1. Theoretical Background

Solar energy is the radiation emitted by the Sun, and it has the remarkable ability to generate heat, initiate chemical reactions, and produce electricity. The quantity of solar energy reaching Earth is significantly more than our current and future energy demands. If effectively captured, this widely available source has the potential to meet all our energy needs. In the 21st century, solar energy is gaining popularity as a renewable energy source due to its limitless supply and environmentally friendly nature. This stands in sharp contrast to finite fossil fuels like coal, petroleum, and natural gas. In simpler terms, solar energy, harnessed properly, could provide a sustainable and clean solution to our growing energy requirements, unlike traditional fossil fuels with their limitations and environmental impact.

2. Solar panels

A solar panel (also known as "PV panels") is a device that converts light from the sun, which is composed of particles of energy called "photons", into electricity that can be used to power electrical loads.

Solar panels can be used for a wide variety of applications including remote power systems for cabins, telecommunications equipment, remote sensing, and of course for the production of electricity by residential and commercial solar electric systems.

• Types of solar panels

There are several types of solar panels available on the market, each with distinct characteristics. Here are the main types:

- ✓ **Monocrystalline Solar Panels:**
  - Made from pure refined silicon in a pulling process.
  - Referred to as "passivated emitter and rear contact" panels.
  - Known for high efficiency and sleek aesthetics.
- ✓ **Polycrystalline (Multi-crystalline) Solar Panels:**
  - Composed of multiple silicon fragments.
  - Generally, less expensive than monocrystalline panels.
  - Slightly lower efficiency compared to monocrystalline.
- ✓ **Thin-Film Solar Panels:**
  - Utilize thin layers of photovoltaic material on a substrate.
  - Generally less efficient but can be flexible and lightweight.
  - Suitable for specific applications like solar shingles and integrated building materials.

- ✓ **Passivated Emitter and Rear Contact (PERC) Solar Panels:**
  - A type of monocrystalline solar panel with an enhanced design.
  - Features a passivation layer for improved efficiency.

The choice of solar panel type depends on factors such as efficiency requirements, space availability, and budget considerations. Monocrystalline panels are often preferred for higher efficiency, while polycrystalline panels may be a cost-effective alternative. Thin-film panels offer flexibility and unique applications, and PERC panels provide enhanced efficiency through advanced design.

3. Inverters

A solar inverter works by taking in the variable direct current, or 'DC' output, from your solar panels and transforming it into alternating 120V/240V current, or 'AC' output. The appliances in your home run on AC, not DC, which is why the solar inverter must change the DC output that is collected by your solar panels.

Once this energy is produced, it is either stored in a battery for later use or sent directly to an inverter (this depends on the type of system you have). When the energy gets sent to the inverter, it is in DC format but your home requires AC. The inverter grabs the energy and runs it through a transformer, which then spits out an AC output. The inverter, in essence, 'tricks' the transformer into thinking that the DC is actually AC, by forcing it to act in a way like AC – the inverter runs the DC through two or more transistors that turn on and off super-fast and feed two varying sides of the transformer.

4. Helioscope

We Are Using Helioscope For Performing Our CEP

Helioscope is the solar industry's leading software platform for designing high-performance solar arrays. Folsom Labs develops Helioscope, an advanced solar PV design & sales tool. It is an online software that gives specific power output from specific area/Location. Helioscope simplifies the process of engineering and selling solar projects by integrating easy layout tools with bankable performance modelling. Helioscope offers CAD caliber layouts, remote shade analysis, and bankable energy yield calculations. It allows anyone to generate solar layouts and performance estimates.

5. Addressing the tasks

✓ Site Selection

So We had to select the place whose annual energy consumption is in kilowatt-hours (kWh), and we are familiar with that place. Therefore, we selected AB Hall UET Taxila.

✓ Load calculation for AB hall

Location	Room Type	Item	Quantity	Wattage	Load
Ground Floor	Small Rooms	Fans	33	120	3960
		Tube lights	66	36	2376
		Led bulbs	33	12	396
	Cubic Room	Fans	72	120	8640
		Tube lights	72	36	2592
		Led bulbs	72	12	864
	Storeroom	Bulbs	5	12	60
		Exhaust fans	3	140	420
		Fans	1	120	120
		PC	1	450	450
		Tube light	3	36	108
	Mess Hall	Lights	15	85	1275
		Fans	17	120	2040
		Refrigerator	1	500	500
		Exhaust	5	140	700
	Mosque	Chiller	2	2000	4000
		Fans	12	120	1440
		Tube lights	12	36	432
		Exhaust fans	4	140	560
First Floor	Small Rooms	Fans	33	120	3960
		Tube lights	66	36	2376
		Led bulbs	33	12	396
	Cubic Room	Fans	72	120	8640
		Tube lights	72	36	2592
		Led bulbs	72	12	864
	Common Room	Tube lights	16	36	576
		Led bulbs	10	12	120

		Exhaust fans	4	140	560
		LED	1	55	55
Second Floor	Small Rooms	Fans	33	120	3960
		Tube lights	66	36	2376
		Led bulbs	33	12	396
	Cubic Room	Fans	72	120	8640
		Tube lights	72	36	2592
		Led bulbs	72	12	864
All Floors	Washrooms	Tube lights	72	36	2592
		Led bulbs	24	12	288
		Exhaust fans	24	140	3360

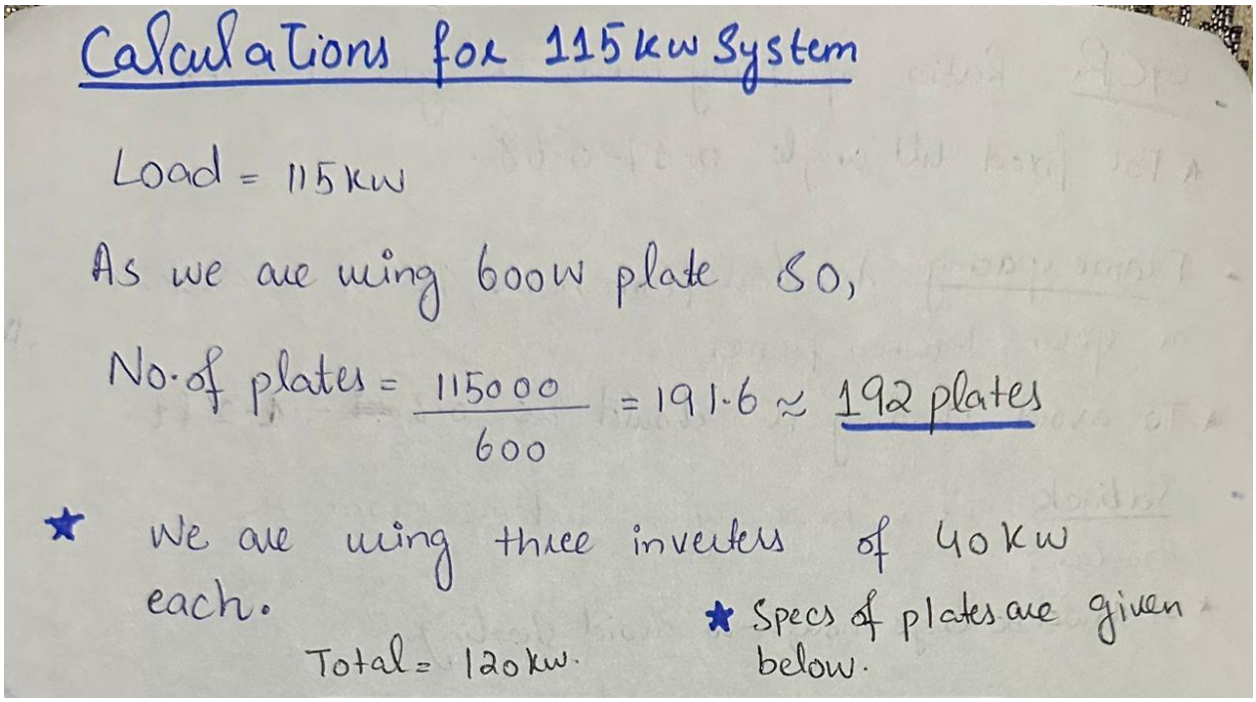
Total load=74760W

After adding safety factor =74760*1.5=112140W

So, we are going to design a 115 kw On grid system for AB hall

6. Designing 115kw On Grid system Using Hellioscope

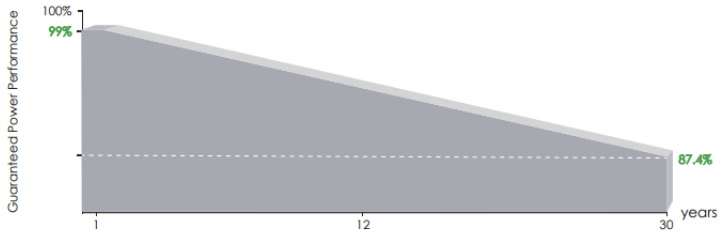
- ✓ **First hand calculations**



✓ Specifications of Tiger Neo N-type 78HL4-BDV 590-610 Watt

Solar JinKO
Building **Your Trust** in Solar

LINEAR PERFORMANCE WARRANTY



12 Year Product Warranty

30 Year Linear Power Warranty

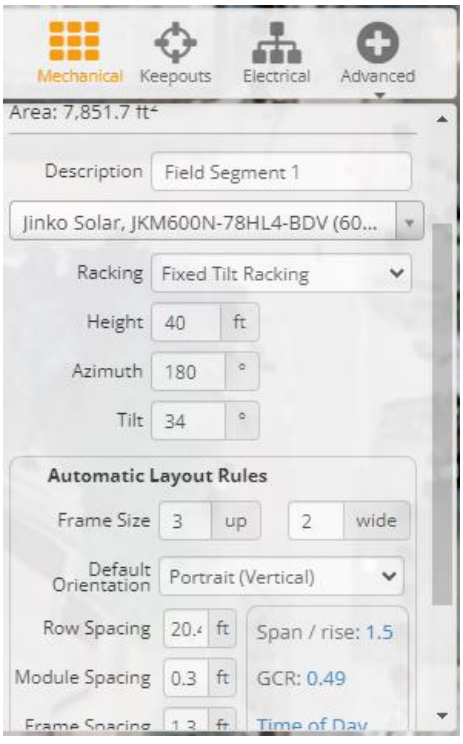
0.40% Annual Degradation Over 30 years

SPECIFICATIONS

Module Type	JKM590N-78HL4-BDV		JKM595N-78HL4-BDV		JKM600N-78HL4-BDV		JKM605N-78HL4-BDV		JKM610N-78HL4-BDV	
	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT	STC	NOCT
Maximum Power (Pmax)	590Wp	444Wp	595Wp	447Wp	600Wp	451Wp	605Wp	455Wp	610Wp	459Wp
Maximum Power Voltage (Vmp)	44.91V	41.89V	45.08V	42.00V	45.25V	42.12V	45.42V	42.23V	45.60V	42.35V
Maximum Power Current (Imp)	13.14A	10.59A	13.20A	10.65A	13.26A	10.71A	13.32A	10.77A	13.38A	10.83A
Open-circuit Voltage (Voc)	54.76V	52.02V	54.90V	52.15V	55.03V	52.27V	55.17V	52.41V	55.31V	52.54V
Short-circuit Current (Isc)	13.71A	11.07A	13.79A	11.13A	13.87A	11.20A	13.95A	11.26A	14.03A	11.33A
Module Efficiency STC (%)	21.11%		21.29%		21.46%		21.64%		21.82%	
Operating Temperature(℃)	-40℃~+85℃									
Maximum system voltage	1500VDC (IEC)									
Maximum series fuse rating	30A									
Power tolerance	0~+3%									
Temperature coefficients of Pmax	-0.30%/℃									
Temperature coefficients of Voc	-0.25%/℃									
Temperature coefficients of Isc	0.046%/℃									
Nominal operating cell temperature (NOCT)	45±2℃									
Refer. Bifacial Factor	80±5%									

7. On Helioscope

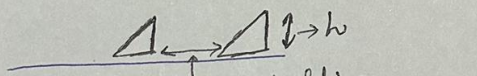
✓ **Mechanical part**



- ✓ **Explanation (hand)**

Mechanical Part explanation:-

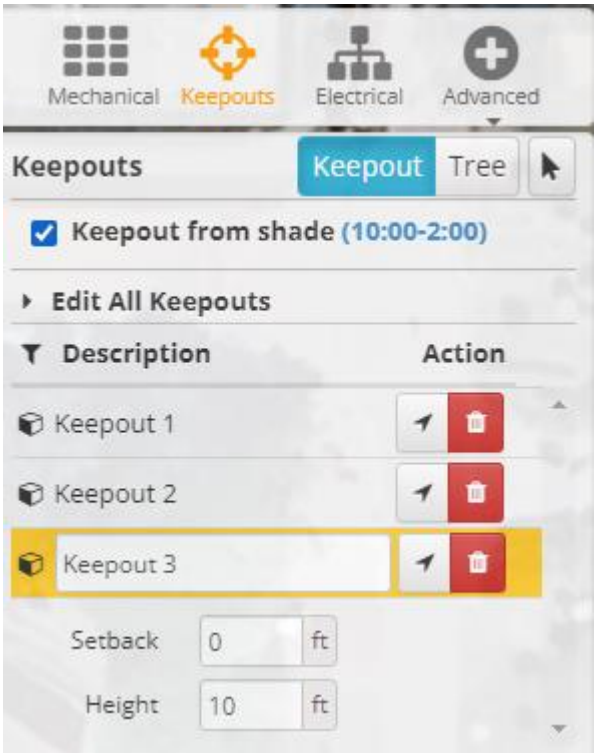
- Azimuth angle:- In pakistan aiming for an azimuth angle of approximately 180° (South-facing) is ideal.
- Tilt Angle:- Tilt angle is in correspondence with Latitude. Latitude of Taxila is 33.74 that's why we are using an angle of 34°.
- SPan/Rise :- It is the relationship b/w the distance or span b/w rows of solar modules and the height or rise of the pannels.
  - ★ For better performance it should be b/w 1.2 – 1.5.



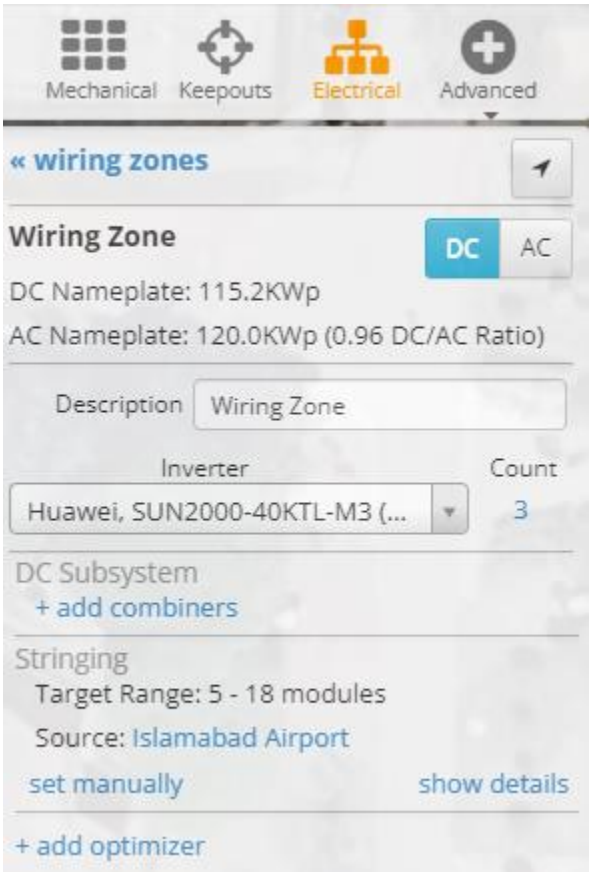
- GCR Ratio of Array area To ground area.
  - ★ For fixed tilt angle 0.17-0.68.
- Frame spacing As clear from name it is a distance or spacing between frames.
  - ★ To avoid shading it should be 0.8 ~~ft~~ – 1.2 ft.
- Setback It is baically a distance from the boundary.
  - ★ It should be large enough to avoid shading.

8. Keep outs

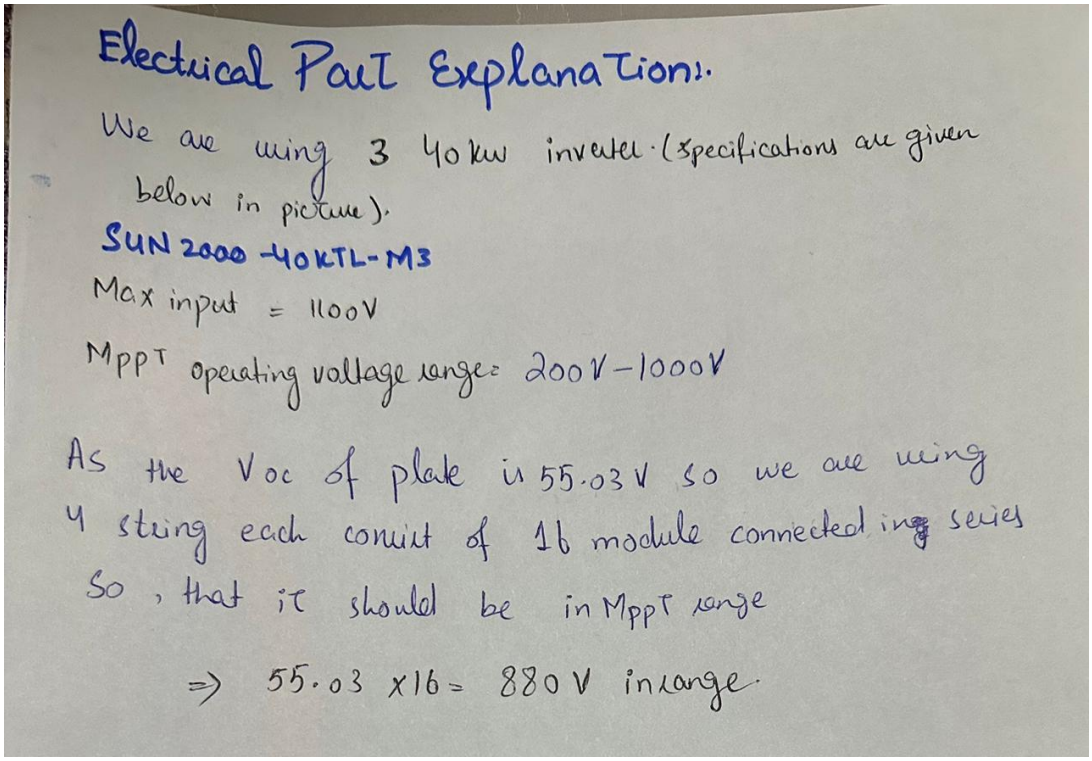

uet taxila ab hall
Preferences
Saved
Showing Array
Mechanical
Keepouts
Electrical
Advanced
Keepouts
Keepout
Tree
Keepout from shade (10:00-2:00)
Edit All Keepouts
Description
Action
Keepout 1
Keepout 2
Keepout 3
Turn LIDAR On
Recenter View


Mechanical
Keepouts
Electrical
Advanced
Keepouts
Keepout
Tree
Keepout from shade (10:00-2:00)
Edit All Keepouts
Description
Action
Keepout 1
Keepout 2
Keepout 3
Setback
0
ft
Height
10
ft

9. Electrical



- ✓ **Explanation (hand)**



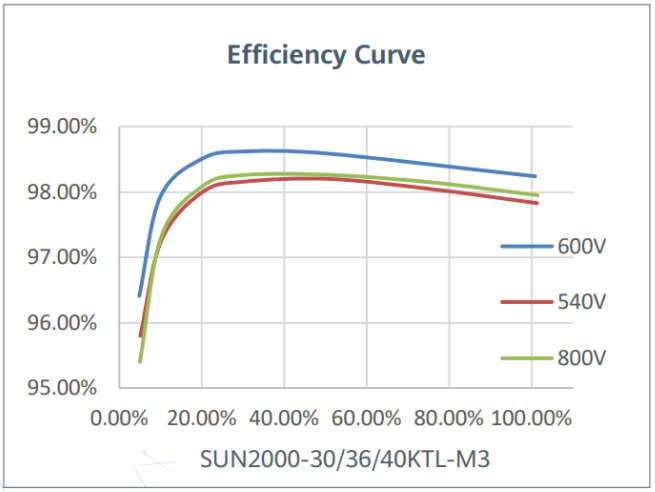
- ✓ **Specifications of SUN2000-40KTL-M3**

HUAWEI

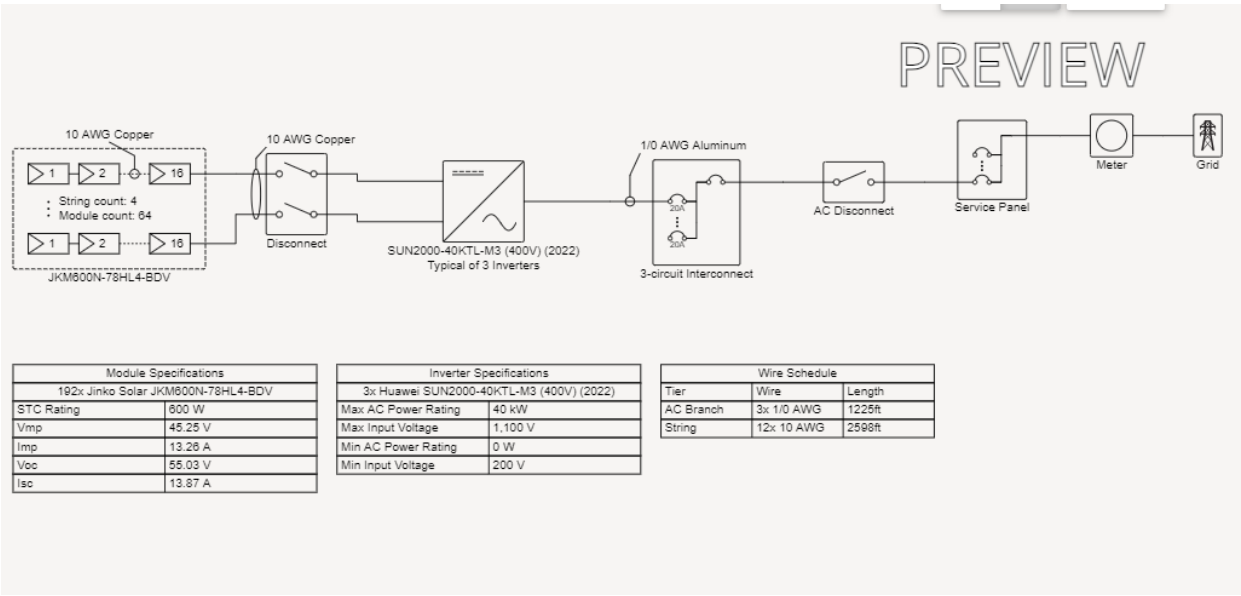
SUN2000-30/36/40KTL-M3

Technical Specification

Technical Specification	SUN2000-30KTL-M3	SUN2000-36KTL-M3	SUN2000-40KTL-M3
Efficiency			
Max. Efficiency	98.7%		
European Efficiency	98.4%		
Input			
Max. Input Voltage [1]	1,100 V		
Max. Current per MPPT	26 A		
Max. Short Circuit Current per MPPT	40 A		
Start Voltage	200 V		
MPPT Operating Voltage Range [2]	200 V ~ 1000 V		
Rated Input Voltage	600 V		
Number of Inputs	8		
Number of MPP Trackers	4		
Output			
Rated AC Active Power	30,000 W	36,000 W	40,000 W
Max. AC Apparent Power	33,000 VA [3]	40,000 VA	44,000 VA
Rated Output Voltage	230 Vac / 400 Vac / 480 Vac, 3W/N+PE		
Rated AC Grid Frequency	50 Hz / 60 Hz		
Rated Output Current	43.3 A	52.0 A	57.8 A
Max. Output Current	47.9 A	58.0 A	63.8 A
Adjustable Power Factor Range	0.8 LG ... 0.8 LD		
Max. Total Harmonic Distortion	< 3%		
Protection			
Input-side Disconnection Device	Yes		
Anti-islanding Protection	Yes		
AC Overcurrent Protection	Yes		
DC Reverse-polarity Protection	Yes		
PV-array String Fault Monitoring	Yes		
DC Surge Arrester	Yes		
AC Surge Arrester	Yes		
DC Insulation Resistance Detection	Yes		
Residual Current Monitoring Unit	Yes		
Arc Fault Protection	Yes		
Ripple Receiver Control	Yes		
Integrated PID Recovery [4]	Yes		



- ✓ **Single line diagram**



Module Specifications	
192x Jinko Solar JKM600N-78HL4-BDV	
STC Rating	600 W
Vmp	45.25 V
Imp	13.26 A
Voc	55.03 V
Isc	13.87 A

Inverter Specifications	
3x Huawei SUN2000-40KTL-M3 (400V) (2022)	
Max AC Power Rating	40 kW
Max Input Voltage	1,100 V
Min AC Power Rating	0 W
Min Input Voltage	200 V

Wire Schedule		
Tier	Wire	Length
AC Branch	3x 1/0 AWG	1225ft
String	12x 10 AWG	2598ft

10. <u>Advanced</u>

11. Helioscope report

Performance ratio is 84.1%

uet taxila ab hall okk, UET taxila

Report

Project Name	okk
Project Address	UET taxila
Prepared By	Mannan Abid mannan.abid10@gmail.com

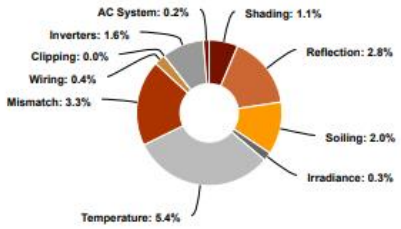
System Metrics

Design	uet taxila ab hall
Module DC Nameplate	115.2 kW
Inverter AC Nameplate	120.0 kW Load Ratio: 0.96
Annual Production	191.3 MWh
Performance Ratio	84.1%
kWh/kWp	1,661.0
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)
Simulator Version	4d27c129a2-2ba890d279-cc5ff22ffc-c525e55a0c

Project Location

Monthly Production

Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,726.8	
	POA Irradiance	1,976.1	14.4%
	Shaded Irradiance	1,954.4	-1.1%
	Irradiance after Reflection	1,900.3	-2.8%
	Irradiance after Soiling	1,862.3	-2.0%
	Total Collector Irradiance	**1,862.3**	**0.0%**
Energy (kWh)	Nameplate	214,551.2	
	Output at Irradiance Levels	213,857.6	-0.3%
	Output at Cell Temperature Derate	202,326.1	-5.4%
	Output After Mismatch	195,708.9	-3.3%
	Optimal DC Output	194,882.2	-0.4%
	Constrained DC Output	194,881.9	0.0%
	Inverter Output	191,763.8	-1.6%
	Energy to Grid	**191,343.0**	**-0.2%**
Temperature Metrics			
	Avg. Operating Ambient Temp		25.2 °C
	Avg. Operating Cell Temp		35.4 °C
Simulation Metrics			
	Operating Hours		4573
	Solved Hours		4573

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km Grid, meteonorm (meteonorm)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
	East-West	-3.56	-0.075	3°C								
	Carport	-3.56	-0.075	3°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											

Module Characterizations	Module	Uploaded By	Characterization
	JKM600N-78HL4-BDV (Jinko Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations	Device	Uploaded By	Characterization
	SUN2000-40KTL-M3 (400V) (2022) (Huawei)	HelioScope	Spec Sheet

Components

Component	Name	Count
Inverters	SUN2000-40KTL-M3 (400V) (2022) (Huawei)	3 (120.0 kW)
AC Home Runs	1/0 AWG (Aluminum)	3 (1,224.6 ft)
Strings	10 AWG (Copper)	12 (2,598.0 ft)
Module	Jinko Solar, JKM600N-78HL4-BDV (600W)	192 (115.2 kW)

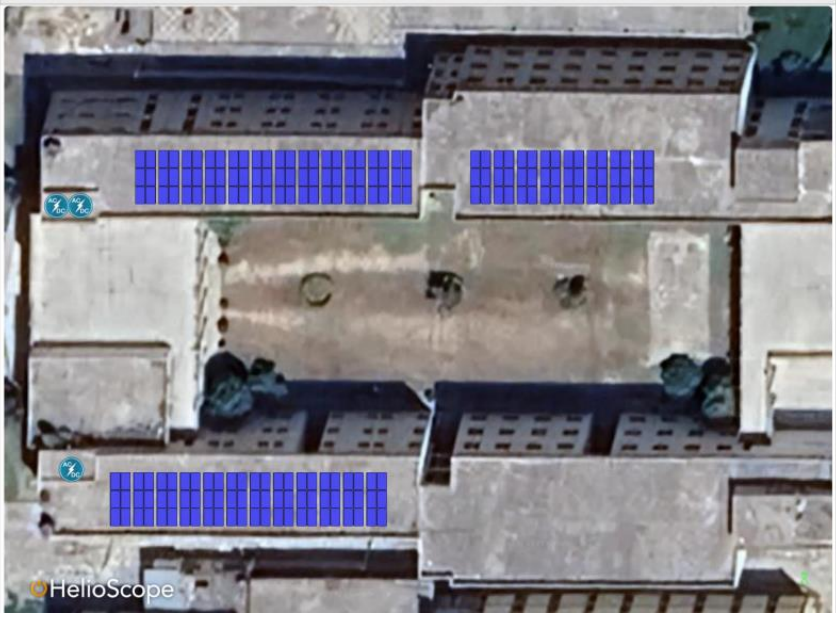
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	5-18	Along Racking

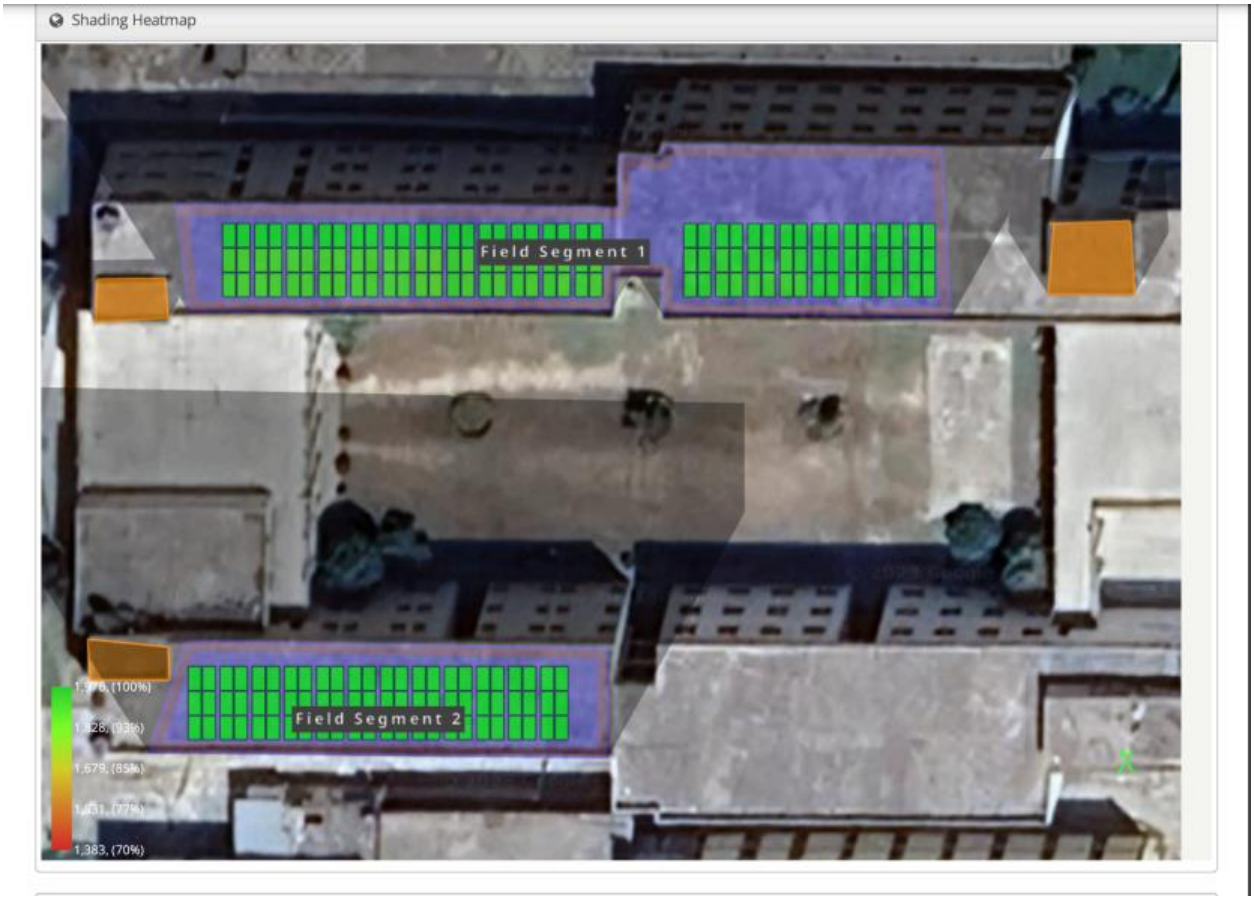
Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Portrait (Vertical)	34°	180°	20.4 ft	3x2	20	120	72.0 kW
Field Segment 2	Fixed Tilt	Portrait (Vertical)	34°	180°	20.4 ft	3x2	12	72	43.2 kW

Detailed Layout



✓ Shading Report



Shading by Field Segment

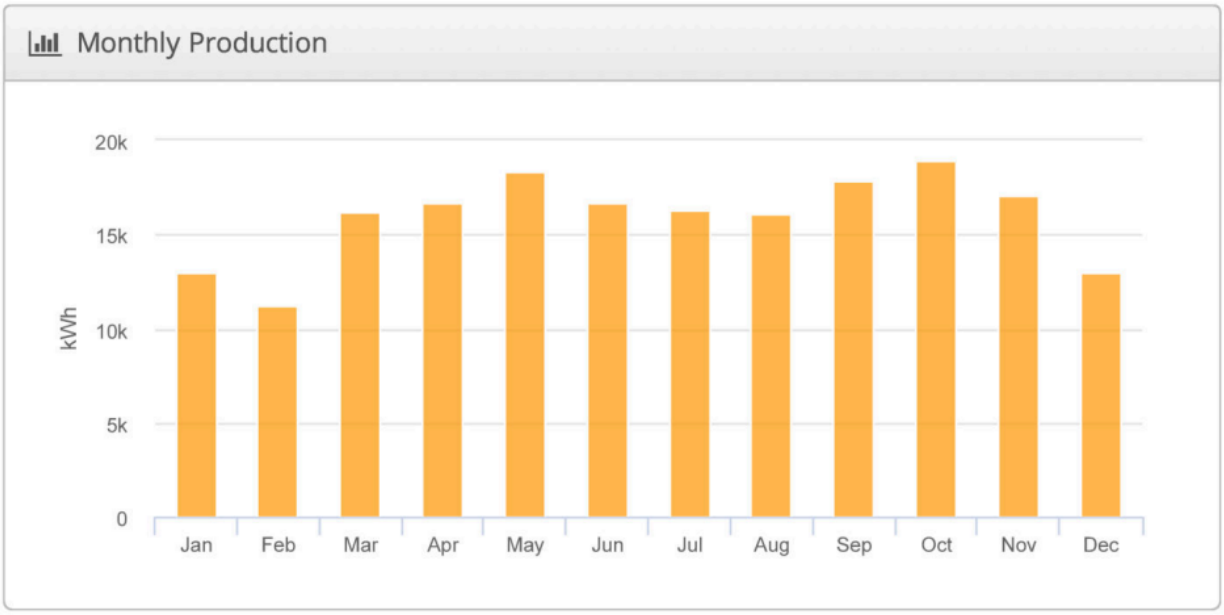
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Field Segment 1	34.0°	180.0°	120	72.0 kWp	1,941.4kWh/m^2	119.5 MWh[1]	100.0%	98.2%	98.3%
Field Segment 2	34.0°	180.0°	72	43.2 kWp	1,976.1kWh/m^2	71.9 MWh[1]	100.0%	100.0%	100.0%
Totals, weighted by kWp			**192**	**115.2 kWp**	**1,954.4kWh/m^2**	**191.3 MWh**	**100.0%**	**98.9%**	**98.9%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,975.8kWh/m^2 at 33.0° tilt and 180.8° azimuth

Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Field Segment 1	99%	98%	98%	98%	98%	98%	98%	98%	98%	99%	99%	99%
Field Segment 2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solar Access, weighted by kWp	**99.2%**	**99.0%**	**98.9%**	**98.8%**	**98.7%**	**98.6%**	**98.6%**	**98.7%**	**98.9%**	**99.1%**	**99.2%**	**99.2%**
AC Power (kWh)	**12,977.6**	**11,225.1**	**16,184.2**	**16,676.8**	**18,339.5**	**16,722.0**	**16,264.5**	**16,116.1**	**17,897.9**	**18,897.8**	**17,109.2**	**12,932.3**

✓ **Monthly Production Chart**



✓ **System Losses**