7VEN.FINANCE

Giving back power to the people for a more sustainable future

DETAILED PROJECT REPORT

100 MW Solar Ground Mounted System

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01. Glossary

Grid	An arrangement of high/low tension cables used to distribute electrical power across a specific area.
Cable	A cable consisting of one or more strands twisted together, employed for the transmission of electrical energy.
Control Room	Space designated for the housing of control equipment.
Inverter	An electronic apparatus that transforms direct current electricity into alternating current electricity, suitable for direct connection to the electrical grid or conventional AC-powered devices.
Current	The movement of electric current through a conductor, quantified in Amperes (Amps)
Lightning Arrestor	Device used to protect all the components from lightning strikes.
Junction Box	Inputs of several strings are connected to this box and taken as single output.
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
PV Cell	The smallest photovoltaic (PV) element that generates electricity from light.
Insolation	It quantifies the amount of solar energy that reaches a specific surface area over a defined period. This measurement is often presented as the average irradiance, indicated in watts per square meter (W/m^2), or as kilowatt-hours per square meter per day ($kWh/m^2 \cdot day$) or hours per day (h/day).
PV Module	An assembly of interconnected photovoltaic (PV) cells, enclosed within protective materials like glass and back sheet (Poly Vinyl Fluoride), or glass and glass, and housed within an aluminum frame. This unit is sealed airtight to ensure its integrity.
SCADA	Instrumentation & Control system for the solar power plant used to detect malfunctions and give information at a given time interval about the availability and performance of the plant.
Sub-station	The place where the generated power from solar is synchronized with utility grid and metered.
Transformer	An electrical device by which alternating current of one voltage is changed to another voltage.

Voltage	The pace at which energy is extracted from a source generating an electric current within a circuit; denoted in volts. It signifies the variance in electrical potential between two designated points within an electrical or electronic circuit, quantified in volts. This measurement reflects the potential of an electric field to initiate an electric current within a conductor.
Array	Several strings of modules with the same orientation and tilt angle, located together.
Photovoltaic	The physical effect of direct conversion of light (sunlight) to electrical energy.

2. Project Details

01 Location details

The proposed solar capacity is 120 MWp (DC) and 99 MW ~ 100 MW (AC). Grid-connected solar power project is located at Bardaï, Chad. For preparing the Detailed Project Report (DPR), the power evacuation options have been analyzed on the basis of meteorological data of the site.

02 Objectives of the report

This project report covers technology selection, site infrastructure, details about solar PV technologies, solar radiation assessment and generation assessment.

The objective of this report are as following:

- Prepare overall development plans and projections for the 100 MW Solar PV Project.
- Provide details about solar pv and inverter technologies
- Solar pv power generation simulation parameters and results

03 Solar radiation source

For annual solar PV power generation Meteonorm 8.0 satellite data is considered as Metro database. As per the analysis, the proposed location receives the annual global horizontal radiation of 1648 kWh/m2 (reference: PVsyst report)

04 Solar radiation source

Sketchup and PVsyst software is used for defining optimum tilt angle of the solar PV system for best solar generation during the year depending on the shadow and generation. Optimum slope angle as per PVsyst database is 18°. Actual tilt angle will be calculated during detail designing and selection of solar mounting structure. Azimuth is considered as 0° as solar modules will be facing true south direction.

Figure 1
Shadow Area for Solar Array
Date: 21 December
Time: 09:00 AM

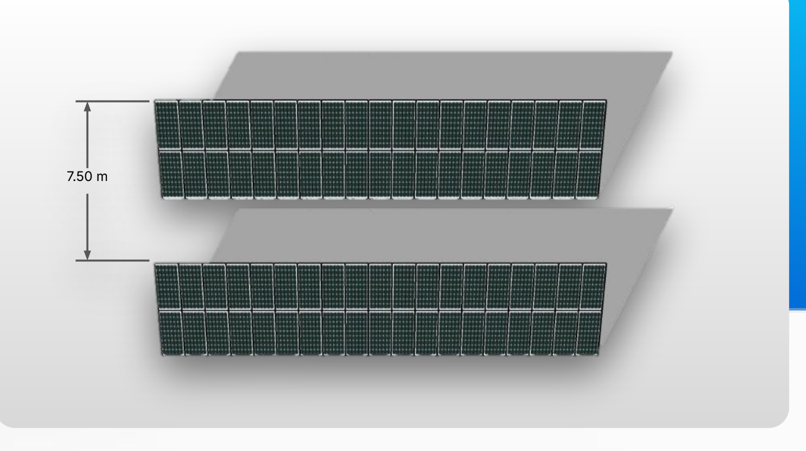
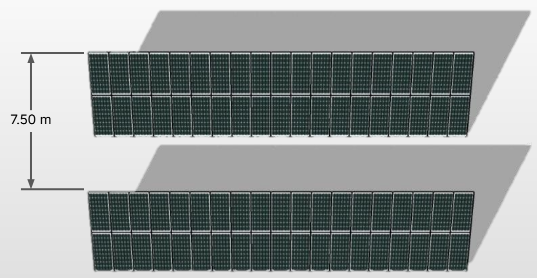


Figure 2
Shadow Area for Solar Array
Date: 21 December
Time: 04:00 PM



05 Photovoltaic module technology

Mono crystalline technology has been used for higher efficiency and evaluation of project location.

06 Solar PV module and Inverter

The table below provides summary of the system.

PARTICULARS	
Solar Module	Trina Solar (TSM-DE19-540W)
Inverter	Sungrow
Solar PV capacity	120 MWp (DC), 100 2,22,224 MWac(AC)
Number of modules	2,22,224 nos.
Number of inverters	30 nos.
DC:AC ratio	1.2
Annual generation (PVsyst)	1648 kWh/kWp/Year
Performance ratio (PVsyst)	75.77 %
Global horizontal radiation	2083.1 kWh/m^2/year

Table 1
Summary of the project

2.7 Considered solar PV module

Monocrystalline modules can be considered for the site. A photovoltaic module is a packaged interconnected assembly of photovoltaic cells, which converts sunlight into energy. For this project, Trina Monocrystalline PV technology solar module of 540 Wp has been considered. Datasheet of (Trina Solar) module has been attached to this report for reviewing specification and features.

Figure 3 - Trina Solar module - 540 Wp (TSM-DE19-540W)

2.8 Considered solar inverter

Sungrow inverter is considered for this project which is in compliance with both IEC and UL safety, EMC and grid support regulations. It is compatible for low/high voltage ride through(L/HVRT) and capable for active & reactive power control & power ramp rate control It is designed for Maximum DC/AC ratio up to (1.5). Inverter is compact design and light weight for easy installation

Figure 4
Sungrow inverter 3.3 MVA

SG3300/4400UD

Outdoor Inverter for 1500 Vdc System

NEW

HIGH YIELD

- Advanced three-level technology, max. inverter efficiency 99 %
- Effective cooling, full power operation at 45 ℃

SMART O&M

- Integrated zone monitoring function for online analysis and trouble shooting
- Modular design, easy for maintenance

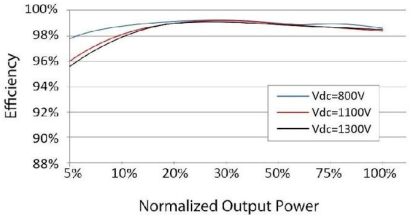
SAVED INVESTMENT

- Low transportation and installation cost due to outdoor design
- DC 1500 V system, low system cost
- Q at night function optional

GRID SUPPORT

- Compliance with standards: IEC 61727, IEC 62116
- Low / High voltage ride through (L/HVRT)
- Active & reactive power control and power ramp rate control

EFFICIENCY CURVE



- 28 -

Type designation	SG3300UD	SG4400UD
Input (DC)		
Max. PV input voltage	1500 V	
Min. PV input voltage / Startup input voltage	895 V / 905 V	
MPP voltage range	895 – 1500 V	
No. of independent MPP inputs	3	4
No. of DC inputs	15 (optional: 18/21 inputs negative grounding)	20 (optional: 24/28 inputs negative grounding)
Max. PV input current	3 * 1435 A	4 * 1435 A
Max. DC short-circuit current	3 * 3528 A	4 * 3528 A
PV array configuration	Negative grounding or floating	
Output (AC)		
AC output power	3300 kVA @ 45 ℃ 3399 kVA @ 40 ℃ 3795 kVA @ 20 ℃	4400 kVA @ 45 ℃ 4532 kVA @ 40 ℃ 5060 kVA @ 20 ℃
Max. AC output current	3 * 1160 A	4 * 1160 A
Nominal AC voltage	630 V	
AC voltage range	536 – 693 V	
Nominal grid frequency / Grid frequency range	50 Hz / 45 – 55 Hz, 60 Hz / 55 – 65 Hz	
Harmonic (THD)	< 3 % (at nominal power)	
Power factor at nominal power / Adjustable power factor	> 0.99 / 0.8 leading – 0.8 lagging	
Feed-in phases / AC connection	3 / 3	
Efficiency		
Max. efficiency	99.0 %	
European efficiency	98.7 %	
Protection & Function		
DC input protection	Load break switch + fuse	
AC output protection	Circuit breaker	
Overvoltage protection	DC Type II / AC Type II	
Grid monitoring / Ground fault monitoring	Yes / Yes	
Insulation monitoring	Yes	
Surge protection	Yes	
Q at night function	Optional	
General Data		
Dimensions (W*H*D)	2130*2235*1690 mm	2845*2235*1690 mm
Weight	≤2.5 T	≤3.3 T
Topology	Transformerless	
Degree of protection	IP65	
Night power consumption	< 200 W	
Operating ambient temperature range	-35 to 60 ℃ (> 45 ℃ derating)	
Allowable relative humidity range	0 – 100 %	
Cooling method	Temperature controlled forced air cooling	
Max. operating altitude	4000 m (> 3000 m derating)	
Display	LED indicators, WLAN+WebHMI	
Communication	Standard: RS485, Ethernet; Optional: optical fiber; MPLC	
Compliance	CE, IEC 62109, IEC 61727, IEC 62116, IEC 62109, IEC 61727, IEC 62116, IEC 60068, IEC 61683, VDE-AR-N 4110:2018, VDE-AR-N 4120:2018, EN 50549-1/2, UNE 206007-1:2013, P.O.12.3, UTE C15-712-1:2013	
Grid support	Q at night function (optional), L/HVRT, active & reactive power control and power ramp rate control, Q-U control, P-f control	

Figure 4 (Part 2)
Sungrow inverter 3.3 MVA

3. Project Location And Site Description

3.1 Project location

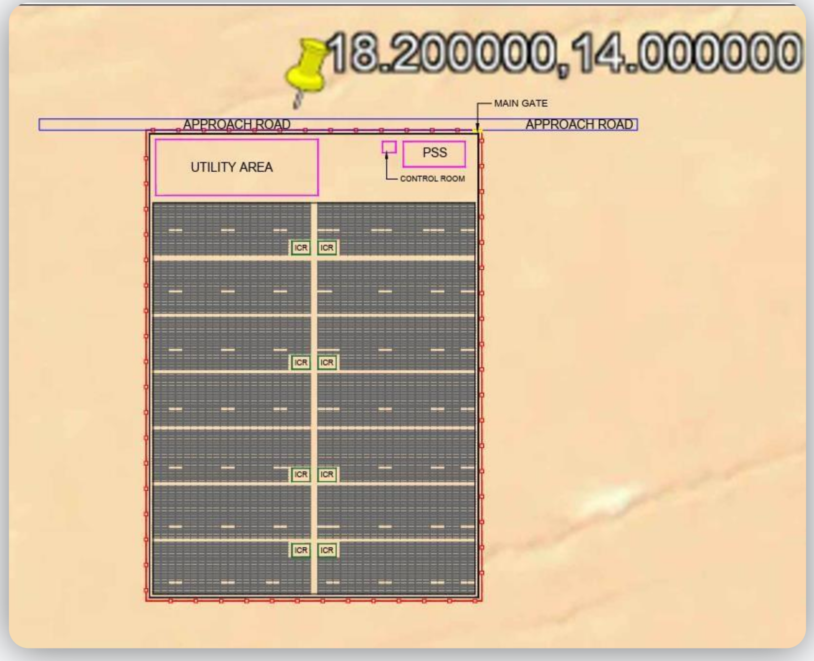


Figure 5
Location Map and marking of the land

The site selection for a solar power plant is predominantly determined by solar insolation availability & grid connectivity for exporting power.

Other essential factors for site selection are:

- Availability of adequate land for power plant and green belt development
- Soil condition like soil bearing capacity etc.
- Proximity to state electricity grid enabling economic evacuation of power generated
- Availability of water and power during construction
- Availability of local workforce in the proximity
- Availability of load centers (towns) within vicinity
- Easy accessibility of the site

According to Figure 5 Location Map and marking of the land area utilized for solar system is: 128 HA.

4. Solar Pv Power Potential And Simulation Result

The average daily global radiation spans from around 5.7 kWh/m²

Illustrating this solar panorama is a map revealing the annual average Global Horizontal Radius (GHI) for Chad. It serves as an indispensable tool for planning and optimizing solar energy endeavors by pinpointing regions of heightened solar potential and guiding the strategic installation and sizing of solar panels.

1. Radiation data sources

Majorly following are the sources for solar radiation data for simulation:

- Meteonorm
- Solar GIS
- NASA-SSE
- PVGIS - SARAH

2. Resource for simulation

For the analysis of solar pv generation simulation by this project Meteonorm data has been considered.

As shown in the graph radiation received is distributed over the year. (Lowest will be in December month). Performance parameters and ratio will be calculated on the basis of radiation data.

Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	ratio
January	136.1	62.0	23.15	161.4	151.4	16090	15442	0.797
February	138.4	74.0	26.63	154.3	144.9	15177	13669	0.738
March	188.9	82.4	31.10	200.6	189.4	19331	18539	0.770
April	197.3	91.4	35.02	196.6	185.2	18641	17892	0.758
May	203.8	102.4	37.58	193.6	181.7	18154	17440	0.751
June	190.9	104.4	36.12	177.8	166.4	16816	16154	0.757
July	201.4	100.4	34.19	188.9	177.2	18085	17367	0.766
August	188.8	105.3	32.44	184.3	172.9	17766	15729	0.711
September	179.1	87.3	34.16	185.1	174.2	17716	17007	0.766
October	175.1	79.1	33.82	193.2	182.4	18461	16508	0.712
November	151.0	56.5	28.67	179.4	169.3	17513	16796	0.780
December	132.3	60.7	24.29	159.3	149.0	15780	15159	0.793
Year	2083.1	1005.9	31.45	2174.3	2044.2	209530	197702	0.758

Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Figure 6
Radiation data considered in solar pv PVsyst simulation

From Meteonorm database radiation data for horizontal and effective radiation received at the level of solar modules is observed.

4.3 Simulation results

The yearly energy production of the intended photovoltaic (PV) power facility is determined by accounting for all forms of generation and distribution losses before injecting energy into the grid. The solar PV-powered plant involves the interplay of optical energy input, influenced by geographical, seasonal, climatic, and operational factors over time, and electrical output, contingent on the technical attributes of the employed electrical devices.

To evaluate the energy generation, the industry-recognized software PVSYST V7.2.5 has been employed for Energy Generation Assessment.

In the first-year solar system is estimated to generate 197702 MWh/year as per the PVsyst report. After which 2 % degradation factor for first of working and thereafter 0.55 % degradation per year has been considered for solar pv module as per the manufacturer datasheet till 25 years.

Performance ratio (PR) and annual specific production are 75.77% and 1648 kWh/kWp/year.

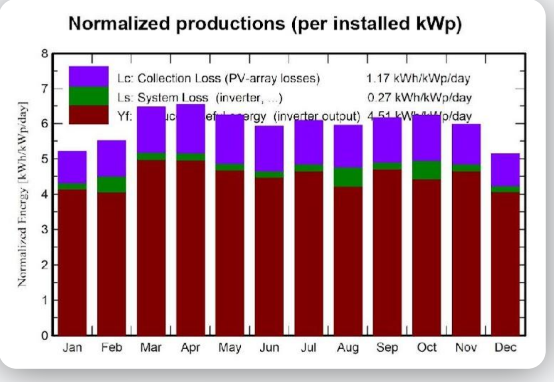


Figure 7 - Normalized production per kWp

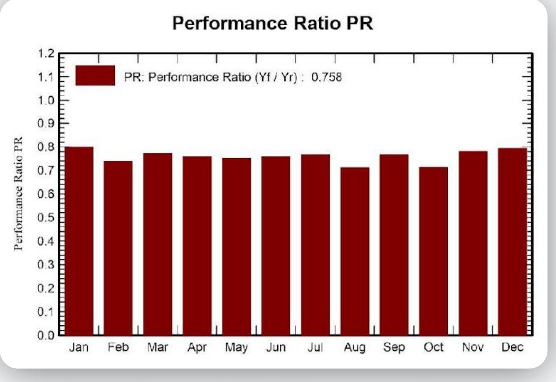


Figure 8 - System Performance ratio (PR)

4.4 Losses consideration for simulation

Following are the losses considered for the simulation of grid-connected solar pv system.

PARTICULAR	
Array soiling losses	3.00 %
Thermal loss factor (Constant loss factor / Thermal factor)	9.74 %
Ohmic wiring losses	1.16 %
Inverter loss during operation (efficiency)	1.11 %
Series diode loss	0.10 %
LID – Light Induced degradation	1.50 %
Module quality loss	0.30 %
Module mismatch losses	2.00 %
Strings mismatch loss	0.10 %
IAM loss factor	1.45 %
Unavailability of the system	1.75 %

Table 2 - System losses considered in the study

4.4.1 Details about losses

SOILING LOSS

Accumulation of dirt and its effect on the system performance is an uncertainty which strongly depends on the environment of the system, raining conditions, etc.

In rural environments with agricultural activity, it may be important during some seasonal activities. In industrial zones, one can observe not negligible effects of the order of several percents. Häberlin reports the effect of metallic dusts near to a railway line, which may initiate further pollution and mosses.

The accumulation of dusts and the growth of mosses and lichens along the frame of the modules produces partial shadings on the bottom cells, and tend to retain more dust. Moreover, these pollutions are not removed by the rainfalls. Therefore, with low tilts, it is recommended to use frameless modules when possible.

Bird's droppings represent a serious problem, as they are usually not removed by rainy events. But their impact is reported as relatively small (less than 2%).

The soiling losses are strongly dependent on the rainfalls of course. Therefore, PVsyst allows the definition of soiling loss factors in monthly values. During the simulation, the soiling loss is accounted for as an irradiance loss.

Thermal loss factor

When the surrounding temperature rises, the temperature of the PV module likewise climbs, leading to a decrease in the power output generated by the PV module. This phenomenon is contingent upon the temperature coefficient of the PV module, a value provided by the manufacturer.
This factor depends on the mounting mode of the modules (sheds, roofing, facade, etc...). For free circulation, this coefficient refers to both faces, i.e., twice the area of the module. If the back of the modules is more or less thermally insulated, this should be lowered, theoretically up to half the value (i.e., the back side doesn't participate anymore to thermal convection and radiation transfer).

Ohmic wiring losses

Electrical resistance in the wires between the power available at the modules and at the terminals of the arrays gives rise to ohmic losses.

LID – Light Induced degradation

LID (Light Induced Degradation) refers to a performance deterioration that occurs within the initial hours of exposure to sunlight in Crystalline modules. This phenomenon can potentially deviate the actual performance from the data obtained through final factory flash tests conducted by certain PV module providers.

The impact of LID on performances concerning specified STC values remains unclear. If the modules are categorized based on their final factory flash test results to determine their Nominal Power class, LID can indeed lead to a performance loss relative to STC. The extent of LID loss, usually in the range of 1% to 3% or even higher, is linked to the quality of wafer manufacturing.

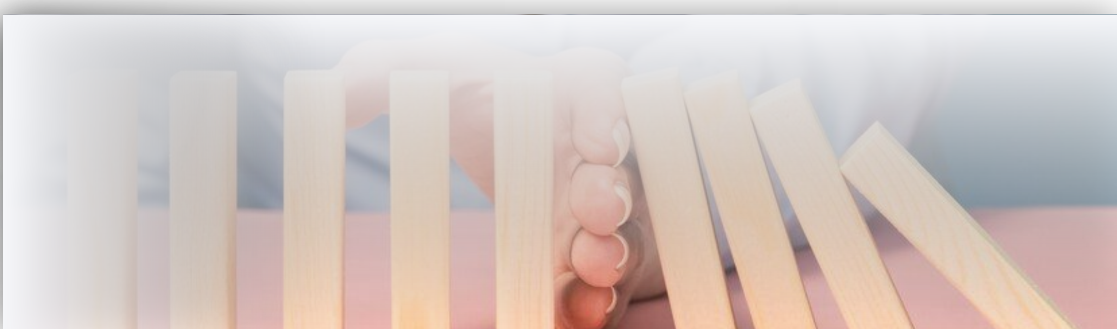
This degradation is attributed to traces of Oxygen present in molten Silicon during the Czochralski process. When exposed to light, these positively-charged O2 dimers tend to diffuse throughout the silicon lattice, forming complexes with boron dopant acceptors. These boron-oxygen complexes introduce their own energy levels within the silicon lattice, capable of capturing electrons and holes that are essential for the PV effect.

Module quality loss

The Module quality loss is a parameter that should express your own confidence to the real module's performance, with respect to the manufacturer's specifications.

Module mismatch losses

Mismatch losses represent the mismatch in current / voltage of modules in a string due to statistical variations.



IAM loss factor

The phenomenon known as the incidence effect is denoted by the term IAM, which stands for "Incidence Angle Modifier." It encompasses the reduction in actual irradiance reaching the surface of PV cells in comparison to the irradiance received under standard perpendicular incidence. This reduction primarily occurs due to reflections on the glass cover, and this reflection effect intensifies

as the angle of incidence increases. The loss in transmission is a fundamental occurrence resulting from the reflections and passage of sunlight rays across different material interfaces (such as air-glass, glass-EVA, EVA-cell), coupled with some absorption within the glass itself. This effect is present for sunlight rays striking from any angle. Under normal incidence, the reflection loss typically amounts to around 5%, and this is accounted for in the measured STC (Standard Test Conditions) performance. The IAM, however, specifically addresses the angular dependence of this phenomenon, meaning it's normalized concerning transmission at a right-angle incidence (0° angle of incidence).

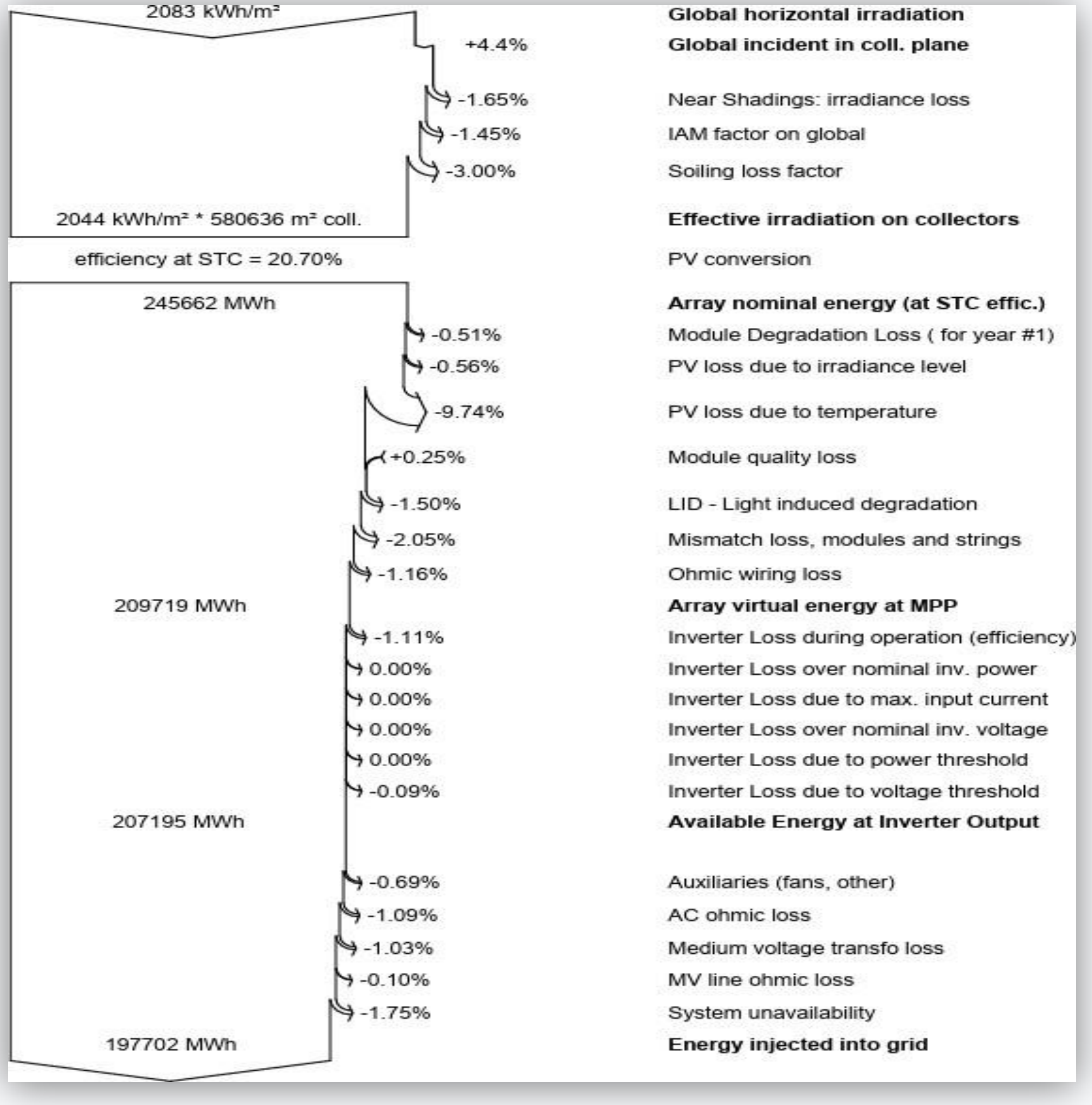


Figure 9 - Loss diagram

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR ratio
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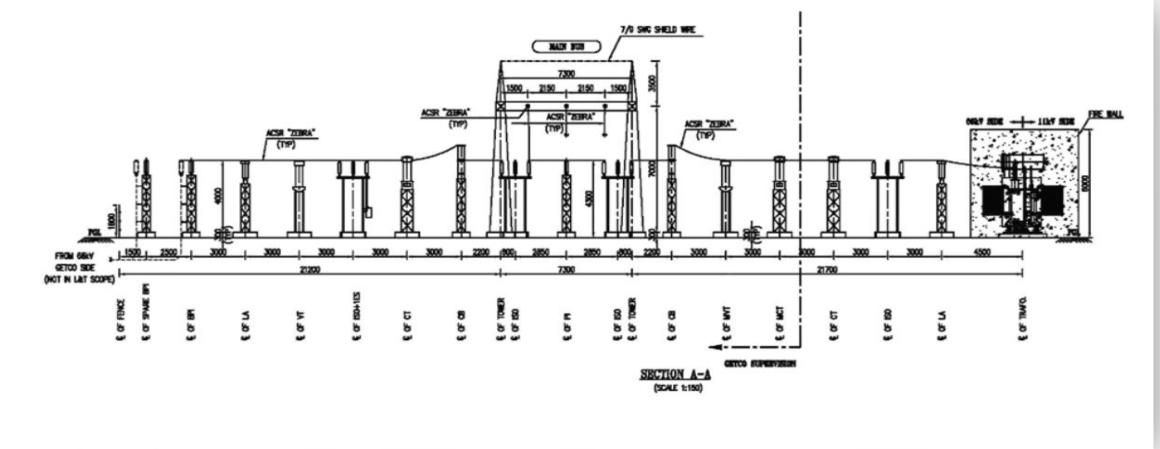
DiffHor Horizontal diffuse irradiation
T_Amb Ambient Temperature
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
PR Performance Ratio

Table 3 - System simulation result

Above table shows the radiation is available in each month and energy generated by the solar PV system. Also, electricity units fed into the grid is included.

5. Substation



Sub-station serves as sources of energy supply for the local areas of distribution in which these are located. Their main functions are to receive energy transmitted at high voltage from the generating station receive energy transmitted at high voltage from the generating station reduce the voltage to a value appropriate for local distribution and provide faculties for switching. A sub-station is convenient place for installing synchronous condensers at the end of the transmission line for purpose of improving power factor and make measurements to check the operation of the various parts of the power system street lighting equipment as well as switching controls for street lights can be installed in a substation.

1. Classifications

1. On the basis of nature of duty

- Step-up or primary substation: These are the sub- station where form power is transmitted to various load centers in the system network.
- Step-up & step-down or secondary sub-station: Sub-station of this type may be located at generating points where from power is fed directly to the loads and balance power generated is transmitted to the network for transmission to other load centers.
- Step-down or distribution substation: Such substation receive power from secondary sub-station at extra high voltage and step down its voltage for secondary distribution.

2. On the basis of operating voltage

- High voltage substations involving voltage between 11KV &66KV
- Extra high voltage substations involving voltages between 132KV & 400KV
- Ultra-high voltage substation operation on voltage above 400 KV

3. On the basis of importance

- **Grid sub-station:** These are the sub-station from where bulk power is transmitted from one point to another point in the grid. These are important because any distribution in this sub-station may cause the failure of grid.
- **Town substation:** These substations are EHV substation, which step down the voltage at 33/11KV for further substation results in the failure of supply for whole of the town.

4. ON the basic of design

- **Indoor type substation:** In such sub-station the apparatus is installed within the sub- station building. Such sub-station is usually for a voltage up to 11KV but can be erected for the 33KV to 66KV when the surrounding atmosphere is contaminated with impurities such as metal corroding gases and fumes conductive dust etc.
- **Outdoor type substation:** These substations are further subdivided into: pole mounted substation. Such sub- station is erected for distribution of power in localities. Single stout pole H-pole & 4-pole structures with suitable platforms are employed for transformers capacity up to 25KV,100 KVA and 100 KV respectively.
- **Foundation mounted substation:** For transformer of capacity above 250KVA the transformer is too heavy for pole mounting. Such sub-station is usually for voltage of 33000V & above.

2. Selection and location of site

3. Instruments used in 66KV sub-station

- Transformer
- Current transformer
- Potential transformer
- Wave trap
- Lighting arrester
- Electric Isolator
- Bus bars
- Bus coupler
- Circuit breaker
- Control panel
- Power line communication
- Earth fault relay
- On load tap charger
- Capacitor bank
- Battery

6. Operation And Maintenance Requirement

These services are meticulously designed to ensure that the solar system attains its designated energy performance and anticipated return on investment.

The objectives to be realized through Operation and Maintenance Services are as follows:

- Enhancing system production to amplify asset revenue
- Diminishing risks for both asset owners and investors
- Safeguarding asset value and promoting its longevity
- Adhering to relevant regulations (e.g., Environmental regulatory bodies
- Providing transparency regarding system production, performance, identified issues, and associated risks.

1. Operation requirements

The system's functioning commences upon commissioning. It is imperative to confirm the full installation of all equipment before operational activities initiate. While achieving this might pose challenges, operating a system lacking adequate instrumentation, controls, and alarms carries substantial risks. It's crucial that commissioning procedures prioritize both personnel and system safety.

A comprehensive checklist needs to be formulated, encompassing all segments of the system. This checklist should consider contractual obligations, the interconnected technological aspects between different segments, pre-commissioning steps, cleaning procedures, and more. The utilization of a checklist serves the following purposes:

- To guarantee the completion of essential inspections for each component of the system before its integration into commercial operation
- To guarantee the provisioning of energy to the equipment or system only when it is deemed safe
- To streamline the documentation of advancements in diverse commissioning tasks
- To establish a foundation for maintaining the historical record of the system's evolution

It remains the duty of the operational staff to ensure the correct configuration and ongoing functionality of safety devices. The system operator should adhere to the following guidelines:

- Regularly inspecting and calibrating instruments
- Comparing indications from different instruments to identify instrument malfunctions or abnormal operational states
- Analyzing the displayed data to accurately anticipate potential issues
- The system must operate in tandem with the expansive power grid. To safeguard its equipment from potential faults or grid-related disturbances, the system should be equipped with directional and reverse power protection. This provision allows for the system to disconnect from the grid during any fault occurrence.

2. Maintenance requirements

The primary aim of the maintenance segment is to ensure the sustained, efficient operation of the system, minimizing any potential disruptions. The reliability of a system suffers when it experiences sudden and unforeseen outages. Implementing the following steps can help diminish breakdowns and enhance the effectiveness of preventive maintenance:

- Thoroughly documenting operational data and periodically analyzing it to identify abnormal or gradually deteriorating conditions.
- Vigilant monitoring and oversight of operational conditions. Swift and significant fluctuations in voltage and frequency can contribute to heightened maintenance needs.
- Regularly conducting routine maintenance tasks, including keeping equipment and modules clean.
- Adhering to proper operating procedures
- Conducting frequent system equipment tests through "Walk Down" assessments to evaluate internal equipment conditions such as module performance and monitoring system functionality.
- Maintaining close collaboration with manufacturers to introduce improvements in system layouts and designs, employ superior materials, and integrate features like lightning protection, as necessary.

3. Module cleaning

- Effective module cleaning is paramount to achieving the desired yield and performance ratio in solar power projects. It has been noted that system performance often falls short due to inadequate cleaning of PV modules or the use of subpar cleaning water. Notably, dirt and bird droppings are the primary culprits affecting module output.
- For module cleaning, it is recommended to employ fresh water with a Total Dissolved Solids (TDS) value below 1500 mg/L. If necessary, a gentle, non-abrasive, non-caustic detergent can be utilized, followed by a final rinse with fresh water and detergent solution, maintaining a pH between 6.5 and 8.5 at 25°C.
- The water used for cleaning should be within a moderate temperature range, avoiding extremes of hot or cold. It's essential for the water to be devoid of dirt and mud. Ideally, de- mineralized water is preferred to prevent salt accumulation on the module surface, which can lead to corrosion on module frames and mounting structures.
- The installation of Reverse Osmosis (RO) plants to provide cleaning water is becoming a common practice. Occasionally, residue like dirt or other marks might persist on the module surface, potentially leading to hot spots on module cells and subsequent damage.
- Such residues can be treated with biodegradable chemical solutions to prevent soil contamination beneath the PV module. If any cleaning agent is used, thorough rinsing with ample water is necessary to eliminate chemical residues from the module surface.
- Acidic or alkaline detergents should be avoided, as they can induce corrosion and erosion on module frames and mounting structures. When employing a cleaning wiper, it should have a non-adhesive surface, and water should be wiped from the top down.

Conclusion

In this report, we have endeavored to incorporate project details to a specific extent. Numerous inclusions and modifications are possible, such as financial calculations, technological comparisons, and carbon reduction calculations.

Mono Multi Solutions

THE Vertex

BACKSHEET MONOCRYSTALLINE MODULE

PRODUCTS
TSM-DE19

POWER RANGE
535-555W

555W
MAXIMUM POWER OUTPUT

21.2%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

High customer value

- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance of System) cost, shorter payback time
- Lowest guaranteed first year and annual degradation;
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power up Mono Perc to 555W

- Up to 21.2% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield

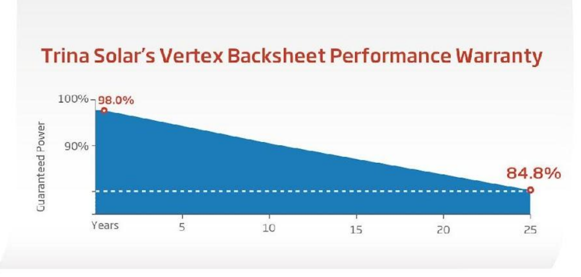
- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions
- Lower temperature coefficient (-0.34%) and operating temperature

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

PV CYCLE

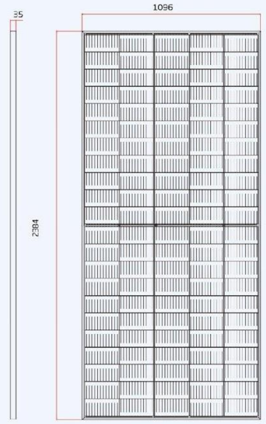


Trinasolar

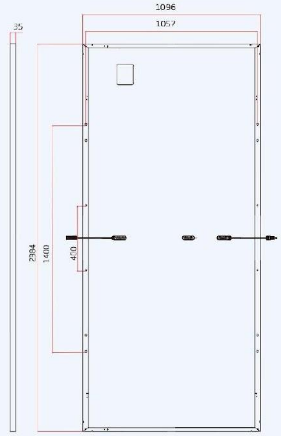
Vertex

BACKSHEET MONOCRYSTALLINE MODULE

DIMENSIONS OF PV MODULE(mm)

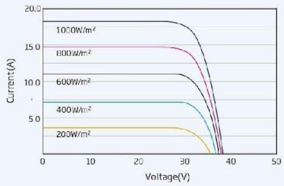


Front View

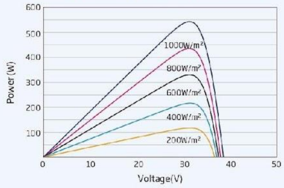


Back View

I-V CURVES OF PV MODULE(545 W)



P-V CURVES OF PV MODULE(545W)



ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	535	540	545	550	555
Power Tolerance-P_{MAX} (W)	0 ~ +5				
Maximum Power Voltage-V_{MPP} (V)	31.0	31.2	31.4	31.6	31.8
Maximum Power Current-I_{MPP} (A)	17.28	17.33	17.37	17.40	17.45
Open Circuit Voltage-V_{OC} (V)	37.3	37.5	37.7	37.9	38.1
Short Circuit Current-I_{SC} (A)	18.36	18.41	18.47	18.52	18.56
Module Efficiency η_m (%)	20.5	20.7	20.9	21.0	21.2

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	405	409	413	417	420
Maximum Power Voltage-V_{MPP} (V)	28.8	29.0	29.2	29.3	29.5
Maximum Power Current-I_{MPP} (A)	14.06	14.10	14.15	14.19	14.23
Open Circuit Voltage-V_{OC} (V)	35.1	35.3	35.5	35.7	35.9
Short Circuit Current-I_{SC} (A)	14.80	14.84	14.88	14.92	14.96

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline
No. of cells	110 cells
Module Dimensions	2384×1096×35 mm (93.86×43.15×1.38 inches)
Weight	28.6 kg (63.1 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant material	EVA
Backsheet	White
Frame	35mm(1.38 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: 280/280 mm(11.02/11.02 inches) Landscape: 1400/1400 mm(55.12/55.12 inches)
Connector	TS4

TEMPERATURE RATINGS

NOCT(Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.34%/°C
Temperature Coefficient of V_{OC}	- 0.25%/°C
Temperature Coefficient of I_{SC}	0.04%/°C

MAXIMUM RATINGS

Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	30A

WARRANTY

12 year Product Workmanship Warranty
25 year Power Warranty
2% first year degradation
0.55% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGURATION

Modules per box: 31 pieces
Modules per 40' container: 558 pieces

Sold in India by: Loop Solar | P: +91-9971136369 | E: info@loopsolar.com | W: www.loopsolar.com

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2020_APAC_A
www.trinasolar.com

7VEN.FINANCE
Giving back power to the people for a more sustainable future

PVSYST
PHOTOVOLTAIC SOFTWARE

PVSYST SIMULATION REPORT

Grid-Connected System

Project:	100 MW Solar power plant
Variant:	New simulation variant Sheds, single array
System power:	120.0 MWp - 100 mw spv

Project - 100 MW Solar Power Plant

Variant: New simulation variant

Project summary

Geographical Site
100 mw spv
Niger

Situation

Latitude	18.20 °N
Longitude	14.00 °E
Altitude	487 m
Time zone	UTC+1

Project settings

Albedo	0.20

Meteo data
100 mw spv
Meteonorm 8.0 (1986-2005), Sat=100% - Synthetic

System summary

Grid-Connected System
Simulation for year no 1

Sheds, single array

PV Field Orientation
Fixed plane
Tilt/Azimuth 18 / 0 °

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

System information

PV Array

Nb. of modules	222222 units
Pnom total	120.0 MWp

Inverters

Nb. of units	28 units
Pnom total	96.24 MWac
Pnom ratio	1.247

Results summary

Produced Energy	197702 MWh/year	Specific production	1648 kWh/kWp/year	Perf. Ratio PR	75.77 %

Table of contents

General parameters

Grid-Connected System

Sheds, single array

PV Field Orientation

Orientation
Fixed plane
Tilt/Azimuth 18 / 0 °

Sheds configuration

Nb. of sheds	220 units
Single array	

Sizes

Sheds spacing	7.00 m
Collector width	4.79 m
Ground Cov. Ratio (GCR)	68.4 %
Top inactive band	0.02 m
Bottom inactive band	0.02 m

Shading limit angle

Limit profile angle	31.5 °

Models used

Transposition	Perez
Diffuse	Perez, Meteonorm
Circumsolar	separate

Horizon
Free Horizon

Near Shadings
Linear shadings

User's needs
Unlimited load (grid)

Project - 100 MW Solar Power Plant

Variant: New simulation variant

PV Array Characteristics

PV module

Manufacturer	Trina Solar
Model	VERTEX TSM-540-DE19
(Custom parameters definition)	
Unit Nom. Power	540 Wp
Number of PV modules	222222 units
Nominal (STC)	120.0 MWp
Modules	6734 Strings x 33 In series
At operating cond. (50°C)	
Pmpp	109.6 MWp
U mpp	933 V
I mpp	117539 A

Inverter

Manufacturer	Sungrow
Model	SG3400-HV-20
(Original PVsyst database)	
Unit Nom. Power	3437 kWac
Number of inverters	28 units
Total power	96236 kWac
Operating voltage	875-1300 V
Max. power (=>25°C)	3593 kWac
Pnom ratio (DC:AC)	1.25

Total PV power

Nominal (STC)	120000 kWp
Total	222222 modules
Module area	580636 m²
Cell area	393555 m²

Total inverter power

Total power	96236 kWac
Nb. of inverters	28 units
Pnom ratio	1.25

Array losses

Array Soiling Losses

Average loss Fraction 3.0 %

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%

Thermal Loss factor

Module temperature according to irradiance

Uc (const) 29.0 W/m²K

Uv (wind) 0.0 W/m²K/m/s

DC wiring losses

Global array res. 0.13 mΩ

Loss Fraction 1.5 % at STC

Serie Diode Loss

Voltage drop 0.7 V

Loss Fraction 0.1 % at STC

LID - Light Induced Degradation

Loss Fraction 1.5 %

Module Quality Loss

Loss Fraction -0.3 %

Module mismatch losses

Loss Fraction 2.0 % at MPP

Array losses

Strings Mismatch loss

Loss Fraction 0.1 %

Module average degradation

Year no 1

Loss factor 1 %/year

Mismatch due to degradation

Imp RMS dispersion 0.4 %/year

Vmp RMS dispersion 0.4 %/year

IAM loss factor

Incidence effect (IAM): User defined profile

0°	25°	45°	60°	65°	70°	75°	80°	90°
1.000	1.000	0.995	0.962	0.936	0.903	0.851	0.754	0.000

Project - 100 MW Solar Power Plant

Variant: New simulation variant

System losses

Unavailability of the system

Time fraction	2.0 %
	7.3 days,
	3 periods

Auxiliaries loss

Proportionnal to Power	7.0 W/kW
0.0 kW from Power thresh.	

AC wiring losses

Inv. output line up to MV transfo

Inverter voltage	600 Vac tri
Loss Fraction	2.00 % at STC

Inverter: SG3400-HV-20

Wire section (28 Inv.)	Alu 28 x 3 x 4000 mm²
Average wires length	216 m

MV line up to Injection

MV Voltage	33 kV
Average each inverter	
Wires	Copper 3 x 2500 mm²
Length	15000 m
Loss Fraction	0.18 % at STC

AC losses in transformers

MV transfo

Grid voltage	33 kV

Transformer from Datasheets

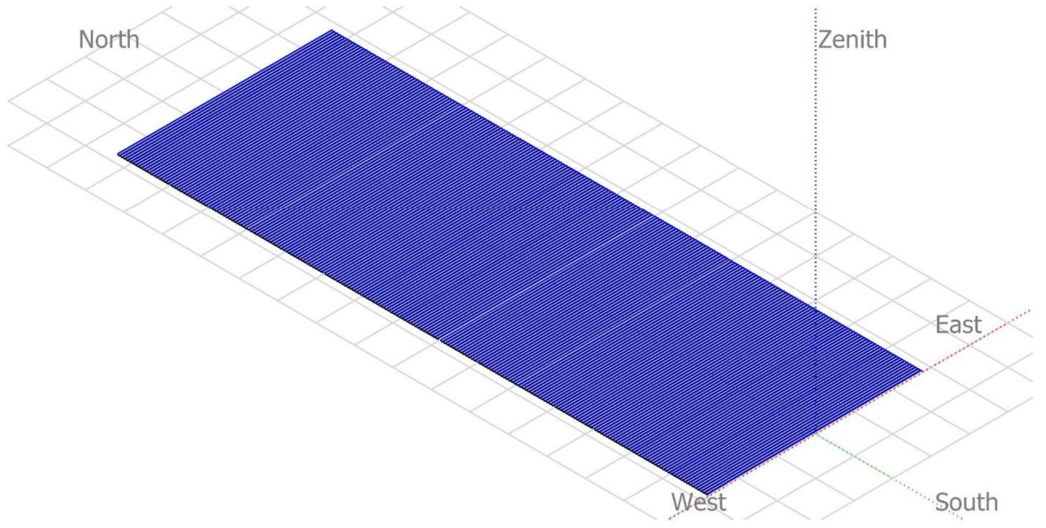
Nominal power	13200 kVA
Iron loss	13.20 kVA
Loss Fraction	0.10 % of PNom
Copper loss	118.80 kVA
Loss Fraction	0.90 % of PNom

Operating losses at STC

Nominal power at STC	118800 kVA
Iron loss (24/24 Connexion)	13.20 kW/Inv.
Loss Fraction	0.08 % at STC
Coils equivalent resistance	3 x 0.25 mΩ/inv.
Loss Fraction	1.16 % at STC

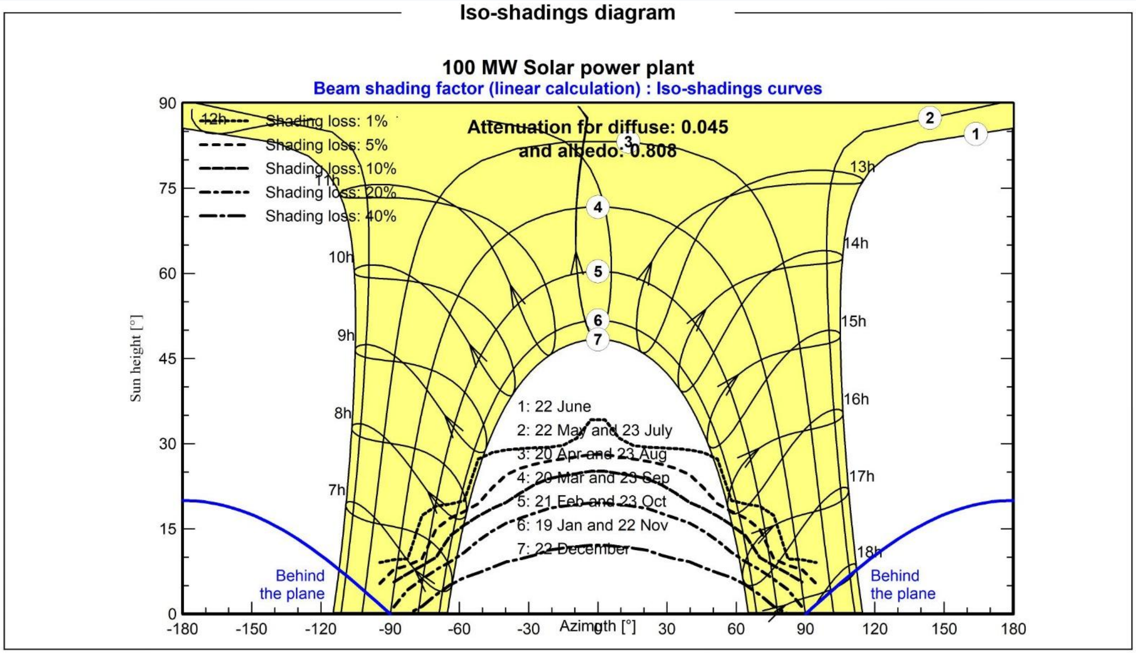
Near shadings parameter

Perspective of the PV-field and surrounding shading scene



Project - 100 MW Solar Power Plant

Variant: New simulation variant



Project - 100 MW Solar Power Plant

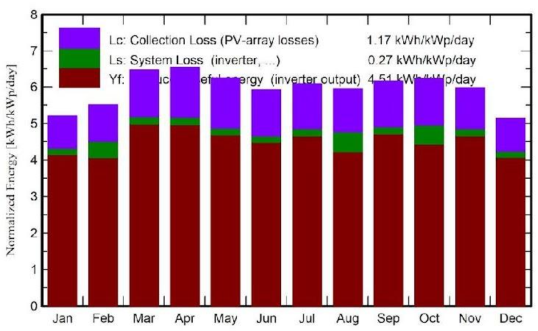
Variant: New simulation variant

Main results

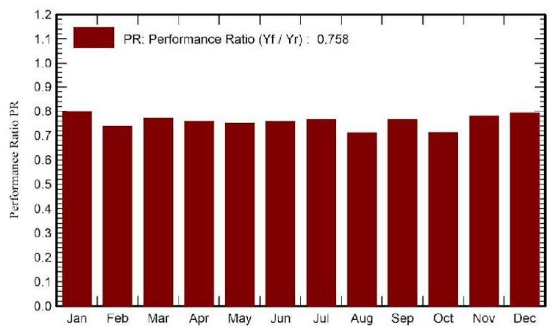
System Production

Produced Energy	197702 MWh/year	Specific production	1648 kWh/kWp/year
		Performance Ratio PR	75.77 %

Normalized productions (per installed kWp)



Performance Ratio PR



Balances and main results

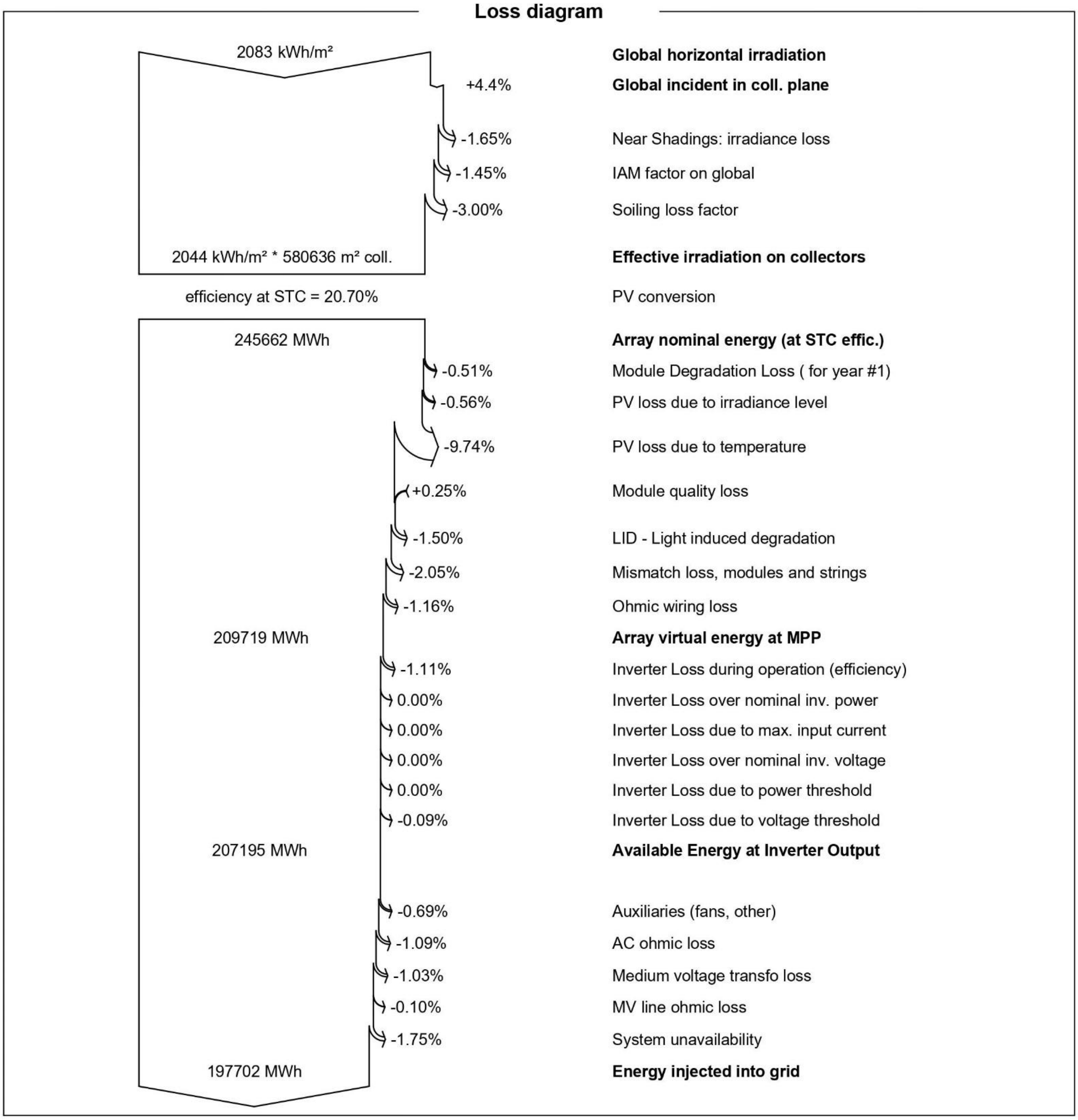
	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	ratio
January	136.1	62.0	23.15	161.4	151.4	16090	15442	0.797
February	138.4	74.0	26.63	154.3	144.9	15177	13669	0.738
March	188.9	82.4	31.10	200.6	189.4	19331	18539	0.770
April	197.3	91.4	35.02	196.6	185.2	18641	17892	0.758
May	203.8	102.4	37.58	193.6	181.7	18154	17440	0.751
June	190.9	104.4	36.12	177.8	166.4	16816	16154	0.757
July	201.4	100.4	34.19	188.9	177.2	18085	17367	0.766
August	188.8	105.3	32.44	184.3	172.9	17766	15729	0.711
September	179.1	87.3	34.16	185.1	174.2	17716	17007	0.766
October	175.1	79.1	33.82	193.2	182.4	18461	16508	0.712
November	151.0	56.5	28.67	179.4	169.3	17513	16796	0.780
December	132.3	60.7	24.29	159.3	149.0	15780	15159	0.793
Year	2083.1	1005.9	31.45	2174.3	2044.2	209530	197702	0.758

Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_Grid	Energy injected into grid
T_Amb	Ambient Temperature	PR	Performance Ratio
GlobInc	Global incident in coll. plane		
GlobEff	Effective Global, corr. for IAM and shadings		

Project - 100 MW Solar Power Plant

Variant: New simulation variant

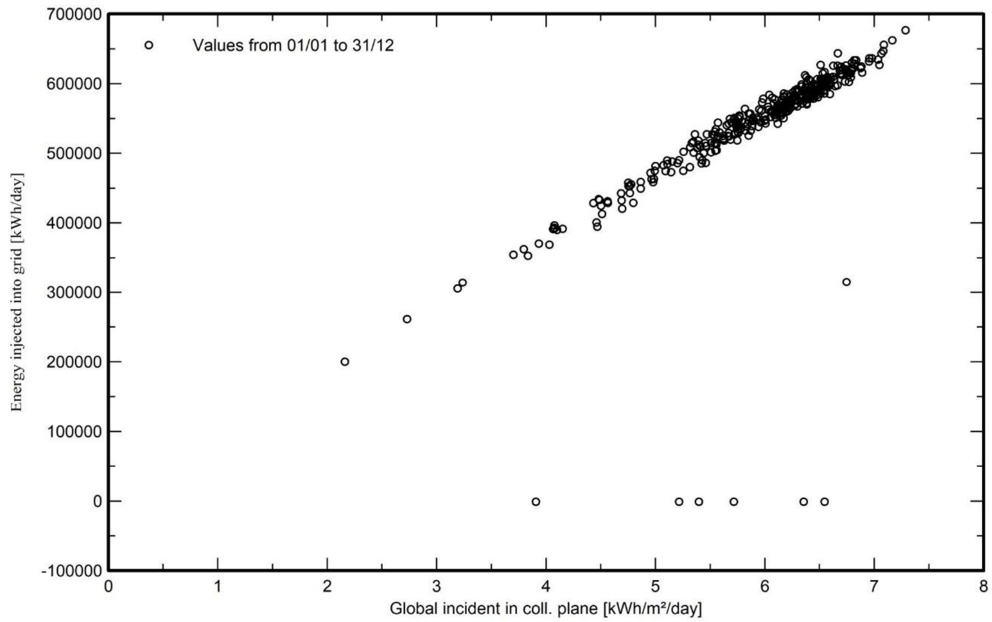


Project - 100 MW Solar Power Plant

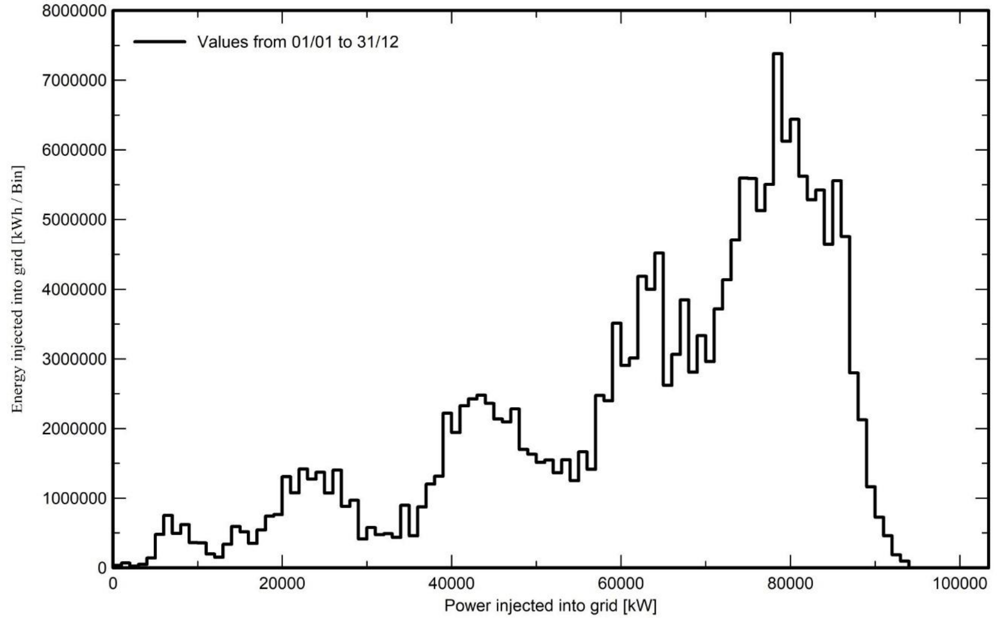
Variant: New simulation variant

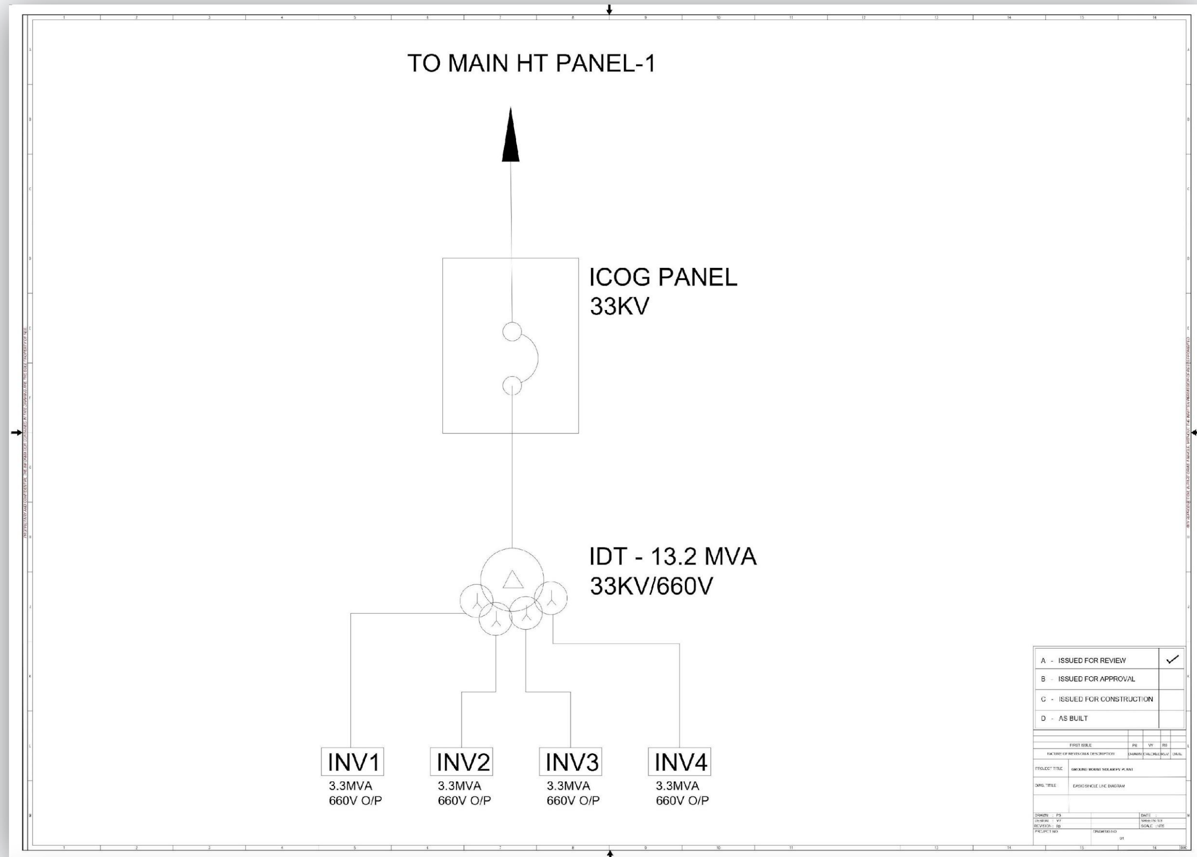
Special graphs

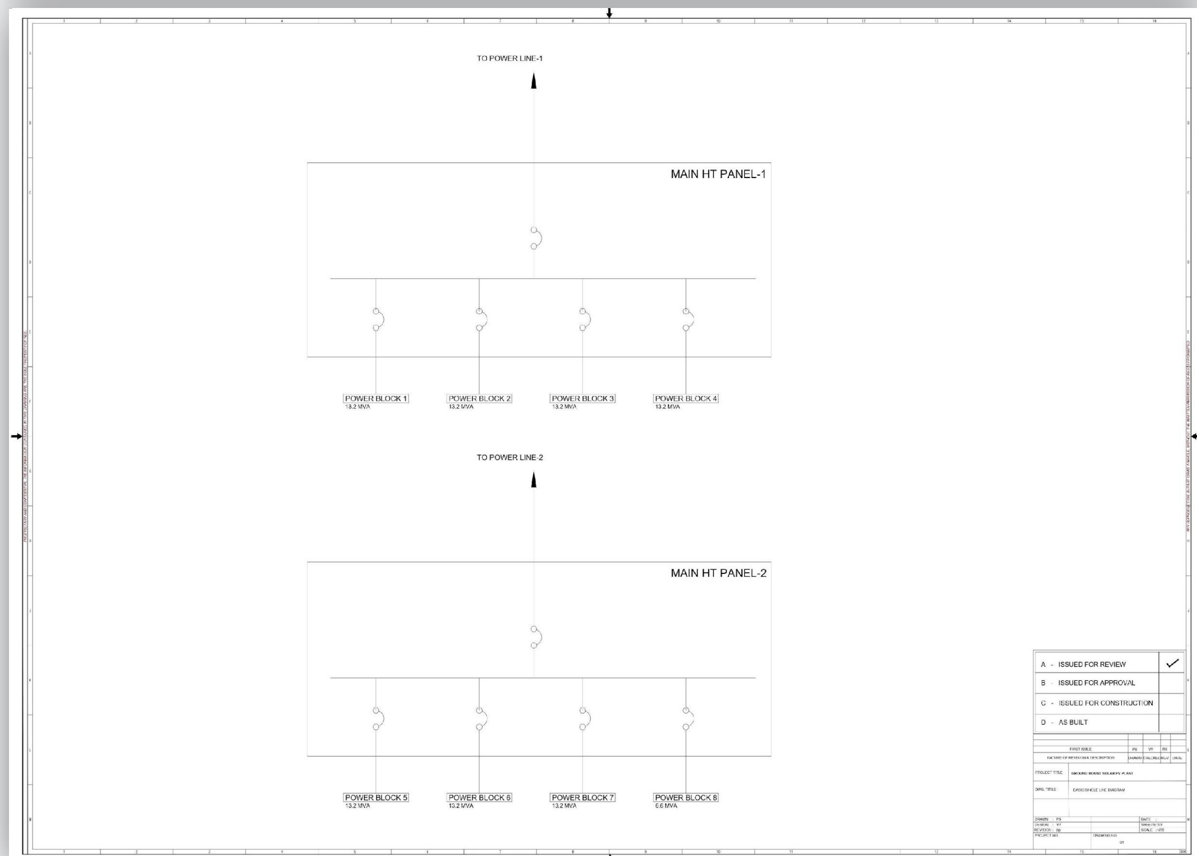
Daily Input/Output diagram

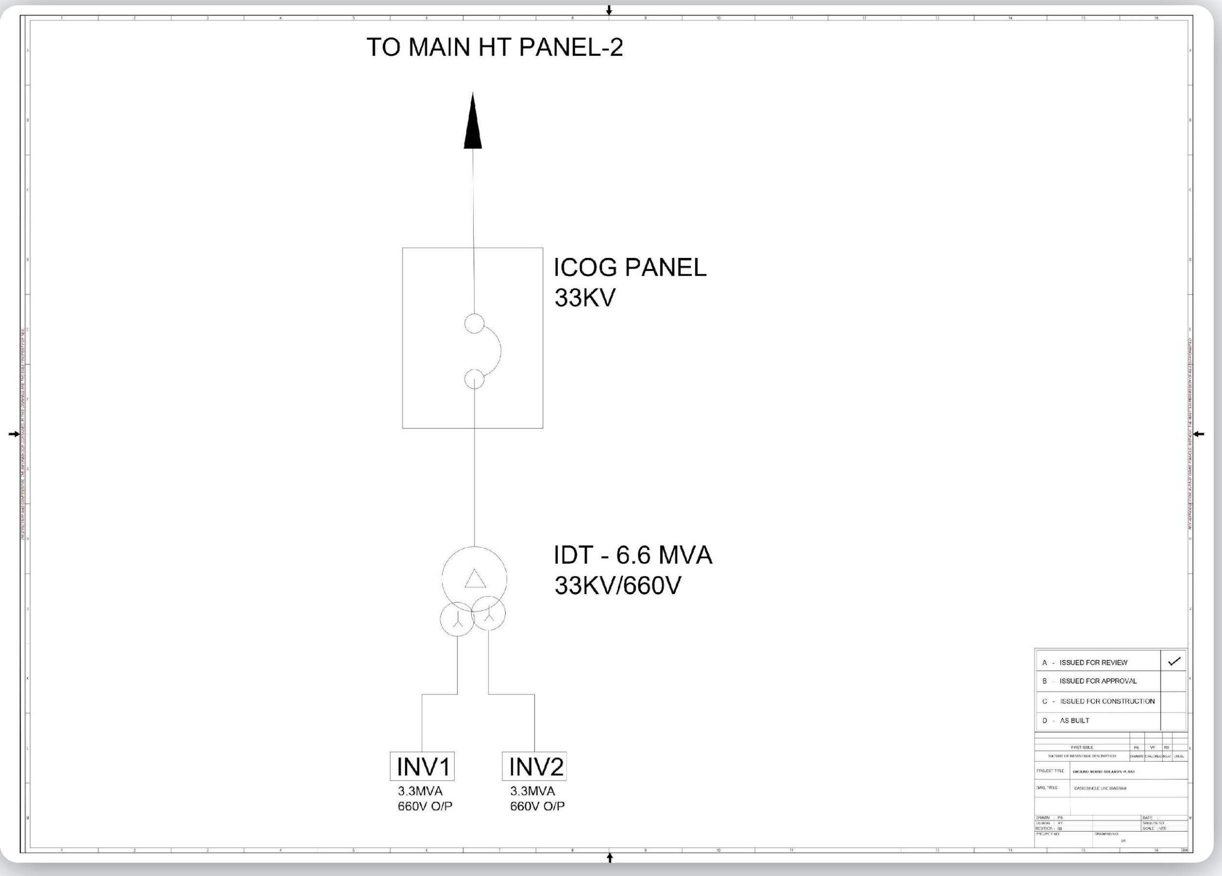


System Output Power Distribution




TO MAIN HT PANEL-1
ICOG PANEL
33KV
IDT - 13.2 MVA
33KV/660V
INV1
3.3MVA
660V O/P
INV2
3.3MVA
660V O/P
INV3
3.3MVA
660V O/P
INV4
3.3MVA
660V O/P
A - ISSUED FOR REVIEW
B - ISSUED FOR APPROVAL
C - ISSUED FOR CONSTRUCTION
D - AS BUILT


TO POWER LINE-1
MAIN HT PANEL-1
POWER BLOCK 1
13.2 MVA
POWER BLOCK 2
13.2 MVA
POWER BLOCK 3
13.2 MVA
POWER BLOCK 4
13.2 MVA
TO POWER LINE-2
MAIN HT PANEL-2
POWER BLOCK 5
13.2 MVA
POWER BLOCK 6
13.2 MVA
POWER BLOCK 7
13.2 MVA
POWER BLOCK 8
6.6 MVA
A - ISSUED FOR REVIEW
B - ISSUED FOR APPROVAL
C - ISSUED FOR CONSTRUCTION
D - AS BUILT



7VEN.FINANCE

Giving back power to the people for a more sustainable future