF 140 KWp (DC) GRID-CONNECTED ROOFTOP SOLAR POWER PLANT*

| | |
|---|---|
| **Client Name** | **Shiv-Om Brass Industries** |
| **Site Address** | **Dared, Jamnagar,** |
| **Latitude - Longitude** | 22.4194° N - 70.0514° E |
| **Utility Name** | PGVCL |
| **Sanction Load/Contract Demand** | 425 KVA |
| **Proposed Solar Capacity** | 140 KW |

| | **Signature** | **Signature** |
|---|---|---|
| | | |
| **Date** | **Prepared by** | **Approved By** |
| 17.05.2018 | Mohit Zala | Mehul Desai |
| | 9978979801 | |
| | marketing.exe2@topsunenergy.com | head.mktg@topsunenergy.com |

**Topsun Energy Ltd.**
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Gandhinagar - 382 028. Gujarat. INDIA.
Phone / Fax : +91 79 23288804, 23288805
Email : info@topsunenergy.com
Website : www.topsunenergy.com

### 3. Bill of Materials:

| Sr.No | Equipment | Technology | Make | Nos. |
|---|---|---|---|---|
| 1 | Solar Module | Poly crystalline | Topsun | 315 Wp -448 Nos |
| 2 | Solar Inverter | String Inverter | INVT/Delta/Kaco | 50 KW& 60 KW &30 KW -1 Nos |
| 3 | Mounting structure for module | Hot dipped G.I/GI | Topsun approved Vendors | As per standard design |
| 4 | Cables | AC & DC | Apar/Siechem/ Havells/polycab | As per standard design |
| 5 | Other items –AJB with String Monitoring , Earthing System , Cable tray & Lighting arrester | Various | Topsun approved Vendors | As per standard design |
| 6 | Monitoring system | Compatible with inverter | - | Customer should provide CAD6 cable Upto inverter Or Sim Card |
| 9 | Solar Meter, Energy Meter | | - | Customer Scope of Work |

# 4. COMMERCIAL OFFER:

| Sr. No. | Description | Amount |
|---|---|---|
| 1 | Supply of **140 KW** Solar Power Plant including Solar Panels, Solar Inverter, Module Mounting Structure and balance of components. | **Rs.63,00,000/-** |
| 2 | **Installation, Testing & Commissioning of Solar Power Plant** | **Inclusive** |
| | **Total Payable to Company** | **Rs.63,00,000/-** |
| | GEDA Registration, Discom TFR, Solar Meter, Bi-directional Meter charges extra at actual. | Customer Scope of Work |

**Our proposal is based on below mentioned Terms & Conditions:**

1) **Taxes & Duties:** **GST 5% are extra.**
2) **Excise Duty:** At present nil. But shall be charged extra if applicable at the time of supply.
3) **Packing Charges:** No additional charges for the standard packing, however customer specific QAP shall be charged extra at actual.
4) **Insurance:** Transit insurance within India is covered in by the seller.
5) **Freight:** **Inclusive .**
6) **Delivery & Handover:** The project will be completed within maximum 15 WEEKS from the date of firm order with advance (after technically & commercially clear orders) and with all the necessary statutory clearances from the government authorities as required. Project shall be deemed to be handed over to the customer, once the system is commissioned by Topsun Energy Limited & generation details are been noted.
7) **Warranty against manufacturing defects:** The entire system carries the warranty of 5 years against manufacturing defects only. PV modules are covered under limited warranty for 5 years for any manufacturing defects and performance warranty is 25 years with degradation ratio of 10% for the first
   10 years 20% for balance of 15 years. Tempering, Misuse, addition, dismantling, reinstallation of any of the system components by unauthorized personnel will render warranty null and void.
8) **Annual Maintenance Contract:** Above offer includes 1 year O & M of the system which includes quarterly visits for routine maintenance and checkup of the overall functioning of the plant. Further AMC shall be extended as per mutually agreed terms and charges.
9) **Payment terms:**
   a. 30% along with acceptance of offer/PO.
   b. 50% before delivery of material at site.
   c. Balance 10% against erection, testing & commissioning of the project.
   d. Balance 10% after bi directional meter.
10) **Validity of offer:** Offer is valid for the period of 10 Days from the date of this proposal.

**Topsun Energy Ltd.** | B-101, GIDC, Electronic Zone, Sector-25, Gandhinagar - 382 028. Gujarat. INDIA.
Phone / Fax : +91 79 23288804, 23288805
Email : info@topsunenergy.com
Website : www.topsunenergy.com

11) **Security & Safety:** On delivery of the material to buyer site in good condition, the buyer shall be responsible for safety & security of the system till handing over the same to our personal for installation.
12) **Installation:** Our offer is for standard installation on the regular building terrace roof or industrial shades with linear slopping roofs or ground mount MMS as per Topsun Standard design. The customer shall allow scrapping of the roof for binding civil foundation, hole fastening the structure on the roof or bolting on the shade roofs. However necessary water proofing treatment shall be taken care during the installation. Any additional ground leveling or earth filling if required as per the site conditions shall be charged extra.
13) **Structural Work: T**he load bearing capacity of the shade should me minimum 75 Kg/sq. mtr (for RCC). Any additional structural work required for improving the basic load bearing capacity shall be charged extra as actual. Also any additional structural work for mounting the modules on the curved shades shall be charged extra as actual.
14) **System Connection:** Our offer is excluding liaison with various government authorities for necessary permissions for power evacuation. However all the applications shall be done in customers name and necessary charges, fees and other expenses shall be paid by the customer. This includes technical feasibility report fees and meter/net metering charges ON TIME BY THE CUSTOMER. Any modifications, if required as per the authorities for giving permissions in existing main LT/HT panels will be in the scope of customer.
15) **Limitation of Liability:** With respect to any claims arising out of performance or Non-performance of obligations under this proposal or resultant purchase orders /contracts whether arising in contracts, warranty, tort, strict liability or otherwise, Topsun's Limited liability shall not exceed 20% of the purchase order / contract value or payments received from the customer whichever is lower.
16) **FORCE MAJEURE:** Topsun shall not be liable for loss, damage, detention or delay to force majeure condition such as Strike, war, insurgencies or riots, floods, natural calamities and other causes of beyond our control and shall not be responsible for delay in supply due to above force majeure conditions.
17) **JURISDICTION:** All contracts effected between Topsun and Buyer shall be subject to court Jurisdiction of Gandhinagar, Gujarat.

**Topsun Energy Ltd.**
B-101, GIDC, Electronic Zone, Sector-25,
Gandhinagar - 382 028. Gujarat. INDIA.
Phone / Fax : +91 79 23288804, 23288805
Email : info@topsunenergy.com
Website : www.topsunenergy.com

## 6. TOPSUN SCOPE OF WORK:

- Site visit and plant capacity feasibility study
- Engineering & Designing of SPV power plant
- Project planning & management
- Supply of PV modules, Inverters & system components
- Installation & Commissioning of the system
- Performance testing of the complete System
- Facilitating remote monitoring of the system
- Operational & Maintenance Training
- Guidance & Liaison with various authorities like Discom, CEI, State Nodal Agency for necessary permissions (All applications charges & fees shall be paid by the customer)
- System monitoring, analysis, technical reports & recommendation.
- Spares support during entire project life time

**Customer Scope of Work:**

- Water and Power Requirements at site during Construction
- Ground leveling if any.
- Water pipeline on the site with water supply for cleaning the modules
- Availability of cleaning equipment for the modules
- Availability of breaker at the bus bar in the LT panel for SPV plant connectivity
- SIM card (with 3G/ 4G) connectivity for data monitoring
- Ensuring complete reversal of the excess material post turnkey execution of the plant

We hope above offer is in line with your requirement. Please feel free to contact us for further queries, if any.

We assure to deliver our expertise and best support for committed benefits to you.

Thanking you,

**For Topsun Energy ltd.**

**Mohit Zala**
**Sr.Exe-Marketing**
**project.exe3@ topsunenergy.com**

# 8.3 Detailed Project Report

SOLARGIS pvPlanner

## YIELD ASSESSMENT OF THE PHOTOVOLTAIC POWER PLANT

Report number: PV-63062-1808-6
Issued: 13 August 2018 11:43 (UTC)

### 1. Site info

| | |
|---|---|
| Site name: | Jamnagar, India |
| Coordinates: | **22° 25' 6.0" N, 70° 03' 48.72" E** |
| Elevation a.s.l.: | 27 m |
| Slope inclination: | 0° |
| Slope azimuth: | 47° northeast |

Annual global in-plane irradiation: **2199 kWh/m$^2$**
Annual air temperature at 2 m: **27.2 °C**

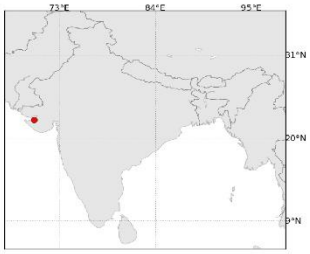
### 2. PV system info

| | |
|---|---|
| Installed power: | **150.0 kWp** |
| Type of modules: | crystalline silicon **(c-Si)** |
| Mounting system: | **fixed mounting, free standing** |
| Azimuth/inclination: | **180° (south) / 30°** |
| Inverter Euro eff.: | 97.5% |
| DC / AC losses: | 5.5% / 1.5% |
| Availability: | 99.0% |

Annual average electricity production: **250.0 MWh**
Average performance ratio: **75.7%**

Location on the map: http://solargis.info/imaps/#tl=Google:satellite&loc=22.4183333163,70.0635319948&z=14

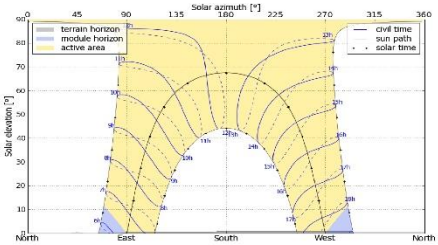
### 3. Geographic position

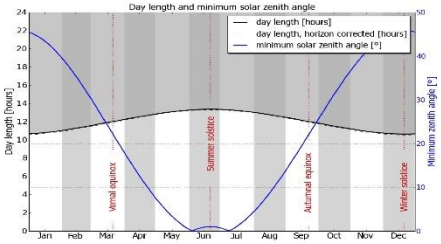




Google Maps © 2018 Google

### 4. Terrain horizon and day length




Left: Path of the Sun over a year. Terrain horizon (drawn by grey filling) and module horizon (blue filling) may have shading effect on solar radiation. Black dots show True Solar Time. Blue labels show Local Clock Time.

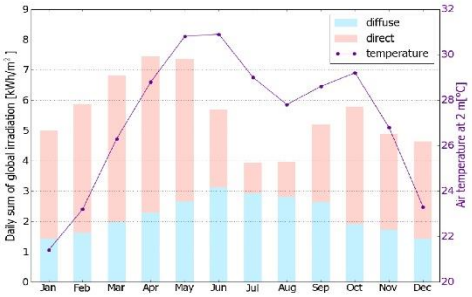
Right: Change of the day length and solar zenith angle during a year. The local day length (time when the Sun is above the horizon) is shorter compared to the astronomical day length, if obstructed by higher terrain horizon.

SOLARGIS pvPlanner

Site: Jamnagar, India, lat/lon: 22.4183°/70.0635°
PV system: 150.0 kWp, crystalline silicon, fixed free, azim. 180° (south), inclination 30°

## 5. Global horizontal irradiation and air temperature - climate reference

| Month | $Gh_m$ | $Gh_d$ | $Dh_d$ | $T_{24}$ |
|---|---|---|---|---|
| **Jan** | 154 | 4.98 | 1.44 | 21.4 |
| **Feb** | 164 | 5.86 | 1.61 | 23.2 |
| **Mar** | 211 | 6.80 | 1.99 | 26.3 |
| **Apr** | 223 | 7.44 | 2.29 | 28.8 |
| **May** | 229 | 7.37 | 2.65 | 30.8 |
| **Jun** | 171 | 5.69 | 3.12 | 30.9 |
| **Jul** | 122 | 3.93 | 2.91 | 29.0 |
| **Aug** | 123 | 3.96 | 2.82 | 27.8 |
| **Sep** | 156 | 5.18 | 2.63 | 28.6 |
| **Oct** | 179 | 5.79 | 1.90 | 29.2 |
| **Nov** | 147 | 4.89 | 1.71 | 26.8 |
| **Dec** | 144 | 4.63 | 1.44 | 23.3 |
| **Year** | **2021** | **5.54** | **2.21** | **27.2** |



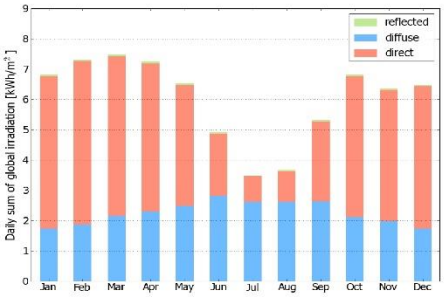

Long-term monthly averages:

$Gh_m$ Monthly sum of global irradiation [kWh/m$^2$]
$Gh_d$ Daily sum of global irradiation [kWh/m$^2$]
$Dh_d$ Daily sum of diffuse irradiation [kWh/m$^2$]
$T_{24}$ Daily (diurnal) air temperature [°C]

## 6. Global in-plane irradiation

Fixed surface, azimuth 180° (south), inclination. 30°

| Month | $Gi_m$ | $Gi_d$ | $Di_d$ | $Ri_d$ | $Sh_{loss}$ |
|---|---|---|---|---|---|
| **Jan** | 211 | 6.81 | 1.74 | 0.04 | 0.1 |
| **Feb** | 205 | 7.31 | 1.87 | 0.05 | 0.1 |
| **Mar** | 232 | 7.48 | 2.15 | 0.06 | 0.1 |
| **Apr** | 218 | 7.25 | 2.30 | 0.06 | 0.1 |
| **May** | 202 | 6.53 | 2.48 | 0.06 | 0.2 |
| **Jun** | 147 | 4.92 | 2.81 | 0.05 | 0.3 |
| **Jul** | 108 | 3.49 | 2.62 | 0.03 | 0.5 |
| **Aug** | 114 | 3.67 | 2.61 | 0.03 | 0.4 |
| **Sep** | 159 | 5.31 | 2.63 | 0.04 | 0.2 |
| **Oct** | 211 | 6.82 | 2.12 | 0.05 | 0.1 |
| **Nov** | 191 | 6.36 | 1.98 | 0.04 | 0.1 |
| **Dec** | 201 | 6.47 | 1.74 | 0.04 | 0.1 |
| **Year** | **2199** | **6.03** | **2.26** | **0.05** | **0.2** |




Long-term monthly averages:

$Gi_m$ Monthly sum of global irradiation [kWh/m$^2$]
$Gi_d$ Daily sum of global irradiation [kWh/m$^2$]
$Di_d$ Daily sum of diffuse irradiation [kWh/m$^2$]
$Ri_d$ Daily sum of reflected irradiation [kWh/m$^2$]

$Sh_{loss}$ Losses of global irradiation by terrain shading [%]

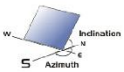
Average yearly sum of global irradiation for different types of surface:

| | kWh/m$^2$ | relative to optimally inclined |
|---|---|---|
| Horizontal | 2021 | 91.7% |
| Optimally inclined (26°) | 2204 | 100.0% |
| 2-axis tracking | 2760 | 125.2% |
| **Your option** | **2199** | **99.8%** |

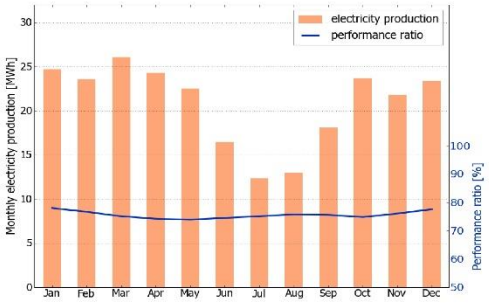
SOLARGIS pvPlanner

Site: Jamnagar, India, lat/lon: 22.4183°/70.0635°
PV system: 150.0 kWp, crystalline silicon, fixed free, azim. 180° (south), inclination 30°

### 7. PV electricity production in the start-up




| Month | $Es_m$ | $Es_d$ | $Et_m$ | $E_{share}$ | PR |
|---|---|---|---|---|---|
| **Jan** | 165 | 5.32 | 24.7 | 9.9 | 78.0 |
| **Feb** | 157 | 5.61 | 23.6 | 9.4 | 76.7 |
| **Mar** | 174 | 5.62 | 26.1 | 10.5 | 75.1 |
| **Apr** | 162 | 5.39 | 24.3 | 9.7 | 74.2 |
| **May** | 150 | 4.84 | 22.5 | 9.0 | 73.9 |
| **Jun** | 110 | 3.67 | 16.5 | 6.6 | 74.5 |
| **Jul** | 82 | 2.64 | 12.3 | 4.9 | 75.1 |
| **Aug** | 87 | 2.80 | 13.0 | 5.2 | 75.8 |
| **Sep** | 121 | 4.03 | 18.1 | 7.2 | 75.6 |
| **Oct** | 158 | 5.11 | 23.7 | 9.5 | 74.8 |
| **Nov** | 145 | 4.85 | 21.8 | 8.7 | 76.1 |
| **Dec** | 156 | 5.03 | 23.4 | 9.3 | 77.6 |
| **Year** | **1667** | **4.57** | **250.0** | **100.0** | **75.7** |




Long-term monthly averages:

$Es_m$ Monthly sum of specific electricity prod. [kWh/kWp]
$Es_d$ Daily sum of specific electricity prod. [kWh/kWp]
$Et_m$ Monthly sum of total electricity prod. [MWh]
$E_{share}$ Percentual share of monthly electricity prod. [%]
PR Performance ratio [%]

### 8. System losses and performance ratio

| Energy conversion step | Energy output [kWh/kWp] | Energy loss [kWh/kWp] | Energy loss [%] | Performance ratio [partial %] | Performance ratio [cumul. %] |
|---|---|---|---|---|---|
| 1. Global in-plane irradiation (input) | 2203 | - | - | 100.0 | 100.0 |
| 2. Global irradiation reduced by terrain shading | 2199 | -4 | -0.2 | 99.8 | 99.8 |
| 3. Global irradiation reduced by reflectivity | 2142 | -57 | -2.6 | 97.4 | 97.2 |
| 4. Conversion to DC in the modules | 1855 | -287 | -13.4 | 86.6 | 84.2 |
| 5. Other DC losses | 1753 | -102 | -5.5 | 94.5 | 79.6 |
| 6. Inverters (DC/AC conversion) | 1709 | -44 | -2.5 | 97.5 | 77.6 |
| 7. Transformer and AC cabling losses | 1684 | -26 | -1.5 | 98.5 | 76.4 |
| 8. Reduced availability | 1667 | -17 | -1.0 | 99.0 | 75.7 |
| **Total system performance** | **1667** | **-536** | **-24.4** | **-** | **75.7** |

Energy conversion steps and losses:

1. Initial production at Standard Test Conditions (STC) is assumed,
2. Reduction of global in-plane irradiation due to obstruction of terrain horizon and PV modules,
3. Proportion of global irradiation that is reflected by surface of PV modules (typically glass),
4. Losses in PV modules due to conversion of solar radiation to DC electricity; deviation of module efficiency from STC,
5. DC losses: this step assumes integrated effect of mismatch between PV modules, heat losses in interconnections and cables, losses due to dirt, snow, icing and soiling, and self-shading of PV modules,
6. This step considers euro efficiency to approximate average losses in the inverter,
7. Losses in AC section and transformer (where applicable) depend on the system architecture,
8. Availability parameter assumes losses due to downtime caused by maintenance or failures.

Losses at steps 2 to 4 are numerically modeled by pvPlanner. Losses at steps 5 to 8 are to be assessed by a user. The simulation models have inherent uncertainties that are not discussed in this report. Read more about simulation methods and related uncertainties to evaluate possible risks at http://solargis.com/products/pvplanner/.