Yield Assessment Report Harre

Harre Solar Farm, (Jutland) Denmark

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Table of Contents

1 Summary of Results

For the photovoltaic system under examination with an STC output of **44,418 kW_p**, an average annual energy yield of **56,477 MWh** has been calculated, taking into consideration the components used and the chosen location.

This results in an average annual specific yield of **1,272 kWh/kW_p** (P50 value) and a Performance Ratio of **91.2 %** (weighted average).

The total uncertainty has a standard deviation of **5.5 %.**

These figures are to be regarded as weighted average figures for an „average irradiation year“ (here: **1,055 kWh/m^2** on the horizontal) in accordance with the consideration of a plant availability of 100 % and a power factor of 1.

The system will be built with 2 structures:

Field 1 fix tilt with an STC output of **6,932 kW_p**, results in an average annual energy yield of **7,311 MWh.**

Field 2 single axis tracker with an STC output of **37,487 kW_p**, results in an average annual energy yield of **49,166 MWh.**

No ageing degradation of the modules is considered for this evaluation.

2 Purpose and object of the Assessment

Forecast of annual average energy yield of the photovoltaic plant till POC including power transformer and MV line.

2.1 System Description

Location: Harre (Jutland), Denmark (56.718° N, 8.934° E)

Total PV power: 44,418 kW_p

2.1.1 Type of Mounting (2 systems)

Free standing fixed system

Arrangement: 2 modules, portrait

Row spacing (Pitch): 6.3 m

Sun Angle (21. December, 12 Noon): 9.8°

Shading Angle: 35.6°

Single axis tracking system East/ West

Arrangement: 1 module, portrait

Rotation limitations: 55°

Row spacing (Pitch): 5.0 m

Sun Angle (21. December, 12 Noon): 9.8°

Shading Angle: 16.0°

2.1.2 Orientation of the Modules

Free standing fixed system

Orientation of the modules: Azimuth 0° South

Inclination of the modules to the horizontal: 25°

2.1.3 Modules

Solar cell type: Mono crystalline silicon BiFi cells

Bifaciality factor: 0.75

Make and Type: Longi, LR4-72HBD-435/ 440 M

DC rated output per module: 435/ 440 W_p

Number of Modules: 30,389/ 70,907

Total DC rated output power: 44,418.30 kW_p

2.1.4 Inverters

Make and Type: Huawei Technologies, SUN2000-105KTL-H1

AC rated output per inverter: 116 kVA

Number of inverters: 325

Total AC rated output power: 37,700 kVA

2.1.5 Transformers

Make and type: Ulusoy electric, ONAN 20/0.8

Output per transformer: 3,150 kVA

Number of transformers: 14

Total output power: 44,100 kVA

2.1.6 Power Transformer on POC

Make and type: SGB, DOTR 60/20

Output per transformer: 55,000 kVA

2.1.7 Module Interconnection

101,296 Modules interconnected in 3,896 strings with each 26 modules (up to 12 strings per inverter).

2.2 Methodology of the Assessment

2.2.1 Component Simulation

For the simulations, the data for solar module and inverter were fed into the PVsyst v6.86 simulation program. The datasheets of the modules and inverters were provided by the client.

2.2.2 Temperature Behaviour

The simulated temperature behaviour of the modules has been based on very good rear ventilation corresponding to their free-standing mounting. The wind speed at the site is also decisive in the heat dissipation of the modules. The long-term average wind speed at the Harre site at 10 meter elevation is 5.4 m/s.

2.2.3 Manufacturer's tolerance

No manufacturing tolerances were taken into account. The following assumption applies for this assessment: All solar modules from the manufacturer Longi, LR4-72HBD-435/ 440 M will achieve at minimum their rated output of 435 and 440 W_p respectively. We recommend that, to eliminate any discrepancies, the investor and/or project developer undertake measurements of individual modules through an independent institution.

2.2.4 Light induced degradation (LID)

The LID loss is related to the quality of the wafer manufacturing with p-type crystalline silicon cells and set up to **1.0 %**.

2.2.5 Mismatch

The power losses through mismatch - owing to the serial interconnection of a number of modules, each having slightly different characteristics - were set at **1.0 %**. Here horizontal string connection and data sheet power tolerance of 0 to +5 W_p were taken into account.

2.2.6 Cable losses

Due to the chosen decentralized inverter concept and according to the client information, the DC-side cable losses were set at **1.5 %** at STC and on the AC-side with cable losses at **0.6 %** rated power (MV line to POC included).

2.2.7 Transformer losses

The transformer losses were set at **0.1 %** constant iron losses and **1.0 %** rated inductive losses. The iron loss remains active and constant during the whole connecting time. Therefor night disconnect is recommended.

Additionally, the power transformer losses were set at **0.05 %** constant iron losses and **0.36 %** rated inductive losses according to transformer tests.

2.2.8 Dirt and Soiling

For solar modules erected in open-spaces, soiling cannot be ruled out and an associated reduction in the modules' output occurs. The known self-cleaning effect of glass panes by rain requires a module tilt of at least 15°, which is the case here.

Since the client intends to undertake cleaning of the modules if necessary, the losses owing to dirt and soiling have been estimated at **1.0 %**.

2.2.9 Horizon shading

With respect to shading analysis, generally a distinction is made between horizon shading (caused by the surrounding topography and vegetation) and internal shading (produced by the rows of panels themselves).

Horizon shading is caused by mountain ranges in the nearby vicinity, for which it is site dependent, whereas internal shading caused by the arrays depends on the tilt angle, row spacing (pitch), module table height and the minimum sun angle at the given site, is design dependent.

The site horizon shows no elevation hence corresponding to no losses due to horizon shading.

2.2.10 Site and Shading

A site visit was not part of the assessment.

Figure 1: Location (source: Client)

The site is located in Northern Jutland in Skive Commune around 2 km away from the sea shore. The terrain is flat and even.

There are some trees around the site which will mostly be cut, one overhead line and wind turbines (75m total height) in the North/ North-East. Thus shading obstacles are taken into account in this simulation if relevant for shading.

The layout provided by the client can be found in the appendix.

To evaluate the influence of the row shading with regards to the overall energy production, the shading scene is built using the 3D- Editor from PVsyst simulation program.

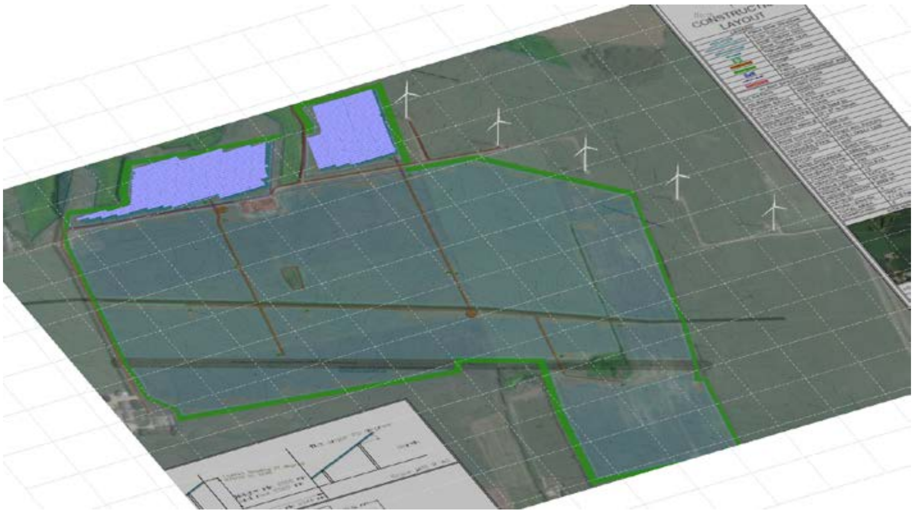


Figure 2: 3-D Shading Scene in PVsyst fix tilt

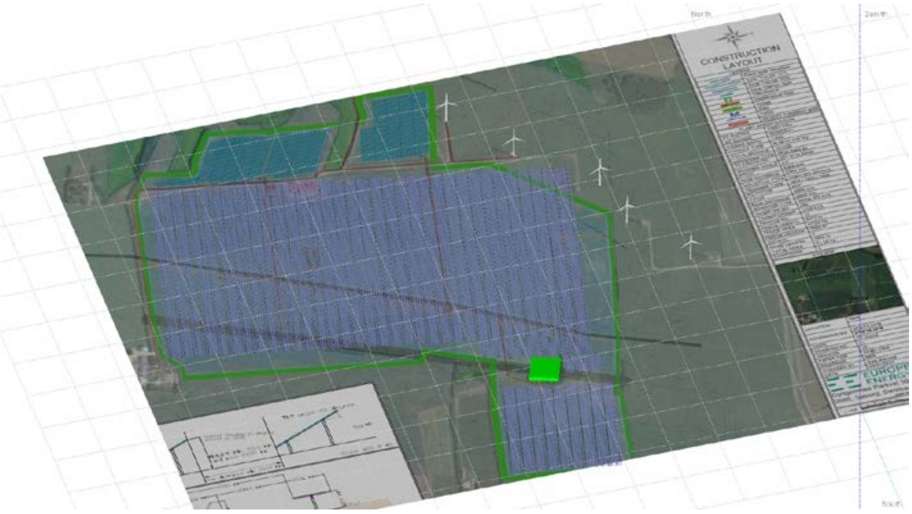


Figure 3: 3-D Shading Scene in PVsyst single axis

The normal solar inclination at the site is 9.8° (December 21, Noon). According to the client the row space (pitch) for fix tilt has been chosen with 6.3 m and the shading angle corresponds to 35.6°. The row space (pitch) for single axis has been chosen with 5 m and the shading angle is only theoretically but corresponds to 16°. Backtracking will lead to lower shading losses.

Here taking into account the string interconnection, the shading accounts for **3.9 %** of losses for both systems as weighted average.

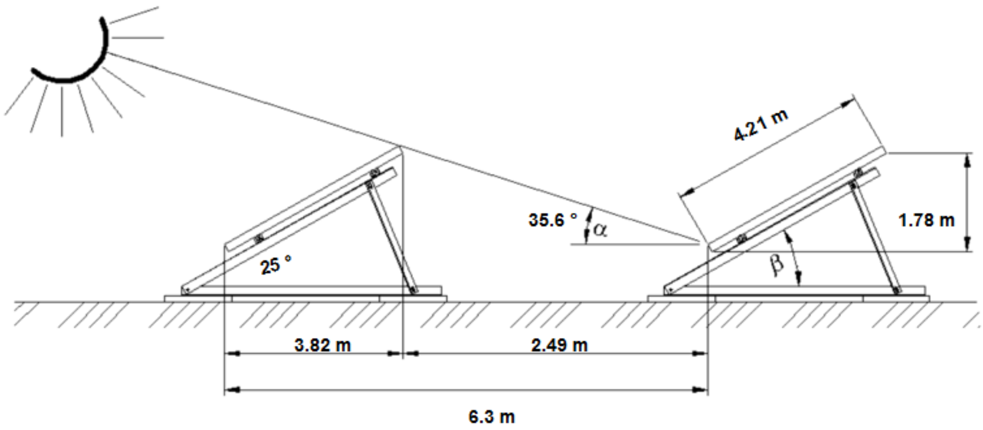


Figure 4: Module rows and shading angle fix tilt

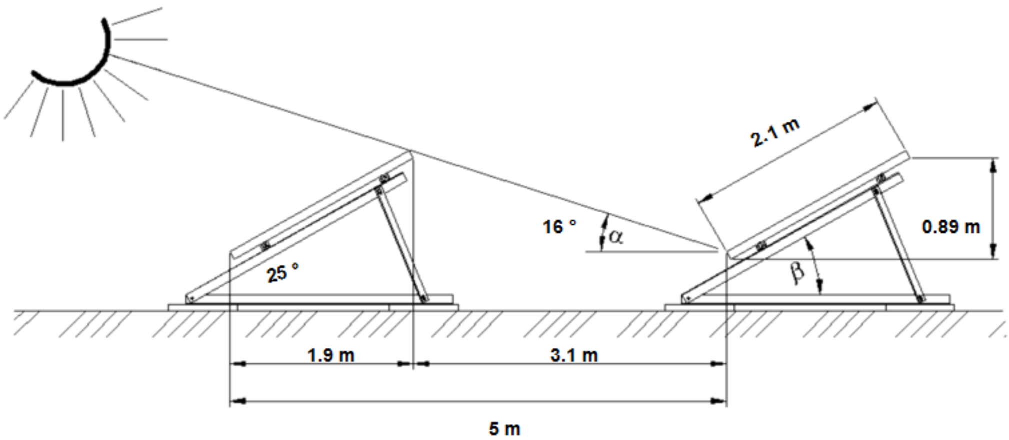


Figure 5: Module rows and shading angle single axis

The assumptions for the losses are based on experiences in connection with the evaluation of other photovoltaic installations.

2.2.11 Meteorological Data

The irradiation data set for the site Harre is assessed based on the weather data provided by Danish Meteorological Institute (DMI). These data as well as the irradiation report Teknisk Rapport 13-09 by DMI are provided by the client and seem plausible.

DMI observes global horizontal irradiation at 28 ground measured stations in Denmark.

In the case of evaluating the expected global solar irradiation level at Harre, data from climate grid Denmark 20x20 km have been used (grid cell 20025). The data represents the period from 2001 till 2010.

DMI observes air temperature by climate grid Denmark 10x10 km.

The annual global horizontal irradiation at the site given by the examined source sum up to **1.055 kWh/m²a**.

When the photovoltaic modules are installed on a mounting, this will enhance the energy yield.

The conversion to the module plane i.e. at an angle of 25° towards 0° south gives an annual global inclined surface irradiation of **1.277 kWh/m²a** and **1,357 kWh/m²** for total system.

The annual diffuse irradiation, ambient temperature and wind speed have been assessed using Meteonorm 6.3 source.

The data set has been created with the weather simulation program Meteonorm and converted to hourly values with the help of a stochastic model.

2.2.12 Simulation program

The Simulation program used PVsyst v6.86- is a time step-increment simulation program developed by the University of Geneva. Here the individual components like the modules and inverters, their interaction with the fed in weather data and the fully shading scene are simulated on the basis of an hourly time scale over the whole year. The conversion from horizontal to tilted surfaces is in accordance with the model from Perez.

3 Assessment of the System's Technical Design

The PV system under assessment is to be operated with 325 decentral three- phase inverters from the manufacturer Huawei Technologies, which allow high plant availability for use in large solar farms.

3.1 Monitoring

The planned monitoring is evaluated positively because it provides rapid troubleshooting. Additionally the client has stated the intention to take out a maintenance contract with the inverter manufacturer for the entire period of the feed-in. This will provide for rapid servicing of any problems and ensure high system availability.

3.2 Module Certification

The mono crystalline solar modules are manufactured by Longi. The bifacial modules are certified and approved to IEC 61215 and IEC 61730 by TUV Sued. Additional certificates for ammonia corrosion and salt mist corrosion are also available.

3.3 Design and Sizing

The ratio of PV generator rated power (DC power) to the inverter rated power (AC power) has been chosen at 1.18. Considering the irradiation and temperatures at the site Harre, regulation losses might occur in the inverter at this design ratio only for single axis system. These regulation losses cannot be reproduced accurately in the simulation based on hourly average values.

The working voltages of the sub-generators lie within the working voltage range of the inverters. The maximum generator open circuit voltage (at cold temperatures of below -10° C and high irradiation of 1,000 W/m²) at 1,415 V (440 W_p module class), is below the maximum system voltage of the inverter (1,500 V) and the maximum system voltage of the modules (1,500 V).

4 *Forecast Energy Yield*

The yield values shown in the table below are to be regarded as long-term averages and are for a PV plant with an availability of 100 % and a power factor of 1.

Table 1: Annual Energy Yield

Annual Energy Yield	
Simulation program	PVsyst v6.86
Specific yield fix tilt	1,055 kWh/kW_p
Specific yield single axis	1,312 kWh/kW_p
Annual yield fix tilt	7,311 MWh
Annual yield single axis	49,166 MWh
Total annual yield	**56,477 MWh**
Total Specific yield	**1,272 kWh/kW_p**

4.1 *Performance Ratio*

The ratio of the actual amount of electricity generated to the theoretically possible yield at the site is referred to as the Performance Ratio (PR). It serves as a kind of plant efficiency figure in the evaluation of different systems at different locations. Average values are 80 %; very good systems can achieve more than 85 %.

For the system under assessment a PR of **91.2 %** is calculated. Here the bifacial effect with gain on front and back side is included (weighted average).

4.2 *Monthly Distribution of yield (P50 values)*

Table 2: Monthly distribution (P50) fix tilt

Month	GlobInc	T Array	E_Grid	Specific Yield	PR
	[kWh/m²]	[°C]	[MWh]	[kWh/kW$_p$/day]	[%]
January	30	5.0	106	0.49	50.2%
February	54	6.4	239	1.23	63.8%
March	115	11.6	603	2.80	75.5%
April	145	16.9	909	4.37	90.6%
May	180	20.7	1,113	5.18	89.3%
June	182	23.1	1,134	5.45	89.7%
July	176	25.8	1,085	5.05	88.8%
August	151	25.9	925	4.30	88.1%
September	114	22.2	658	3.17	83.0%
October	73	15.9	340	1.58	67.4%
November	32	9.6	124	0.60	56.7%
December	24	5.7	76	0.35	45.9%
Year	**1,277**	**18.0**	**7,311**	**2.89**	**82.6%**

Table 3: Monthly distribution (P50) single axis

Month	GlobInc	T Array	E_Grid	Specific Yield	PR
	[kWh/m²]	[°C]	[MWh]	[kWh/kW$_p$/day]	[%]
January	20	4.8	651	0.56	86.7%
February	44	6.4	1,540	1.47	94.4%
March	113	11.8	4,074	3.51	96.3%
April	163	18.0	5,803	5.16	95.3%
May	223	23.0	7,712	6.64	92.3%
June	236	25.8	8,178	7.27	92.3%
July	222	28.0	7,616	6.55	91.7%
August	172	27.0	5,944	5.12	92.4%
September	121	22.7	4,209	3.74	92.9%
October	64	15.8	2,239	1.93	93.0%
November	23	9.2	748	0.67	88.8%
December	15	5.5	451	0.39	83.2%
Year	**1,413**	**19.1**	**49,166**	**3.59**	**92.8%**

4.3 Uncertainty Analysis

Table 4: Loss factors and uncertainty analysis total system

	Loss/ Gain	Specific Yield	Unit	PR	Uncertainty
Global horizontal irradiation, for collectors		220174.1	m²		
Horizontal global irradiation		**1054.9**	kWh/m²		3.0%
Global incident in coll. plane	31.90%	1394.0	kWh/m²	100%	2.5%
Global incident below threshold	-0.07%	1390.3	kWh/m²	99.9%	0.1%
Near Shadings: irradiance loss	-3.95%	1336.2	kWh/m²	96.0%	0.5%
IAM factor on global	-2.08%	1308.5	kWh/m²	94.0%	0.5%
Soiling loss factor	-1.00%	1295.4	kWh/m²	93.0%	0.5%
Ground reflection on front side	0.49%	**1301.7**	kWh/m²	93.5%	0.1%
Bifacial: Global horizontal irrad. on reference reflexive ground		484777.6	m²		
Global incident on ground		463.3	kWh/m²		
Ground reflection loss (albedo)	-70.00%	139.0	kWh/m²		
Irradiation on the rear side, renormalized to collectors		220174.1	m²		
View Factor for rear side	-67.04%	99.7	kWh/m²		
Sky diffuse on the rear side	25.55%	125.9	kWh/m²		
Beam effective on the rear side	0.36%	126.1	kWh/m²		
Shadings loss on rear side	-5.00%	119.9	kWh/m²		
Global Irradiance on rear side		119.9	kWh/m²		
Useable irradiance on the rear side - Bifacial fact	75.00%	89.9	kWh/m²		
Effective irradiation on collectors		1302.7	kWh/m²		
Global effective energy		**1392.6**	kWh/m²	99.9%	3.0%
on an area of		220174.1	m2		
Total energy on collectors		306822.9	MWh		
STC efficiency		20.19	%		
Array losses					
Array nominal energy at STC efficiency		1380.0	kWh/kW_p	99.0%	
PV loss due to irradiance level	-1.03%	1365.8	kWh/kW_p	98.0%	0.5%
PV loss due to temperature	-0.57%	1358.0	kWh/kW_p	97.4%	0.5%
Shadings: Electrical Loss acc. to strings	-0.63%	1349.4	kWh/kW_p	96.8%	0.5%
LID - Light induced degradation	-1.00%	1335.9	kWh/kW_p	95.8%	0.5%
Module array mismatch loss	-1.00%	1322.5	kWh/kW_p	94.9%	0.5%
Mismatch for back irradiance	-0.85%	1311.2	kWh/kW_p	94.1%	1.0%
Ohmic wiring loss	-0.86%	1300.0	kWh/kW_p	93.3%	1.0%
Array virtual energy at MPP					
System losses					
Inverter Loss during operation (efficiency)	-1.18%	1300.0	kWh/kW_p	93.3%	1.0%
Inverter Loss over nominal inv. power	-0.22%	1297.1	kWh/kW_p	93.1%	
Inverter Loss due to max. input current		1297.1	kWh/kW_p	93.1%	
Inverter Loss over nominal inv. voltage		1297.1	kWh/kW_p	93.1%	
Inverter Loss due to power threshold	-0.01%	1297.1	kWh/kW_p	93.0%	
Inverter Loss due to voltage threshold		1297.1	kWh/kW_p	93.0%	
Night consumption	-0.01%	1297.0	kWh/kW_p	93.0%	
Available Energy at Inverter Output		1297.0	kWh/kW_p	93.0%	
Losses after the inverter					
AC ohmic loss	-0.31%	1292.9	kWh/kW_p	92.7%	0.5%
External transfo loss	-1.62%	1272.0	kWh/kW_p	91.2%	0.5%
Energy injected into grid		**1272.0**	**kWh/kW_p**	**91.2%**	**5.5%**

4.3.1 Margin of variation

Assuming a normal distribution of the expected yields, an annual specific yield between **1,203 kWh/kW$_p$** and **1,341 kWh/kW$_p$** will be achieved with a probability of 68.3 % (one standard deviation) - i.e. **1,272 kWh/kW$_p$ ± 5.5%** (weighted average).

4.3.2 Probability of excess production

There is a probability of 90.0 % that the annual yield will exceed **1,183 kWh/kW$_p$** (P90 weighted average value).

There is a probability of 75.0 % that the annual yield will exceed **1,225 kWh/kW$_p$** (P75 weighted average value).

4.3.3 Variations in annual yield

The annual yield of the planned photovoltaic system could, however, deviate from the forecast given here. The following factors are mainly responsible for this:

Variations in the solar irradiation

Typical meteorological deviations for individual years against the long-term mean can be up to 8 %. In 2003, for example, the solar irradiation in parts of Europe was approximately 20 % above the long-term mean.

Reductions in performance

The actual generator output does not always accord with the sum of the module outputs according to their rating plates. In our yield forecast, we have not taken any output reduction into account.

Power Factor

In order to maintain grid stability some utilities require the supply of reactive power. This is giving by the power factor cos phi which describes the ratio of active power over apparent power. With power factor unequal 1 the active power is reduced thus the plant yield decreases.

Impact of Shading

The behaviour of photovoltaic systems is sensitive to shading. Even the (partial) shading of just a single cell is equivalent to shading all the in-series connected cells of the module concerned. As a result the output performance, even for small shadows such as those caused by overhead lines, lightning conductors, guy wires, antennas or tree branches, can result in output reductions.

Impact of Soiling

For free-standing solar panels, soiling and its associated output reduction cannot be ruled out. The known self-cleaning effect of glass panes by rain requires a minimum module slope of 15 °, which is the case here.

Inverter malfunction

At this site, the largest part of the annual solar energy yield is generated in the time from spring to autumn and only a small portion in the winter months. Inverter malfunctions - especially in the months of highest irradiation - may therefore result in significant yield losses. A monitoring system allows for quick trouble shooting and repair.

Bifacial factor

The bifacial factor is given my module manufacturer and mainly dependent on ground albedo.

5 Glossary

Albedo

Describes the ground reflection of the surroundings of a photovoltaic system. This reflected radiation is added to the irradiation present. If the surroundings are covered with snow, the albedo can reach 95 %. On average the reflection amounts to 20 %.

Azimuth

The azimuth angle gives the orientation of the PV generator. This has the value 0° for an orientation to the South (-90° East, +90° West).

Degradation

Degradation is used to describe the ageing processes in the module, which reduce its performance. The extent of degradation is dependent on the cell materials used; for crystalline modules it has a value of, for example, around 0.25 % annually.

Generator

Several interconnected modules, including the necessary cabling and the mounting assemblies, are described as a generator.

Global irradiation

This describes the total solar radiation that strikes a horizontal surface on earth and is measured in kilowatt-hours per square meter (kWh/m^{2}a) for a specific period (generally yearly).

Inverter

Solar modules generate direct current (DC). If this is to be fed into the mains electricity grid, the direct current must be converted by an inverter into alternating current (AC). Depending on the manufacturer and type, modern inverters have many more functions than just generating alternating current from direct current. These include:

- Operating the modules/string/generator at their maximum power point (MPP tracking)
- Converting the generator voltage up to grid level (transformation)
- Safety devices for monitoring the grid connection
- Feed-in management
- Grid support functions
- Production of reactive power

Irradiation assessment

These are not to be confused with yield reports. Weather services, such as, in Germany, the DWD create an irradiation assessment for a particular location, which depict the periodic progression of solar radiation. Irradiation assessments serve as a basis for yield reports.

Light induced degradation (LID)

LID describes a loss of performances arising in the very first hours of exposure to the sun, with crystalline modules (p-type) based on crystalline silicon cells fabricated on Czochralski (CZ) wafers until it stabilizes.

The LID loss is related to the quality of the wafer manufacturing and may be up to 3%.

Low light behaviour

The low light behaviour defines performances of the module under different irradiations. Usually the relative efficiencies at 200 W/m² and 25°C, with respect to the STC efficiency are taking into account.

As per the module datasheet, the low light behaviour of the module at 200 W/m² ranges between 1 and 5 % efficiency reduction.

Maintenance

In general, PV systems are very low maintenance because the generator responsible for the electricity generation contains no moving parts. However, it is recommended that a maintenance contract is taken out for the undertaking of module cleaning and checking all components so as to avoid outages.

Mismatch

Mismatch is a reduction in the output of a string or entire generator as a result of factory production tolerances. Here, the worst module within a series connection reduces the output of the entire string to its output. Properly pre-selected modules and verification on site can almost completely eliminate mismatch.

Nowadays typical values with plus sorted modules are below 1 % of the system output.

Module

A photovoltaic module generates electricity from sunlight and consists of a pre-assembled unit of solar cells connected together under factory conditions. A module is defined according to its nominal power output, current and voltage with accordingly approved tolerances. In the factory, the solar cells are 'encapsulated' in a solar module to protect them from the effects of weather, air and moisture. Several modules together form a solar generator.

Nominal or rated output

This is a module's peak output in kilowatt peak (kW_p) determined under standard test conditions (STC) in the laboratory. Tolerances are permissible to an extent defined by the manufacturer (e.g. 0/+ 5 W_p). Nowadays one finds mostly plus sorted modules.

To simplify comparison it is usual to relate parameters such as system costs and system yields to the nominal output. The total nominal output of a generator/power plant is the sum of the installed module outputs.

Performance Ratio

The “Performance Ratio” (PR) is an international measure for the efficiency of a complete system in operation. The PR can be described as the proportion of usable energy (at the inverter output) to the nominal value of energy which may be produced, arising from module area, module efficiency (according to data sheet) and the irradiation on the inclined module plane. It therefore allows for a comparison of differently designed installations, which is largely independent of the specific irradiation conditions for location and year. Values over 85 % will be achieved in very good facilities, which comprise the best selected components combined with "perfect" system engineering at a minimally shaded location.

Power Factor

In order to maintain grid stability some utilities require the supply of reactive power (kVAr). This is giving by the power factor cos phi which describes the ratio of active power (kW) over apparent power (kVA). With power factor equally 1 the active power is completely feed into the grid.

Usual power factors for utility scale PV plants might vary between -0.9 (inductive) and +0.9 (capacitive). Thus the active power and the energy feed into the grid are reduced.

Reactive power control

To facilitate higher levels of distributed PV penetration, utility scale PV plants need to participate in voltage regulation. Thus reactive power can be generated as a means of raising voltage levels or absorbed as a means of lowering voltage levels.

Solar Cells

Manufactured from silicon wafers (slices of silicon blocks) or thin film, this smallest electricity-producing unit consists of conducting paths applied to the substrate. Several interconnected solar cells build a solar module. Solar cells produce electricity by utilizing the photovoltaic effect to convert light falling on them.

Solar inclination

The lowest altitude of the sun (equivalent to the lowest solar elevation angle) at noon on the day of the winter solstice (Dec 21st in the northern hemisphere) is generally used as a basis for the shading calculation. This calculation basis is an economic compromise, and does not represent complete freedom of shading, as the sun occupies low positions morning and evening.

Theft protection

Especially in the case of open space facilities some means of theft protection for the modules is usually advisable or will be required by the insurers. Whether a fence is sufficient or the provision of additional safety measures must be determined on a case by case basis. The solar panels should be laid out sufficiently far from a fence to avoid shading.

6 List of figures

7 List of tables

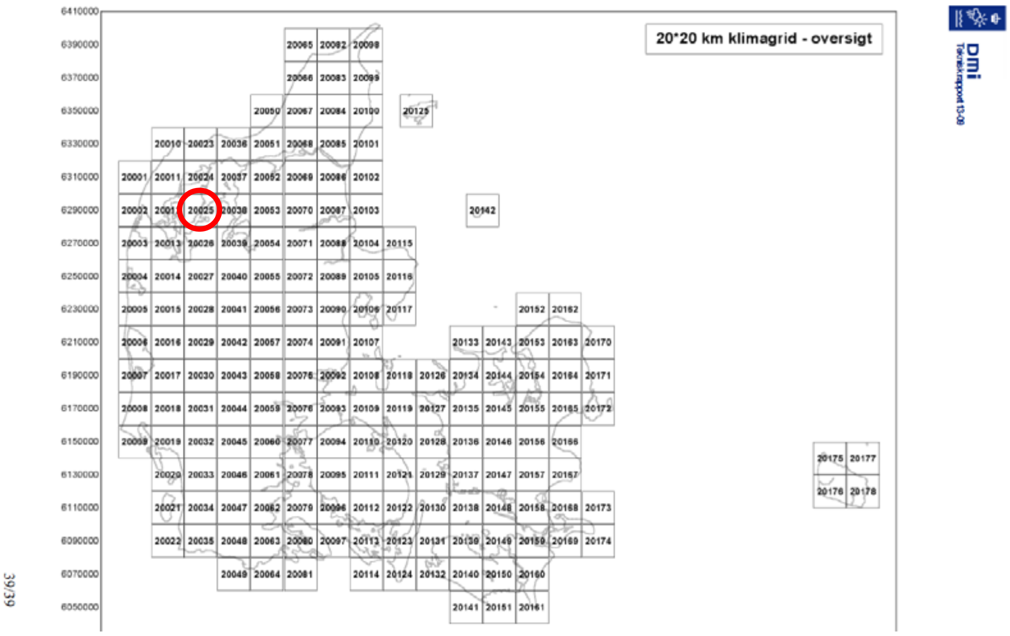
A Appendix

Meteorological Data Summary based on DMI source 2001-2010

meteo for Harre -DK - Synthetically Generated Data

Interval beginning	GlobHor kWh/m².mth	DiffHor kWh/m².mth	T_Amb °C	WindVel m/s
January	14.2	8.20	1.6	6.3
February	30.8	14.70	1.2	5.7
March	79.4	29.60	2.9	5.5
April	120.8	52.50	7.3	5.0
May	167.8	72.50	10.8	5.2
June	177.2	77.40	13.9	5.3
July	166.9	76.30	16.8	4.7
August	132.5	67.70	16.9	4.9
September	88.6	40.20	13.7	5.5
October	48.1	25.80	9.4	5.5
November	17.8	11.50	5.8	6.0
December	10.8	7.10	2.5	5.5
Year	1054.9	483.50	8.6	5.4

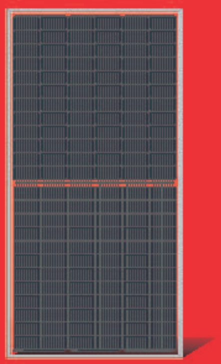
DMI Grid cell 20x20km



Layout (Source: Client):

Datasheets:

PV Modul



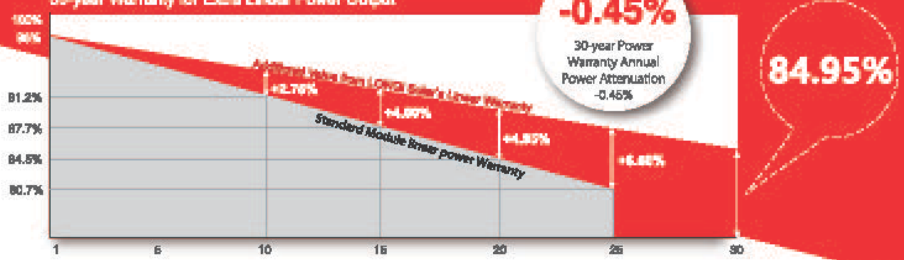
LR4-72HBD

435~455M

Hi-MO4 NEW

High Efficiency
Low LID Bifacial PERC with
Half-cut Technology

10-year Warranty for Materials and Processing;
30-year Warranty for Extra Linear Power Output



Complete System and Product Certifications

IEC 61215, IEC61730, UL61730

ISO 9001:2008: ISO Quality Management System

ISO 14001: 2004: ISO Environment Management System

TS62941: Guideline for module design qualification and type approval

OHSAS 18001: 2007 Occupational Health and Safety

* Specifications subject to technical changes and tests. LONGi Solar reserves the right of interpretation.

Front side performance equivalent to conventional low LID mono PERC:
- High module conversion efficiency (up to 20.9%)
- Better energy yield with excellent low irradiance performance and temperature coefficient
- First year power degradation <2%

Bifacial technology enables additional energy harvesting from rear side (up to 25%)

Glass/glass lamination ensures 30 year product lifetime, with annual power degradation < 0.45%, 1500V compatible to reduce BOS cost

Solid PID resistance ensured by solar cell process optimization and careful module BOM selection

Reduced resistive loss with lower operating current

Higher energy yield with lower operating temperature

Reduced hot spot risk with optimized electrical design and lower operating current

LONGi

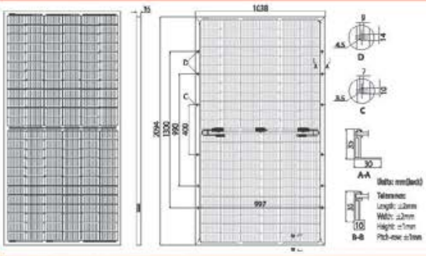
Room 801, Tower 3, Lujiazui Financial Plaza, No.826 Century Avenue, Pudong Shanghai, 200120, China
Tel: +86-21-80162606 E-mail: module@longi-silicon.com Facebook: www.facebook.com/LONGi Solar

Note: Due to continuous technical innovation, R&D and improvement, technical data above mentioned may be of modification accordingly. LONGi have the sole right to make such modification at anytime without further notice; Demanding party shall request for the latest datasheet for such as contract need, and make it a consisting and binding part of lawful documentation duly signed by both parties.

20191205-Draft

LR4-72HBD 435~455M

Design (mm)



Mechanical Parameters

Cell Orientation: 144 (6×24)
Junction Box: IP68, three diodes
Output Cable: 4mm², 300mm in length, length can be customized
Glass: Dual glass 2.0mm coated tempered glass
Frame: Anodized aluminum alloy frame
Weight: 28.0kg
Dimension: 2094×1038×35mm
Packaging: 30pcs per pallet

Operating Parameters

Operational Temperature: -40℃ ~ +85℃
Power Output Tolerance: 0 ~ +5 W
Voc and Isc Tolerance: ±3%
Maximum System Voltage: DC1500V (IEC&UL)
Maximum Series Fuse Rating: 25A
Nominal Operating Cell Temperature: 45±2℃
Safety Class: Class II
Fire Rating: UL type 3
Bifaciality: Glazing ≥70%

Electrical Characteristics

Test uncertainty for Pmax: ±3%

Model Number	LR4-72HBD-435M		LR4-72HBD-440M		LR4-72HBD-445M		LR4-72HBD-450M		LR4-72HBD-455M	
Testing Condition	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax/W)	435	323.5	440	327.2	445	330.9	450	334.6	455	338.3
Open Circuit Voltage (Voc/V)	49.1	45.7	49.2	45.8	49.4	46.0	49.6	46.2	49.8	46.4
Short Circuit Current (Isc/A)	11.36	9.20	11.45	9.27	11.52	9.32	11.58	9.38	11.65	9.43
Voltage at Maximum Power (Vmp/V)	40.8	37.9	41.0	38.1	41.2	38.3	41.4	38.4	41.6	38.6
Current at Maximum Power (Imp/A)	10.66	8.54	10.73	8.60	10.80	8.65	10.87	8.70	10.93	8.76
Module Efficiency(%)	20.0		20.2		20.5		20.7		20.9	

STC (Standard Testing Conditions): Irradiance 1000W/m², Cell Temperature 25℃, Spectra at AM1.5

NOCT (Nominal Operating Cell Temperature): Irradiance 800W/m², Ambient Temperature 20℃, Spectra at AM1.5, Wind at 1m/S

Electrical characteristics with different rear side power gain (reference to 445W front)

Pmax /W	Voc/V	Isc /A	Vmp/V	Imp /A	Pmax gain
467	49.4	12.09	41.2	11.34	5%
490	49.4	12.67	41.2	11.88	10%
512	49.5	13.24	41.3	12.42	15%
534	49.5	13.82	41.3	12.96	20%
556	49.5	14.40	41.3	13.50	25%

Temperature Ratings (STC)

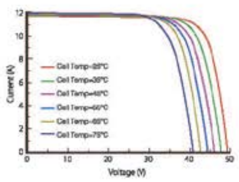
Temperature Coefficient of Isc	+0.060%/℃
Temperature Coefficient of Voc	-0.300%/℃
Temperature Coefficient of Pmax	-0.370%/℃

Mechanical Loading

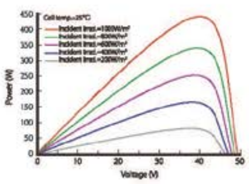
Front Side Maximum Static Loading	5400Pa
Rear Side Maximum Static Loading	2400Pa
Hailstone Test	25mm Hailstone at the speed of 23m/s

I-V Curve

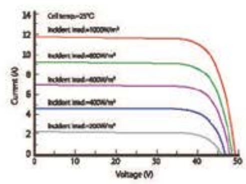
Current-Voltage Curve (LR4-72HBD-445M)



Power-Voltage Curve (LR4-72HBD-445M)



Current-Voltage Curve (LR4-72HBD-445M)



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20191205-Draft

Inverter

Item	SUN2000-90K TL-H0	SUN2000-90K TL-H1	SUN2000-90K TL-H2	SUN2000-95K TL-INH0	SUN2000-95K TL-INH1
x H x D)					
Net weight	76±1 kg	76±1 kg	79±1 kg	76±1 kg	79±1 kg
Operating temperature	–25°C to +60°C				
Cooling mode	Natural convection				
Highest operating altitude	4000 m				
Operating relative humidity	0%–100% RH				
Input terminal	Amphenol UTX				
Output terminal	Cable gland + OT/DT terminal				
Overvoltage level	II (DC)/III (AC)				
IP rating	IP65				
Protection level	I				
Pollution degree	III				

10.2 SUN2000-(100KTL, 105KTL) Series Technical Data

Efficiency

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Maximum efficiency	99.00%			
Chinese efficiency	98.55%	N/A	98.55%	N/A
EU efficiency	98.80%	98.80%	98.80%	98.80%

Input

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Maximum input	112,200 W	107,100 W	112,200 W	118,400 W

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
power				
Maximum input voltage	1500 V	1500 V	1500 V	1500 V
Maximum input current (per MPPT)	22 A	22 A	25 A	25 A
Maximum short-circuit current (per MPPT)	33 A			
Maximum backfeed current to the PV array	0 A			
Lowest operating/startup voltage	600/650 V			
Operating voltage range	600–1500 V			
Full-load MPPT voltage range	880–1300 V			
Rated input voltage	1080 V			
Number of inputs	12			
Number of MPP trackers	6			

Output

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Rated active power	100 kW	100 kW	100 kW	105 kW
Maximum apparent power	110 kVA	105 kVA	110 kVA	116 kVA
Maximum active power (cosφ = 1)	110 kW	105 kW	110 kW	116 kW
Rated output voltage	800 V AC, 3W+PE			
Rated output current	72.2 A	72.2 A	72.2 A	75.8 A
Adapted power grid frequency	50 Hz/60 Hz			
Maximum output	80.2 A	80.2 A	80.2 A	84.6 A

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
current				
Power factor	0.8 leading... 0.8 lagging			
Maximum total harmonic distortion (rated power)	< 3%			

Protection

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Input DC switch	Supported			
Anti-islanding protection	Supported			
Output overcurrent protection	Supported			
Input reverse connection protection	Supported			
PV string fault detection	Supported			
DC surge protection	Type II			
AC surge protection	Type II			
Insulation resistance detection	Supported			
Residual current monitoring	Supported			

Display and Communication

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Display	LED, Bluetooth module + app, USB data cable + app			
RS485	Supported			
PLC	Supported			

Common Parameters

Item	SUN2000-100KTL-H0	SUN2000-100KTL-H1	SUN2000-100KTL-H2	SUN2000-105KTL-H1
Dimensions (W x H x D)	1075 mm x 605 mm x 310 mm			
Net weight	76±1 kg	76±1 kg	79±1 kg	79±1 kg
Operating temperature	–25°C to +60°C			
Cooling mode	Natural convection			
Highest operating altitude	4000 m			
Operating relative humidity	0%–100% RH			
Input terminal	Amphenol UTX			
Output terminal	Cable gland + OT/DT terminal	• With the terminal clamp: cable gland + terminal clamp • With the OT/DT terminal: cable gland + OT/DT terminal	Cable gland + OT/DT terminal	Cable gland + OT/DT terminal
Overvoltage level	II (DC)/III (AC)			
IP rating	IP65			
Protection level	I			
Pollution degree	III			

PVsyst Simulation Results

SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 1/5
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Grid-Connected System: Simulation parameters

Project :	**Harre**			
Geographical Site	**Harre -DK**		Country	**Denmark**
Situation	Latitude	56.72° N	Longitude	8.93° E
Time defined as	Legal Time	Time zone UT+1	Altitude	30 m
	Albedo	0.20		
Meteo data:	**Harre -DK**	DMI 2001-2010 - Synthetic		

Simulation variant :	**Fix tilt**			
	Simulation date	28/02/20 10h04		

Simulation parameters	System type	**Sheds on ground**		
Collector Plane Orientation	Tilt	25°	Azimuth	0°
Sheds configuration	Nb. of sheds	294	Identical arrays	
	Sheds spacing	6.30 m	Collector width	4.21 m
Shading limit angle	Limit profile angle	35.6°	Ground cov. Ratio (GCR)	66.8 %
Models used	Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon	Free Horizon			
Near Shadings	According to strings		Electrical effect	100 %
Bifacial system	Model	Unlimited sheds, 2D calculation		
	Sheds spacing	6.30 m	Sheds width	4.21 m
	Limit profile angle	35.6°	GCR	66.8 %
	Ground albedo	30.0 %	Height above ground	0.50 m
	Module bifaciality factor	75 %	Rear shading factor	5.0 %
	Module transparency	0.0 %	Rear mismatch loss	10.0 %
User's needs :	Unlimited load (grid)			

PV Arrays Characteristics (2 kinds of array defined)

Sub-array "Fix tilt 435"	Si-mono	Model	**LR4-72 HBD 435 M- fk**		
Custom parameters definition		Manufacturer	Longi Solar		
Number of PV modules		In series	26 modules	In parallel	182 strings
Total number of PV modules		Nb. modules	4732	Unit Nom. Power	435 Wp
Array global power		Nominal (STC)	**2058 kWp**	At operating cond.	1868 kWp (50°C)
Array operating characteristics (50°C)		U mpp	947 V	I mpp	1972 A
Sub-array "Fix tilt 440"	Si-mono	Model	**LR4-72 HBD 440 M- fk**		
Custom parameters definition		Manufacturer	Longi Solar		
Number of PV modules		In series	26 modules	In parallel	426 strings
Total number of PV modules		Nb. modules	11076	Unit Nom. Power	440 Wp
Array global power		Nominal (STC)	**4873 kWp**	At operating cond.	4424 kWp (50°C)
Array operating characteristics (50°C)		U mpp	950 V	I mpp	4656 A
Total	Arrays global power	Nominal (STC)	**6932 kWp**	Total	15808 modules
		Module area	**34360 m²**	Cell area	31368 m²

Inverter	Model	**SUN2000-105KTL-H1-fk**		
Custom parameters definition	Manufacturer	Huawei Technologies		
Characteristics	Operating Voltage	600-1500 V	Unit Nom. Power	105 kWac
			Max. power (=>25°C)	116 kWac

Grid-Connected System: Simulation parameters

Sub-array "Fix tilt 435"	Nb. of inverters	15 units	Total Power	1575 kWac
			Pnom ratio	1.31
Sub-array "Fix tilt 440"	Nb. of inverters	36 units	Total Power	3780 kWac
			Pnom ratio	1.29
Total	Nb. of inverters	51	Total Power	5355 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	1.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	8.0 mOhm	Loss Fraction	1.5 % at STC
	Array#2	3.4 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	1.0 %
Module Quality Loss			Loss Fraction	0.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

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

System loss factors

AC wire loss inverter to transfo	Inverter voltage	800 Vac tri		
	Wires: 3x20000.0 mm²	596 m	Loss Fraction	0.6 % at STC
External transformer	Iron loss (24H connexion)	10282 W	Loss Fraction	0.1 % at STC
	Resistive/Inductive losses	1.08 mOhm	Loss Fraction	1.2 % at STC

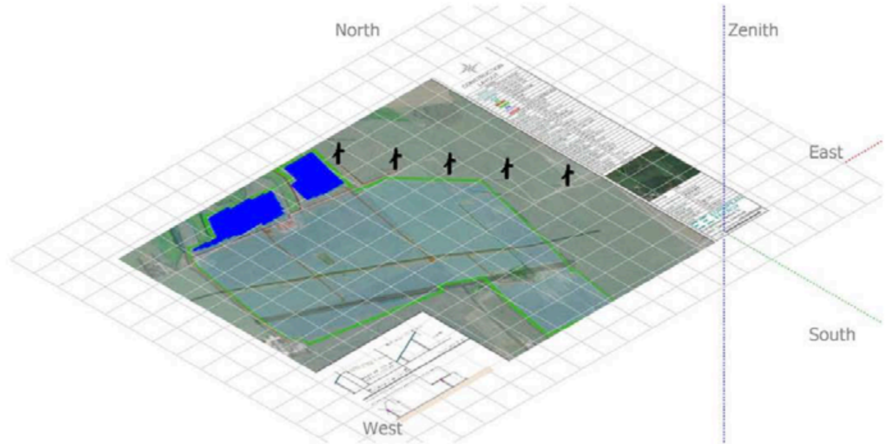
Grid-Connected System: Near shading definition

Project : **Harre**

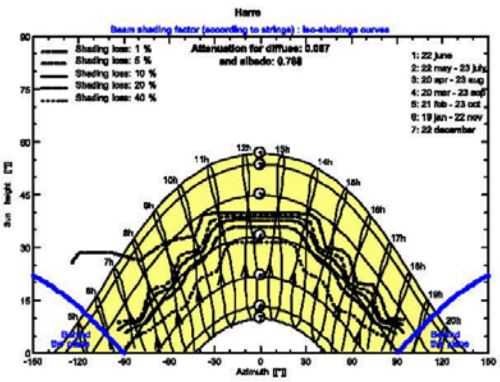
Simulation variant : **Fix tilt**

Main system parameters	System type	**Sheds on ground**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	LR4-72 HBD 435 M- fk	Pnom	435 Wp
PV modules	Model	LR4-72 HBD 440 M- fk	Pnom	440 Wp
PV Array	Nb. of modules	15808	Pnom total	**6932 kWp**
Inverter	Model	SUN2000-105KTL-H1-fk	Pnom	105 kW ac
Inverter pack	Nb. of units	51.0	Pnom total	**5355 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 4/5
	info@solarpraxis.com			

Grid-Connected System: Main results

Project : **Harre**

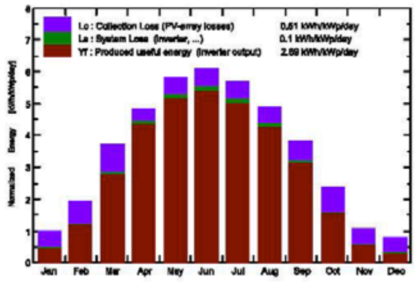
Simulation variant : **Fix tilt**

Main system parameters	System type	**Sheds on ground**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	LR4-72 HBD 435 M- fk	Pnom	435 Wp
PV modules	Model	LR4-72 HBD 440 M- fk	Pnom	440 Wp
PV Array	Nb. of modules	15808	Pnom total	**6932 kWp**
Inverter	Model	SUN2000-105KTL-H1-fk	Pnom	105 kW ac
Inverter pack	Nb. of units	51.0	Pnom total	**5355 kW ac**
User's needs	Unlimited load (grid)			

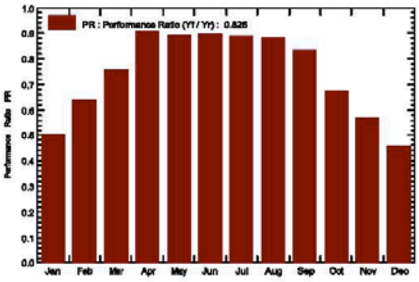
Main simulation results

System Production	**Produced Energy**	**7311 MWh/year**	Specific prod.	1055 kWh/kWp/year
	Performance Ratio PR	82.62 %		

Normalized productions (per installed kWp): Nominal power 6932 kWp



Performance Ratio PR



Fix tilt

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	14.2	8.20	1.60	30.4	20.2	116	106	0.502
February	30.8	14.70	1.20	54.1	41.5	250	239	0.638
March	79.4	29.60	2.90	115.1	102.6	621	603	0.755
April	120.8	52.50	7.30	144.8	135.2	936	909	0.906
May	167.8	72.50	10.80	179.8	168.0	1146	1113	0.893
June	177.2	77.40	13.90	182.3	170.1	1166	1134	0.897
July	166.9	76.30	16.80	176.3	164.4	1116	1085	0.888
August	132.5	67.70	16.90	151.3	140.8	952	925	0.881
September	88.6	40.20	13.70	114.4	105.4	679	658	0.830
October	48.1	25.80	9.40	72.8	59.8	353	340	0.674
November	17.8	11.50	5.80	31.6	22.5	134	124	0.567
December	10.8	7.10	2.50	23.8	15.1	85	76	0.459
Year	1054.9	483.50	8.61	1276.6	1145.3	7555	7311	0.826

Legends:
- GlobHor: Horizontal global irradiation
- DiffHor: Horizontal diffuse Irradiation
- T_Amb: T amb.
- 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

SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 5/5
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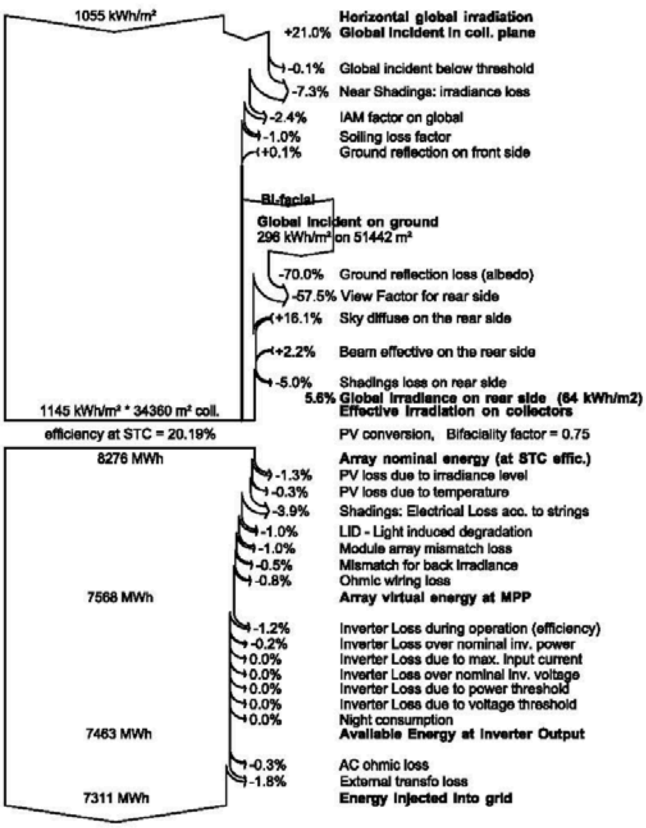
Grid-Connected System: Loss diagram

Project : **Harre**

Simulation variant : **Fix tilt**

Main system parameters	System type	**Sheds on ground**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tilt	25°	azimuth	0°
PV modules	Model	LR4-72 HBD 435 M- fk	Pnom	435 Wp
PV modules	Model	LR4-72 HBD 440 M- fk	Pnom	440 Wp
PV Array	Nb. of modules	15808	Pnom total	**6932 kWp**
Inverter	Model	SUN2000-105KTL-H1-fk	Pnom	105 kW ac
Inverter pack	Nb. of units	51.0	Pnom total	**5355 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



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SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 1/5
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Grid-Connected System: Simulation parameters

Project :	**Harre**				
Geographical Site		**Harre -DK**		Country	**Denmark**
Situation		Latitude	56.72° N	Longitude	8.93° E
Time defined as		Legal Time	Time zone UT+1	Altitude	30 m
		Albedo	0.20		
Meteo data:		**Harre -DK**	DMI 2001-2010 - Synthetic		

Simulation variant :	**Single Axis**				
		Simulation date	28/02/20 10h15		

Simulation parameters		System type	**Tracking system with backtracking**		
Tracking plane, tilted Axis		Axis Tilt	0°	Axis Azimuth	11°
Rotation Limitations		Minimum Phi	-55°	Maximum Phi	55°
		Tracking algorithm	Astronomic calculation		
Backtracking strategy		Nb. of trackers	275	Identical arrays	
		Tracker Spacing	5.00 m	Collector width	2.10 m
Backtracking limit angle		Phi limits	+/- 64.9°	Ground cov. Ratio (GCR)	42.1 %
Models used		Transposition	Perez	Diffuse	Perez, Meteonorm
Horizon		Free Horizon			
Near Shadings		According to strings		Electrical effect	100 %
Bifacial system		Model	Unlimited trackers, 2D calculation		
		Tracker Spacing	5.00 m	Tracker width	2.14 m
		Backtracking limit angle	64.5°	GCR	42.9 %
		Ground albedo	30.0 %	Axis height above ground	1.50 m
		Module bifaciality factor	75 %	Rear shading factor	5.0 %
		Module transparency	0.0 %	Rear mismatch loss	10.0 %
User's needs :		Unlimited load (grid)			

PV Arrays Characteristics (2 kinds of array defined)

Sub-array "Single Axis 435"	Si-mono	Model	**LR4-72 HBD 435 M- fk**		
Custom parameters definition		Manufacturer	Longi Solar		
Number of PV modules		In series	26 modules	In parallel	986 strings
Total number of PV modules		Nb. modules	25636	Unit Nom. Power	435 Wp
Array global power		Nominal (STC)	**11152 kWp**	At operating cond.	10119 kWp (50°C)
Array operating characteristics (50°C)		U mpp	947 V	I mpp	10681 A
Sub-array "Single Axis 440"	Si-mono	Model	**LR4-72 HBD 440 M- fk**		
Custom parameters definition		Manufacturer	Longi Solar		
Number of PV modules		In series	26 modules	In parallel	2302 strings
Total number of PV modules		Nb. modules	59852	Unit Nom. Power	440 Wp
Array global power		Nominal (STC)	**26335 kWp**	At operating cond.	23906 kWp (50°C)
Array operating characteristics (50°C)		U mpp	950 V	I mpp	25160 A
Total	Arrays global power	Nominal (STC)	**37487 kWp**	Total	85488 modules
		Module area	**185814 m²**	Cell area	169636 m²
Inverter		Model	**SUN2000-105KTL-H1-fk**		
Custom parameters definition		Manufacturer	Huawei Technologies		
Characteristics		Operating Voltage	600-1500 V	Unit Nom. Power	105 kWac
				Max. power (=>25°C)	116 kWac

Grid-Connected System: Simulation parameters

Sub-array "Single Axis 435"	Nb. of inverters	82 units	Total Power	8610 kWac
			Pnom ratio	1.30
Sub-array "Single Axis 440"	Nb. of inverters	192 units	Total Power	20160 kWac
			Pnom ratio	1.31
Total	Nb. of inverters	274	Total Power	28770 kWac

PV Array loss factors

Array Soiling Losses			Loss Fraction	1.0 %
Thermal Loss factor	Uc (const)	29.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
Wiring Ohmic Loss	Array#1	1.5 mOhm	Loss Fraction	1.5 % at STC
	Array#2	0.63 mOhm	Loss Fraction	1.5 % at STC
	Global		Loss Fraction	1.5 % at STC
LID - Light Induced Degradation			Loss Fraction	1.0 %
Module Quality Loss			Loss Fraction	0.0 %
Module Mismatch Losses			Loss Fraction	1.0 % at MPP

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

System loss factors

AC wire loss inverter to transfo	Inverter voltage	800 Vac tri		
	Wires: 3x20000.0 mm²	110 m	Loss Fraction	0.6 % at STC
External transformer	Iron loss (24H connexion)	55602 W	Loss Fraction	0.1 % at STC
	Resistive/Inductive losses	0.200 mOhm	Loss Fraction	1.2 % at STC

SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 3/5
	info@solarpraxis.com			

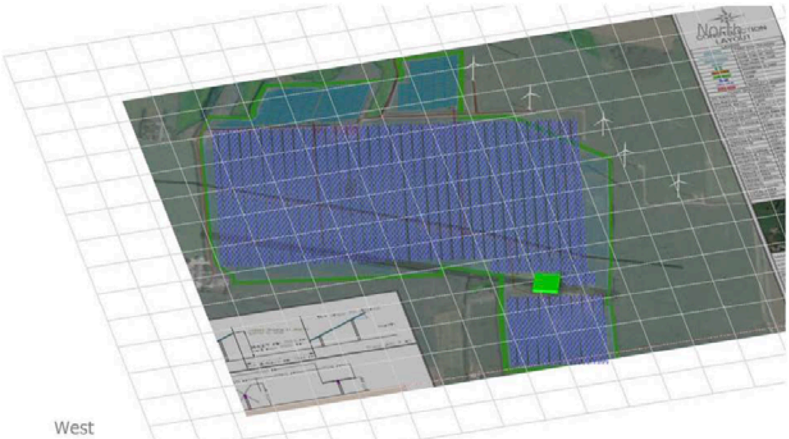
Grid-Connected System: Near shading definition

Project : **Harre**

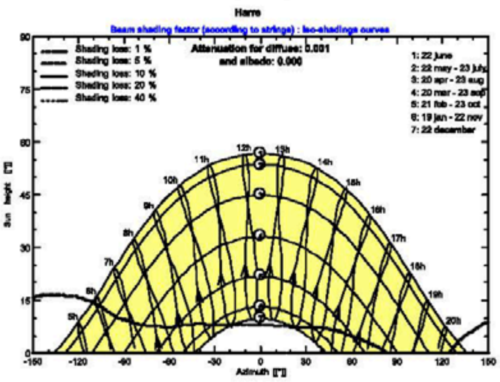
Simulation variant : **Single Axis**

Main system parameters	System type	**Tracking system with backtracking**		
Near Shadings	According to strings		Electrical effect	100 %
PV Field Orientation	tracking, tilted axis, Axis Tilt	0°	Axis Azimuth	11°
PV modules	Model	LR4-72 HBD 435 M- fk	Pnom	435 Wp
PV modules	Model	LR4-72 HBD 440 M- fk	Pnom	440 Wp
PV Array	Nb. of modules	85488	Pnom total	**37487 kWp**
Inverter	Model	SUN2000-105KTL-H1-fk	Pnom	105 kW ac
Inverter pack	Nb. of units	274.0	Pnom total	**28770 kW ac**
User's needs	Unlimited load (grid)			

Perspective of the PV-field and surrounding shading scene



Iso-shadings diagram



SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 4/5
	info@solarpraxis.com			

Grid-Connected System: Main results

Project : **Harre**

Simulation variant : **Single Axis**

Main system parameters	System type	**Tracking system with backtracking**		
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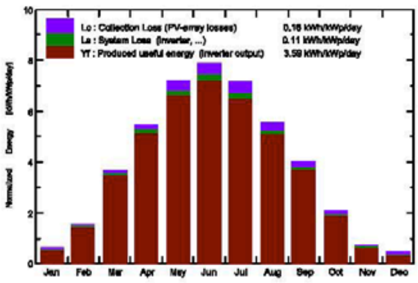
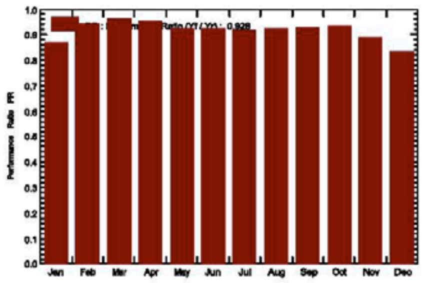
User's needs	Unlimited load (grid)			

Main simulation results				
System Production	**Produced Energy**	**49166 MWh/year**	Specific prod.	1312 kWh/kWp/year
	Performance Ratio PR	92.80 %		

Normalized productions (per installed kWp): Nominal power 37487 kWp



Performance Ratio PR



Single Axis

Balances and main results

	GlobHor kWh/m²	DiffHor kWh/m²	T_Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E_Grid MWh	PR
January	14.2	8.20	1.60	20.0	17.7	705	651	0.867
February	30.8	14.70	1.20	43.5	40.0	1604	1540	0.944
March	79.4	29.60	2.90	112.8	106.5	4194	4074	0.963
April	120.8	52.50	7.30	162.5	154.0	5968	5803	0.953
May	167.8	72.50	10.80	222.9	211.9	7936	7712	0.923
June	177.2	77.40	13.90	236.3	224.3	8410	8178	0.923
July	166.9	76.30	16.80	221.7	210.1	7833	7616	0.917
August	132.5	67.70	16.90	171.6	161.9	6114	5944	0.924
September	88.6	40.20	13.70	120.9	114.1	4335	4209	0.929
October	48.1	25.80	9.40	64.2	59.5	2322	2239	0.930
November	17.8	11.50	5.80	22.5	20.1	802	748	0.888
December	10.8	7.10	2.50	14.5	12.6	502	451	0.832
Year	1054.9	483.50	8.61	1413.3	1332.7	50726	49166	0.928

Legends:
- GlobHor: Horizontal global irradiation
- DiffHor: Horizontal diffuse Irradiation
- T_Amb: T amb.
- 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

SOLARPRAXIS engineering	PVSYST V6.86	Solarpraxis (Germany)	28/02/20	Page 5/5
	info@solarpraxis.com			

Grid-Connected System: Loss diagram

Project : **Harre**

Simulation variant : **Single Axis**

Main system parameters	System type	**Tracking system with backtracking**		
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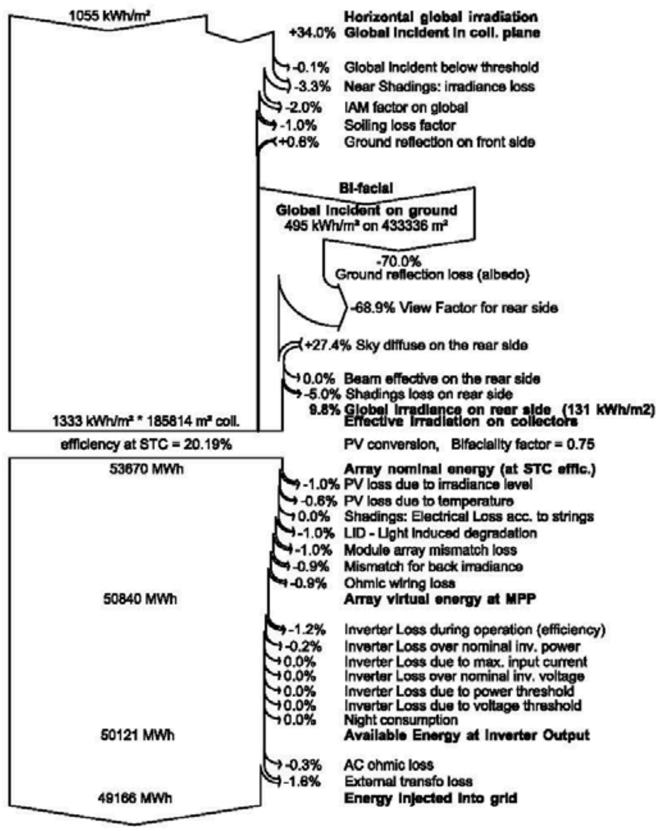
Loss diagram over the whole year



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