July 2018

DETAILED PROJECT REPORT
ON
225 kWp SOLAR ROOF-TOP PV SYSTEM

M/s Rajhans Impex Pvt ltd – Jamnagar Brass Cluster

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

Bureau of Energy Efficiency
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Prepared by

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List of Abbreviations

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

Confederation of Indian Industry (CII) would like to express its sincere thanks to United Nations Industrial Development Organization (UNIDO), Global Environment Facility (GEF) and Bureau of Energy Efficiency (BEE) for the role played by them in guiding and steering this prominent assignment - "Capacity Building of Local Service Providers in Jamnagar Brass Cluster". 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.

CII is grateful to Mr. Milind Deore, Director, Bureau of Energy Efficiency, Mr. Sanjay Shrestha, Industrial Development Officer, Industrial Energy Efficiency Unit, Energy and Climate Branch, UNIDO , Mr. Suresh Kennit, National Project Coordinator, UNIDO, Mr. Niranjan Rao Deevela, National Technology Coordinator, UNIDO and Mr. Samir Patel, UNIDO ,Cluster Leader, Jamnagar-Brass Cluster for their support and guidance during the project.

Last but not least we are thankful to Rajhans Impex Pvt Ltd, especially Mr. Dhaval J Shah, Director 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	Rajdhans Impex Pvt Ltd
Name(s) of the Plant Head	Mr.Dhaval J shah
Contact person	Mr.Dhaval J Shah
Constitution	Private Company
MSME Classification	Small
Address:	Plot No. 8, GIDC, Phase II, 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 225 kWp Grid connected rooftop solar PV based power generation project at Rajhans Impex private

limited. The expected electricity generation is 3,37,500 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 225 kWp Grid connected Solar Power Plant**	3,37,500	29.0	23	118.20	62	277

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	118
ii	**Means of Finance**	Self / Bank Finance	Self
Iii	**IRR**	%	37.95
Iv	**NPV at 70 % Debt**	Rs. Lakh	190.6

2. INTRODUCTION ABOUT RAJHANS IMPEX PVT. LTD.

2.1 Unit Profile

Rajhans Impex is an autonomous family run company and was established in the year 2004. Plant is involved in manufacturing of Extruded Brass Rods, Brass Hollow Rods, Brass Wires & Coils, Brass Flat Bars, and Brass Section & Profiles and Centrifugal castings. Since its inception Rajhans Impex has sought to raise the bar in brass extrusion industry with modern manufacturing processes and technology the company provides quality products & services. It has carved a niche in the industry by rapid innovation and prompt response to the market trends. As a result, today Rajhans Impex is a preferred name not only amongst domestic brass semis consumers but on the list of overseas consumers as well.

Rajhans Impex has focused on meeting the highest quality expectations as well as short delivery times of products along with the optimization of resources and energy consumption.

Table 4: Unit Profile

Particulars	Details
Name of Plant	Rajhans Impex Private Limited
Name(s) of the Plant Head	Mr.Dhaval J.shah
Contact person	Mr.Dhaval J shah
Contact Mail Id	info@rajhansimpex.com
Contact No	+919825119571
Constitution	Private Company
MSME Classification	SME
No. of years in operation	14 Years
No of operating hrs./day	24
No of operating days/year	306 Days
Address:	Plot No.8, GIDC,Phase II,Dared,Jamnagar-361004
Industry-sector	Manufacturing
Type of Products manufactured	Extruded Brass Rods, Brass Hollow Rods, Brass Wires & Coils, Brass Flat Bars, Brass Sections

2.2 Production Details

The various products manufactured in Rajdhans Impex are Extruded Brass Rods, Brass Hollow Rods, Brass Wires and Coils, Brass Flat Bars, Brass Section & profiles and centrifugal castings. Last

year plant had an average production of 284 Tonne per Annum[1]. The graph below shows the Brass produced during last one year

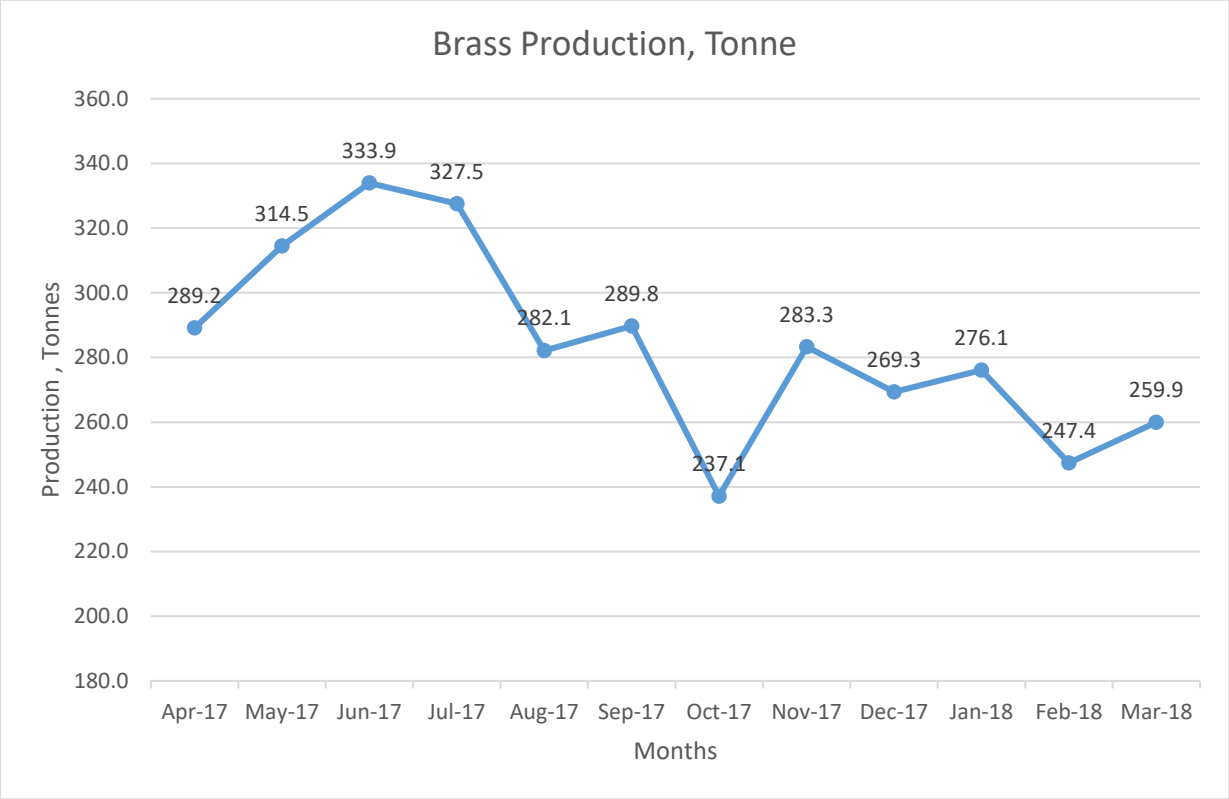


Figure 1: Production Details

[1] Final product output

2.3 Typical Brass Production Flow Diagram

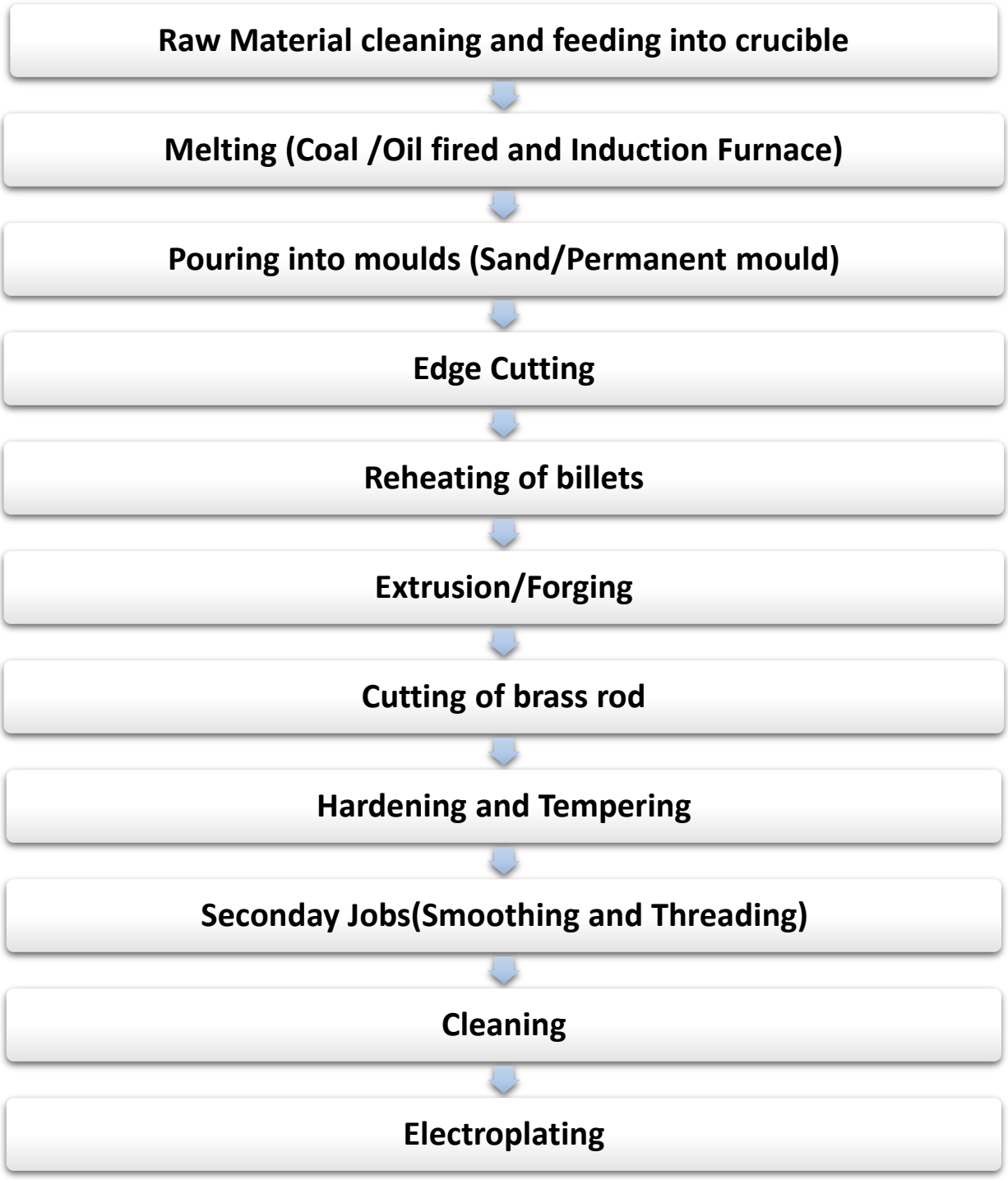


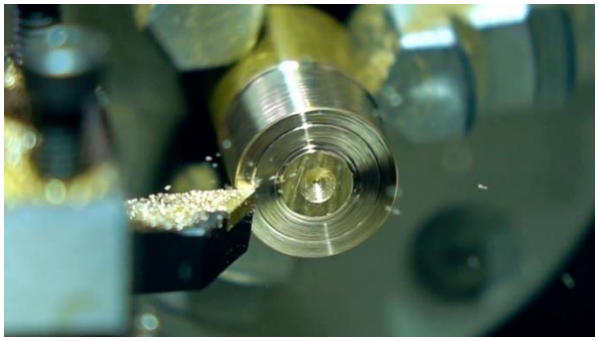
Figure 2: Typical Process Flow Chart for Brass Products in Jamnagar

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

Both electricity and thermal energy are used for carrying out various activities in plant like melting, machining, operation of utilities etc. The following fuels are used in the plant:

Table 5: Type of fuel used

Type of fuel/Energy used	Unit	Tariff	GCV
Electricity	Rs./kWh	**6.8**	-
FO	Rs/kg	**32**	9800

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 6: Energy Consumption and Finished product Details

Month	Electricity Consumption (kWh)	Total Electricity Bill , Rs.(Lakhs)	Total Coal Consumption, (Tonnes)	Total Fuel Bill, Rs.(Lakhs)	Final Product, (Tonnes)[2]
Apr-17	140456	10.71	13.49	4.32	289
May-17	130240	10.08	13.71	4.39	315
Jun-17	135320	10.44	14.09	4.51	334
Jul-17	155824	11.95	15.30	4.90	328
Aug-17	137216	10.32	13.64	4.36	282
Sep-17	142160	10.80	14.33	4.59	290

[2] Average annual final product output of the plant was approximately 15.24% less than the melting production due to processing losses of brass alloy at different stages such as casting and machining

Oct-17	137328	10.55	12.31	3.94	237
Nov-17	112184	8.78	14.06	4.50	283
Dec-17	131464	10.21	13.30	4.26	269
Jan-18	129128	10.00	13.34	4.27	276
Feb-18	131352	10.02	12.20	3.90	247
Mar-18	110584	8.63	12.74	4.08	260

The major form of energy used in the plant is electricity which is imported from PGVCL grid supply at 415kV. Apart from electricity, furnace oil is the major source of thermal energy in the plant. Annual electricity accounts for 70.20% of the total fuel cost and rest 29.80% thermal cost in the plant. Based on the data collected from the plant, the graph below shows the variation of energy/fuel cost over the last 6 months. Average electricity cost was Rs. 10.2 Lakhs/month whereas the average thermal energy cost was Rs 4.30 Lakhs/month.

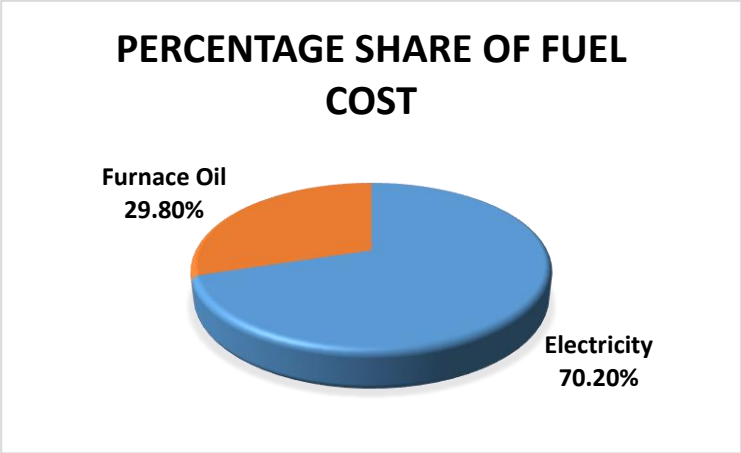


Figure 3: Percentage share of fuel cost

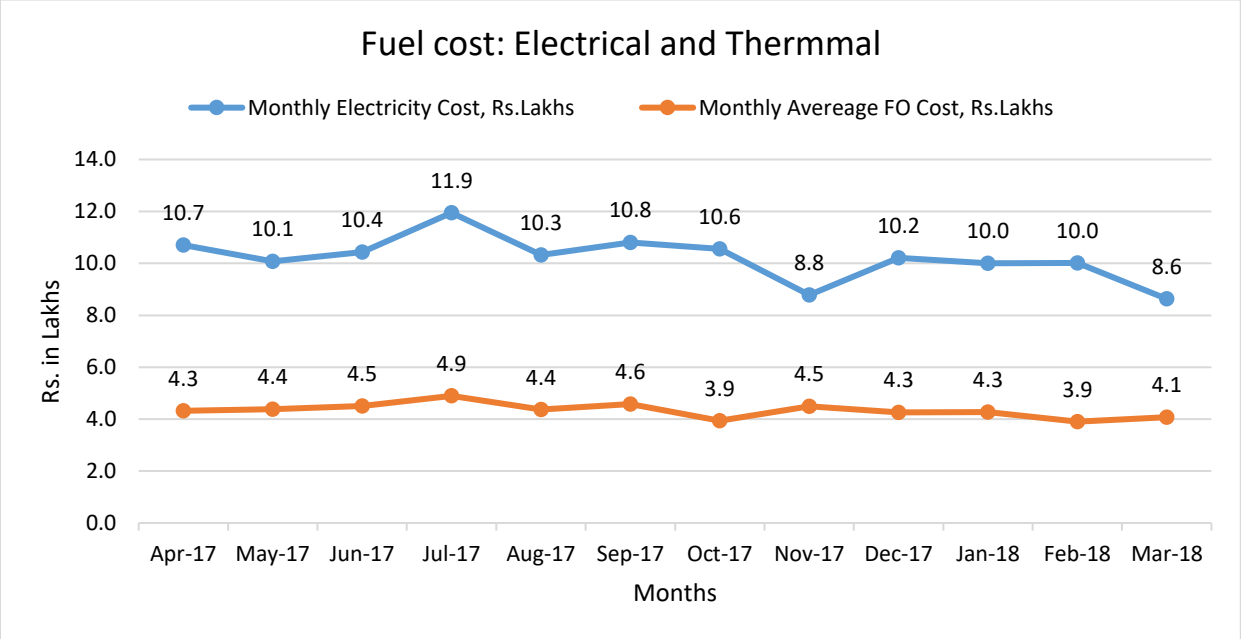


Figure 4: Energy Cost- Fuel & Electricity

3. PROPOSED EE MEASURE – INSTALL 225 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 induction melting furnace, extrusion press, CNC machines and other electrical utilities whereas furnace oil is only used in reheating furnaces.

Figure 5: Plant Rooftop area

Observation

During the course of study, it was observed that plant has a total 2,695m^2 roof top area available which can be utilized to install solar PV panel to harness solar energy and generate electricity.

Table 7: Basic Site details

Parameters	
Total Rooftop available ,m^2	2,695
Location	Latitude: - 22.41 degrees Longitude: - 70.06 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[3]:

Table 8: 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 9: 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

[3] Detailed report is attached in the annexure

3.2 Recommendation

As per the site feasibility study it was found that plant can install a 225 kWp Solar PV power plant which will generate an average of around 3.37Lakhs 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 10: 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 11: 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 12: Supplier Details

Equipment Detail	225 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

3.5 Savings

The expected monetary savings is around 18.7%[4] in overall energy bill of the plant which is equivalent to saving 3, 37,500 kWh/Year. The annual monetary saving for this project is Rs. 23.0 Lakhs with an investment of Rs. 118.2 Lakhs and payback for the project is 62 months.

Detailed savings calculations are given in below table:

Table 13: Savings Calculation

Parameters	Install of Solar Systems 225kWp Systems
Proposed Roof top Solar installation, kWp	225
Average Annual units generation per kW of Solar PV, kWh/Annum	1500
Total Energy Generation Per Annum, kWh/Year	3,37,500
Cost Savings in Energy Bill per Annum, Rs. Lakhs/Year	23.0
Investment including GST @ 5 %, INR	118.2
Payback period, Months	62
Annual **CO_2 Reduction, Tons**	277
Annual Energy Saving, TOE	29

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

4. FINANCIAL ANALYSIS

4.1 Project Cost

Table 14: Project Cost

Parameter	Amount in Rs Lakhs
Install 225kWp Solar PV Power systems	112.5
GST @5%	5.91
Total Project Cost	118.2

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% [5]
- 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 15: 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	118.2							
Energy Savings		23.0	23.4	23.9	24.4	24.8	**25.3**	**25.8**
O&M Cost		-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4
Depreciation		47.3	28.4	17.03	10.22	6.13	3.68	2.21
Net Cash Flow	-118.2	67.9	49.4	38.5	32.2	28.6	26.7	25.7

[5] 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
26.4	**26.9**	**27.4**	**28.0**	**28.5**	**29.1**	**29.7**	**30.3**	**30.9**
-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4
1.32	0.79	0.48	0.29	0.17	0.10	0.06	0.04	0.02
25.3	25.3	25.5	25.9	26.3	26.8	27.4	28.0	28.5

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
31.5	32.1	32.8	33.4	34.1	34.8	35.5	36.2	36.9
-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4
0.013	0.008	0.005	0.003	0.000	0.000	0.000	0.000	0.000
29.2	29.8	30.4	31.1	31.7	32.4	33.1	33.8	34.5

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

Table 16: 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 17: 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)	-118.2	61.5	40.6	28.7	21.7	17.5	14.7	12.9
NPV at CS 2 (50:50)	-118.2	60.8	39.6	27.7	20.7	16.5	13.7	11.8
NPV at CS 3 (100% Equity)	-118.2	59.0	37.4	25.3	18.4	14.2	11.5	9.7

Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
11.5	10.4	9.5	8.7	8.1	7.4	6.9	6.4	5.9
10.4	9.4	8.4	7.7	7.0	6.4	5.8	5.3	4.9
8.3	7.2	6.3	5.6	4.9	4.4	3.9	3.4	3.1

Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	NPV
5.4	5.0	4.7	4.3	4.0	3.7	3.4	3.2	2.9	190.6
4.4	4.1	3.7	3.4	3.1	2.8	2.6	2.4	2.2	166.5
2.7	2.4	2.1	1.9	1.7	1.5	1.3	1.2	1.0	120.2

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 18: Sensitivity analysis: based on energy savings

Sensitivity analysis: based on energy savings			
	at 100% Savings	at 75% Savings	at 50% Savings
IRR	38.0%	31.0%	23.2%
NPV at CS 1 (D70:E30)	190.61	131.65	72.69
NPV at CS2 (D50:E50)	166.48	92.70	46.26
NPV at CS3 (D0:E100)	120.21	78.27	36.34

Table 19: 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	38.0%	35%	32%
NPV at CS 1 (D70:E30)	190.61	167.02	143.44
NPV at CS2 (D50:E50)	166.48	145.26	124.04
NPV at CS3 (D0:E100)	120.21	103.43	86.66

Table 20: 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)	216.90	205.88	200.63	190.61	185.83	181.19

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 21: 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 • The program aims to bridge the gap by providing financial support to the companies.	• Rate of interest is according to credit rating • 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) • Min loan amount: Rs 25 Lakhs • Term Loan: 75% of the project cost as debt	Mr.Chandra Kant SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008. Contact no : 0288 275 3954 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. • 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 • Min loan amount: Rs 10 Lakhs • Max loan amount: Rs 150 Lakhs • 90% of the project cost as debt	Mr.Chandra Kant SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008. Contact no : 0288 275 3954 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. • The scheme address barrier related to the financing aspects for energy efficiency	• Term Loan: 12%-15% • Min loan amount: Rs 10 Lakhs • Max loan amount: Rs 15 Cr • Total Project funding of – USD 43 million • Risk Sharing facility component of USD 37 million to be managed by SIDBI • Technical assistance component of USD 6 billion to be managed by SIDBI and EESL	Mr Chandra Kant SIDBI,NO.1-2-3/4,Shreeji Patel Colony,Jamnagar-361008. Contact no : 0288 275 3954 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 • 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 Saru Section Road,Swastik Society,Park colony,Jamnagar,Gujarat,361008 Contact no : 0288 266 0779 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). • Max. loan: INR 10 million (EUR 130,000) • Security: collateral free up to INR 5 million (EUR 65,000), beyond INR 5 million collateral required as determined by the bank • Margin: 10% of project costs	Canara Bank, 1st Floor,New Super Market,Bedi Road,Jamnagar,Gujarat,361001 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. • 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 Junagadh Jamnagar Highway, Maheswari Nagar, Opp Anupam Cinema Hall, Kadiawad, Jamnagar, Gujarat 361001. Ph no : 0288 2554026 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% • Max. repayment time: 9 years • Minimum promoter's contribution: 30% • The applicant's minimum capacity needs to be 1MW	IREDA Camp Office 603, Atlanta Towers Near Panchvati Circle, Gulabi Tekra Ahmedabad Ph No : 9811889805 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 energy efficiency measure of installing energy efficient furnace will result in reduction of 29.TOE per annum. The proposed EE measure will result in decrease of CO_2 emissions by 277 TCO_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 225Kwp 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 3, 37,500 kWh with 277 TCO_2 reduction.

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

Table 22: 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 225 kWp Grid connected Solar Power Plant**	3,37,500	29.0	23	118.20	62	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 225 kWp solar PV system.

Table 23: Financial Analysis

Sl. No.	Particulars	Unit	Value
i	**Total Investment (Incl. of Tax)**	Rs. Lakh	118
ii	**Means of Finance**	Self / Bank Finance	Self
Iii	**IRR**	%	37.95

Iv	**NPV at 70 % Debt**	Rs. Lakh	190.6

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

Date: - 13th April 2018

To,

Shri Dhavalbhai Shah
Rajhans Impex
Jamnagar,
India

K.A. Shri Dhavalbhai Shah

Dear Mr. Shah,

Subject: - Budgetary Offer for installation of Solar PV rooftop system at your factory

With respect to above-mentioned subject matter we are pleased to offer our 225 kWp solar PV system as follows: -

Sr. No	Description	Price
1	225 kWp Solar Rooftop PV System	INR 112.5 Lac

Scope of Supply: -

Position # 1

- **225 kWp Monocrystalline Solar Modules from Waaree**
- **Solar Inverter from ABB**
- Mounting structure
- DC Combiner box
- DC Cables
- AC Distribution box
- AC Cables
- Remote Monitoring System
- Weather Monitoring System
- Design, installation and commissioning of complete system
- **Comprehensive O & M Service for 5 years (12 visit / year)**
- All Government Liaison and permit related work

Warranty: -

- Solar Modules: - Warranty for 25 years as provide by module manufacturer
- Inverter: - Warranty for 5 years as provided by manufacturer
- Balance of System: - Warranty for 5 year

Delivery Terms: -

- Ex-Works at your site in Jamnagar.

Delivery Time: -

- 60 days from acceptance of order

Payment Terms: -

- 30 % Advance along with PO
- 20 % on delivery of Solar Module
- 20% on delivery of Solar Inverter
- 20 % on installation
- 10 % in 15 days from date of commissioning.

Exclusion: -

- Government Taxes as applicable. Current GST rate is 5%
- Government fees as applicable. GEDA registration Fee is INR 11,800 (10,000 + 18% GST).
- PGVCL Fees will be after survey by PGVCL at actual.

Your Scope: -

- Customer should provide safe access to roof for installation and commissioning.
- Roof should have sufficient anchor points for hooking safety belt of personnel
- RO water for O&M.

Validity: -

- 30 days. After 30 days offer shall be subject to over confirmation.

We hope you will find our offer is in-line with your expectation.

Thanking you.

Best Regards

For, RENESYS POWER SYSTEMS PVT. LTD.
DIRECTOR/AUTHORISED SIGNATORY

Jay P. Mehta
Director

8.2 Design Details of Modules

WAAREE
One with the Sun

WSM - 350

350 Wp SPV MODULE

Electrical Characteristics*	
Nominal Maximum Power (P_m) in Watts	350
Power tolerance	0 / +5 W
Open Circuit Voltage (V_{oc}) in Volts	46.40
Short Circuit Current (I_{sc}) in Amps	9.80
Voltage at Maximum Power (V_{mp}) in Volts	37.50
Current at Maximum Power (I_{mp}) in Amps	9.35
Maximum System Voltage in Volts	1000
Module Efficiency (%)	18.07
Maximum Series Fuse Rating (A)	15

*Under Standard Test Conditions (STC) of 1000 W/m² irradiance, AM1.5 spectrum and 25°C cell temperature.

Mechanical Characteristics	
Length x Width x Thickness (L x W x T) - mm	1960 x 990 x 40
Mounting Holes Pitch (Y) – mm	1060
Mounting Holes Pitch (X) –mm	942
Weight (kg)	22.50
Solar Cells per Module (Units) / Arrangement	72 / (12*6)
Solar Cell Type	Mono Crystalline Silicon
Front Cover (Material / Thickness)	Tempered & Low Iron Glass / 3.2mm / 4mm
Encapsulate	Ethylene Vinyl Acetate
Frame Material	Anodized Aluminum Alloy
Junction Box (Material / Type)	Weatherproof PPO / IP67 enclosure with bypass diodes
Connector (Protection degree / Type)	IP67 rated / MC4 compatible
Cable cross-section	4 mm²

- Positive tolerance Modules
- Excellent generation performance with reasonable cost
- Undergoes rigorous quality control and in-house testing
- 100% Electroluminescence test to ensure error free Modules
- Heavy duty anodized Aluminum frames with pre-drilled holes for quick installation
- Salt mist corrosion resistance and Ammonia corrosion resistance
- Long lasting and high efficiency modules
- Withstands hail, snow and ice storms

Warranty

- 10 years Limited Product Warranty
- 25 years Limited Power output Warranty:
  - Minimum 90% at the end of 10 years
  - Minimum 80% at the end of 25 years

LINEAR DEGRADATION OF WARRANTY

Certifications

IEC 61215 | IEC 61730-1 & 2 | IEC 61701 | IEC 62716 | ISO 9001:2008 | ISO 14001:2004 | OHSAS 18001:2007

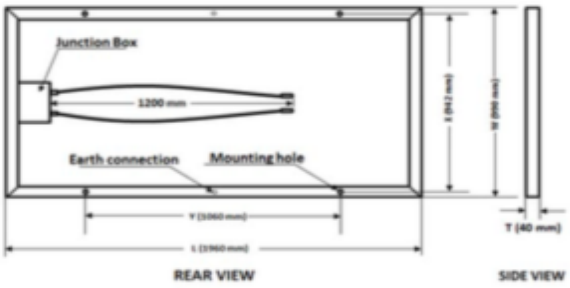
www.waaree.com

WAAREE
One with the Sun

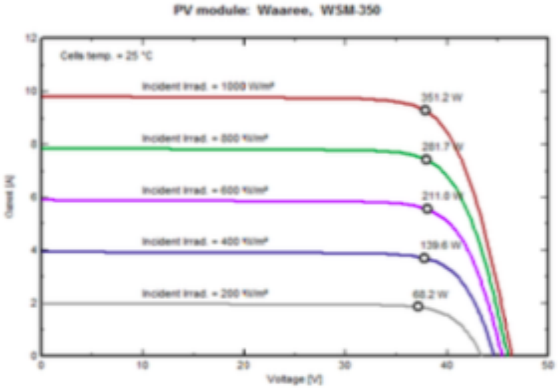
WSM - 350

Design specifications

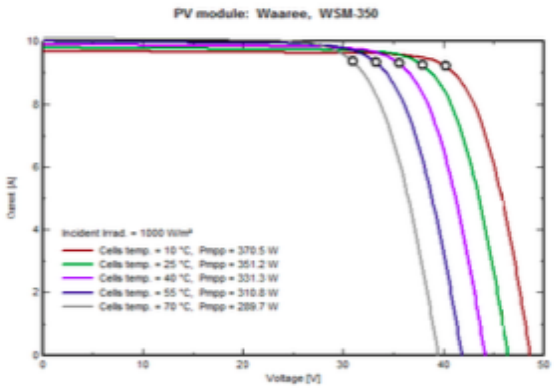
Thermal Characteristics	
Temperature coefficient of Current (I_{sc}), α (%/°C)	0.0118
Temperature coefficient of Voltage (V_{oc}), β (%/°C)	-0.2627
Temperature coefficient of Power (P_m), γ (%/°C)	-0.3677
NOCT (°C)	46 ± 2
Operating temperature range (°C)	-40 to 85



I-V Curve Variation with Irradiance



I-V Curve Variation with Temperature



About Waaree: WAAREE is one of India's leading multi-technology companies, headquartered at Mumbai. Founded in 1989, WAAREE successfully developed cutting edge technologies to become one of the most preferred brands in the field of Instrumentation. The company has transformed itself from a single business into a multi-technology organization, diversifying into exciting areas of Solar Energy, Industrial Valves, Petroleum Equipment's and Process control Instrumentation. WAAREE has a presence in over 68 countries, serviced through its 20 sales offices in India & Dubai, and more than 105 global channel partners. WAAREE has a huge list of satisfied customers over the years. WAAREE is committed to supply the best quality products & technology to its customers. WAAREE's products are manufactured at its state-of-the-art manufacturing facilities and is committed to excel in providing the society with world class quality products.

Contact: WAAREE ENERGIES LIMITED
602, Western Edge-I, Off. Western Express Highway,
Borivali (E), Mumbai 400066, Maharashtra
Ph.: +91-22-66444444, Fax: +91-22-66444400, Email: *waaree@waaree.com*

- The specifications in this datasheet are subject to change without prior notice.

www.waaree.com

8.3 Detailed Project Report

DETAILED PROJECT REPORT

225 kWp Solar Roof-Top PV System

PLANT LOCATION: - RAJHANS IMPEX
JAMNAGAR, GUJARAT

CHAPTER 1: GLOSSARY

Photovoltaic The physical effect of direct Conversion of light (sunlight) to electrical energy

PV Cell The smallest photovoltaic (PV) element that generates electricity from light.

PV Module A collection of interconnected PV cells, encapsulated between protective materials such as glass and back sheet (Poly Vinyl Fluoride) or glass and glass, and mounted in an aluminium frame. This is a hermetically sealed unit.

String Multiple PV modules connected in series electrically.

Array Several strings of modules with the same orientation and tilt angle, located together.

Inverter An electronic device that converts direct current electricity into alternating current electricity suitable for feeding directly to the electrical grid or to normal AC loads.

Insolation It is a measure of solar radiation energy received on a given surface area in a given time. It is commonly expressed as average irradiance in watts per square meter (W/m^2) or kilowatt-hours per square meter per day ($kW \cdot h/(m^2 \cdot day)$) (or hours/day)

Solar Irradiation The total electromagnetic radiation emitted by the Sun.

STC "Standard Test Conditions" - Incident Solar Irradiance of 1000 Watts/m2, at a spectral density of AM1.5 and cell temperature of 25˚C

Mounting Structure Device used to hold modules in place, at desired angle & direction

Power Evacuation Power generated from Solar PV Power Plant is transmitted to a point (sub station) where it is distributed for consumer use.

Sub-station The place where the generated power from solar is synchronized with utility grid and metered.

Control Room A room housing control equipment.

Cable A conductor with one or more strands bound together, used for transmitting electrical energy.

Efficiency The ratio of the output to the input of any system.

Combiner boxes Inputs of several strings are connected to this box and taken as single output

Current A flow of electricity through a conductor measured in Amps.

Voltage The rate at which energy is drawn from a source that produces a flow of electricity in a circuit; expressed in volts It is the difference of electrical potential between two points of an electrical or electronic circuit, expressed in volts. It is the measurement of the potential for an electric field to cause an electric current in an electrical conductor.

CHAPTER 2: EXECUTIVE SUMMARY

India is both densely populated and has high solar insolation, providing an ideal combination for **Solar Power in India.**

India lies in sunny regions of the world. Most parts of India receive 4.7 kWh of solar radiation per square meter per day with 300-325 sunny days in a year. India has abundant solar resources, as it receives about 3000 hours of sunshine every year, equivalent to over 5,000 trillion kWh. India can easily utilize the solar energy.

Government of India has separately set up a Ministry called MNRE - Ministry of New Renewable Energy for the promotion of Power Generation through Renewable Energy. The Ministry has been facilitating the implementation of broad spectrum program's including harnessing renewable power/ Energy (make use of one), renewable energy to rural areas for lighting, cooking and motive power, use of renewable energy in urban, industrial and commercial applications and development of alternate fuels and applications.

MNRE has announced a host of fiscal incentives such as concessional custom duties, exemption, accelerated depreciation, etc. for Solar PV based Power Plants. At the State level, promotion of Solar Power generation is being encouraged by local policies that cover buy back, wheeling and banking of the generated electricity by State Electricity Boards, besides other incentives.

This Technical Proposal highlights the implementation of 225 kWp Grid connected rooftop solar PV based power generation project at Rajhans Impex

The proposed Power Plant will have Solar PV modules, String Inverters as the major components & other accessories for the Power production.

All the necessary auxiliary facilities of the Power Plant like Plant Monitoring system, Safety equipment, Instrumentation, Control system etc., will be provided for the Power Plant. The water requirement for the module cleaning & for other requirements can be met by installing RO water plant at site.

The Plant and equipment facilities will be designed to comply with all applicable stipulations guidelines of statutory authorities.

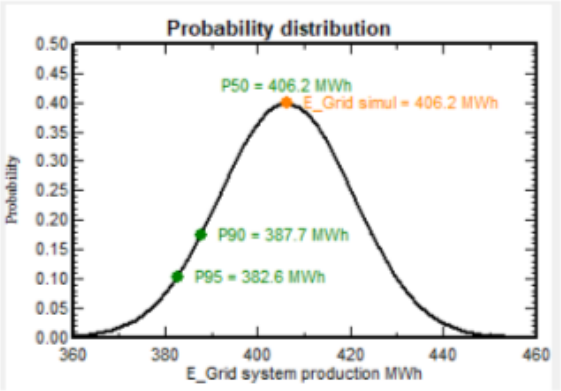
The electricity generated out of power plant of 225 kWp Power Plant is estimated to be 337500 kWh per annum.

This report highlights the details of the proposed power generation scheme, site facilities, features of the main plant & electrical systems and evacuation of generated power. It also highlights the complete schedule for the project implementation.

CHAPTER 3: PROJECT SUMMARY

Name of Company	Rajhans Impex
Proposed Project Location	Jamnagar, Gujarat
District	Jamnagar
State	Gujarat
Proposed Power Plant Capacity	225 kWp
Technology	Mono Si based Solar System
Location	Latitude: - 22.418317 degrees, Longitude: - 70.063224 degrees
Altitude	26 m above mean sea level
Average Annual Solar Isolation	5.60 kWh/m^2/day
Type of Module Proposed	Mono Crystalline Based Module
Type of Inverter	String Inverter
Project Annual Energy Production @ 100% Grid availability	**337500 kWh/ year**

Details of the Annual power generation (in kWh/ year) v/s. Probability of occurance for the specific site locations and environmental conditions are as follows:



Based on the specific site location and site environmental conditions:

- **There is 50% chance** that Solar power generation will exceed **406200 kWh/ year (units/ year) for the system proposed**
- **There is 90% chance** that Solar power generation will be **387700 kWh/year (units/year) for the system proposed.**
- **There is more than 95% chance** that Solar power generation will be **minimum 382600 kWh/year (units/ year) for the system proposed.**

CHAPTER 4: LOCATION AND INFRASTRUCTURE FACILITIES

4.1 Site Information: -

Rajhans Impex has manufacturing facility located in Jamnagar, Gujarat. The building has roof space of around 2695 sq. m of roof space. This is sufficient to install 225 kWp system.

4.2 Topographical & Geological Conditions

The site is located at Latitude: - 22.418317 Longitude: - 70.063224. The average altitude of the site is 26 m above mean sea level.

4.3 Electric Power

The factory has connection from PGVCL at 66 kV voltage level. The sanction load is 650 kVA. Hence, as per Gujarat solar policy maximum 292.5 kWp solar system can be installed at site. The system will work on net metering basis.

CHAPTER 6: POWER PLANT SCHEME

6.1 Power Plant Sizing

The Power Plant is sized on the following major criteria:

- Average Solar Radiation in the area (average insolation available)
- Annual Consumption requirement.

The Design is based to offer the best solution in terms of technology, innovative components, reliable results and performance during the lifetime of the power plant.

Few details from our design process and ideology are presented as follows:

Optimal Plant design:

The total area required for installing the 225 KWp solar Power Plant is approximately 24,000 sq ft.

For a complete reliable system and to ensure high energy yield from the plant, innovative components with latest technology are selected. The inverter that is selected is of very high efficiency over a wide range of load. The inverter operates at more than 97.0% efficiency.

The system will be equipped with monitoring system which helps to: -

- Monitors the performance of the entire power plant (string wise monitoring, junction boxes, inverters, etc)
- Evaluates (strings, inverter, nominal/actual value), quantity of DC Power & AC Power produced.
- Measures instantaneous irradiation level and temperature at site. It also measures the module back surface temperature. (optional)
- Alerts in case of error (discrepancy in normal operation of components, like module string/ diodes/ inverter/ junction box / loose contacts/ etc,) to facilitate recognition and correction of the fault with minimum downtime.
- Visualizes nominal status of the connected components via Control Center PC Software (diagnosis on site or remote)
- Logs system data and error messages for further processing or storing
- Stores and visualizes energy yield data (for life of the plant) in the Portal from where the data can be accessed remotely.

We will adopt the best engineering practice for complete cable routing in the power plant by using minimal cable length while connecting in series string, using optimal size cables to ensure the entire plant cable losses are minimum.

The junction boxes proposed are completely pre-wired to ensure ease of installation, maintenance and eliminates any installation hassles. These junction boxes not only combine the DC power from strings but also monitor each string performance and feed the same data to the central monitoring system.

6.2 Major Components of the Power Plant

The following are the major components that would be discussed in the following section.

A. Solar Modules
a. Crystalline Modules – Mono
B. Inverter
a. String Inverter
C. Module Mounting Structure
D. Balance of System
a. Junction boxes
b. Cables
c. Monitoring System
d. Remote Monitoring System
e. Earthing & Lightning Protection

6.3 Basic System Description

Solar Photovoltaic power generator consists of solar modules in series and parallel connections, these convert solar radiations into DC electrical power at the pre-determined range of Voltages whenever sufficient solar radiation is available. The individual crystalline solar cells are connected in a module (in series connection), which are hermetically sealed to survive in rugged weather conditions and ensures optimum performance during its ling life.

To achieve a higher system voltage, modules are installed in a row arrangement, called a string. A higher system voltage has the advantage of lesser installation work, higher efficiency of the entire plant and usage of smaller cross section cables. Calculated no. of strings is connected in parallel by cables in the Main Combiner Box (MCB). This Main Combiner Box output is fed to the central inverters/Power Control Unit (PCU) to invert solar generated DC power in to conventional 3 phase AC power. AC power from inverters will be fed to LV panel.

6.4 Operation Philosophy

Solar panels mounted on the roof generate DC electric power. The DC electric power generated by the solar panels cannot be fed directly in to the utility grid. The inverters invert the direct current output from the solar array into grid compliant AC voltage, feeds it in to the utility grid system with proper protection and control. The system automatically starts up in the morning and begins to export power to the grid, provided there is sufficient solar energy and the grid voltage, frequency is within the range. If the grid goes out of range the inverter will be immediately disconnected and reconnected automatically at a pre-determined time after the grid comes back within range.

The system will work on net metering basis. i.e. system will power the local load at the factory. In case if the solar power production is more than the load requirement, power will be feed back to the grid. In case of solar power is less then load requirement, balance power will be taken from the grid.
The billing settlement will happen as the per prevailing billing cycle. i.e. customer must pay for the net power drawn from the grid on monthly basis.

CHAPTER 7: POWER PLANT COMPONENT DESCRIPTION

This chapter discusses in detail the technical aspects of the components that shall be used in the Power Plant. As indicated the following are the major components of the Power Plant.

Sr. No	Item	Description
1	Solar Module	340 Wp Module
2	Module Mounting Structure	Fixed Tilt Structure
3	Inverter	Latest Transformer less inverter
4	Combiner box	DC combiner box to combine modules
5	Cables	Special AC and DC Cables
6	Accessories	Special installation accessories
7	Lightening and Earthing Protection kit	For proper protection of system
8	Remote Monitoring System	To monitor the complete system

7.1 Solar PV Panel

Solar cells produce Direct Current (DC) electricity from light, which can be used to power equipment Cells require protection from the environment and are usually packaged tightly behind a glass sheet. When more power is required than a single cell can deliver, cells are electrically connected together to form photovoltaic modules, or solar panels. A photovoltaic module is a packaged, interconnected assembly of photovoltaic cells, which converts sunlight into electrical power. The cells are hermitically sealed between glass and back cover (Tedlar) to protect them from harsh environments.

Broad Technical Specification

Description	Value
Capacity of PV module	340 Wp
Output Power	340 Watt
Voltage at Pmax	36.70 V
Current at Pmax	9.13 A
Open Circuit Voltage	45.80 V
Short Circuit Current	9.50 A
Module Efficiency	17.53%
Maximum System Voltage	1000 VDC

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Prahladnagar Road, Ahmedabad 380 015, Gujarat, India.
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7.2 Module Mounting Structure

The module mounting structure is designed for holding suitable number of modules in series. The frames and leg assemble of the array structures is made of Aluminium of suitable sections of Angle, Channel, Tubes or any other sections conforming to IS:2062 for steel structure to meet the design criteria. All nuts & bolts considered for fastening modules with this structure are of very good quality of Stainless Steel. The array structure is designed in such a way that it will occupy minimum space without sacrificing the output from SPV panels at the same time it will withstand severe wind speed.

Broad Technical Specification

Description	Value
Material	GI
Overall Dimension	As per Design
Tilt Angle	22°
Hardware	Stainless Steel

7.3 Combiner Boxes

In the combiner boxes, individual module strings are bundled and safely routed to the inverter. It is combination of an exact, well-organized string monitoring system and a safety concept adapted to the PV technology. The combiner boxes will have suitable cable entry points fitted with cable glands of appropriate sizes for both incoming and outgoing cables. They monitor the output of solar PV arrays. If difference between string outputs is too large, the operator is informed though monitoring system. Active disconnection allows string voltages to be measured separately. These junction boxes are enclosed in an IP 65 rated housing, making it ideal for long term use in PV systems. In addition, the direct connection between the strings and the spring clamp connectors ensures a durable and safe installation. The combiner box will all include fuses and disconnect switches as well as appropriate circuit-breakers.

Broad Technical Specification

Description	Value
Material	Thermoplastic / Metal
Protection Class	IP 65
Hardware	Stainless Steel
Cable Gland	Thermoplastic

7.4 Inverter

Inverter is the main power conversion component in the system. It takes the DC power coming from the various Solar PV module strings as Input and converts this power into Output AC power. The inverter used in such systems is grid-connected/ grid-synchronized inverter. The grid-connected inverter monitors the grid voltage and grid power frequency and synchronizes its output to match the grid voltage and frequency. The inverter supplied shall be from leading inverter suppliers like ABB.

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7.5 Cables

The size of the cables between array interconnections, array to junction boxes, junction boxes to PCU etc shall be so selected to keep the voltage drop and losses to the minimum. The bright annealed 99.97% pure bare copper conductors that offer low conductor resistance, they result in lower heating thereby increase in life and savings in power consumption. These wires are insulated with a special grade PVC compound formulated. The skin coloration offers high insulation resistance and long life.
Cables are flexible & of annealed electrolytic grade copper conductor and shall confirm to IS 1554/694-1990 and are extremely robust and resist high mechanical load and abrasion. Cable is of high temperature resistance and excellent weatherproofing characteristics which provides a long service life to the cables used in large scale projects. The connectors/lugs of copper material with high current capacity and easy mode of assembly are proposed.

Broad Technical Specification

Description	Value
Type	PV Insulated, Sheath and UV resistant
Material	Copper / Aluminum
Voltage	Max 1000 VDC
Temperature	10 to 70

7.6 Protection System

Earthing: The array structure of the PV modules will be grounded properly using adequate number of earthing kits. All metal casing / shielding of the plant shall be thoroughly grounded to ensure safety of the power plant.

Lightning Protection: The SPV Power Plant shall be provided with lightning & over voltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. Metal oxide varistors shall be provided inside the Array Junction Boxes. In addition, suitable SPDs also shall be provided in the Inverter to protect the inverter from over voltage.

7.7 Remote Monitoring System

Remote monitoring system will be provided along with the Solar PV roof-top installation. The basic functions of the remote monitoring system will be:

- Monitoring the Power generated from the installed Solar PV system- Daily, weekly, monthly and annually.
- Historical trending of the Power generated from the installed Solar PV system.
- Monitoring of all Strings/ Arrays, Inverters and all balance of plant components to provide health status, generation status etc.
- Provide prediction of generated power based on 2 to 3 day weather forecast.

CHAPTER 8: DESIGN OF THE POWER PLANT

The Power Plant components are selected & discussed on the previous chapter. Based on the component selection the Power Plant Design is discussed in this chapter.

8.1 Design Assumption for Crystalline Modules

Description	Value
Location	Jamnagar, Gujarat
Latitude	22.418317 degrees
Longitude	70.063224 degrees
Elevation	26 m above mean sea level
Annual Solar Irradiance	5.60 kWh/m2
Module Facing	True South
Module Tilt Angle	22 degree
Type of System	Grid Connected
Shading	No Shading
NOCT	45 C
Module efficiency loss	As per technical data sheet
Inverter loss	As per technical data sheet
Soiling loss	3 %

CHAPTER 9: PROJECT IMPLEMENTATION AND SCHEDULE

The project is planned to be implemented at the earliest. Following are key milestone and steps of the project. They are not mutually exclusive and some overlap is expected.

- Preparation of Detailed Project report
- Getting various Government Clearances
- Engineering and procurement of product
- Installation and Erection
- Final Commissioning

Detailed time frame along with deliverables and responsibility will be finalized at latter date.

CHAPTER 10: BILL OF MATERIAL

Bill of Material for Power Plant

Sr. No.	Description	Qty.
1	340 Wp Solar Module	662 nos.
2	Inverter	5 nos.
3	Combiner Box	As per design
4	Module Mounting structure	As per design
5	DC Cable	As per design
6	AC Cable	As per design
7	Earthing Kit	1 kit
8	Lightening Protection System	1 kit
9	Weather Station	1 no
10	Remote Monitoring System	1 no.

CHAPTER 11: BASIC SITE SIMULATION RESULTS

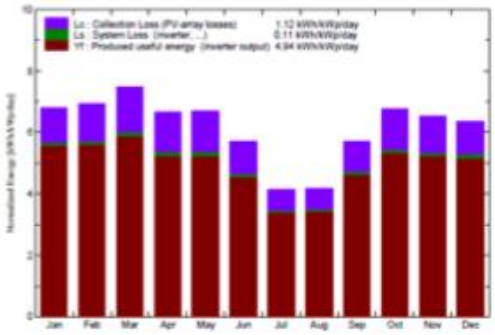
Grid-Connected System: Main results

Project :	**Grid-Connected Project at Rajhans Impex**
Simulation variant :	**New simulation variant**

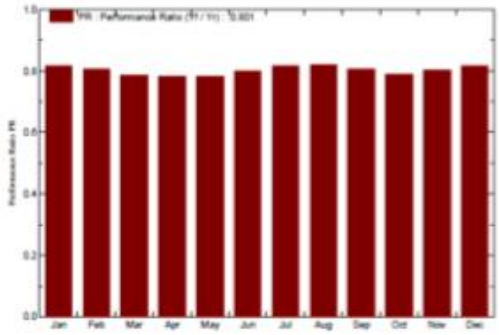
Main system parameters	System type	**Grid-Connected**			
PV Field Orientation	tilt	22°	azimuth	0°	
PV modules	Model	WSM-340	Pnom	340 Wp	
PV Array	Nb. of modules	663	Pnom total	**225 kWp**	
Inverter	Model	TRIO-50_0-TL-OUTD-400	Pnom	50.0 kW ac	
Inverter pack	Nb. of units	4.0	Pnom total	**200 kW ac**	
User's needs	Unlimited load (grid)				

Main simulation results				
System Production	**Produced Energy**	**406.2 MWh/year**	Specific prod.	1802 kWh/kWp/year
	Performance Ratio PR	80.1 %		

Normalized productions (per installed kWp): Nominal power 225 kWp



Performance Ratio PR



New simulation variant
Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	EffArrR %	EffSysR %
January	159.1	20.61	211.1	200.4	39.76	38.94	14.64	14.34
February	159.9	23.21	194.4	184.6	36.15	35.36	14.45	14.14
March	210.3	27.86	232.3	220.6	42.05	41.06	14.07	13.74
April	199.6	30.48	200.5	188.7	36.23	35.41	14.04	13.73
May	221.5	32.03	207.8	195.2	37.51	36.66	14.03	13.71
June	167.3	30.90	171.7	160.7	31.61	30.91	14.31	14.00
July	137.4	29.03	128.6	120.1	24.22	23.71	14.63	14.33
August	133.3	27.67	129.3	120.9	24.44	23.93	14.69	14.39
September	163.3	26.12	171.7	161.6	31.95	31.27	14.46	14.15
October	178.5	29.55	209.6	198.2	38.14	37.30	14.15	13.83
November	151.9	26.00	195.8	185.6	36.17	35.37	14.36	14.04
December	144.3	22.27	196.7	186.3	37.00	36.23	14.62	14.32
Year	2046.4	27.33	2249.5	2123.0	415.21	406.16	14.35	14.03

Legends:

GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

Grid-Connected System: Loss diagram

Project : **Grid-Connected Project at Rajhans Impex**
Simulation variant : **New simulation variant**

Main system parameters	System type	**Grid-Connected**			
PV Field Orientation	tilt	22°	azimuth	0°	
PV modules	Model	WSM-340	Pnom	340 Wp	
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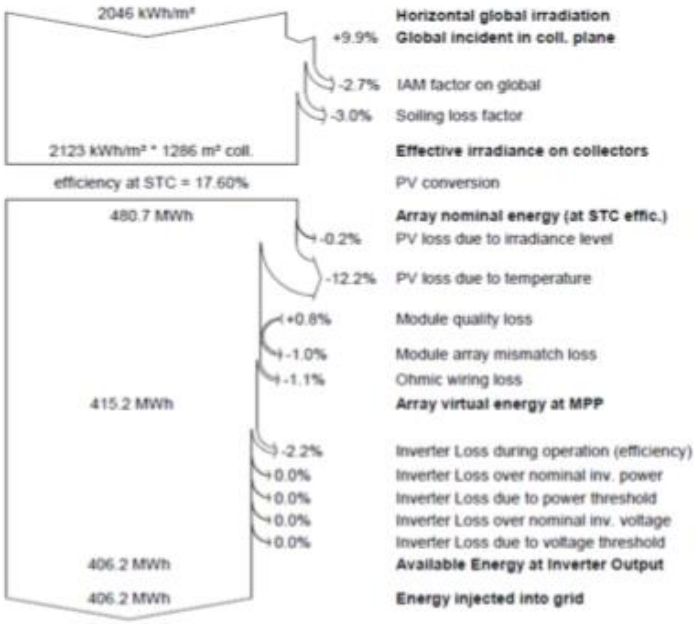
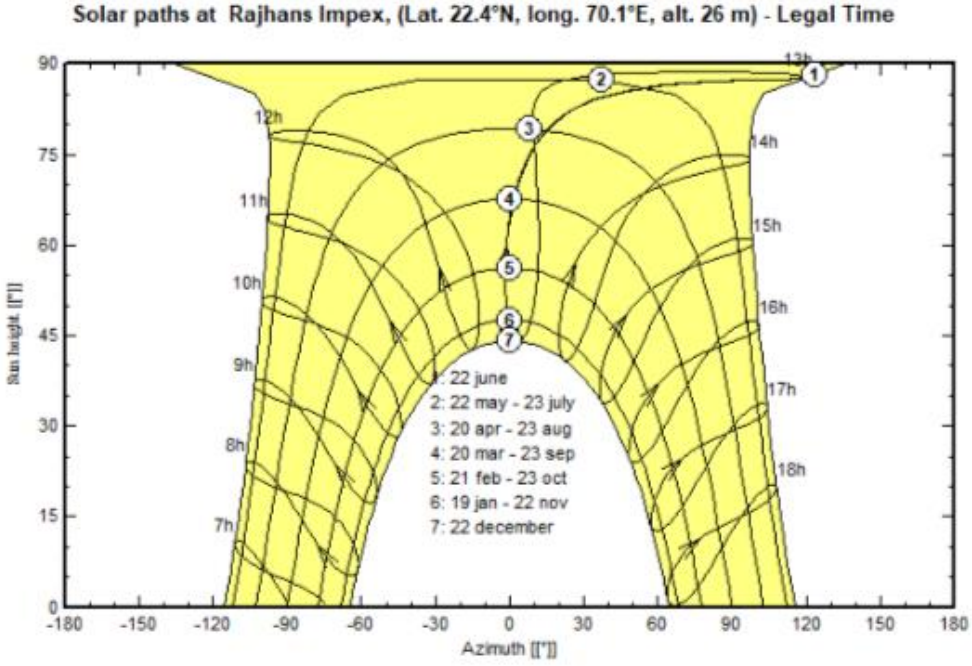
User's needs	Unlimited load (grid)				

Loss diagram over the whole year




Solar paths at Rajhans Impex, (Lat. 22.4°N, long. 70.1°E, alt. 26 m) - Legal Time
Sun height [[°]]
Azimuth [[°]]
1: 22 june
2: 22 may - 23 july
3: 20 apr - 23 aug
4: 20 mar - 23 sep
5: 21 feb - 23 oct
6: 19 jan - 22 nov
7: 22 december
12h
11h
10h
9h
8h
7h
13h
14h
15h
16h
17h
18h