Agro-solar power plant SE Kutnjak – feasibility study

2023/04/05

Zagreb, Croatia

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1. INTRODUCTION

This report presents the results of the feasibility report for agrosolar power plant SE Kutnjak project, a photovoltaic solar power plant coupled with the enhancement of agro production on the development area The product is developed by EEG Group.

The project of agro-solar power plant Kutnjak of total connection capacity of 299 MWac and installed capacity up to 360 MWdc which is located in North-West part of Croatia. Project is developed on ≈250 ha (2,5 million m^2) of agricultural land including the up to 300x300m location of future connection substation 400/35 kV Kutnjak. The project is divided into 3 phases, each up to 99 MW of connection capacity.

This agro-solar power plant is developed to offer renewable power to the grid in Central and South Europe while maintaining the agro production in the area and increasing the inclusion of local stakeholder. Immediate surrounding of the future solar plant is experiencing demand for renewable power capacity and existing PPA and spot prices support development of this project.

Furthermore, the project facilitates the green energy transition of the Republic of Croatia which aims to increase the total solar power capacity and increase its own independence and the independence of the EU and follow the goals set by the recent strategic EU documents. Yearly power deficit in Croatia amounts 10,5 TWh leading to the average import of 1200 MWh per hour with deficit increasing in 2022 due to low hydrology. Location is also excellent to deliver power to Austrian and Hungarian customers – cross border high voltage (400 kV) connection is available. The region and EU are experiencing high electricity prices similar to the case is Croatia with average prices increasing more than 500% from 2020 until 2022.Croatian electrical energy market CROPEX can be considered as relevant price defining mechanism.

Project initiator is a Swiss company (EEG Advisory Trade & Logistic GmbH "EEG ATL") holding 100% EEG Energy Gas d.o.o. and BEB Solar d.o.o.(SPV). The EEG ATL GmbH provides front end project development financing for land acquisition, spatial planning and zoning, securing technology for both solar and for agricultural production, commercial and technical consultancy is provided by Faculty of Electrical Engineering and Computing, University of Zagreb, Shearman & Sterling Frankfurt, Risen Energy CO. Ltd, Law Firm Horvat & Zebec & Bajsić Bogović j.t.d and SMA GmbH Solar technology Germany.

The plant's conceptual configuration considering the use east-west structures and preferred equipment

Table 1 General data of the agro-solar SE Kutnjak project

Description	Value
SPP Kutnjak	Agro-solar power plant
Peak power (DC)	359 MWdc
Rated power (AC)	299 MWac
Ratio DC/AC	1.20 (20% overpanelling)
Ground coverage ratio (GCR)	80 %
Structure type	East-west structure
Pitch distance / Tilt angle	10.45 m / up to 15 ° to 22 °
PV Modules (700.0 Wp Jinko Solar)	512736
Power station (up to 5000 kW)	65
Number of inverters (up to 5000 kVA)	65

The primary tasks for this document are:

- Solar resource assessment, using meteorological data for the site location;
- Estimation of the energy production;
- Estimation of associated uncertainty estimate to energy's production;
- Estimation of expected costs;
- General assessment of the project viability.

No solar resource measurements campaigns were conducted at the project's location yet. In the absence of local measurements, the analysis was based on a long term meteorological databases.

The annual energy production estimate was calculated with PVdesign developed by company RatedPower based in Madrid, Spain.

2. KUTNJAK/SELNICA PODRAVSKA SITE

2.1. General location

The agrosolar project SE Kutnjak location has the characteristics shown in table below (Table 2). The project is located in the northern Croatia in the municipalities of Kutnjak and Selnica Podravska under the Koprivnica-Križevci county.

The location in the region is shown on Figure 1 with the closer look at the location of Kutnjak on the general map visible on Figure 2.

Table 2 Location characteristics

PV Plant location characteristics	
City / Town	Selnica Podravska
Region	Koprivnica-Križevci County
Country	Croatia
Latitude	+46.28 °
Longitude	+16.77 °
Altitude	135.36 m a.m.s.l.
Timezone	UTC +1

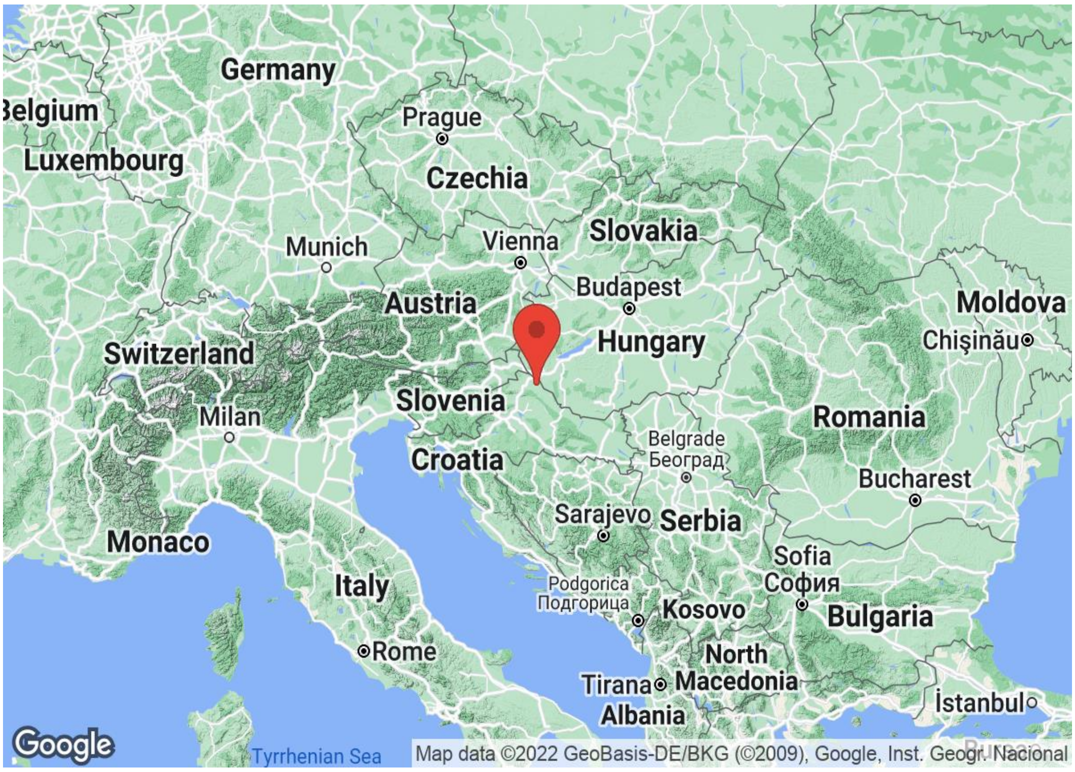


Figure 1 Location of SE Kutnjak in the region of Koprivnica-Križevci County, in Croatia

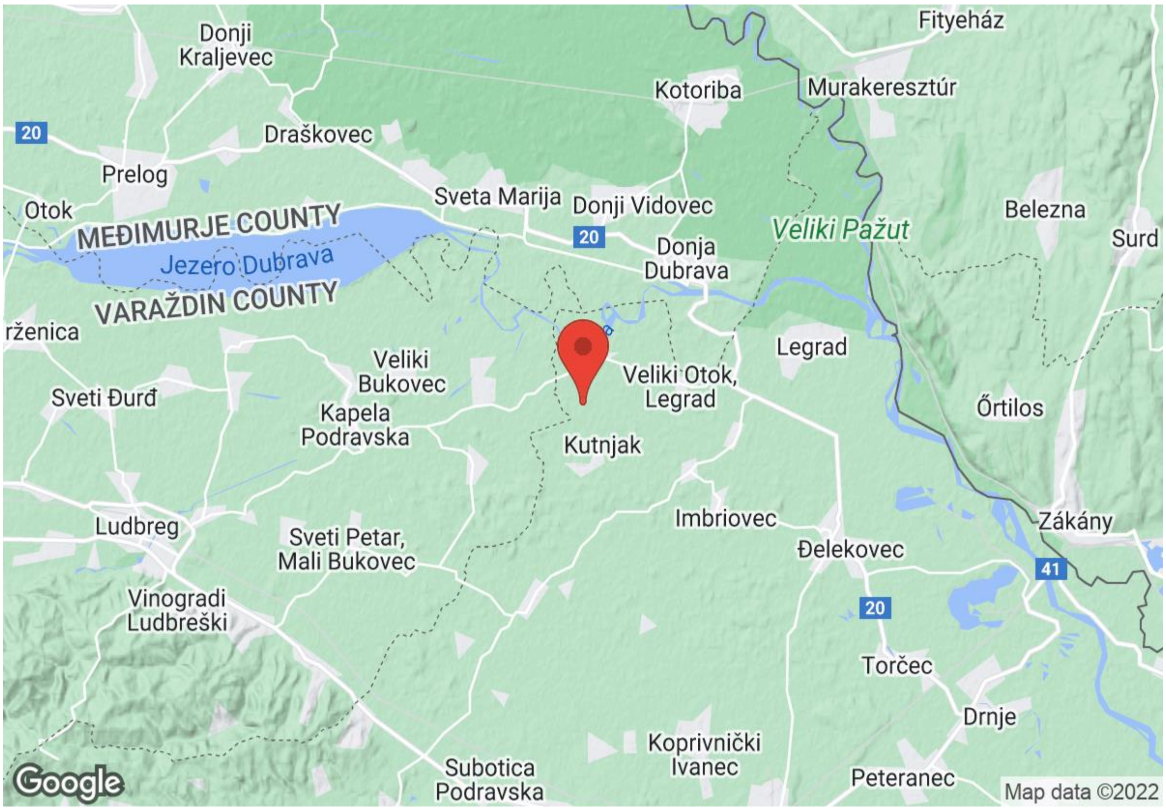


Figure 2 Closer view of the SE Kutnjak in the region of Koprivnica-Križevci County

2.2. Area and surface coverage

The area where the agro-solar power plant Kutnjak is to be built consists of a single total available area that is all connected and convex. The total area on which the project is developed includes 250 ha with a total surface area of expected panel coverage of approximately 154 ha.

The assumed number of solar panels for the expected installed capacity of 359 MWdc is 512736. Panel dimensions are 2384x1303 (3,106 m^2). Direct panel coverage is panel number x panel surface x cos(tilt angle 15°) = 1.538.467 m^2 or 153,8 ha. The selected tilt angle can be adjusted in accordance to the needs and construction required for the agro production. The tilt angle of 8° leads to the surface area covered with the panels which is panel number x panel surface x cos(tilt angle) = 512736 x 3,106 x cos(8°) = 157,7 ha.

The 46 central inverter stations take 1367 m2 (29,724 m^2 each) and the transformer station direct construction area is 120x120 meters which together with inverters equals to 1,5 ha.

The direct construction element coverage is around 155 ha which comes down to ≈62% of surface coverage. The allowed surface coverage on the Kutnjak/Selnica site is 80% in accordance with the spatial plan of the municipality and furthermore there are no limitations for the agrosolar area usage.

The size of each area and the total suitable area for installation purposes is shown in Table 3 with the graphical representation on figure below (Figure 3).

Table 3 Size of plot areas of the project

Area	Surface
Available areas	
Total project land	250.3 ha
Restricted areas – roads and security perimeters	
Existing transmission 400 kV line corridor	3.59 ha
Connection line transmission 400 kV line corridor	2.05 ha
Substation access road	0.22 ha
Existing roads corridor	0.75 ha
Substation outer maximum boundaries area	
Substation outer perimeter area	4.26 ha

Figure 3 Plot areas of the SE Kutnjak

EEG Group is in the process of securing the ownership/rights for the 100% of the area on which the project is developed. The contracts with all the owners have been prepared and the majority of the area has already been secured or the land concession for 99 years has been signed with the local authorities. The status as of end of March 2023 of the land ownership is shown in the table (Table 4) with the graphical representation of the process shown on figure below (Figure 4).

Table 4 The ownership status of the area on which SE Kutnjak is developed, not including additional approximately 3,8 ha that are also owned by the project

Area	Surface	Percentage
AREA types based on situation of the cadastral units *Status vlasništa katastarskih čestica uključenih u obuhvat*	m^2	% of total area
Privately owned land (purchase in process) *Privatno zemljište (u procesu kupnje)*	1.291.387	51,59%
Land secured by EEG Group *Zemljište pod koncesijom EEG Grupe*	753.121	30,09%
Land secured (Land owned in full) by EEG Group *Zemljište u vlasništvu EEG Grupe*	352.274	14,07%
In acquisition process from the Republic of Croatia / Local authorities *U procesu dobivanja koncesije za korištenje zemljišta*	17.339	0,69%
Land secured (Land access ways and roads - usage rights acquired) *Zemljište s osiguranim pristupom (putevi i ceste)*	71.725	2,87%
Developed area in totals: *Ukupna površina zemljišta uključenog u obuhvat*	2.502.984	100%

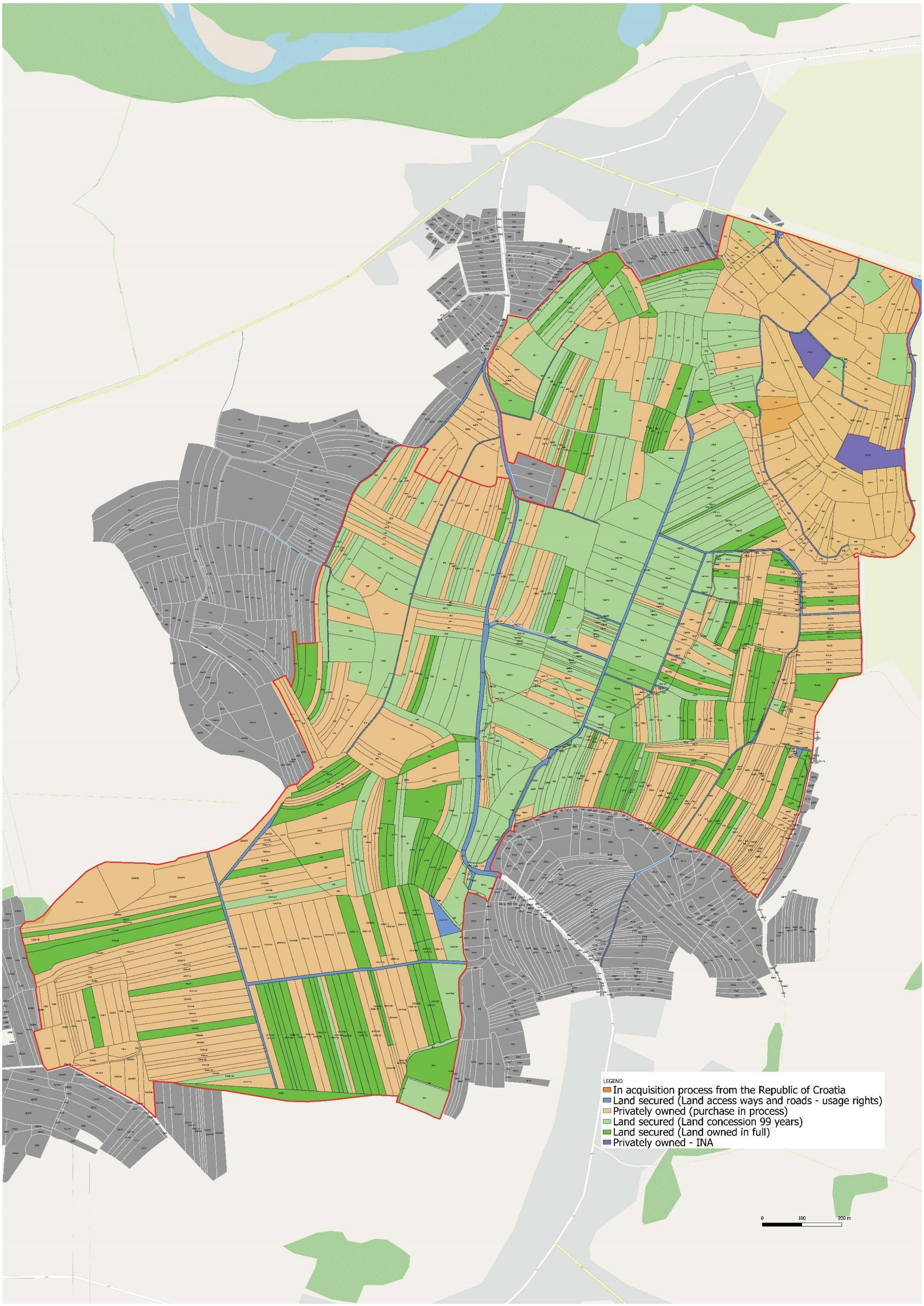


Figure 4 Land ownership status on agrosolar project SE Kutnjak developed area in April 2023

2.3. Topography

A preliminary terrain topography analysis was performed to study the suitability of the terrain for the construction of a photovoltaic plant. The North-South and East-West slopes were calculated and are shown in Figure 5.

The grid resolution of the elevation data is 30.0 m (North-South and East-West directions). This data was provided by Google Earth (SRTM-30).

The analysis of the terrain slopes results in three differentiated areas:

Zones where the slope is lower than 5.00 %.
Zones where the slope is between 5.00 % and 10.00 %.
Zones where the slope is greater than 15.00 %.

The slopes measured on site when performing a detailed topographical analysis could be greater than the slopes obtained using this analysis.

The map shown in Figure 5 the represents the slopes of the terrain, with the following colors representing:

- Slopes <5.00 %
- Slopes >5.00 % and <10.00 %
- Slopes >10.00 % and <15.00 %
- Slopes >15.00 %

Using the previously mentioned elevation data, the position of the mounting structures in the terrain was calculated. The slope of the terrain in the North-South and East-West directions under the structures was calculated. The position of the structure posts was also calculated, including ground elevation and post height.

The preliminary conclusion is that the topography at the SE Kutnjak location is suitable and there are no predicted problems with the terrain preparation and installation of the PV panels.

The land is agricultural and flat with access roads available from all directions of the total area that is predefined for SE Kutnjak.

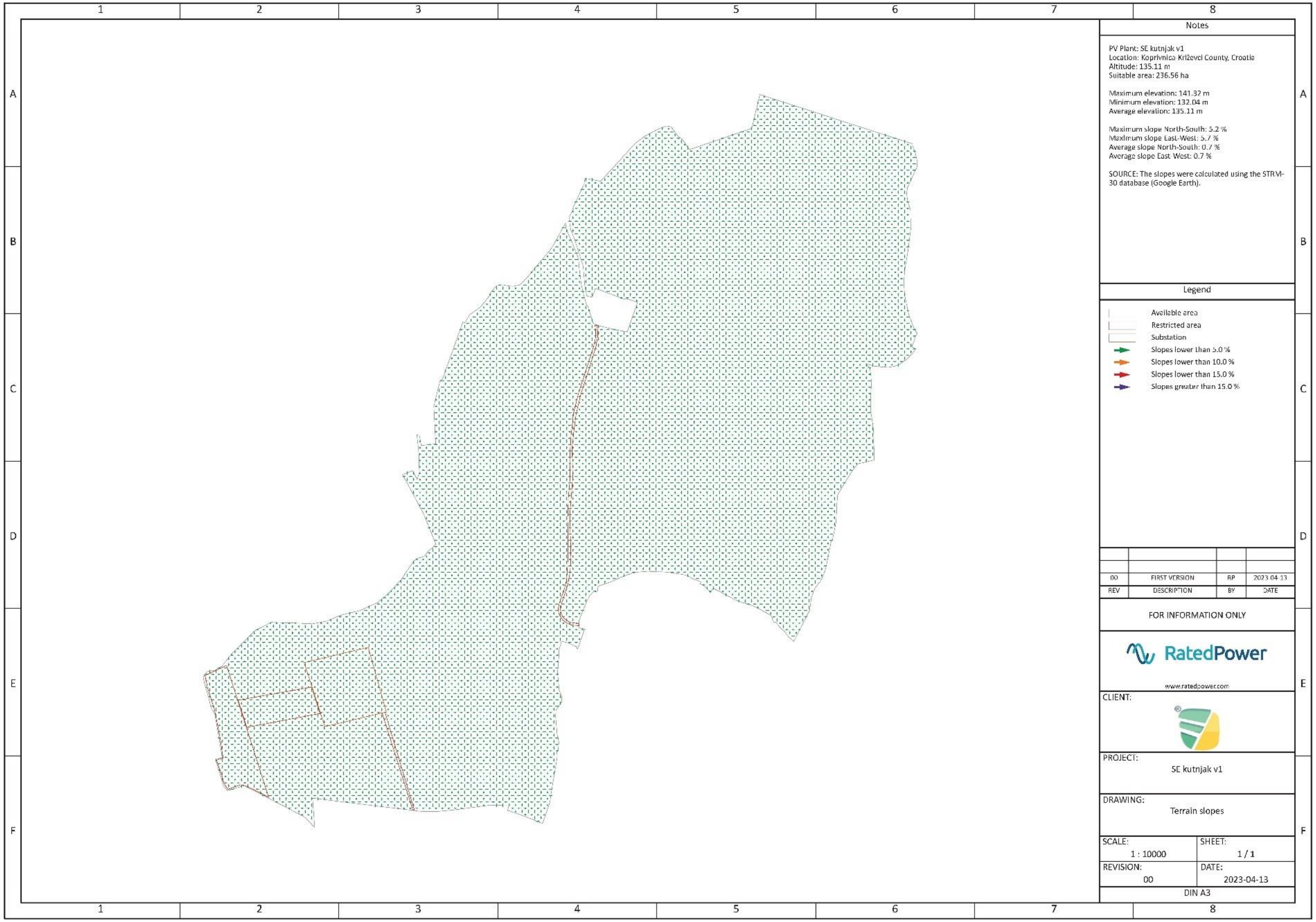


Figure 5 Slopes of the plot areas of SE Kutnjak

2.4. Horizon profile

The solar irradiance reaching the photovoltaic modules will change if there are hills or mountains on the horizon. These physical obstructions will block the beam component of the irradiance during some periods of the day and will have an impact on the diffuse component as well. Therefore, the horizon profile directly impacts the energy yield of the photovoltaic plant.

The horizon line has an average elevation of 0.4° and a maximum elevation of 0.8°. Throughout the year, the Sun will be blocked by the horizon line for a expected total of 34 hours. The data source for the horizon line was the PVGIS 5 database.

The blocked elevations over the complete azimuth range are shown in Figure 6.

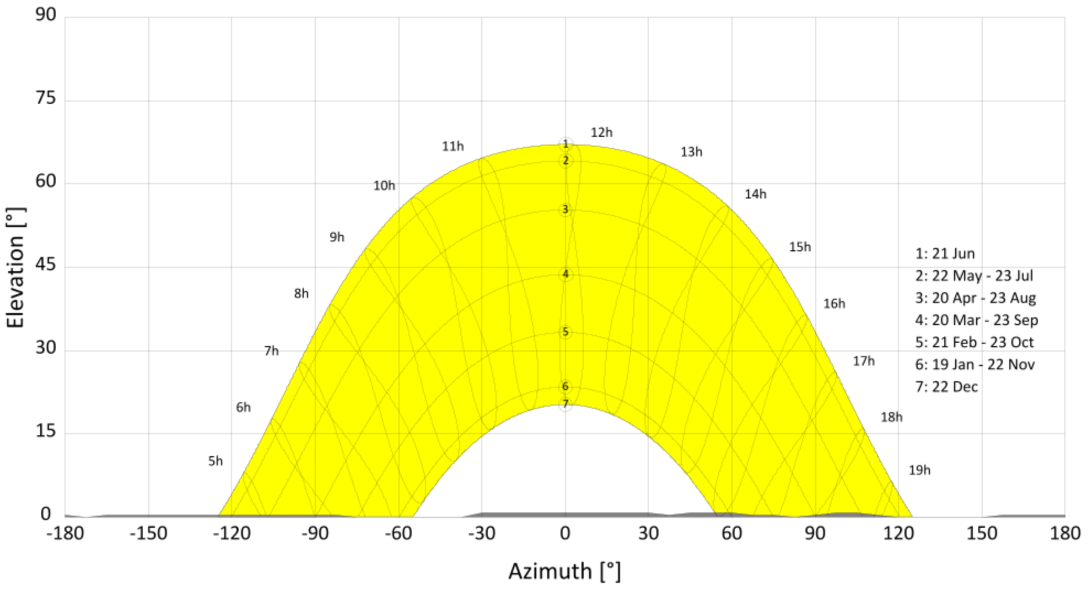


Figure 6 Horizon profile (data source: PVGIS 5)

Other than the terrain horizon blockage, obstacles above ground level blockages were also screened, such as houses or trees, which may also produce shadow and depreciate energy production and preliminary assessment is that there are no problems in regard to the horizon profile due to the area being flat and agricultural and outside the high built residential buildings.

3. SOLAR RESOURCE

The aim of the solar resource analysis is to provide an estimation of the solar energy the photovoltaic power plant on a specific location would receive throughout a typical year.

The solar resource is usually given as a series of hourly values for the irradiance and temperature, for a period of one year. This series is called the Typical Meteorological Year (TMY).

The source used to generate the TMY was the PVGIS database. It includes meteorological data ranging from 2005 to the present (the actual period used may vary depending on the location) and has a spatial resolution of 4 km by 4km.

The uncertainty of the PVGIS data varies between ±3% to ±10%, depending on the location and the recent years show an increase of solar days trends and increase of average production per square meter..

The trends based on statistics of production of existing solar power plants in Croatia in the recent years also show the growing number of sunny hours and less cloud cover meaning the expected production on the Kutnjak/Selnica location could be even higher which will be confirmed with the solar measurement on the location which is planned to be set up in 2023.

The hourly temperature values found in the TMY yield the following aggregates for the given location of Kutnjak/Selnica podravska which are important for solar panel efficiency consideration:

- Minimum temperature: -21.48 °C.
- Maximum temperature: 35.59 °C.
- Average temperature: 11.79 °C.

The results of the solar resource analysis are shown in the table - Table 5.

A chart representing these results is shown on figure below (Figure 7).

Table 5 Solar resource monthly values

Month	GHI [kWh/m2]	DHI [kWh/m2]	Temperature
1	48.5	21.6	5.46 °C
2	37.4	29.4	-2.56 °C
3	92.0	47.6	6.48 °C
4	137.9	58.2	11.25 °C
5	175.8	71.9	15.94 °C
6	202.7	78.0	21.66 °C
7	201.3	64.4	24.17 °C
8	166.6	65.3	21.07 °C
9	89.7	52.3	16.13 °C
10	76.0	35.9	13.57 °C
11	38.3	24.0	3.49 °C
12	32.9	18.1	3.61 °C
Year	**1299.1**	**566.8**	**11.69 °C**

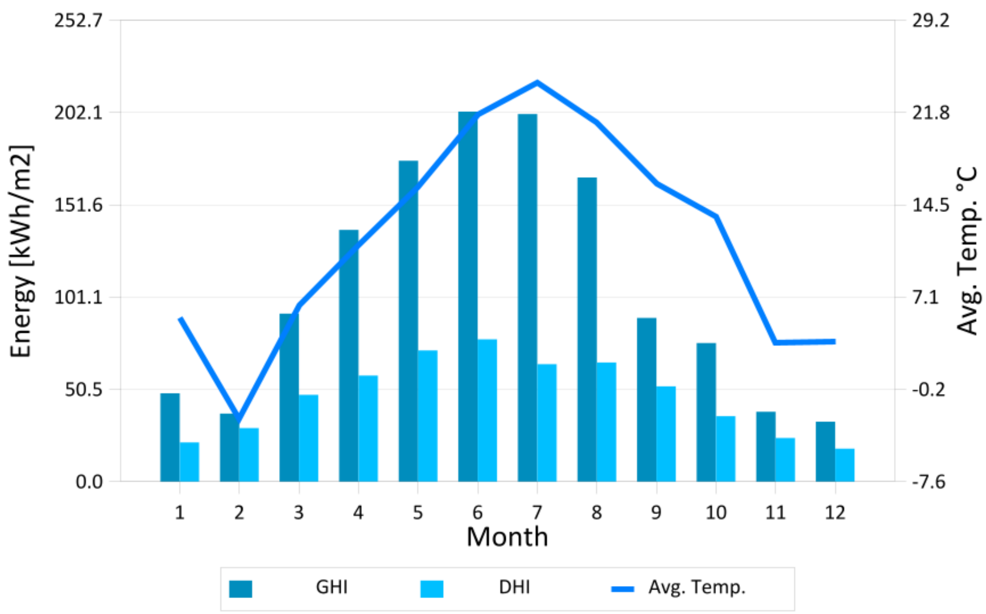


Figure 7 Horizon profile (data source: PVGIS 5)

3.1. PVGIS data source

PVGIS has been in continuous development for more than 10 years at the European Commission Joint Research Centre. The focus of PVGIS is solar resource assessment research, photovoltaic (PV) performance studies, and the dissemination of knowledge and data about solar radiation and PV performance.

The latest version of PVGIS (PVGIS 5.2) has extended the capabilities of the system and improved the coverage of the meteorological database. PVGIS 5.2 uses PVGIS-SARAH-2, PVGIS-NSRDB and PVGIS-ERA5 databases.

The main features of the PVGIS 5.2 database are:

- Source: satellite.
- Spatial coverage: Worldwide.
- Time period: at least ten years starting in 2005 or 2006 depending on the region.
- Spatial resolution: site dependent, with an average value of 4 km x 4 km.
- Temporal resolution: hourly.
- Uncertainty: site dependent, ±3% to ±10% on average.

In Figure 8 the spatial coverage of the PVGIS 5.2 database is shown with PVGIS-Sarah2 covering the area of Croatia.

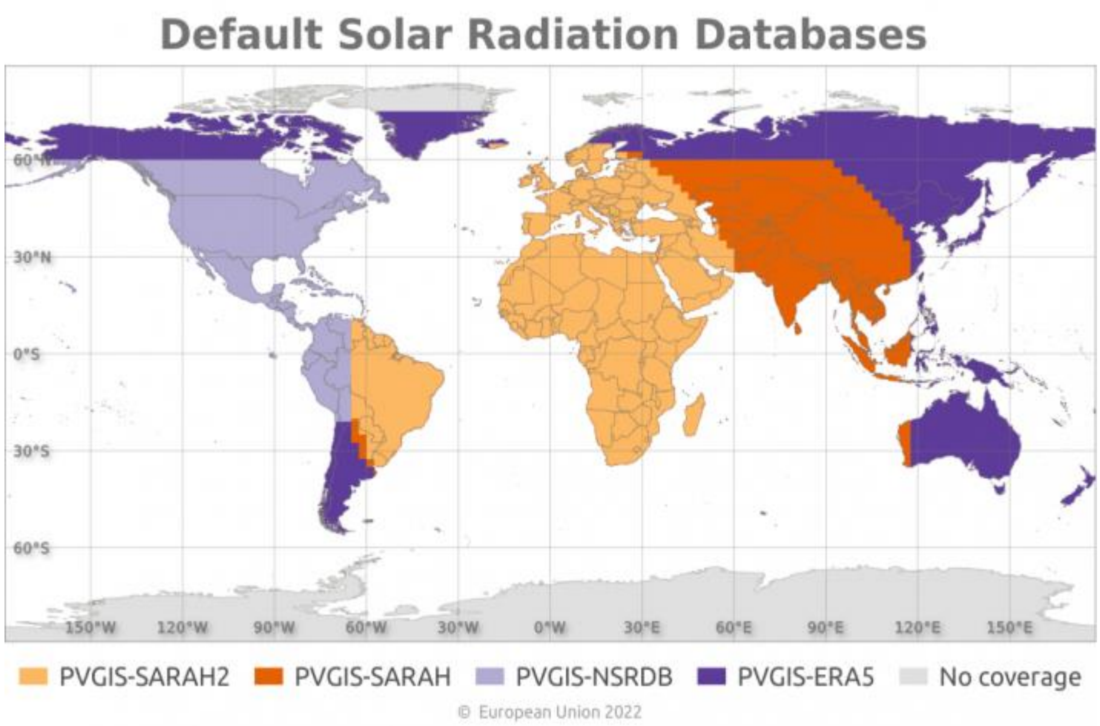


Figure 8 Spatial coverage of the PVGIS 5.2 database.

The solar irradiance data of PVGIS has been calculated using satellite data. There are several satellite databases available as mentioned previously:

- PVGIS-SARAH-2 is a database based on data provided by the EUMETSAT CM SAF. It uses the images of the METEOSAT geostationary satellites covering Europe, Africa and Asia. The temporal period is 2005 to 2020.
- PVGIS-NSRDB is a collaboration between PVGIS and the NREL (National Renewable Energy Laboratory), and it consists of the implementation of the NSRDB in PVGIS. The temporal period is from 2005 to 2015.

3.2. Typical Meteorological Year (P50)

The Typical Meteorological Year (TMY) is a set of representative values of any given meteorological parameter, for some given location. It is given in hourly resolution and is derived from long-term meteorological data.

In Table 6 a monthly summary of the TMY data is shown. A chart representing the data is shown in the figure below (Figure 9).

Table 6 TMY monthly irradiation and temperature.

Month	GHI [kWh/m2]	DHI [kWh/m2]	Temperature
1	48.5	21.6	5.46 °C
2	37.4	29.4	-2.56 °C
3	92.0	47.6	6.48 °C
4	137.9	58.2	11.25 °C
5	175.8	71.9	15.94 °C
6	202.7	78.0	21.66 °C
7	201.3	64.4	24.17 °C
8	166.6	65.3	21.07 °C
9	89.7	52.3	16.13 °C
10	76.0	35.9	13.57 °C
11	38.3	24.0	3.49 °C
12	32.9	18.1	3.61 °C
Year	**1299.1**	**566.8**	**11.69 °C**

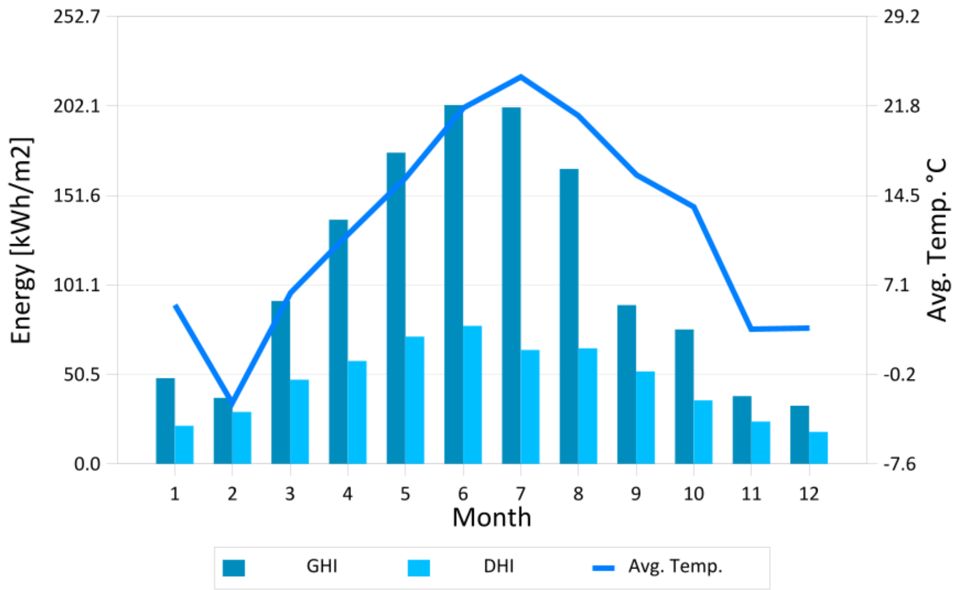


Figure 9 Solar resource chart for agrosolar power plant SE Kutnjak location

The selected albedo in the project corresponds to the "Grass" surface type since agro-solar production is planned and the area below the solar panels will be an agricultural one.

A fixed surface albedo value of 25 % was considered for the year which can be considered an expected bifacial gain for the expected surface type.

4. MAIN EQUIPMENT

The main equipment used to convert solar energy to electricity is similar in all solar power plants with some adjustments. Therefore, in SE Kutnjak project there will be installed:

- Photovoltaic modules, which convert solar radiation into direct current.
- The string combiner boxes, which consolidate the output of the strings of photovoltaic modules before reaching the inverter.
- Central inverters, which convert DC from solar field to AC.
- Power Transformers, which raise the voltage level from low voltage on the inverters to medium voltage of the solar power plant.
- Power Station, which holds the necessary equipment to convert the DC power to AC and connect the power plant to the transmission system.

The electrical configuration of the PV plant can be seen in Figure 10.

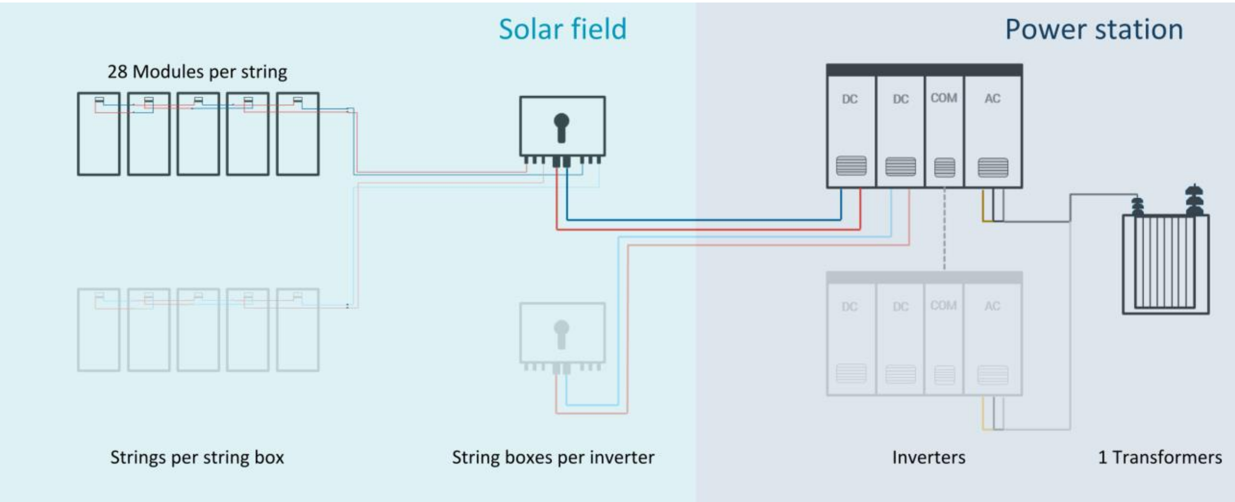


Figure 10 Simplified electrical configuration diagram

4.1. Photovoltaic module

The selected photovoltaic module is the RSM132-8-690BNDG Bifacial model, manufactured by Risen Energy Co., Ltd. It has a peak power of 700 W, and the technology of the cells is Si-mono. The average output power can vary ±3% and these modules are available in 715 Wp formats.

The features of the photovoltaic module are shown in Table 7 in accordance with the producer datasheets.

The module has a bifaciality factor of 80.00 % for the usage of back-face irradiation and for the increase of total production.

Table 7 Photovoltaic module characteristics

Photovoltaic Risen energy RSM132-8-690BNDG Bifacial model module characteristics	
Main characteristics	
Module model	RSM132-8-690BNDG
Manufacturer	Risen Energy Co., Ltd
Technology	Si-mono
Type of module	Bifacial
Maximum voltage	1500 V
Standard test conditions (STC)	
Peak power	700.0 W
Efficiency	22.26 %
MPP voltage	39.1 V
MPP current	17.67 A
Open circuit voltage	47.4 V
Short circuit current	18.54 A
Temperature coefficients	
Power coefficient	-0.320 %/°C
Voltage coefficient	-0.260 %/°C
Current coefficient	0.046 %/°C
Mechanical characteristics	
Length	2384.0 mm
Width	1303.0 mm
Thickness	35.0 mm
Weight	38.5 kg

An example picture of a selected bifacial of silicone monocrystalline (Si-mono) module is shown in Figure 11.

Figure 11 Example of a selected Bifacial Si-mono photovoltaic module

4.2. East-west panel structures

The modules will be mounted on a customized east-west structure. The structure will establish the orientation and inclination of the modules that is to an extend adoptable based on the terrain. Also, the separation between the rows can also be adjusted.

The structure will be composed of the following elements:

- A mounting structure formed by different types of metallic profiles.
- Foundation elements for anchoring the structure to the ground.
- Clamping elements and screws to assemble the structure and for mounting the modules on the structure.
- Structural reinforcement elements.

An example of one of the tables of the east west structure that will be used on one side of the structures is shown in Figure 12. Two vertical modules alignment (2V) is assumed to be used on each of the sides of the structure. The structure height can be modular and range from 1,2 meters to 4,5 meters height. The minimum height is based on the minimum height required for agro production beneath the modules.

The elements and concept of the east-west orientation is depicted on the figure below showing all the important elements - Figure 13.

The main features of the east west structure are shown in Table 8.

What is important to note is that based on the type of agro production that will be an important component of the agrosolar power plant SE Kutnjak the height of the structure can be adjusted on different segment of the total area.

Figure 12 Example of a table (2V) with 2 vertical panels aligned

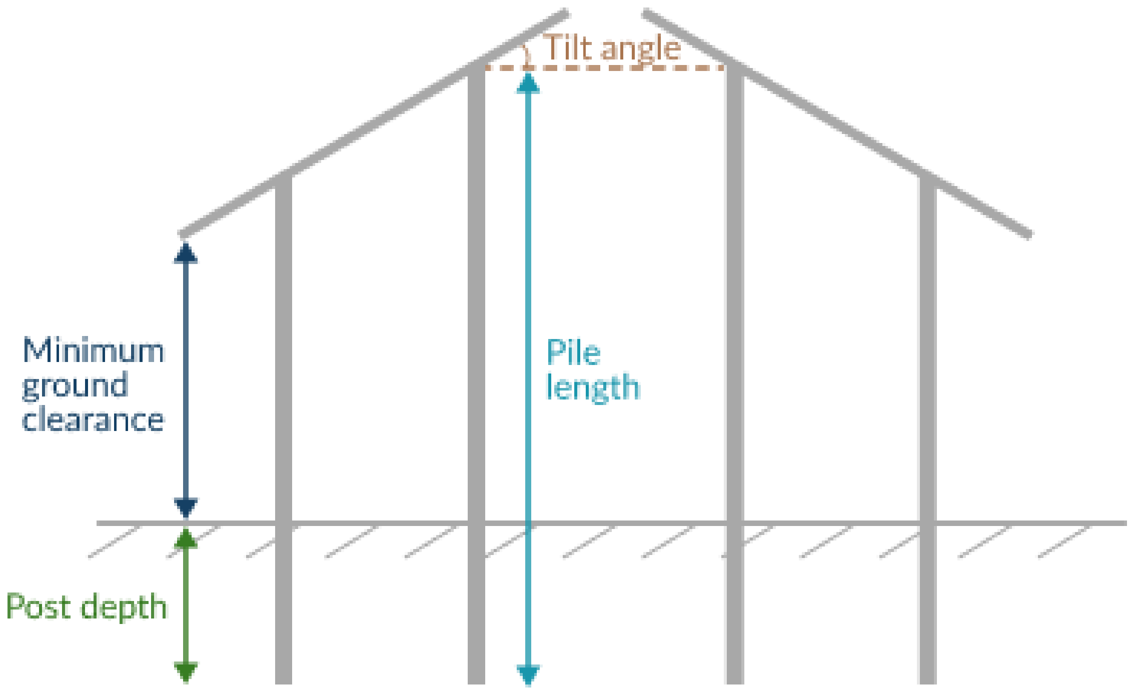


Figure 13 Example of an east-west structure dimensions definition

Table 8 Main characteristics of the east west mounting structure

East west structure characteristics	
Structure type	2 vertical alignments
Tilt angle	5° to 21°
Poles type	Bi pole
Pitch distance	10,45 m
Designed for	BIFACIAL modules
Minimum ground clearance	Min 1,2 meters with 4,5 meters max
Gap between modules in the axis direction	20 mm
Gap between modules in the pitch direction	19 mm
Ridge distance	0.2 m
Row to row clearance	1.0 m

The general overview of the values from table can be seen from the 3D representation of the SE Kutnjak on the figure below:

- Figure 14 General overview of the 3D model of SE Kutnjak
- Figure 15 Detail showing the structures, distances, and central inverter positioning example

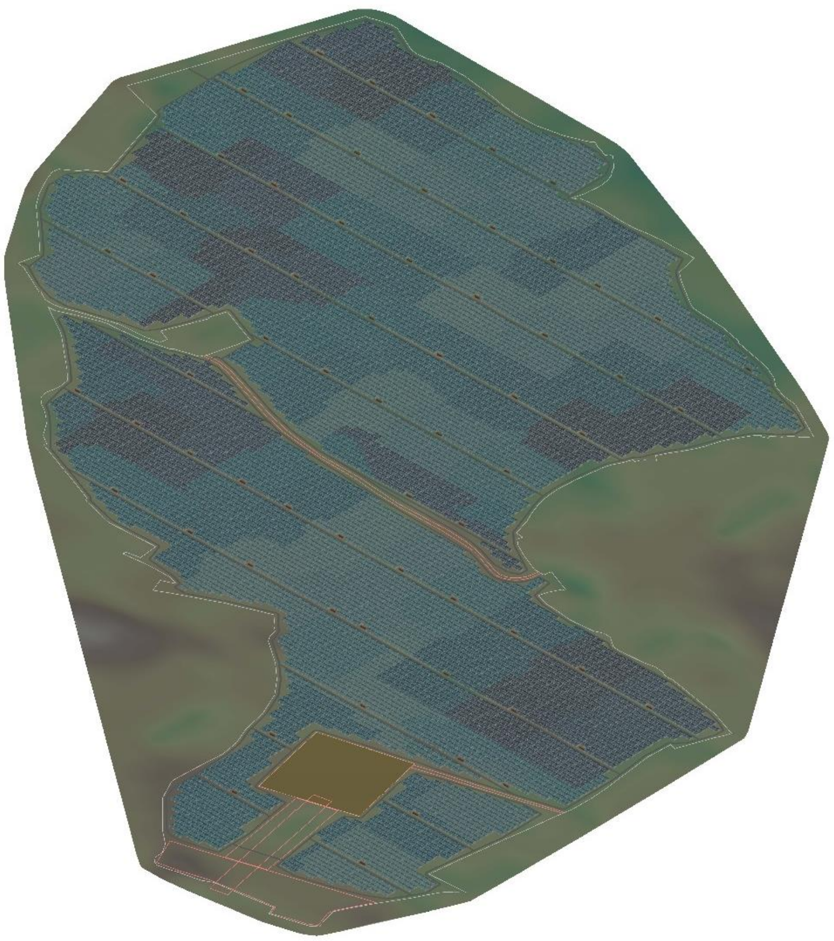


Figure 14 General overview of the 3D model of SE Kutnjak

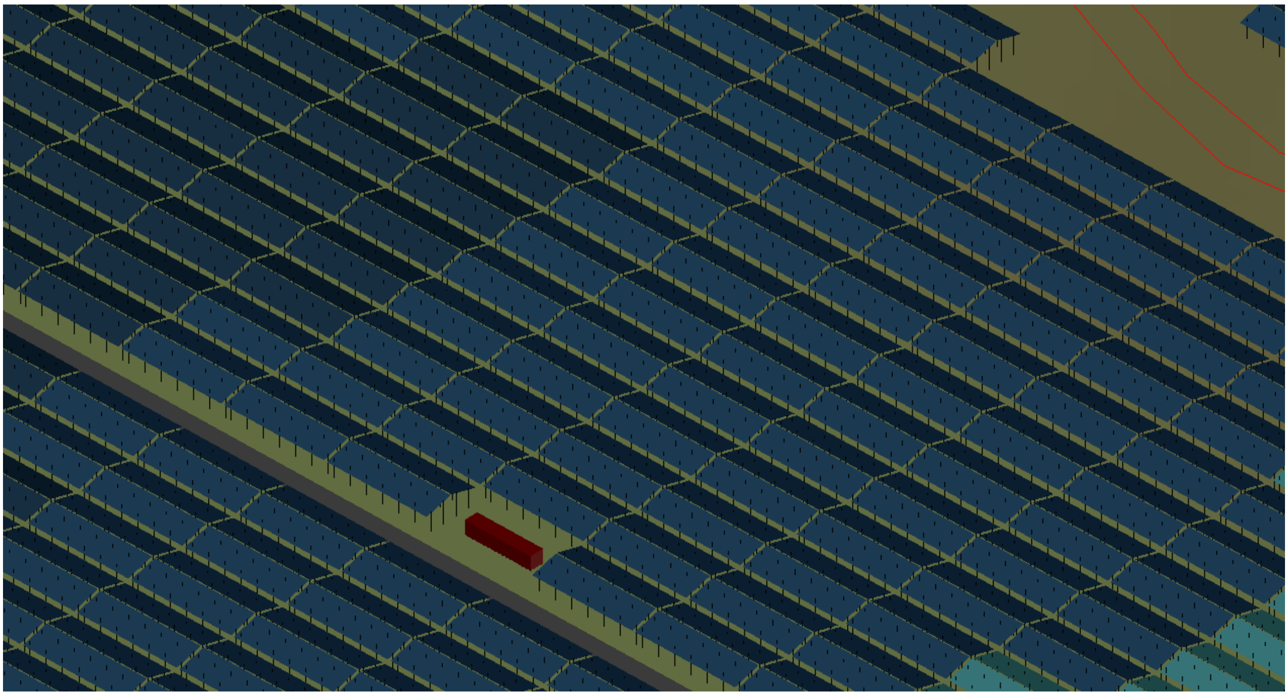


Figure 15 Detail showing the structures, distances, and central inverter positioning example

4.3. String combiner box

The string boxes collect the power generated by the DC array of the solar panels, connect the strings in parallel to the inverter, and provide electrical protection to the PV field/strings. To match the number of inputs of the inverters, several parallel strings will be concentrated to function as a single circuit. Junction boxes shall be installed with a fuse per string to protect each array. Overvoltage DC dischargers will be installed, and one DC switch will be situated in the output line. Additionally, a communication system will be installed to monitor the string current and voltage on a central SCADA system. An example of a string box is shown in Figure 16.

Figure 16 Example string box (Schneider Electric)

The string boxes will be installed in a shaded area under the panels and shall be easily accessible to facilitate maintenance. They will be placed behind the PV modules and use existing structure poles f east-west structure, so that they remain shaded as much as possible and to prevent damage caused by rainwater or other meteorological phenomena.

The main features of the different types of string boxes that are required for a predicted layout of agrosolar power plant SE Kutnjak are shown in Table 9.

Table 9 Main string box characteristics

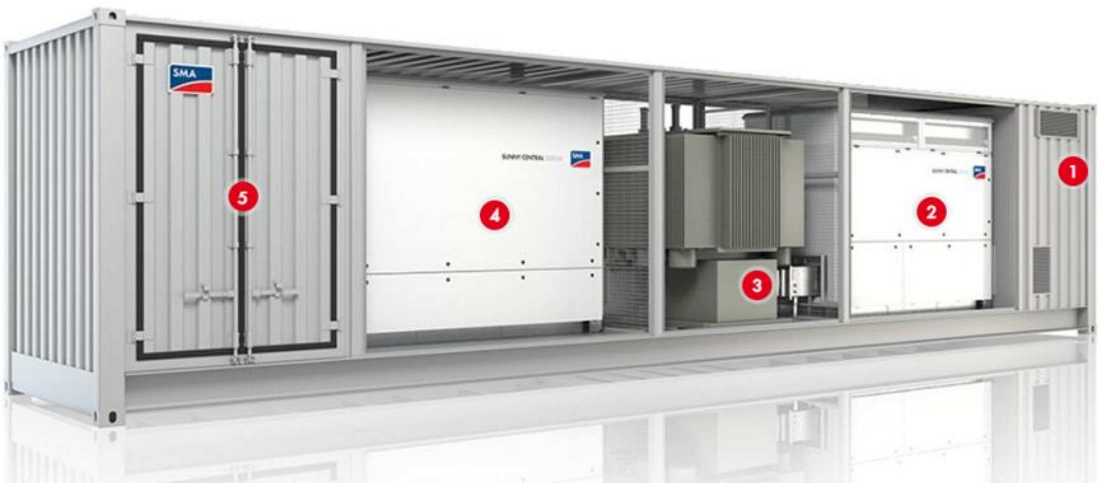
String box	Quantity	Inputs	Power	Fuse Current	Switch current	Overvoltage Arrester
1	1302	13 strings	252 kW	30 A	315 A	Yes
2	70	10 strings	193 kW	30 A	315 A	Yes
3	48	12 strings	232 kW	30 A	315 A	Yes
4	10	11 strings	212 kW	30 A	315 A	Yes

4.4. Central inverter

The inverter converts the direct current produced by the photovoltaic modules to an alternating AC current. It is composed of the following elements:

- One or several DC-to-AC power conversion stages, each equipped with a maximum power point tracking system (MPPT). The MPPT will vary the voltage of the DC array to maximize the production depending on the operating conditions in coordination with combiner boxes.
- Protection components against high operation temperatures, over or under voltage, over or under-frequencies, minimum operating current, mains failure of transformer protection, anti-islanding protection, protection against voltage gaps, etc. In addition to the electrical protection, protection for the safety of the staff personnel is also included
- A monitoring system, which has the function of relaying data regarding the inverter operation to the owner (current, voltage, power, etc.) and external data from monitoring of the strings in the DC array from a string monitoring system.

Figure 17 shows the presumably used photovoltaic central inverter for utility-scale PV plants from the SMA producer.



1 – low voltage bay

2 and 4 – Inverters – SMA Sunny Central up to 5 MVA

3 -transformer station

5 – Medium voltage bay

Figure 17 Example of central photovoltaic inverter (SMA)

The main characteristics of the primary inverter are shown in Table 10, and the characteristics of the secondary inverter are shown in Table 11.

Table 10 Inverter characteristics (Primary inverter SMA up to 5 MVA)

SMA Sunny Central Inverter 5 MVA characteristics (primary inverter)	
Main characteristics	
Inverter model	Sunny Central 4600 UP (Preliminary)
Inverter type	CENTRAL
Manufacturer	SMA
Maximum DC to AC conversion efficiency	98.52 %
Input side (DC)	
MPPT search range	1003 - 1350 V
Maximum input voltage	1500 V
Output side (AC)	
Rated power	4600.0 kVA
Power at 30 C (datasheet)	4600.0 kVA
Power at 50 C (datasheet)	4600.0 kVA
Output voltage	690 V (after transformation 35000 V)
Output frequency	50 Hz

Table 11 Inverter characteristics (secondary inverter) for better utilization of area

SMA Sunny central Inverter 1 MVA characteristics (secondary inverter)	
Main characteristics	
Inverter model	Sunny Central 1000 MV-11
Inverter type	CENTRAL
Manufacturer	SMA
Maximum DC to AC conversion efficiency	97.60 %
Input side (DC)	
MPPT search range	450 - 820 V
Maximum input voltage	1000 V
Output side (AC)	
Rated power	1120 kVA
Power at 30 C (datasheet)	1120 kVA
Power at 50 C (datasheet)	1000 kVA
Output voltage	690 V (after transformation 35000 V)
Output frequency	50 Hz

The total expected numbers of inverters per different types for the total DV power of up to 360 MWdc are shown in table below (Table 12) and there are 65 planned central inverters.

Table 12 Inverters total numbers

Inverter	Quantity	DC inputs	Power DC	DC/AC ratio
Sunny Central 4600 UP (Preliminary) (4600 kWac)	35	1 String Box of 10 string 10 String Box of 13 string	5410 kW	1.176
Sunny Central 4600 UP (Preliminary) (4600 kWac)	24	10 String Box of 13 string 1 String Box of 12 string	5487 kW	1.193
Sunny Central 4600 UP (Preliminary) (4600 kWac)	5	1 String Box of 11 string 10 String Box of 13 string	5448 kW	1.184
Sunny Central 4600 UP (Preliminary) (4600 kWac)	1	11 String Box of 13 string	5526 kW	1.201

4.5. Power transformer – internal

The power transformer transforms the voltage of the inverter AC output to achieve a higher efficiency transmission in the power lines of the photovoltaic plant. An illustrative example of a power transformer is shown in Figure 18 which is part of the central inverter container unit and is part of the container type central inverter unit.

Figure 18. Example of medium voltage power transformer

The main features of the power transformer inside the same container as inverter station are shown in Table 13.

Table 13 Power transformer characteristics

Power transformer characteristics	
Rated power	4600.0 kVA
Voltage ratio	0.69/36.0kV
Cooling system	ONAN
Tap changer	2.5%, 5%, 7.5%, 10%
Short circuit (Xcc)	0.08

4.6. Internal Power Station

The power stations or transformer stations are outdoor platforms. The voltage of the energy collected from the solar field is increased to a higher level (medium voltage level of 35 kV) to facilitate the evacuation of the generated energy towards the central grid connection transformer station.

The inverters and power transformers will be housed inside the central inverter power station and the total number of inverters being 65 each situated inside the standard size container.

An example of an SMA outdoors container central power station which is jointly used with the inverter is shown in figure below (Figure 19).

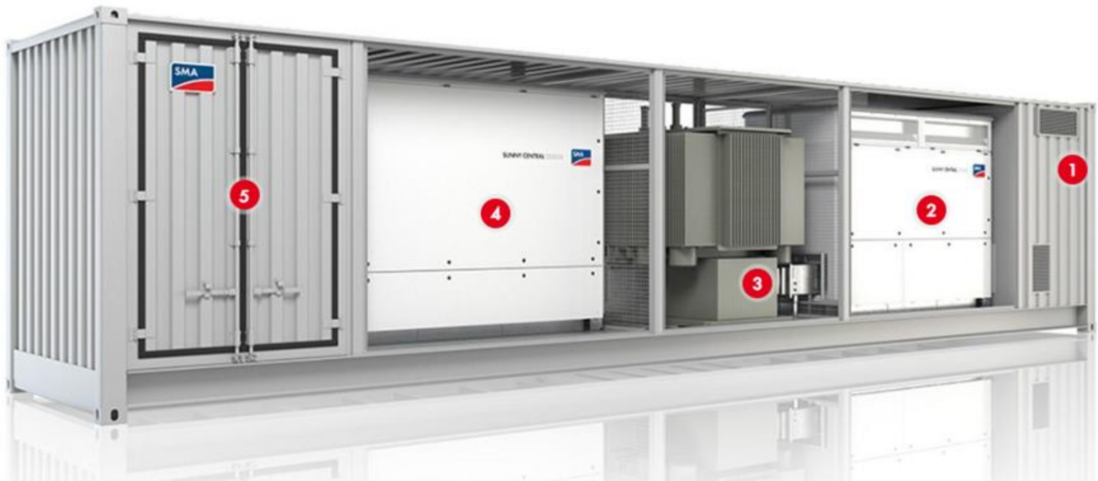


Figure 19. Example of an Outdoors power station (SMA)

The power station shall be supplied with medium voltage switchgear 35 kV that include one transformer protection unit, one direct incoming feeder unit, one direct outcoming feeder unit and electrical boards. Particularly, for the first power station of each MV line, a direct incoming unit will not be installed.

The main features of the SMA power station are shown in Table 14 and the total numbers are summarized in Table 15.

Table 14 Power station characteristics

Power station characteristics	
Number of transformers	1
Voltage ratio	0.69/36.0kV
Service	Outdoors or indoors

Table 15 Internal PV power stations total numbers

Power stations	Quantity	Num Inverters	Power AC	Power DC	DC/AC ratio
1	35	1	4.6 MW	5.410 MW	1.176
2	24	1	4.6 MW	5.487 MW	1.193
3	5	1	4.6 MW	5.448 MW	1.184
4	1	1	4.6 MW	5.526 MW	1.201

4.7. Electrical configuration

The photovoltaic generator array consists of photovoltaic modules connected in serial and parallel associations. This configuration is defined by the module and inverter technical features, the power system requirements, and the meteorological conditions of the specific location Kutnjak/Selnica Podravska.

The methodology used to define the electrical configuration consists of sizing the strings of modules, electrical junction boxes, wiring and inverters to find an electrical configuration that satisfies the DC/AC ratio goal and respects the maximum and minimum inverter and array voltage. Some of the design criteria considered were:

- Reaching the maximum DC voltage possible, staying below the maximum rated voltage of the photovoltaic modules, 1500 V. This is done to minimize the DC power transmission losses of the power plant.
- The photovoltaic generator array (DC field) is oversized with respect to the rated power of the AC system, to maximize the energy yield.
- The strings located in the east tables were separated from the strings in the west tables. Each side is connected to the inverter using a separate low voltage electrical system.
- The two separate low voltage systems in each inverter are connected to two distinct MPPT controller system. The east side strings are connected to one MPPT system, and the west side strings to another to maximize the output.

The main features of the electrical configuration described in the previous paragraph are shown in the table below (Table 16).

Table 16 Electrical configuration characteristics

Electrical configuration characteristics	
Plant rated power	299 MWac
Plant peak power	359 MWdc
DC/AC Ratio	1.19
Modules per string	28

The medium voltage network connecting the power stations to the substation operates at 36 kV. It is composed of 12 medium voltage branches all grouped on the medium voltage bay of the grid connection transformer station.

4.8. Grid connection and connection 400 kV line

Connection vise, 400 kV transmission line is available at the location of the solar power plant and the existing 400 kV line is encircled by the land owned by the EEG (Figure 20).

The available capacity of the existing 400 kV grid exceeds the output power of the SE Kutnjak project. Therefore, the connection is planned through entrance-exit action into the existing 2x400 kV line Žerjavinec-Heviz which goes right above the SE Kutnjak developed area.

The connection substation will be located in predefined space which is 200 meters or one tower span (Figure 21) distanced from the predefined entrance-exit location to the existing double 400 kV line Žerjavinec-Heviz (Figure 22).

The connection line based on the preliminary design of the Dalekovod projekt Ltd. is shown on the figure with the components of the entrance-exit action depicted (Figure 23).

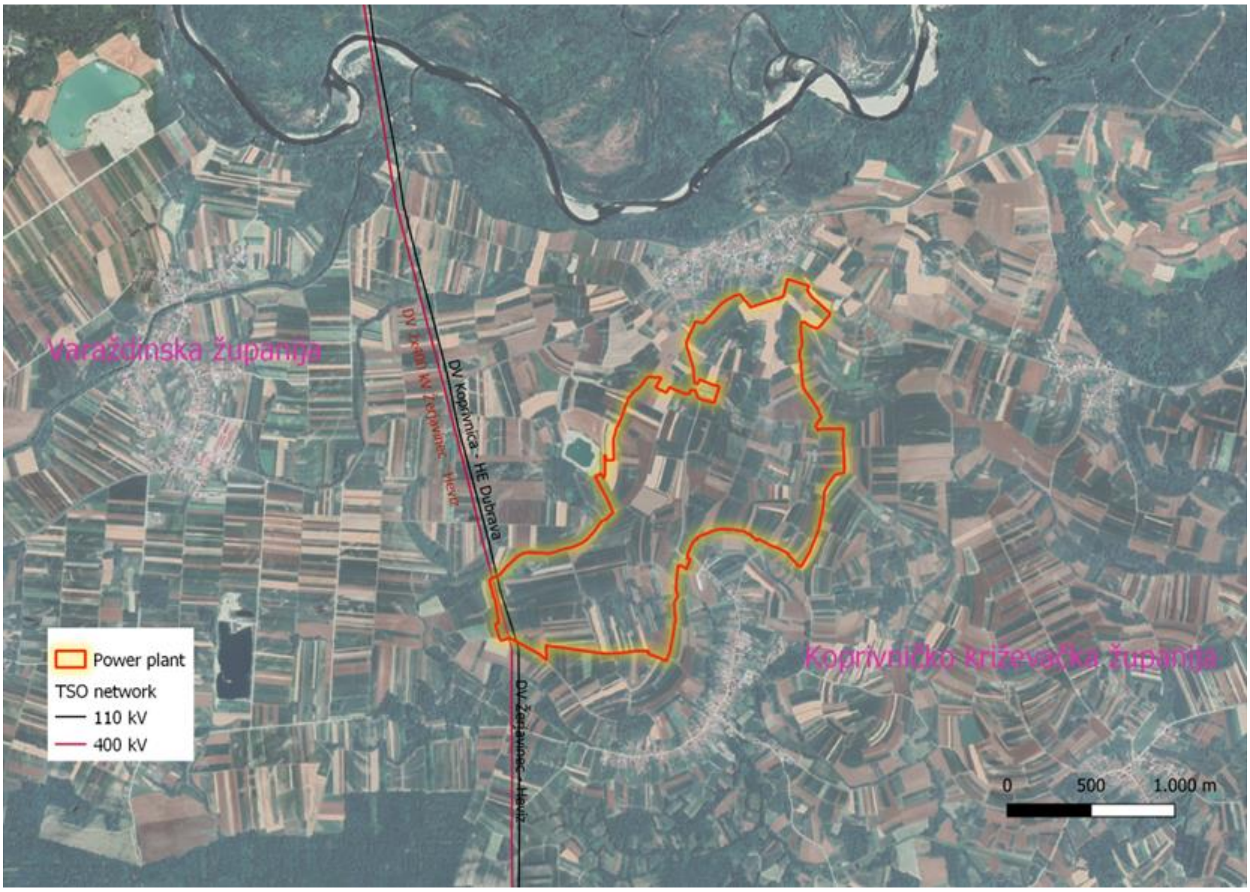


Figure 20. Basic depiction of existing transmission system operator HOPS available infrastructure

Figure 21. Basic layout of the transformer substation TS 35/400 kV Kutnjak according to substation design project by Ravel Ltd.

Figure 22. Existing 400 kV line 2xOHL 400 kV Žerjavinec-Heviz

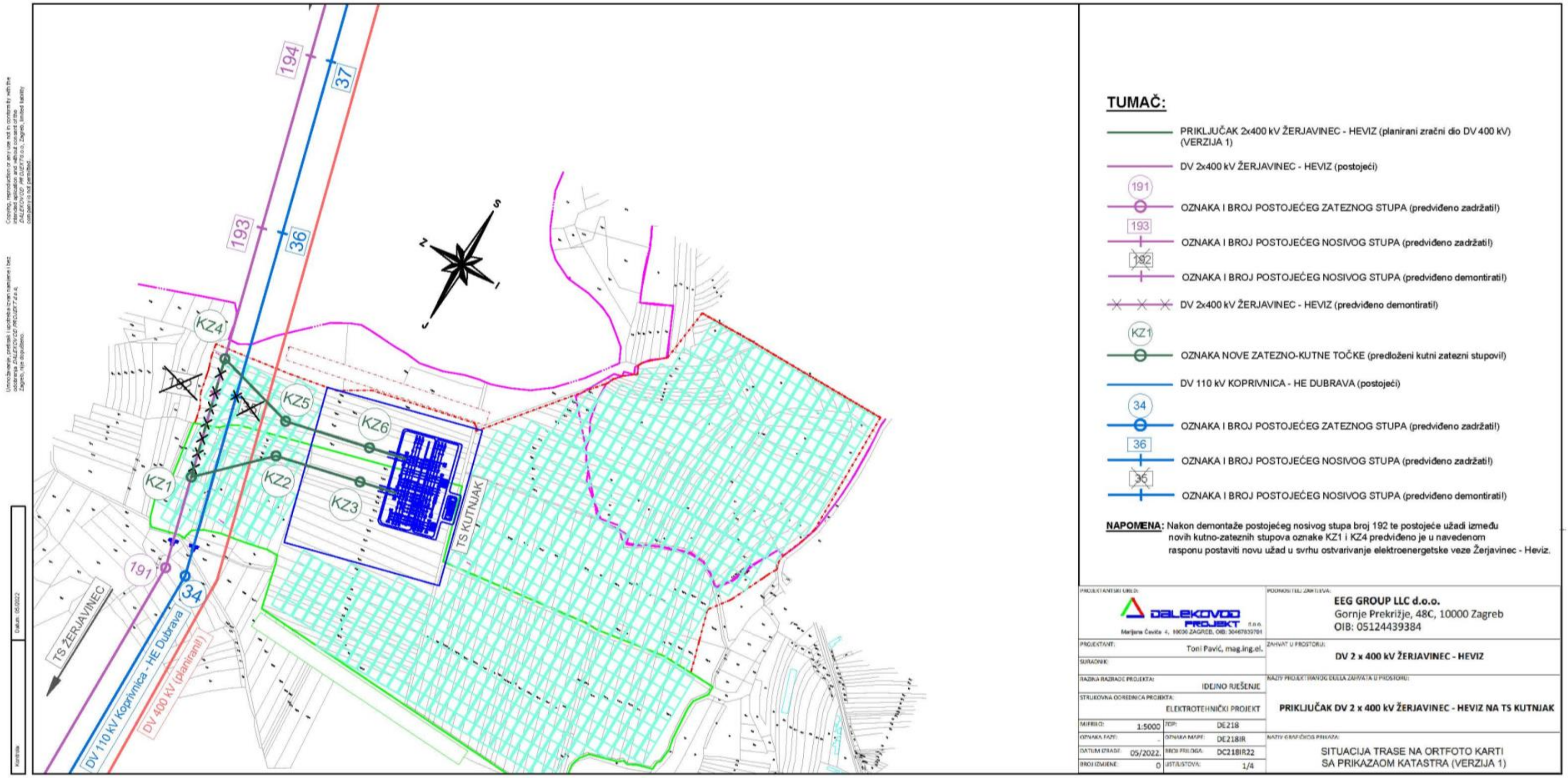


Figure 23. 400 kV connection line from transformer station to existing 400 kV line Žerjavinec-Heviz from connection line idea project by Dalekovod projekt ltd.

The current project timeline of the construction will start with the phase I of the project which includes the area of approximately 69 ha that will hold up to 99 MW of installed capacity. Phase one will include the construction of a connection facility, namely 400/35 kV transformer substation that will be used for connection (**Error! Reference source not found.**).

The phase I initiation of the construction is expected to start in 2024. The phase II and phase III construction will be initiated in 2025 and with a complete agrosolar power plant SE Kutnjak expected to be in operation in 2026.

All phases comprise the project of up to 300 MW connection power.

Figure 24. Basic depiction of project phases with the total connection power of up to 300 MW

5. ENERGY CALCULATION

The methodology used is an established energy calculation performed by the PVdesign software and requires the following inputs:

- The typical meteorological year calculation;
- The parameters of the electrical equipment to be used;
- The electrical configuration of the photovoltaic plant;
- Simulation parameters such as losses or calculation settings.

With these inputs the following steps are performed sequentially to compute the final value of the energy yield:

- The transposition of the radiation components to the tilted plane.
- Using a library to compute the sun position.
- The sun-tracking algorithm used in single-axis trackers (backtracking).
- Computation of the effects of shadows on the irradiance received by a tilted plane.
- Electrical generation of a photovoltaic module being irradiated, and its associated losses.
- Estimating the effect of partial shading on strings of modules.
- Performance of an electrical inverter and window of operation.
- Electrical losses in a utility-scale photovoltaic plant.

5.1. Losses estimation

The energy calculation considers detailed estimation of losses from a wide range of losses sources that are listed in the following section.

5.1.1. Transposition of GHI to the plane of array

The irradiance seen by the plane of array is computed by transposition of the global horizontal irradiance to the tilted plane. Because of the tilt angle, the transposition results in an irradiance gain with respect what would be received by a horizontal plane. This gain will be greater if the mounting structure is sun-tracking.

The transposition to the plane of array for the front-face resulted in a gain of -1.14 %.

In the back-face, the ground reflected irradiance was transposed to the tilted plane of array. The tilted plane also perceives diffuse and beam irradiance. The transposition resulted in a gain of +5.91 %.

5.1.2. Ground shades effect in the back-face

The shades cast on the ground by the structures result in a loss of irradiance for the back-face. Parameters such as the pitch distance between structures, the minimum ground clearance and the transparency fraction affect the value of this loss.

A value of 30% was considered to model the transparency of the photovoltaic module and the mounting structure. The loss due to the ground shades depends on the transparency of the modules.

5.1.3. Far shading

The presence of obstacles in the horizon line (such as hills or buildings) will negatively impact the irradiance reaching the photovoltaic modules. This will occur in the times of day when the sun elevation is lower. An obstacle is usually considered to be part of the horizon profile if the size of its shade is more than ten times greater than the size of the photovoltaic plant.

The far shading loss is computed against a hypothetical plant with no horizon obstacles. In Figure 25 the horizon profile of the photovoltaic plant is shown.

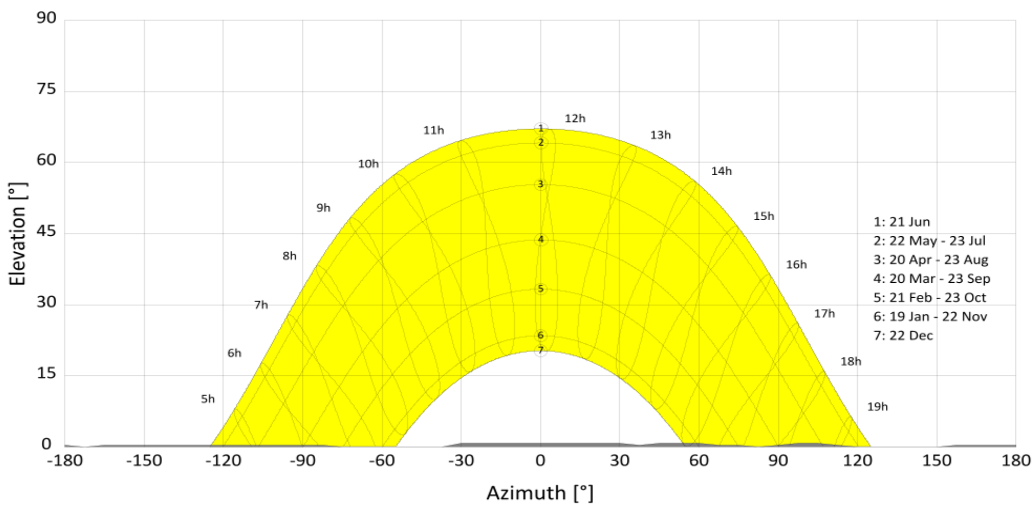


Figure 25 Horizon profile (source: PVGIS) at the Kutnjak and Selnica Podravska location

This horizon profile results in front-face irradiance loss of -0.04 %.

In the back-face, the horizon profile is only considered for the beam component shading, which was not considered.

5.1.4. Near shading

Contiguous rows of photovoltaic modules will block the sunlight to nearby rows whenever the sun elevation is low. These shades will negatively impact the irradiance received by the photovoltaic modules.

The yearly loss due to front-face near shadings was -1.34 %. It was caused due to the shades cast from one structure to the next.

5.1.5. Soiling

The deposition of dirt and dust on the surface of the module causes a direct loss of irradiance known as soiling loss. This impact is greater for oblique sun rays than for perpendicular rays.

The soiling loss is easily minimized by regularly cleaning the photovoltaic modules. It also is reduced whenever the atmospheric conditions result in the removal of dirt from their surface (through rain or wind). However, in transient conditions of high pollution the loss may be as high as 8 %, e.g. in between cleaning operations. Other conditions which influence the soiling loss are the proximity of roads, the terrain characteristics, or the tilt angle of the modules.

The soiling loss is modeled as an average value constant throughout the whole year. The front-face soiling loss was of -1.00 %, and the back-face soiling loss was of 0.00 %.

5.1.6. Incidence Angle Modifier effect

A loss is incurred due to the non-zero angle of incidence of the sun rays on the plane of array, in addition to the cosine effect. A fraction of the light reaching the surface of the modules is reflected by the glass cover protecting them. This loss is computed using an Incidence Angle Modifier (IAM) coefficient, which is a function of the glass used.

The front face glass was modeled according to the manufacturer specifications, using a custom IAM profile found in the PAN file.

The back-face glass was modeled using the air-glass model for normal glass, with an index of refraction value of 1.526 (n parameter).

The losses due to the IAM effect caused by the front-face glass were of -0.36 %, and the back-face glass caused a loss of -5.45 % from the bifacial gain.

5.1.7. Photovoltaic module degradation

An initial degradation of the module performance occurs in the first hours of exposure to sunlight, known as the Light Induced Degradation loss (LID).

However, after this initial degradation, a more long-term process takes place which results in a yearly loss of performance.

This degradation occurs due to corrosion of the conductors and a gradual failure of the back-sheet seal of the module. Atmospheric conditions such as high temperature swings, rain, ambient humidity, and salinity may accelerate the corrosion.

The value of the yearly degradation considered was -0.30 % for the first year of operation, and -0.30 % for subsequent years.

5.1.8. Irradiance level

The loss due to the irradiance level refers to the lower production of the photovoltaic module whenever the irradiance is lower than 1000 W/m2 (STC conditions).

The irradiance level loss was -0.20 %.

5.1.9. Temperature loss

The production of photovoltaic cells is negatively affected by high operation temperatures. The loss is a consequence of the photovoltaic module characteristics. The cell temperature is always higher than the ambient temperature.

A value of 29.00 W/m2/K was considered as the heat transfer coefficient constant component. The heat transfer coefficient wind component was regarded as 0 W·s/m3/K.

The yearly loss due to the module cell temperature inside the high temperature region was -2.23 %.

5.1.10. Photovoltaic module quality

The rated power of mass-produced photovoltaic modules varies on a module-to-module basis. This dispersion of the module performance is usually modeled as percentage of the variation against the rated power in STC conditions. The dispersion often results in a net gain, as the manufacturers usually aim for tighter tolerances with a bias towards a slightly higher than rated performance. The gain due to module quality dispersion was of +1.00 % due to high quality of the selected module producer.

5.1.11. Light induced degradation

The light induced degradation (LID) occurs in the first hours of exposure the photovoltaic module is exposed to sunlight. After these initial hours, the degradation sets in and is constant for the remaining lifetime of the module. This effect is not usually reflected in the module datasheet.

The used value of the LID loss was a conservative -2.00 %.

5.1.12. Bifacial mismatch

The bifacial mismatch is caused by heterogeneous illumination of the back-face. It is more pronounced in 1V single axis trackers where the torque beam casts a shade on the back face and there are photovoltaic cells in the shaded area and is less important for east-west orientation.

A value of 3.00 % of bifacial mismatch was considered. This value does not directly translate into the final loss result, as it is applied proportionately to the ratio of front to back irradiance.

5.1.13. Electrical mismatch

The mismatch loss occurs because of the variation of electrical characteristics between photovoltaic modules connected in series in an array. This means the modules are not always able to operate at their maximum power operating point.

The value of the loss was constant throughout the whole year, -1.00 %.

5.1.14. Shading mismatch

The presence of partial shadings in an array gives rise to a mismatch between the partially (or completely) shaded modules and the unshaded ones. This loss can be minimized by increasing the pitch distance between rows.

The shading mismatch loss was -0.30 %.

5.1.15. DC cable losses

There is a loss due to the ohmic effect incurred in the electrical transmission of DC power. This loss occurs in the cables connecting the photovoltaic module strings to the string boxes and inverters (or directly to the inverters if the plant is designed using a DC bus system).

The value of the transmission losses depends on the cable cross sections and cable lengths, which are usually calculated by specifying a value for the voltage drop in STC conditions.

5.1.16. Inverter loss

The main loss incurred in the electrical inverter is the conversion of DC to AC, usually known as the efficiency loss. Additional losses may occur if the sizing of the DC array with respect to the rated power of the inverter is not optimal (inverter operation window losses).

The combined losses in the inverter were -1.61 % and this value includes the efficiency loss, operation window losses and the auxiliary consumption loss.

5.1.17. AC cable losses from the inverter to transformer station

The losses incurred in the AC cables due to the ohmic effect depending on the cable cross sections and lengths. The loss is typically specified as a percentage of voltage drop in STC conditions. Because of the short length of the cables connecting inverter to transformer in the SE Kutnjak, this loss is low.

The AC cable losses in the cables connecting inverters to transformers were 0.20 %.

5.1.18. Internal power station transformer loss

The power transformer losses are two-fold: a constant loss value, known as the iron or core loss, and a converted power dependent loss, known as the copper or winding loss. Although these losses are usually very low, because the transformer has a very high efficiency, they must be considered.

The resulting losses for the iron and copper components were -0.29 % and -0.57 %, respectively.

The yearly average loss in the power station transformers was -0.86 %.

5.1.19. Medium voltage network losses (MV cables)

The losses incurred in the MV network due to the ohmic effect depend on the cable cross sections and lengths. The loss is typically specified as a percentage of voltage drop in STC conditions.

The medium voltage network consists of a series of lines connecting the power station transformers to the substation switch gears. The power loss considered in the 35 kV network of SE Kutnjak was -0.28 %.

5.1.20. Photovoltaic plant auxiliary consumptions

The photovoltaic plant will consume part of the power it generates to power its own systems, such as the security devices, cleaning equipment, or night lighting. These consumptions may also be present during nighttime.

The photovoltaic plant auxiliary consumptions resulted in a loss of -0.01 %.

5.1.21. Grid Substation transformer loss

The substation power transformer raises the voltage of the power plant AC output to match the grid voltage of 400 kV.

The resulting losses for the iron and copper components were -0.29 % and -0.57 %, respectively.

The substation transformer loss was -0.86 %.

5.1.22. HV line to grid

The loss incurred in the AC line connecting the photovoltaic plant to the grid is due to the ohmic effect, and it depends on the cable cross sections and length. Usually the loss is specified as a percentage of voltage drop in STC conditions.

The AC high voltage line loss was 0.00 % since in the electrical sense the connection location is right next to the SE Kutnjak location.

5.1.23. Plant unavailability

The photovoltaic plant unavailability was estimated to be 0 % or in others words the plant is predicted to be operation constantly. The unavailability occurs because of scheduled maintenance operations, which may require the plant to be unproductive, and unscheduled stops due to unforeseen circumstances. The loss value is dependent on the plant location and grid conditions. It assumed the 100% availability of the photovoltaic power plant.

5.2. Energy yield results

A summary of the results for the first year is shown in table below (Table 17). The performance ratio is calculated using the front-face plane of array irradiance, which may result in a performance ration value greater than 100% for bifacial simulations with very high back-face irradiance.

Table 17 Summary of results for the first year

Description	Value	Unit
First year production	414.12	GWh
Performance ratio	91.15 %	-
Specific production	1170.5	kWh/kWp
Bifacial gain	4.31 %	-

5.3. First year energy yield and losses (P50)

The front-face irradiance results are shown in Table 18 and the back-face results in Table 19. The losses after the conversion to electrical energy are shown in Table 20 for the first year.

Table 18 Front-face solar irradiance results

Description	Value	Unit	Loss
Solar resource			
Global horizontal irradiation	1299.0	kWh/m2	
Transposition to the plane of array	1284.2	kWh/m2	-1.14 %
Far shadings (horizon profile)	1283.7	kWh/m2	-0.04 %
Near shadings	1266.4	kWh/m2	-1.34 %
Soiling	1253.8	kWh/m2	-1.00 %
IAM loss	1249.2	kWh/m2	-0.36 %
Front-face effective irradiation	**1249.2**	**kWh/m2**	

Table 19 Back face solar irradiance results

Description	Value	Unit	Loss
Solar resource			
Global horizontal irradiation	1299.0	kWh/m2	
Ground reflected irradiance	324.8	kWh/m2	-75.00 %
Transposition to the plane of array	343.9	kWh/m2	+5.91 %
Effect of ground shades	49.2	kWh/m2	-85.71 %
Far shadings (horizon profile effect on beam)	49.2	kWh/m2	0.00 %
Near shadings	36.0	kWh/m2	-26.79 %
Soiling	36.0	kWh/m2	0.00 %
IAM loss	34.0	kWh/m2	-5.45 %
Back-face effective irradiation	**34.0**	**kWh/m2**	

Table 20 Yields and losses for the first year of production of SE Kutnjak

Description	Value	Unit	Loss
Solar resource			
Front face effective irradiation	1249.2	kWh/m2	
Back face effective irradiation	34.0	kWh/m2	
Global effective irradiation	**1283.2**	**kWh/m2**	
Photovoltaic conversion (nominal efficiency)			
Total receptive surface	1592738	m2	
Effective solar energy reaching the photovoltaic cells	2043.8	GWh	
Effective energy after the bifaciality factor	2033.0	GWh	-0.53 %
STC photovoltaic module efficiency	22.26	%	
Energy with STC conversion efficiency	**452.52**	**GWh**	
Photovoltaic module losses			
Module degradation	451.16	GWh	-0.30 %
Irradiance level loss	450.28	GWh	-0.20 %
Temperature loss	440.23	GWh	-2.23 %
Spectral correction	440.23	GWh	0.00 %
Quality	443.31	GWh	+0.70 %
LID (Light Induced Degradation)	438.88	GWh	-1.00 %
Bifacial mismatch	438.76	GWh	-0.03 %
Electrical mismatch	434.37	GWh	-1.00 %
Shading mismatch	433.09	GWh	-0.30 %
DC cable losses	429.51	GWh	-0.83 %
Energy at the inverter input	**429.51**	**GWh**	
Inverter DC to AC conversion			
Loss due to the inverter input voltage threshold	429.48	GWh	0.00 %
Loss due to the inverter maximum input voltage limit	429.48	GWh	0.00 %
Loss due to the inverter input power threshold	429.48	GWh	0.00 %
Loss due to the inverter output power limit	429.47	GWh	0.00 %
Auxiliary consumption	429.47	GWh	0.00 %
Conversion efficiency loss	422.58	GVAh	-1.60 %
Energy at the inverter output	**422.58**	**GWh**	
Power station and MV System losses			
AC cable from inverter to transformer loss	422.58	GWh	0.00 %
Transformer iron loss	421.33	GWh	-0.29 %
Transformer copper loss	418.93	GWh	-0.57 %
MV network transmission loss	417.75	GWh	-0.28 %
Energy available at the MV system output	**417.75**	**GWh**	
Reactive energy at the MV system output	0.0	GVArh	
Power factor at the MV system output	1.000		
Substation losses			
Plant auxiliary consumption	417.71	GWh	-0.01 %
Substation transformer iron loss	416.46	GWh	-0.30 %
Substation transformer copper loss	414.12	GWh	-0.56 %
Delivery point limitation loss	414.12	GWh	0.00 %
Energy available at the substation output	**414.12**	**GWh**	
Reactive energy at the substation output	0.0	GVArh	
Power factor the substation output	1.000		

Description	Value	Unit	Loss
Transmission to grid and availability			
HV line from substation to grid loss	414.12	GWh	0.00 %
Plant unavailability loss	414.12	GWh	0.00 %
Grid unavailability loss	414.12	GWh	0.00 %
ENERGY INJECTED TO GRID	**414.12**	**GWh**	
reactive energy injected to grid	0.0	GVArh	
power factor at grid connection	1.000		

5.4. First year nighttime consumption

In the Table 21 nighttime consumption results of the photovoltaic plant are shown. The consumptions come from the night loss of the inverters, the transformer core (iron) losses, and the plant auxiliary consumption loss.

The total yearly nighttime power consumption was of -2248 MWh and this is assumed to be imported from the grid.

Table 21 Nighttime consumption results for the first year

Description	Value	Unit	Percentage of total
Inverter			
Nighttime loss	0.0	MWh	0.00 %
Power station			
Transformer iron loss	-1372.71	MWh	49.18 %
Substation			
Plant auxiliary consumption	-45.9	MWh	1.64 %
Substation transformer iron loss	-1372.71	MWh	49.18 %
TOTAL POWER CONSUMPTION	**-2791.34**	**MWh**	**100.00 %**

5.5. 25 years energy yield (P50)

The energy yield of the photovoltaic plant has been calculated for a period of 25 years with no replacements considered. In Table 22 the energy yield, specific production and performance ratio are shown for each year with the starting equipment. The project lifetime is assumed to be 25 years with the conservative assumption of production decreasing each year.

Table 22 Results for the 25 year period

Year	Energy yield [GWh]	Specific production [kWh/kWp]	Performance Ratio [%]
1	414	1162.6	90.53
2	413	1159.0	90.25
3	412	1155.4	89.97
4	410	1151.7	89.69
5	409	1148.1	89.40
6	408	1144.5	89.12
7	407	1140.8	88.84
8	405	1137.2	88.55
9	404	1133.6	88.27
10	403	1129.9	87.99
11	401	1126.3	87.70
12	400	1122.7	87.42
13	399	1119.0	87.14
14	398	1115.4	86.86
15	396	1111.8	86.57
16	395	1108.1	86.29
17	394	1104.5	86.01
18	392	1100.9	85.73
19	391	1097.2	85.44
20	390	1093.6	85.16
21	389	1090.0	84.88
22	387	1086.4	84.59
23	386	1082.7	84.31
24	385	1079.1	84.03
25	383	1075.5	83.75
Total	**9970**	**1119.0**	**87.1**

5.6. Probabilistic yield estimation

The probabilistic yield estimation is a statistical analysis. It can be used to ascertain the effect that some uncertainties have on production over the course of several years. The weight of these uncertainties is quantified using the standard deviation (sigma value), which represents the expected annual variability. It can used to consider uncertainties in meteorological data, equipment performance, or long-term degradation.

The analysis consists of assuming that production will follow a normal distribution throughout the PV plants lifetime. The mean of the normal distribution meets the production of the first year (345.67 GWh).

The standard deviation of the normal distribution was assumed to be of its value of 3.00 % as an usual value used in such calculation.

The results are shown in Table 23.

Table 23 Probabilistic yield estimation

Probability	Energy yield [GWh]
P50	414.1
P75	405.7
P90	398.2
P95	393.7
P99	385.2

6. CO2 SAVINGS RESULTS

During the normal operation of solar power plant there are no greenhouse gasses emission. Due to clean production of solar power plant the C02 savings are generated with each produced kWh. The total saving was calculated in accordance to the statistical data.

There were several different sources used:

1. Average carbon intensity of the power sector in Croatia from 2000 to 2021(in grams of CO_2 per kilowatt-hour)
    a. 245 gCO_2/kWh
    b. (source: https://www.statista.com/statistics/1290149/carbon-intensity-power-sector-croatia/)
    c. 101.430 ton/CO_2eq
2. Average carbon intensity of power sector in Croatia in the last 5 years ((in grams of CO_2 per kilowatt-hour)
    a. 164 gCO_2/kWh
    b. (source: https://www.statista.com/statistics/1290149/carbon-intensity-power-sector-croatia/)
    c. 68.000 ton/CO_2eq
3. Average carbon intensity of power sector in Croatia in 2021
    a. 142 gCO_2/kWh
    b. 59.000 ton/CO_2eq
4. Average carbon intensity of the largest Croatian production company HEP Ltd. for the production of electricity in 2021 HEP-a[1].
    a. 154 gCO_2/kWh
    b. source: https://www.hep.hr/o-hep-grupi/publikacije/godisnje-izvjesce/62
    c. 64.000 ton/CO_2eq
5. Average EU carbon intensity in 2019
    a. 249 gCO_2/kWh
    b. source:https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-3/
    c. 103.000 ton/CO_2eq

Additionally, the EU Carbon permits prices (EU ETS) at the moment are ranging around 80 EUR/tCO_2 with:

a. the average price in the last 2 years:64 EUR/tCO_2.
b. price on 06/08/2022 and on 01/12/2022: 85 EUR/tCO_2.

The total predicted net production is expected to be 414 GWh (414 000 000 kWh) as calculated in the section 5.

The total expected CO2 emissions reduction range from 64.000 ton/CO_2eq up to 103.000 ton/CO_2eq yearly for SE Kutnjak.

[1] HEP group report on sustainability; HEP grupa 2020

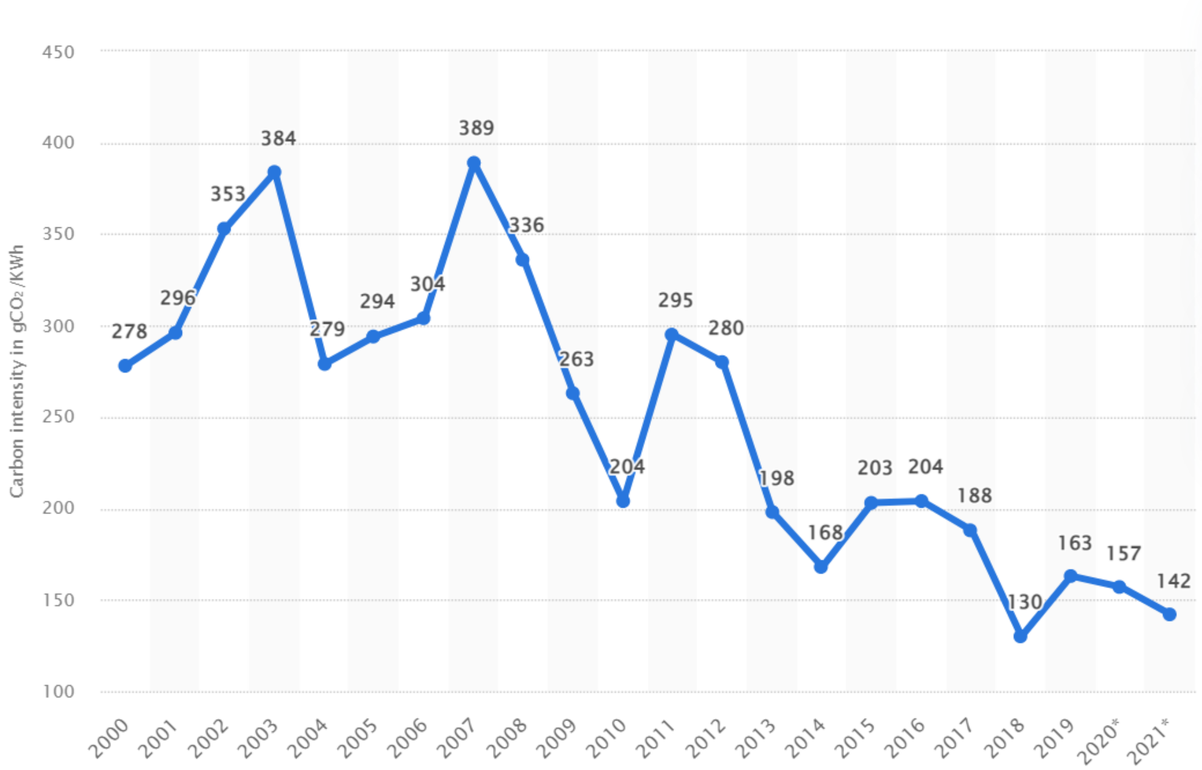


Figure 26 Carbon intensity of the power sector in Croatia from 2000 to 2021 (in grams of CO_2per kilowatt-hour)[2]

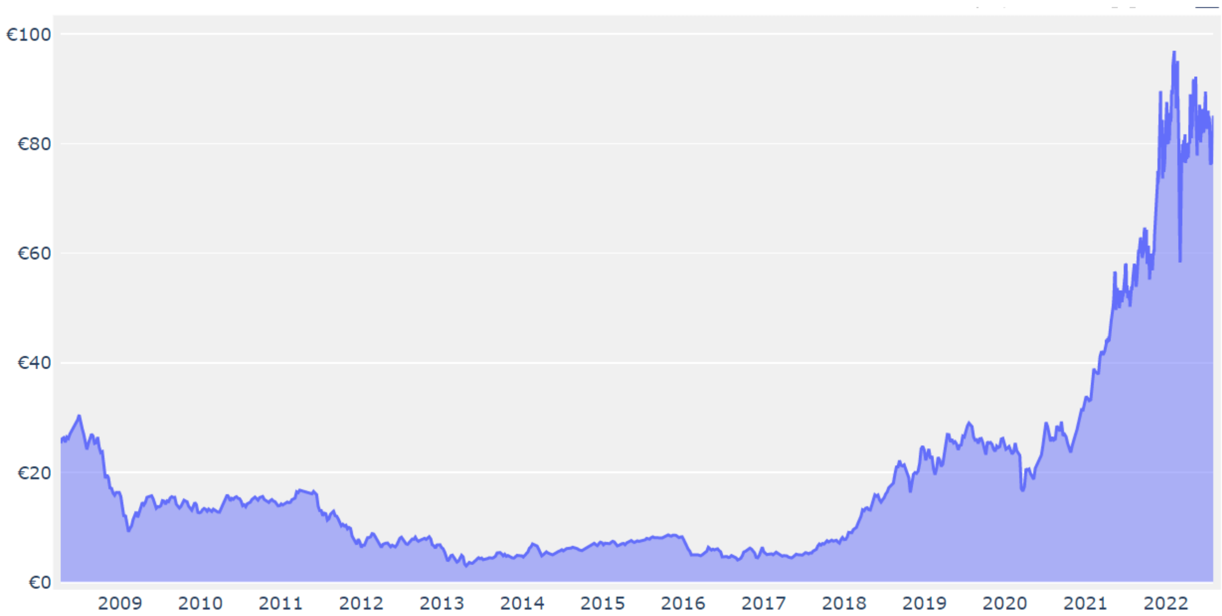


Figure 27 C02 emission prices (EU ETS) from 2009 to 2022)[3]

[2] *source: https://www.statista.com/statistics/1290149/carbon-intensity-power-sector-croatia/

[3] *source: https://sandbag.be/index.php/carbon-price-viewer/

7. COSTS ESTIMATION

7.1. Investment cost

The total costs that are assumed for the completion of the project are shown in the table below - Table 24 SE Kutnjak financial analysis.

The CAPEX cost which is based on tailored offers from different renewed companies in the solar energy sections:

- Mounting and construction including civil works from Corigi Ltd.
- Central inverters from SMA Ltd.
- Solar panels from Jinko Solar
- Grid substation from Končar group and Ravel Ltd.
- Connection line from Dalekovod Ltd.

These CAPEX costs assume the investment required for the construction of the agrosolar power plant Kutnjak and its start of solar production. **The CAPEX cost is 221,7 mil EUR.** The CAPEX does not include the cost of project acquisition of 100% of company's shares.

The total costs include the takeover of 100% shares of the SE Kutnjak owner company which is set to 34 mil EUR. **The TOTAL project cost is 255 mil EUR.**

The assumed total project development cost, permitting cost including land rights and design process is in range of 4 mil EUR.

The OPEX cost including:

- Project yearly insurance;
- Land lease annual rent;
- Local municipal contribution;
- Management and control costs;
- Maintenance and servicing costs;
- Reserve funds.

The total **OPEX sums to a range of 5,5 mil EUR yearly** and it separately considers the maintenance cost and replacement of equipment costs, but also the amortization and equity cost.

It is important to note that the agricultural production yields and incomes that will be enhanced by the solar construction are not included in the calculation and they will create the additional value for the SE Kutnjak project.

Table 24 SE Kutnjak financial analysis with acquisition price cost

Item		Amount	Unit	Unitary price		Price	
1	Investment costs						
1.1	MAIN EQUIPMENT						
1.1.1	The price of 100% of the company's share	1,00	unit	34.000.000,00	€/unit	34.000.000,00	€
1.1.2	Civil works + Steel Structures 15º fix, (19.10.2022)	1,00	unit	14.126.000,00	€/unit	14.126.000,00	€
1.1.3	Solar panel GEP production with installation	1,00	unit	116.770.000,00	€/unit	116.770.000,00	€
1.1.4	Inverter MWMVPS-4400-S2-10 /403577+30%	1,00	unit	35.379.000,00	€/unit	35.379.000,00	€
1.1.5	Grid connection fee HOPS	1,00	unit	19.500.000,00	€/unit	19.500.000,00	€
1.1.6	Transmission line connection to 400 kV network	1,00	unit	3.000.000,00	€/unit	3.000.000,00	€
1.1.7	Construction infrastructure cables and protective equipment	1,00	unit	7.076.000,00	€/unit	7.076.000,00	€
1.1.8	Security system infrared cameras	1,00	unit	708.000,00	€/unit	708.000,00	€
1.1.9	Grid Substation	1,00	unit	22.224.000,00	€/unit	22.224.000,00	€
1.1.10	Energy approval Ministry	1,00	unit	2.400.000,00	€/unit	2.400.000,00	€
							€
	CAPEX TOTAL					**255.183.000,00**	**€**
2	OPEX						
2.1	Yearly total replacements	1	unit	900.000,00	€/unit	900.000,00	€
2.2	Municipal Contribution	1,00	unit	220.000,00	€/unit	220.000,00	€
2.3	Monitoring and control	1,00	unit	353.750,00	€/unit	353.750,00	€
2.4	Inspection	1,00	unit	353.790,00	€/unit	353.790,00	€
2.5	Annual rent	220,10	ha	2.500,00	€/ha	550.250,00	€
2.6	Costs of management incl. travel expenses	2.000,00	h/y	25,00	€/h/y	50.000,00	€
2.7	Maintenance and servicing	0,50%	% of Inv./y	255.183.000,0	€/% of Inv./y	1.275.915,00	€
2.8	Insurance	0,50%	% of Inv./y	255.183.000,0	€/% of Inv./y	1.275.915,00	€
2.9	Reserve	0,20%	% of Inv./y	255.183.000,0	€/% of Inv./y	510.366,00	€
	OPEX TOTAL					**5.489.986,00**	**€**

Table 25 Estimated cash flow

CASH FLOW (after taxes)		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
OPERATING INCOME PER YEAR (after local taxes)		12.245.031	11.758.720	12.252.019	13.104.397	13.973.308	20.435.115	21.370.982	22.325.475	23.266.216	24.225.444
Depreciation construction		22.118.300	22.118.300	22.118.300	22.118.300	22.118.300	22.118.300	22.118.300	22.118.300	22.118.300	22.118.300
Depreciation mechanical and instrument engineering		6.800.000	6.800.000	6.800.000	6.800.000	6.800.000	0	0	0	0	0
Dept repayment		0	0	-12.586.508	-12.964.104	-13.353.027	-13.753.618	-14.166.226	-14.591.213	-15.028.949	-15.479.818
CASH FLOW (liquidity results) per year	-76.554.900	41.163.331	40.677.020	28.583.811	29.058.593	29.538.581	28.799.797	29.323.055	29.852.562	30.355.566	30.863.926
CASH FLOW (liquidity results) acc		41.163.331	81.840.351	110.424.162	139.482.755	169.021.336	197.821.133	227.144.189	256.996.750	287.352.317	318.216.243

CASH FLOW (after taxes)	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	Total
OPERATING INCOME PER YEAR (after local taxes)	43.340.573	44.338.011	45.355.192	46.392.556	47.450.553	48.026.092	48.608.092	49.196.585	49.791.602	50.393.172	51.001.321	51.616.075	52.237.457	52.865.489	53.500.192	909.069.667
Depreciation construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	221.183.000
Depreciation mechanical and instrument engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34.000.000
Dept repayment	-15.944.212	-16.422.539	-16.915.215	-17.422.671	0	0	0	0	0	0	0	0	0	0	0	-178.628.100
CASH FLOW (liquidity results) per year	27.396.361	27.915.473	28.439.977	28.969.885	47.450.553	48.026.092	48.608.092	49.196.585	49.791.602	50.393.172	51.001.321	51.616.075	52.237.457	52.865.489	53.500.192	985.624.567
CASH FLOW (liquidity results) acc	345.612.603	373.528.076	401.968.053	430.937.938	478.388.491	526.414.583	575.022.675	624.219.260	674.010.862	724.404.034	775.405.354	827.021.429	879.258.886	932.124.375	985.624.567	985.624.567

Return on Equity (ROE)		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Operating income (after interests, after tax)		12.245.031	11.758.720	12.252.019	13.104.397	13.973.308	20.435.115	21.370.982	22.325.475	23.266.216	24.225.444
Equity (without promotion)		76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900
ROE in % per year		16,0%	15,4%	16,0%	17,1%	18,3%	26,7%	27,9%	29,2%	30,4%	31,6%
		116,0%	115,4%	116,0%	117,1%	118,3%	126,7%	127,9%	129,2%	130,4%	131,6%

Return on Equity (ROE)	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Total
Operating income (after interests, after tax)	43.340.573	44.338.011	45.355.192	46.392.556	47.450.553	48.026.092	48.608.092	49.196.585	49.791.602	50.393.172	51.001.321	51.616.075	52.237.457	52.865.489	53.500.192	909.069.667
Equity (without promotion)	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	76.554.900	
ROE in % per year	56,6%	57,9%	59,2%	60,6%	62,0%	62,7%	63,5%	64,3%	65,0%	65,8%	66,6%	67,4%	68,2%	69,1%	69,9%	47,5%
	156,6%	157,9%	159,2%	160,6%	162,0%	162,7%	163,5%	164,3%	165,0%	165,8%	166,6%	167,4%	168,2%	169,1%	169,9%	

Discounted Cash Flows		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Factor		1	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
Discount Rate		11,41%	12,18%	12,53%	12,87%	13,19%	13,49%	13,76%	13,96%	14,14%	14,26%
Discounting Factors		0,8976	0,7947	0,7018	0,6161	0,5381	0,4679	0,4056	0,3514	0,3042	0,2636
Cash-Flow per period discounted by discount factor		36.947.958	32.325.828	20.058.767	17.902.561	15.895.480	13.475.760	11.894.250	10.491.602	9.232.805	8.135.740
Cash Flows acc by disount factors		36.947.958	69.273.787	89.332.553	107.235.114	123.130.594	136.606.355	148.500.604	158.992.206	168.225.011	176.360.751

Discounted Cash Flows	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Total
Factor	11,00	12,00	13,00	14,00	15,00	16,00	17,00	18,00	19,00	20,00	21,00	22,00	23,00	24,00	25,00	
Discount Rate	14,33%	14,40%	14,42%	14,44%	14,47%	14,47%	14,47%	14,47%	14,47%	14,62%	14,62%	14,62%	14,62%	14,62%	14,62%	
Discounting Factors	0,2292	0,1990	0,1736	0,1513	0,1317	0,1150	0,1005	0,0878	0,0767	0,0653	0,0570	0,0497	0,0434	0,0378	0,0330	
Cash-Flow per period discounted by discount factor	6.278.708	5.555.654	4.937.480	4.382.283	6.247.387	5.523.719	4.883.824	4.318.009	3.817.700	3.290.935	2.905.872	2.565.827	2.265.540	2.000.366	1.766.200	
Cash Flows acc by disount factors	182.639.458	188.195.112	193.132.593	197.514.876	203.762.263	209.285.982	214.169.806	218.487.815	222.305.515	225.596.451	228.502.322	231.068.150	233.333.690	235.334.056	237.100.256	237.100.256

7.2. LCOE calculation

The Levelized Cost of Energy (LCOE) is an economical metric which represents the cost of producing electricity. It takes into account the raw energy output of the plant, the cost of building the plant, the cost of operating the plant, and the number of years the plant will operate for. It also considers the discount rate associated with future costs and cash inflows.

It is used as a metric for benchmarking and comparing the cost-effectiveness of different energy generation technologies1. Additionally, it is also used in the design process of PV plants to evaluate the impact of technical decisions in the cost of electricity.

The following inputs are required from the user for this calculation:

- Latitude and longitude where the PV plant is located.
- The type of mounting structure, either SAT (single axis tracker), fixed structure, or east west structure.
- Peak DC capacity of the plant.
- Specific CAPEX, the cost of building the PV plant;
- Specific OPEX, the cost of operating the PV plant;
- The return rate, usually given in percentage points.

The calculated production from the energy estimation is used.

To calculate the cost of building the PV plant, known as capital expenditure (CAPEX), the equation assumes that the cost of building the PV plant is paid upfront in the year zero. Financing costs could be indirectly included as part of the specific CAPEX value.

To calculate the costs associated with operating the plant, known as operation expenditures (OPEX) the assumptions were made

Finally, the equation to calculate the LCOE with a simplification of the LCOE calculation which does not consider the residual value of the PV plant.

$$LCOE = \frac{CAPEX + OPEX_u}{E_{grid,u}}$$

- LCOE is the levelized cost of energy, in EUR per kWh.
- CAPEX is the cost of building the PV plant
- $OPEX_u$ is the updated OPEX to n years
- $E_{grid,u}$ is the updated energy production to n years, in kWh with r being interest rate: $\sum_{i=0}^{n} \frac{E_{grid}}{(1+r)^{1+i}}$

The SE Kutnjak project LCOE calculation assumes the constant level of production and 9% discount rate throughout the project lifetime and the LCOE in range from 80 EUR/MWh to 90 EUR/MWh.

The PVdesign methodology used in the modelling software with annual productions according to probabilistic yield estimation and with the system design, permitting and land acquisition cost instead of the 100% acquisition cost returns the LCOE of 79 EUR/MWh for 10% discount rate and specific price of 647.61€/kWp per kW installed capacity.

Table 26 LCOE calculation with project acquisition cost

Levelized Cost of Energy (LCOE) approximate calculation

Assumptions

Initial Investment Cost (100'thousEUR)	255.183	total investment for 300 MWpeak/360 MWdc
Operations and Maintenance Costs (100'thousEUR/	5.500	OPEX (insurance, management, maintenance, reserve, annual rent, (plus debt))
O&M Growth Rate (%)	0,50%	
Annual Fuel Costs (EUR)	-	
Annual Electricity Output (GWh)	414.137	Energy production on the grid level continious for 25 years...
Project Lifespan (years)	25	
Discount Rate (%)	9,00%	
Entry Date	31.12.2025	

Total Costs	Entry	Construction	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations
Date	31.12.2025	31.12.2026	31.12.2027	31.12.2028	31.12.2029	31.12.2030	31.12.2031	31.12.2032	31.12.2033	31.12.2034	31.12.2035
Year Operation (From Start Date)		1	2	3	4	5	6	7	8	9	10
Initial Investment	255.183	-	-	-	-	-	-	-	-	-	-
O&M Costs	-	-	5.500	5.528	5.555	5.583	5.611	5.639	5.667	5.695	5.724
Fuel Costs	-	-	-	-	-	-	-	-	-	-	-
Discount Factor		91,7%	84,2%	77,2%	70,8%	65,0%	59,6%	54,7%	50,2%	46,0%	42,2%
Present Value of Costs	255.183	-	4.629	4.268	3.935	3.629	3.346	3.085	2.844	2.622	2.418
NPV of Total Costs	**$306.088**										

Total Costs	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations	Operations
Date	31.12.2036	31.12.2037	31.12.2038	31.12.2039	31.12.2040	31.12.2041	31.12.2042	31.12.2043	31.12.2044	31.12.2045	31.12.2046	31.12.2047	31.12.2048	31.12.2049	31.12.2050
Year Operation (From Start Date)	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Initial Investment	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00	11,00	12,00	13,00	14,00	15,00
O&M Costs	5.753	5.781	5.810	5.839	5.868	5.898	5.927	5.957	5.987	6.017	6.047	6.077	6.107	6.138	6.169
Fuel Costs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discount Factor	38,8%	35,6%	32,6%	29,9%	27,5%	25,2%	23,1%	21,2%	19,4%	17,8%	16,4%	15,0%	13,8%	12,6%	11,6%
Present Value of Costs	2.229	2.055	1.895	1.747	1.611	1.485	1.370	1.263	1.164	1.074	990	913	841	776	715

Total Energy Output	Entry	1	2	3	4	5	6	7	8	9	10
Yearly Output	-	-	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137
Discount Factor	-	91,7%	84,2%	77,2%	70,8%	65,0%	59,6%	54,7%	50,2%	46,0%	42,2%
Present Value of Costs	-	-	348.571	319.790	293.385	269.161	246.936	226.547	207.841	190.680	174.936
NPV of Total Output	**3.687.951 kWH**										

Total Energy Output	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Yearly Output	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137	414.137
Discount Factor	38,8%	35,6%	32,6%	29,9%	27,5%	25,2%	23,1%	21,2%	19,4%	17,8%	16,4%	15,0%	13,8%	12,6%	11,6%
Present Value of Costs	160.492	147.240	135.083	123.929	113.696	104.309	95.696	87.794	80.545	73.895	67.793	62.196	57.060	52.349	48.027

LCOE	0,083	EUR/kWh	83 EUR/MWh

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7.3. Financial data

The main income source of the agro-solar power plant SE Kutnjak in this document are the sales of energy produced by the solar. This income from the agro segment of the production is not assessed here.

The prices estimations based on historical CROPEX data (Table 27) and based on estimated PPA long term pay-as-produced price of 120 EUR/MWh given by Pexapark (Figure 28 and Figure 29)

Table 27 CROPEX average prices

CROPEX energy market price [EUR/MWh]*	2020	2021	2022	price change 2020 vs 2021	price increase 2021 vs 2022
Base Average	38,1	114,7	273,5	301%	238%
Peak Average	42,1	126,5	279,3	300%	221%
Highest hourly	172,1	533,2	742	310%	139%
Lowest hourly	-23,5	-263,3	55,4	1120%	21%
*https://www.cropex.hr/en/market-data/yearly-and-monthly-reports.html					

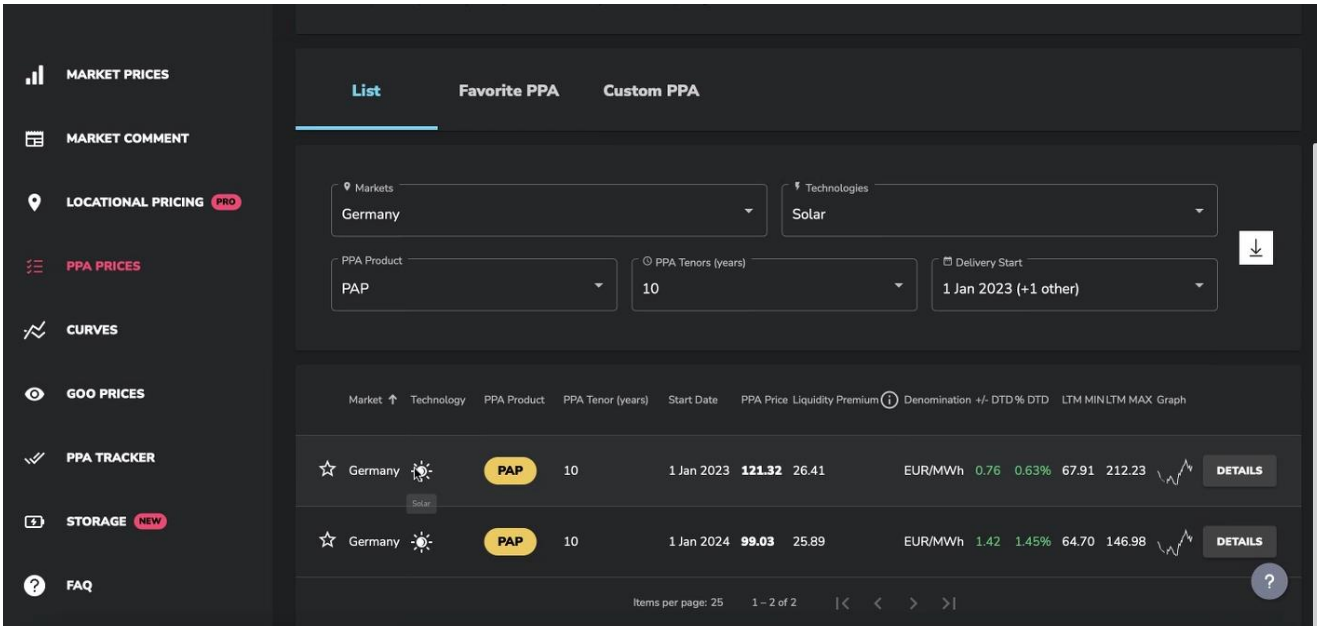


Figure 28 The PPA historical PPA prices in Germany

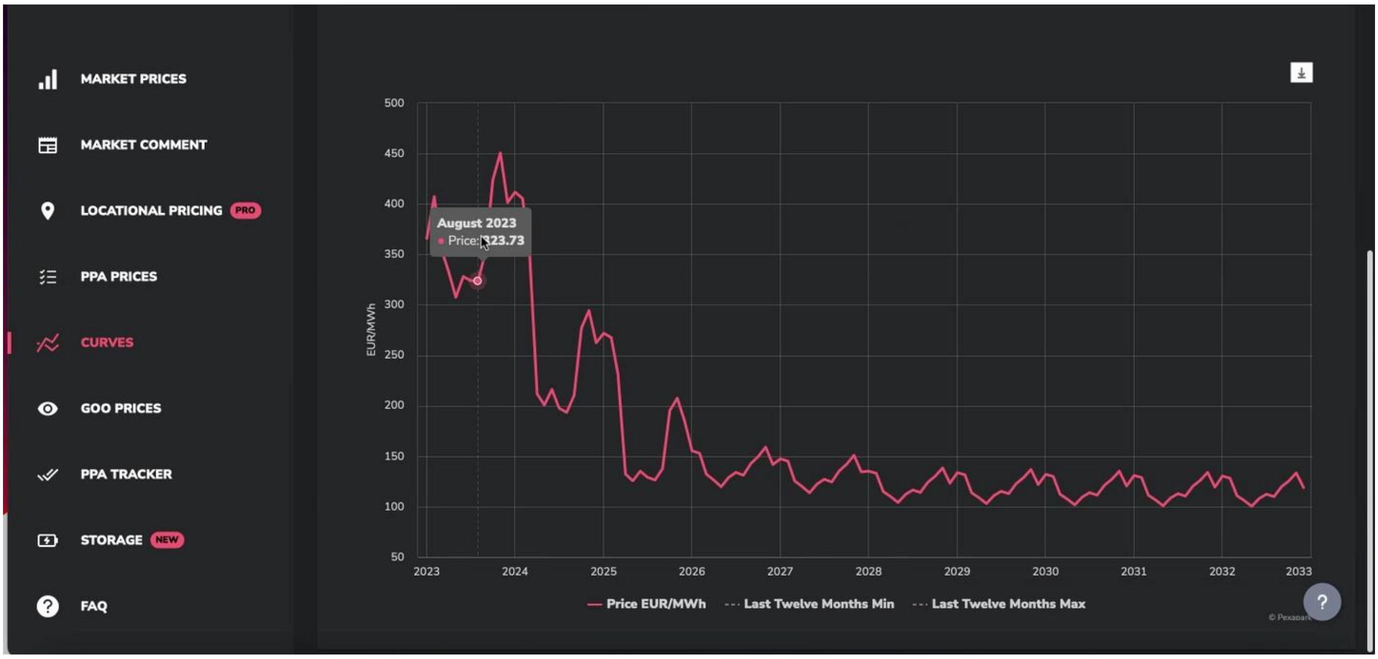


Figure 29 Expected PPA prices in the 10 year horizon averaging to 121 EUR/MWh

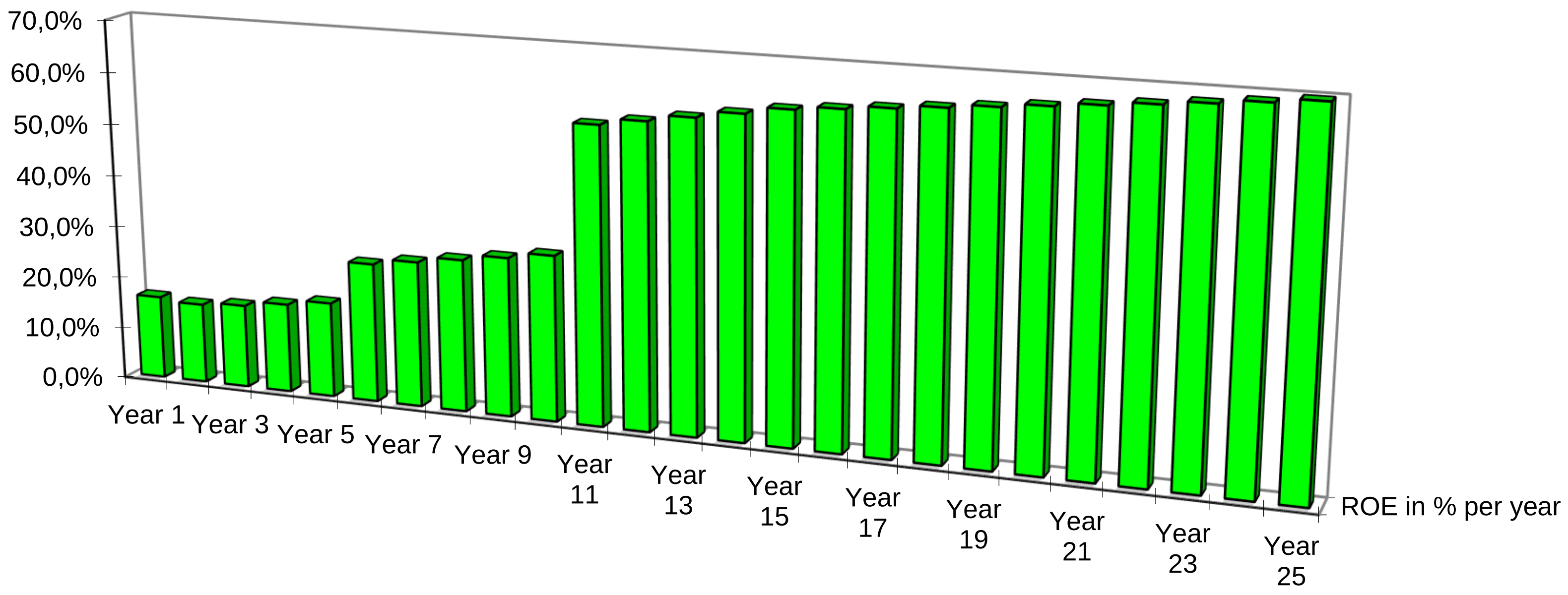
The expected rate of equity (ROE) of the SE Kutnjak project for the expected project duration of 25 years is shown on figure below (Figure 30).

The table summarizing the financials of the project are shown below (Table 28).

Table 28 Main financial components and assumptions of the SE Kutnjak project

Financial component	Unit (measure)	Remark
Investment cost CAPEX	221,7 mil of EUR	Excl. the purchase price of the project
Purchase price of the project	34 mil of EUR	Expected purchase price of the project
Life time of the project	25 years	Datasheet lifetime of solar panels
Revenues from electrical power purchase agreement	47,53 mil EUR	414000 MWh for 114,8 EUR/MWh
Revenue from electrical power over life time (anticipated)	1136.3 mil EUR	25 year production
Revenues from sales of CO2 certificates	5.19	180 g/kWh for 64 EUR/ton
Revenue from CO2 certificates over life time (anticipated)	118.75 mil EUR	164 g/kWh for 64 EUR/ton
Operational expenses yearly OPEX	5,5 mil EUR	Maintenance and replacement cost
Operational expenses over life time	139,8 mil EUR	0,5% increase yearly
Corporate tax rate in Croatia	18%	Discount up to 75% first 5 years

ROE in % (after interests and taxes)



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25
ROE in % per year	16,0%	15,4%	16,0%	17,1%	18,3%	26,7%	27,9%	29,2%	30,4%	31,6%	56,6%	57,9%	59,2%	60,6%	62,0%	62,7%	63,5%	64,3%	65,0%	65,8%	66,6%	67,4%	68,2%	69,1%	69,9%

Figure 30 Calculated ROE of SE Kutnjak project

8. SOUTH ORIENTATION

The selected design of the solar power plant Kutnjak was done based on the maximum energy yield on the given development area. Furthermore, the selection was done in order to provide the best support to agricultural segment of the photovoltaic production which in case of the E-W structure the controlled conditions for different cultures below can be realized. But, this document observes the electrical parameters and electrical production segment of the project and therefore only these parameters were shown.

The comparison of different designs and solar power plant layouts of the south orientation are given in this chapter with the reference design being the already described east-west orientation of the peak connection capacity of 299 MW and installed DC capacity 359 MW.

In the southern design the main factor that influences the total installed capacity and the energy yield is the distance between the rows, or pitch distance and clearance distance (Figure 31). This directly influences the ground coverage ratio (GCR) of the design.

The preliminary designs were done for a range of different distances between rows of the panels which all result in different ground coverage ratios and consequently with different total installed output power capacity, both DC and AC.

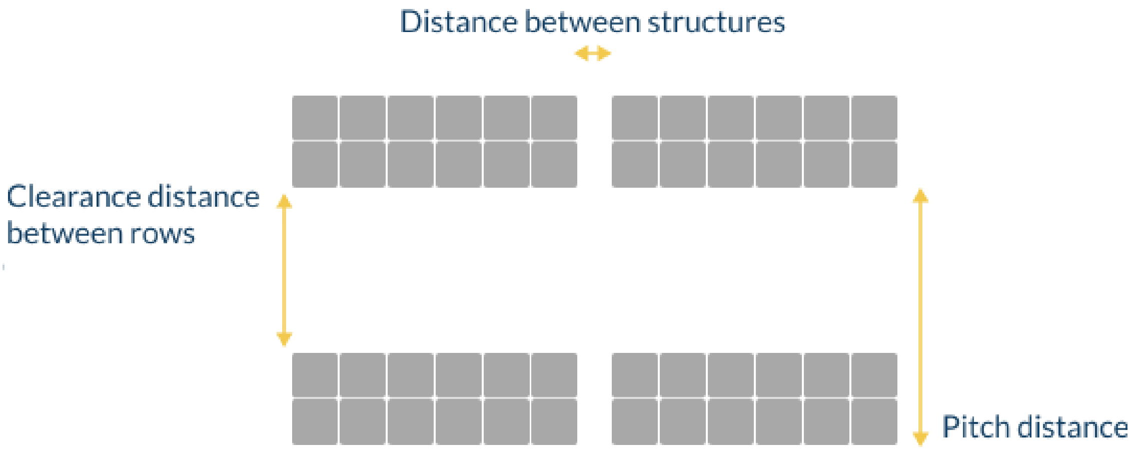


Figure 31 Clearance and pitch distance in south orientation

The general configuration of all simulated south orientation preliminary designs is given in the table below - Table 29.

The distances between rows for east-west structure is observed according to the distances shown on the figure below.

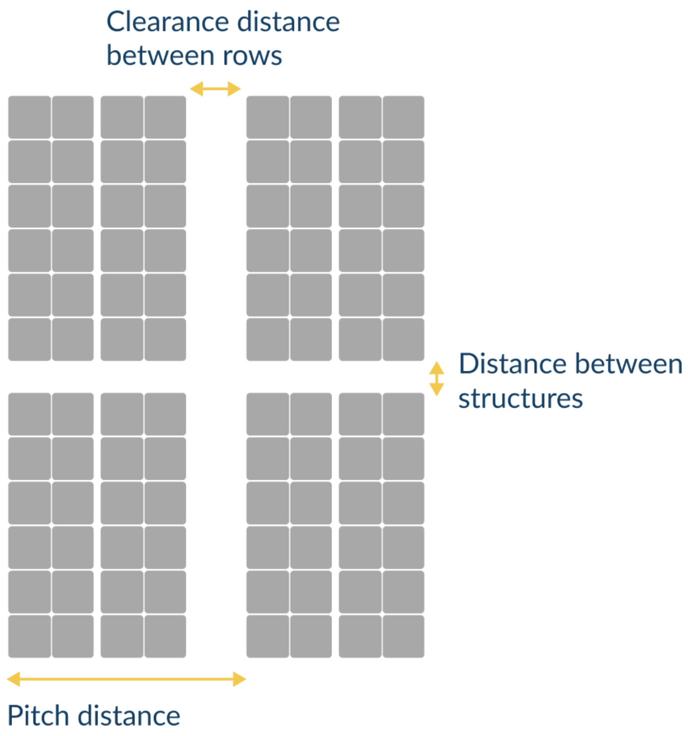


Figure 32 Clearance and pitch distance in east-west orientation

a

Table 29 South orientation design general parameters

Description	Value
SPP Kutnjak	Solar power plant
Peak power (DC)	from 180 to 360 MWdc - depending on the clearance distance between rows
Rated power (AC)	From 150 to 300 MWac - depending on the clearance distance between rows
Ratio DC/AC	1.20 - (aimed design for ≈20% overpaneling)
Ground coverage ratio (GCR)	From 37% to 80 % - depending on the clearance distance between rows
Structure type	South orientation 2V (2 vertical panels orientation)
Pitch distance / Tilt angle	From 10 meters to 4,5 meters m / 39° to 40 °fixed angle
PV Modules (700.0 Wp Jinko Solar) Power stations/inverters (up to 5000 kW) Number structures	From 259756 up to 522088 From 34 to 66 From 9277 to 18646

Figure 33 Example of a table (2V) with 2 vertical panels aligned in south orientation

General design performance indicators are shown in the summarizing table (Table 30) for different preliminary desings.

As can be seen from the table the E-W (east-west) orientation best fits the design goals to have the maximum energy production on the given area. It can provide up to 180 GW more of energy compared to 150 MW south orientation solar power plant.

For an example the design figures for the 226 MWac and 272 MWdc south layout are shown on the following figures.

The selected southern design yields 100 GWh of energy less than the east-west design.

It must be noted that the panel and inverter are similar to the equipment used in the main east-west design. Also, the costs are assessed and scaled based on the unit prices of the same equipment. The same PVdesign LCOE calculation methodology was used with the 10% discount rate and yearly OPEX seen in the table.

SUMMARY

Rated Power	226,5 MW
Peak Power	271,3 MW
Ratio DC/AC	1,2
Specific Production	1.171 kWh/kWp
Energy (year 1)	318 GWh
Performance Ratio	76,82 %

MAIN EQUIPMENT

PV Module

Risen Energy Co., Ltd	690 Wp
RSM132-8-690BNDG	SI_MONO

Fixed structure

Generic	6.58 m (pitch)
Generic-2V-64	

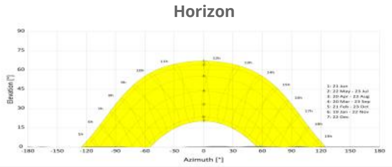
Central inverter

SMA	4.600 kVA
Sunny Central 4600 UP (Preliminary)	98,52 % (Efic. Max)

LOCATION

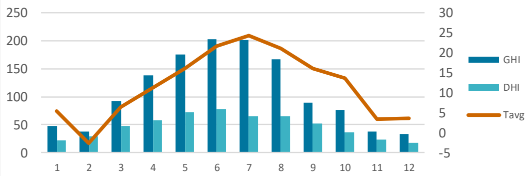
Latitude / Longitude	+46.28 ° / +16.78 °
Region	vnica-Križevci County
Country	Croatia
Altitude	135 m a.m.s.l.
Available area	207,67 ha

Horizon



METEOROLOGICAL DATA

Global Horizontal Irradiation	1.299 kWh/m2
Beam Horizontal Irradiation	732 kWh/m2
Diffuse Horizontal Irradiation	567 kWh/m2
Temperature average	11,8 °C



Source: PVGIS

ENERGY YIELD - PROBABILISTIC STUDY, σ = 3.00 %

Probability	Energy
P50	317,70 GWh
P75	311,20 GWh
P90	305,50 GWh
P95	302,00 GWh
P99	295,50 GWh

ENERGY YIELD - LONG TERM

Year	Specific (kWh/kWp)	PR	Energy
1	1171,0	76,8%	317,7 GWh
13	1130,7	74,2%	306,7 GWh
25	1088,2	71,4%	295,2 GWh
Avg	**1130,3**	**74,2%**	**306,6 GWh**

Figure 34 Summary of the example south-4 design with 271 MWdc installed capacity

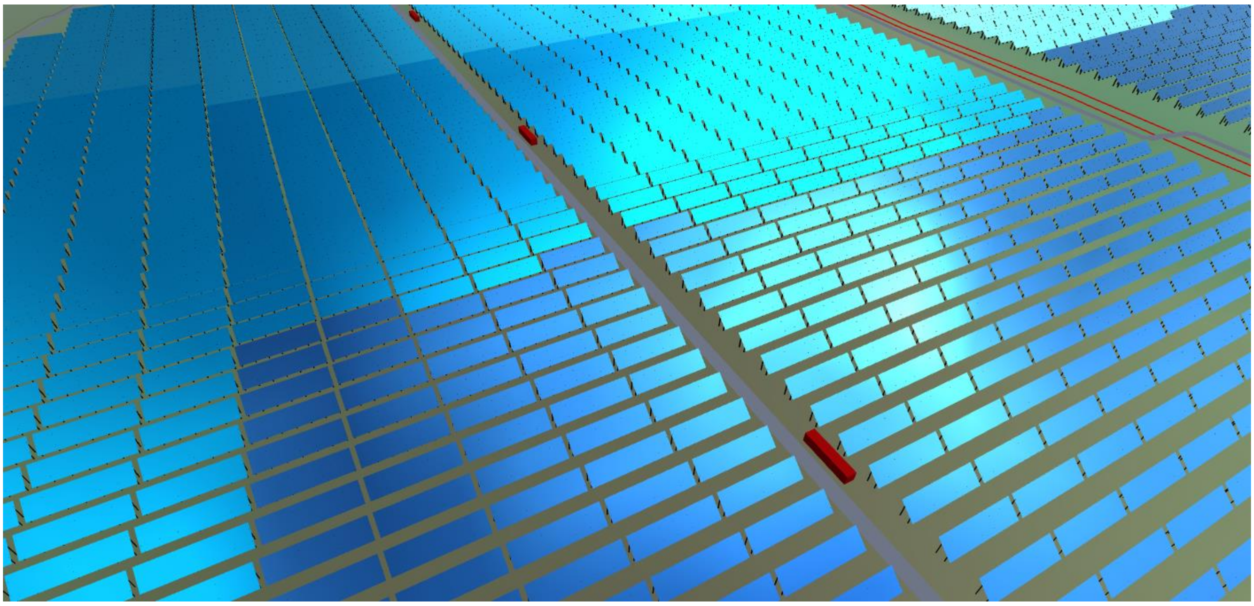


Figure 35 Example of a table and central inverter arrangement

In addition to fixed angle orientation, the tracker configuration can also be considered.

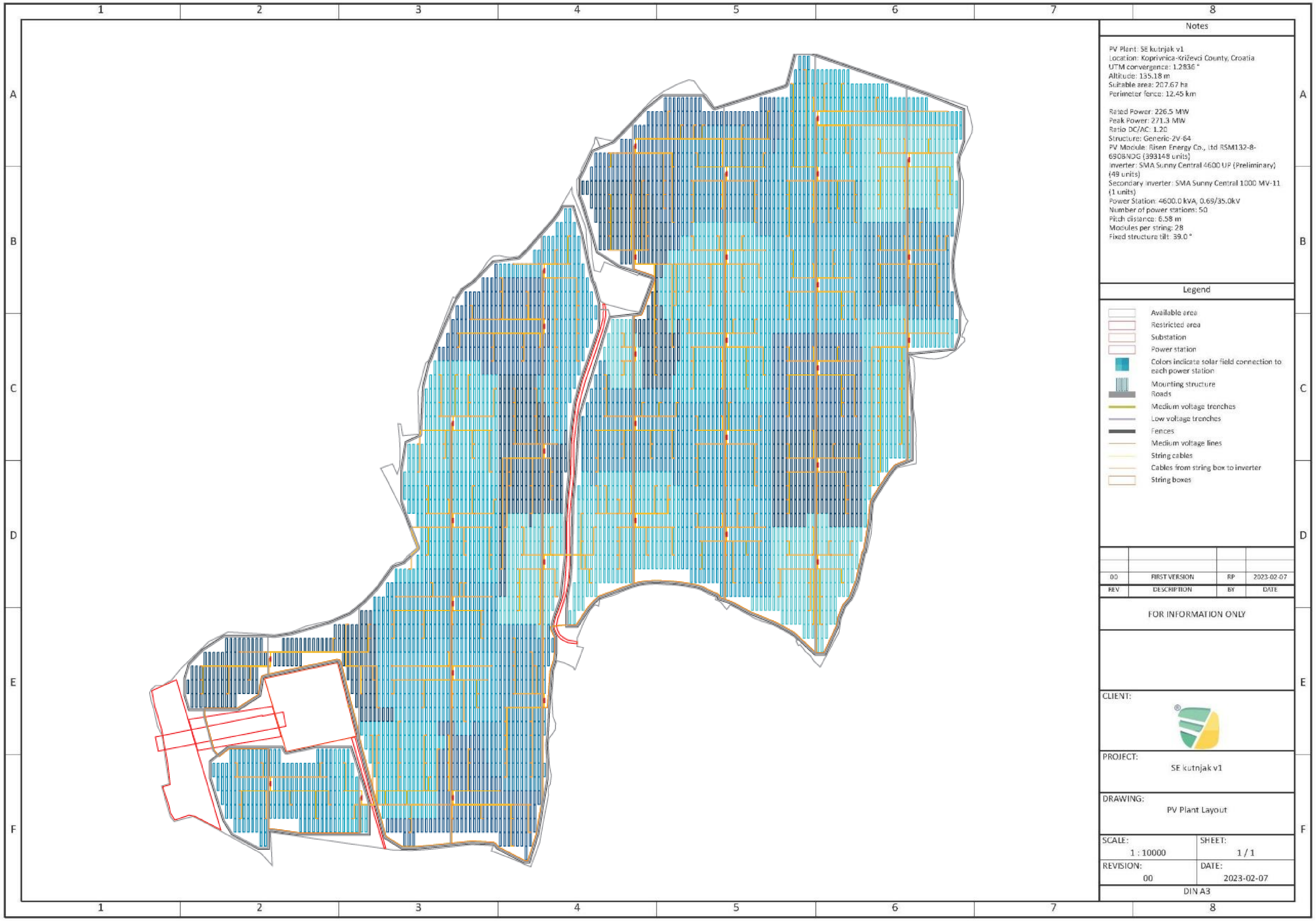


Figure 36 South-4 design with 271 MWdc installed capacity in south orientation – general layout of the panels

Table 30 Comparison of the design parameters for different south orientation preliminary designs

No.	layout config.	Rated AC power [MW]	Peak DC power [DC]	GCR [%]	Pitch distance [meters]	Clearance distance between rows [meters]	Tilt angle [degrees]	Total number of panels [units]	Total number of structures [units]	Total number of central inverters [units]	CAPEX [mil EUR]	OPEX [mil/EUR/yearly]	Total cost including purchase price	Energy to grid (1-year) [GWh]	specific production [kWh/kWp]	Perform. ratio [%]	Specific constr. price [€/kWp]	Specific price [€/kWp]	LCOE [€/MWh]
0	E-W	300	355	80%	10,4	1,0 m	15°	512736	9154	65	222	5,50	256	414	1171	91,3%	625	720	78,7
1	S-1	149	179	37%	10,1	6,3	39°	259756	9277	34	134	2,77	152,8	234	1306	85,7	749	854	78,4
2	S-2	177	212	44%	8,5	4,7	39°	307328	10976	40	151	3,29	173	268	1266	83,1	710	816	77,7
3	S-3	203	244	51%	7,3	3,6	39°	354844	12673	45	166	3,77	191	297	1213	79,6	683	785	77,9
4	S-4	225	270	56%	6,6	2,9	39°	393148	14041	50	177	4,20	205	317	1172	76,8	655	762	78,9
5	S-5	250	300	63%	5,9	2,1	39°	435344	15548	56	193	4,65	223	332	1106	72,7	644	745	81,8
6	S-6	274	329	69%	5,3	1,7	39°	476644	17023	61	207	5,09	239	340	1036	68,0	630	729	85,6
7	S-7	300	360	76%	4,8	1,1	39°	522088	18646	66	222	5,58	256	333	922	63	617	711	94,4

9. GCR

300 MWac and 359 MWdc with total production of 414 GWh annually with east-west orientation.

The area where the agro-solar power plant Kutnjak is to be built consists of a single total available area that is all connected and convex. The total area on which the project is developed includes 250,2 ha with a total surface area of expected panel coverage of approximately 154 ha.

The assumed number of solar panels for the expected installed capacity of 359 MWdc is 512736. Panel dimensions of the selected panel modelled are 2384x1303 (3,106 m2). Direct panel coverage is panel number x panel surface x cos(tilt angle 15°) = 1.538.467 m2 or 153,8 ha.

The 65 central inverter stations take 1932 m^2 (29,724 m^2 each) and the transformer station direct construction area is 120x120 meters which together with inverters equals to 1,5 ha. The total maximum transformer station surface area that can be used is 300x300 meters or 9 ha.

The direct construction element coverage is around 158 ha which comes down to 62% of surface coverage. The allowed surface coverage on the Kutnjak/Selnica site is 80% in accordance with the spatial plan of the municipality with no ground coverage ratio limitation for agrosolar type of the production.

The size of each area and the total suitable area for installation purposes is shown in below with the graphical representation on figure below.

Table 31- Size of plot areas of the project

Area	Surface
Available areas	
Total project land	250,2 ha
Restricted areas – roads and security perimeters	
Existing Transmission 400 kV line corridor	3,59 ha
Connection Transmission 400 kV line corridor	2,05 ha
Substation Access road	0,22 ha
Existing road	0,75 ha
Substation outer maximum boundaries area	
Substation outer perimeter area	4,26 ha

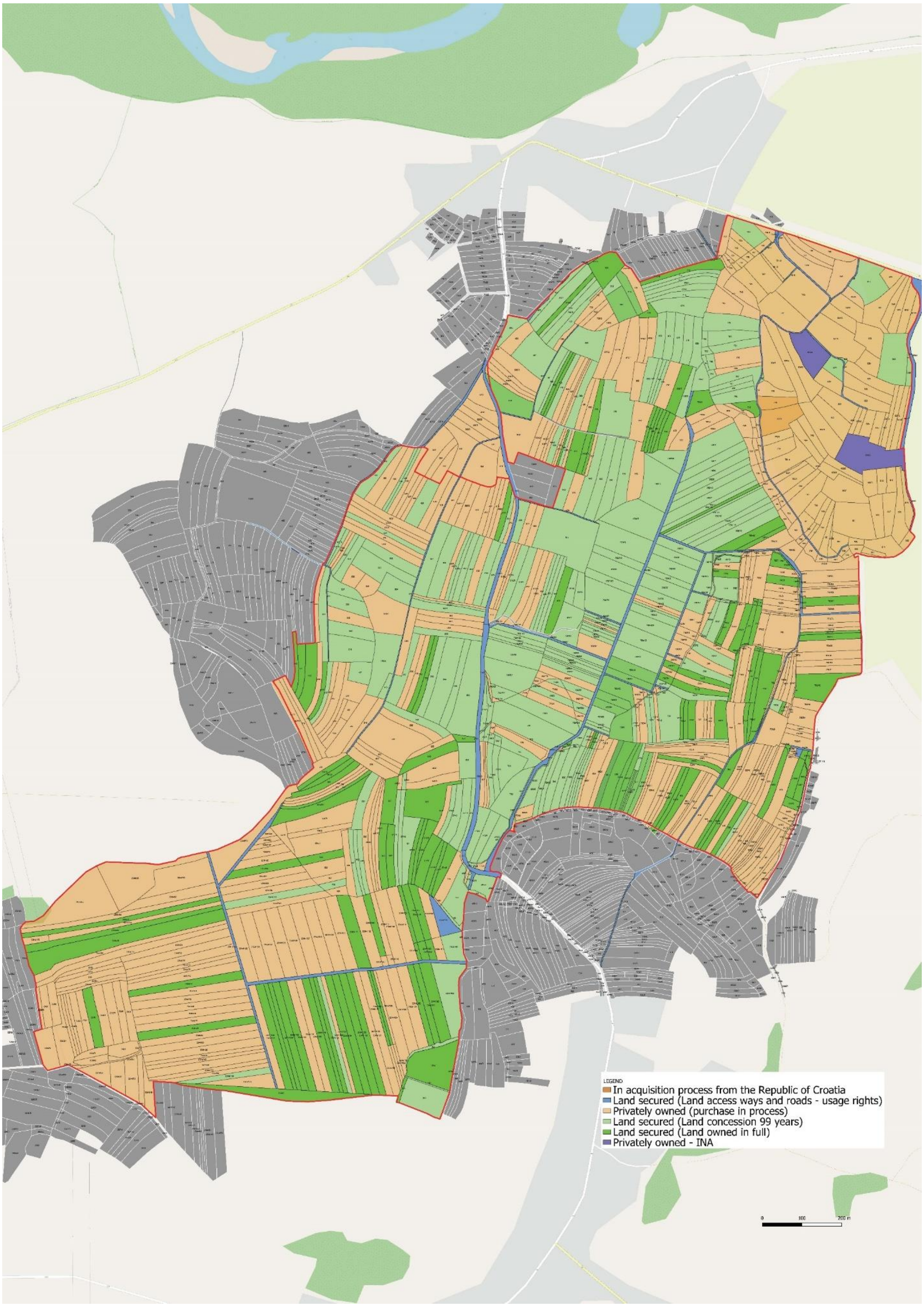


Figure 37 – Outer perimeters of the project as of April 2023

Also, if approximately one ha is considered and the panels are the same, 690(700W), 2384x1303 mm which is 225 W/m2 since their surface is 3,106 m^2 the total area of 10000 m^2 can be used for 2,25 MW under the assumption 100% coverage is made and with tilt angle 0 degrees and with 3219 panels.

The tilt angle reduces the surface area of the panels, with tilt angle between 15 and 20 degrees reducing the panel surface area for 6%. If GCR is considered to be 80% then the total number of panels that can fit into one ha of area is 2575 with approximate installed power of 1,77 MW.

If approximately 200 ha are considered, 1,77 MWdc on each unit of land, total solar power plant DC capacity can be in range from 350 MWdc to 360 MWdc. Leading to a project of up to 300 MWac and 360 MWdc on the total area of 250 ha.

10. SUMMARY

The specifications of the PV modules and remaining electrical equipment presented, as well as the power plant configuration, were based on the current information provided in the offers and the respective datasheets from the manufacturers. To the moment, there has been no knowledge of any specific guarantee associated to the specification and/or the performance of the equipment themselves.

Transposition from horizontal to tilted radiation is performed according to PVdesign model (Perez radiation model), separately calculating each irradiance component. The conversion of the direct component of the radiation, from the horizontal plane to the tilted one, is the result of basic trigonometry operations. In the case of the diffuse component, it is necessary to use a model for simulation. To estimate the reflected component of the radiation an assumed value of 25% of the soil's Albedo. The annual production estimates for the power plant were based on hourly data, incidence angle effects, radiation and temperature variations as well as the specific characteristics of the PV modules and AC/DC inverter groups. The received radiation by a horizontal PV module comprises all its components in order to transform them into energy. Depreciation factors such as soiling, shading and other were considered within the simulation and were all listed in detail.

The normal operation of the power plant was modelled using PVdesign software, which allowed for the detailed calculation of the energy production estimates, taking into consideration standard practices worldwide. The net annual energy production (P50) averaged over 25 years is 63 076 MWh. An evaluation according to the confidence limits, or exceedance, was performed based on an expanded uncertainty and assuming an independent relation between all components. The first year production estimate is 414 GWh. The standard deviation of the normal distribution was assumed to be of its value of 3.00 % as an usual value with 25 year P95 average 394 GWh. The measurement campaign is expected to be conducted in 2023. This measurement campaign on the sight should last for a period of period longer than a year to account for seasonal effects. Due to nature of the solar resource on site, the mentioned measurement campaign should have the ability to record not only global irradiation but also the diffuse or direct components, in order to better ascertain the consequent gains in energy production. The short term measurements of the mast combined with accurate long term data from a meteorological database should provide the best chance for uncertainty mitigation on the energy production results.

The equipment's depreciation considered, although supported by various studies of long-term exposure, assumes the execution of a schedule preventive maintenance program as well as a proper management and operation of all the power plant's components.

The project is regarded as an agrosolar system which enables more efficient use of land through the simultaneous cultivation of agricultural crops, livestock breeding and PV solar production. For agrosolar no restrictions to the land acquiring process and agro-production is further strengthened by the geothermal source located right on the SE Kutnjak site and owned by EEG Group. Furthermore, the agrosolar project allows for higher ground coverage ratio and therefore more efficient usage of the available land. The agricultural component will gain importance in coming years and intensive food production at Kutnjak location will gain in value but the financial aspects of this production were not part of this document.

The CAPEX cost of the project is 221,7 mil EUR. CAPEX does not include the cost of project acquisition.

The total costs include the takeover of 100% shares of the SE Kutnjak owner company which is set to 34 mil EUR. The TOTAL project cost is 255 mil EUR.

The total OPEX sums to a range of 5,5 mil EUR yearly and it separately considers the maintenance cost and replacement of equipment costs.

The SE Kutnjak project LCOE calculation assumes the constant level of production and 9% discount rate throughout the project lifetime and the LCOE in range from 80 EUR/MWh to 90 EUR/MWh.

As a final remark, the results and conclusions of this report should be reviewed in case of changes to the configuration considered for the power plant, PV modules, inverters and its features or significant changes in the surroundings of project area.