Yuma Desert Solar Frontier
Designing a 20-MW Jinko Tiger Neo PV + LFP Storage Plant for Maximum Energy in America’s Sunniest City

By: Henry Hartman & Moses Hernandez

Abstract: This paper discusses the design of a 20-MW photovoltaic solar power plant near Yuma, Arizona. It presents the requirements to create such a power plant by using the efficiency of a selected PV solar cell as a parameter to determine the cost and area requirements, along with capacity factor and expected average power output throughout the year. The meteorological data used includes wind speed, temperature, solar zenith angle, surface albedo, direct normal irradiance (DNI), diffuse horizontal irradiance (DHI), and global horizontal irradiance (GHI), collected at 30-minute intervals from 2018 to 2024 sourced from the National Renewable Energy Laboratory's National Solar Radiation Database (NSRDB) at coordinates 32.08°N, 113.87°W.

Data Method: This study utilized half-hourly solar irradiance and meteorological data spanning seven years (2018–2024) obtained from the National Renewable Energy Laboratory's National Solar Radiation Database (NSRDB) for Yuma, Arizona at coordinates 32.08°N, 113.87°W, elevation 225 m. The dataset contained 122,736 time-step intervals per variable, including direct normal irradiance (DNI), diffuse horizontal irradiance (DHI), global horizontal irradiance (GHI), ambient temperature, wind speed, solar zenith angle, and surface albedo. The selected panel for this design is the Jinko Tiger Neo N-Type TOPCon 670W, with a rated efficiency of 24.8% and temperature coefficient of −0.26%/°C. At each time step, the angle of incidence was computed based on the panel's fixed southward orientation and 32.7° tilt angle — matching Yuma's latitude — to determine how directly the sun's rays struck the panel surface. The total irradiance reaching the tilted panel surface, known as the plane of array irradiance, was then calculated by combining the direct beam radiation from the sun, diffuse radiation scattered from the sky, and radiation reflected off the desert ground surface using a surface albedo of 0.23. Panel efficiency was modeled as a temperature-dependent value that remains at its rated 24.8% under cool conditions and decreases as cell temperature rises above 25°C, using the manufacturer's published temperature coefficient. Module power output at each interval was then calculated from the plane of array irradiance, the temperature-corrected efficiency, and the panel's physical area of 2.583 m². The total plant output was scaled across all 29,851 panels required to achieve the 20 MW rated capacity, and an 85% system efficiency factor was applied to account for real-world losses including inverter conversion, wiring resistance, dust and soiling, and panel mismatch. Annual energy output and capacity factor were computed by summing all half-hourly power outputs across each calendar year. All data processing and simulation were performed using MATLAB with input data sourced from Microsoft Excel.

Main Conclusion: The design and simulation of a 20-MW photovoltaic solar power plant in Yuma, Arizona confirm that the site is an outstanding candidate for utility-scale solar generation. Using seven years of NREL NSRDB data (2018–2024), the modeled plant delivers an average annual energy output of 45,414 MWh with a capacity factor of 27.0%, closely matching published performance benchmarks for fixed-tilt PV in high-irradiance desert locations and showing less than 3% variation between years, which underscores the stability of Yuma's solar resource. The selected Jinko Tiger Neo JKM610–635N-66HL4M-(V)-F2 N-type TOPCon 635 W module—deployed in roughly 31,500–32,000 units over about 65 acres—proves well-suited to the harsh environment thanks to its high efficiency and favorable temperature coefficient of −0.29%/°C, which help limit thermal losses when cell temperatures climb into the 60–70°C range during summer. The base 20 MW PV plant is estimated to cost about $23.7 million, or $1.18/W, comfortably within current utility-scale cost ranges of roughly $0.90–$1.30/W. When enhanced with single-axis tracking and a 20 MW / 80 MWh lithium iron phosphate battery system, the design's projected annual output rises to 56,768 MWh and the capacity factor to 32.4%, for a total installed cost near $55 million. Over a 25-year life, assuming 0.55%/year panel degradation, annual O&M of $200,000, and a blended PPA price of $38/MWh, the project yields an estimated $45.2 million in cumulative net revenue. Taken together, these results show that rigorous thermal modeling, high-efficiency N-type TOPCon modules, single-axis tracking, and LFP storage form a coherent, high-performance strategy for maximizing both the technical output and financial viability of utility-scale PV plants in high-irradiance desert environments.

Losses

- Inverter conversion loss: about **2–4%** (96–98% efficient inverters).
- DC wiring and connections: **1–3%** (voltage drop, resistive heating).
- AC wiring / transformer losses: **1–2%**.
- Soiling (dust, bird droppings): typically **2–5%**, higher in deserts like Yuma.
- Mismatch, LID, degradation allowance, etc.: another **2–4%**.
- Inverter: **0.97**
- DC wiring: **0.98**
- AC wiring/transformer: **0.98**
- Soiling: **0.95**
- Mismatch/other: **0.95**
- Overall BOS efficiency ≈ $0.97 \times 0.98 \times 0.98 \times 0.95 \times 0.95 = 0.85$ → **85%**. Effiecncy Rate for Calculations

Definitions

- Angle of Incidence: The angle between the sun's incoming rays and an imaginary line perpendicular to the surface of the solar panel.
- Plane of Array Irradiance: The total amount of solar radiation striking the tilted surface of the solar panel, measured in watts per square meter (W/m^2).
- Direct Normal Irradiance (DNI): The amount of solar radiation received per unit area from the sun's direct beam, measured on a surface that is always held perpendicular to the sun's rays (W/m^2).
- Diffuse Horizontal Irradiance (DHI): The amount of solar radiation received per unit area on a horizontal surface that has been scattered by the atmosphere — by clouds, dust, aerosols, and air molecules — so that it arrives from all directions across the sky rather than directly from the sun (W/m^2).
- Global Horizontal Irradiance (GHI): The total solar radiation received per unit area on a flat horizontal surface, combining both the direct beam component and the diffuse sky component (W/m^2).
- Surface Albedo: The fraction of incoming solar radiation that is reflected off the ground surface back upward toward the solar panels, expressed as a dimensionless number between 0 and 1.

Methodology

$$Angle\ of\ Incidence = Cos(\beta)Cos(Solar\ Zenith) + Sin(\beta)Sin(Solar\ Zenith)$$

$$Plane\ of\ Array\ Irradiance = DNICos(Angle\ of\ Incidence) + DHI\left(\frac{1+Cos(\beta)}{2}\right) + GHI * Surface\ Albedo\left(\frac{1-Cos(\beta)}{2}\right)$$

$$Efficiency = \eta_{pv} = if\ Temperature > 25, then\ \eta_{pv} = \eta_{25} + Temperature\ coefficient(Temperature - 25)$$

$$if\ Temperature \leq 25, then\ \eta_{pv} = \eta_{25}$$

$$Module\ Power = Plane\ of\ Array * Area\ of\ Panel * \eta_{pv}$$

$$\text{Number of Panels} = \frac{\text{Power of system}}{\text{Power of panel}} = \frac{20\ \text{MW}}{635\ \text{W}} \approx 31{,}496\ \text{panels}$$

$$Annual\ Energy = \sum_{i=1}^{n} P_{Plant,i} * 0.5hour * \eta_{system}$$

$$Capacity\ Factor = \frac{Annual\ Energy\ Output}{Plant\ rated\ pwer * Total\ hours\ in\ a\ year} * 100\%$$

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Jinko Solar

TigerNeo

66HL4M-(V)

610-635 Watt

MONO-FACIAL MODULE

N-type

N-type Technology

N-type modules with Tunnel Oxide Passivating Contacts (TOPcon) technology offer lower LID/LeTID degradation and better low light performance.

Durability Against Extreme Environment

High salt mist and ammonia resistance.

SMBB Technology

Better light trapping and current collection to improve module power output and reliability.

HOT 3.0 Technology

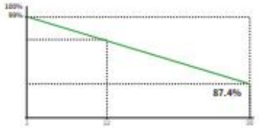
N-type modules with JinkoSolar's HOT 3.0 technology offer better reliability and efficiency.

Mechanical Load Enhanced

Certified to withstand:
5400 Pa front side max static test load
2400 Pa rear side max static test load

Anti-PID guarantee

Minimizes the chance of degradation caused by PID phenomena through optimization of cell production technology and material control.



12 Year | 30 Year | 1 % | 0.40 %

- IEC61215:2021 / IEC61730:2023
- IEC61701 / IEC62716 / IEC60068 / IEC62804
- ISO9001:2015: Quality Management System
- ISO14001:2015: Environment Management System
- ISO45001:2018: Occupational health and safety management systems

JKM610-635N-66HL4M-(V)-F2-EN

66HL4M-(V) 610-635 Watt

Mechanical Characteristics

Cell Type	N -type Mono-crystalline
No. of cells	132 (66×2)
Dimensions	2382×1134×35 mm
Weight	28.2 kg
Front Glass	3.2mm, Anti-reflection Coating, High Transmission, Low Iron, Tempered Glass
Frame	Anodized Aluminium Alloy
Junction Box	IP68 Rated
Protection Class	Class II
IEC Fire Type	Class C
Connector Type	JK03M/MC4/Others
Output Cables	4.0 mm² (+): 400 mm , (-): 200 mm or Customized Length

Packaging Configuration

Pallet Dimensions	2396×1110×1251 mm
Packing detail (Two pallets=One stack)	31 pcs/pallets, 62 pcs/stack, 620 pcs/ 40'HQ Container

Specifications (STC)

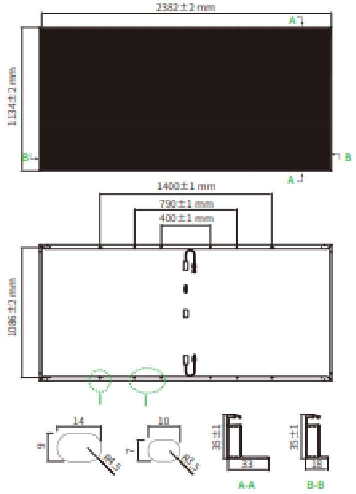
Maximum Power – Pmax [Wp]	610	615	620	625	630	635
Maximum Power Voltage – Vmp [V]	40.56	40.73	40.90	41.07	41.23	41.39
Maximum Power Current – Imp [A]	15.04	15.10	15.16	15.22	15.28	15.34
Open-circuit Voltage – Voc [V]	48.63	48.79	48.95	49.11	49.27	49.43
Short-circuit Current – Isc [A]	16.01	16.08	16.15	16.22	16.29	16.36
Module Efficiency STC [%]	22.58	22.77	22.95	23.14	23.32	23.51
Power Tolerance	0 ~ +3 %					
Temperature Coefficients of Pmax	-0.29 %/℃					
Temperature Coefficients of Voc	-0.25 %/℃					
Temperature Coefficients of Isc	0.045 %/℃					

STC: Irradiance 1000W/m², Cell Temperature 25℃, AM=1.5

Application Conditions

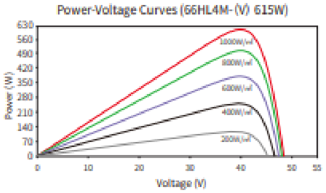
Operating Temperature	-40 ℃ ~ +70℃
Maximum System Voltage	1000/1500 VDC (IEC)
Maximum Series Fuse Rating	30 A

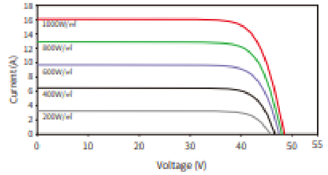
Engineering Drawings



*Note: For specific dimensions and tolerance ranges, please refer to the corresponding detailed module drawings.

Electrical Performance





Solar

How to Connect to Grid?

- **Step 1 — Your panels produce DC at low voltage** Each string of ~20 panels produces around 800–1,000V DC underground to combiner boxes.
- **Step 2 — Inverters convert DC → AC at medium voltage** Your 4 central inverters (5 MW each) convert that DC into 3-phase AC electricity at 480–690V. This is the same type of electricity in every building, just at a much higher scale.
- **Step 3 — Transformers step up to 34.5 kV** Each inverter feeds a transformer that boosts the voltage to 34.5 kV — your on-site collector voltage. Higher voltage means less energy lost as heat over distance.
- **Step 4 — Underground collector cables tie everything together** 34.5 kV underground cables run between all 4 inverter stations across your 65-acre site, all converging at the main substation near the site entrance.
- **Step 5 — Main substation steps up to 115 kV** Your on-site substation contains the biggest transformer on the property. It boosts from 34.5 kV → 115 kV, which is transmission level — the voltage used to move power across long distances with minimal loss. The substation also has circuit breakers, protection relays, and revenue metering.
- **Step 6 — Transmission line to the utility grid** A new or existing 115 kV transmission line (estimated 5 miles to the nearest APS/IID grid tie point in Yuma) carries your power to the utility's network. From there it flows wherever it's needed — homes, businesses, other cities.
- **Step 7 — Safety: Anti-islanding protection** This is critical and required by law (IEEE 1547). If the utility grid loses power — say a line goes down — your inverters must instantly disconnect within milliseconds. This protects utility workers who might be repairing lines and don't want your plant secretly still energizing them. All modern inverters have this built in.
- **Step 8 — The meter and getting paid** A revenue-grade bidirectional meter at your substation counts every kWh you send to the grid. This triggers payment under your Power Purchase Agreement (PPA) — a 20–25 year contract with APS or another buyer at a fixed price per MWh.

PV Array (Solar Panels)

DC Combiner Boxes & Underground DC Cables

Central Inverters (DC → AC)

Pad-Mounted Step-Up Transformers (LV → 34.5 kV)

Inverter Stations

34.5 kV AC Collector System

Main Substation

Main Power Transformer (34.5 kV → 69–115 kV)

Switchgear, Breakers & Protection

High-Voltage Transmission Line

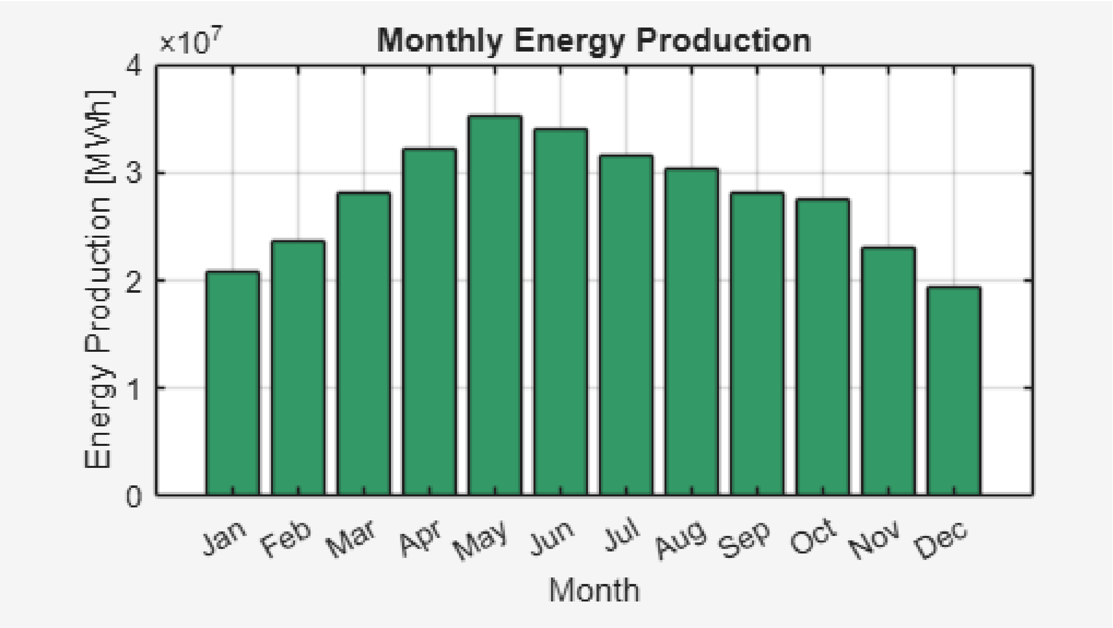
Utility Grid

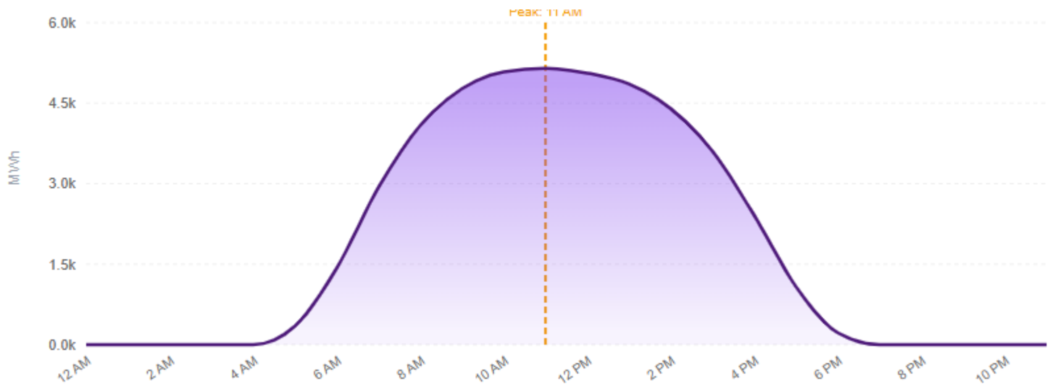
	Hour	Minute	DHI	DNI	GHI	Wind Speed	Solar Zenith	Surface Albedo	Temperature	Angle of incidence	surface inclined	η_{25} (%)	k_tc	Efficiency (%)	POA Irr. (W/m²)	Module Power (W)	Area(m^2)
1	0	0	0	0	0	1.4	168.87	0.23	11	-0.72884914	0	0.248	-0.0029	0.248	0	0	2.583252
1	0	30	0	0	0	1.4	165.26	0.23	10.7	-0.684292606	0	0.248	-0.0029	0.248	0	0	
1	1	0	0	0	0	1.4	160.07	0.23	10.3	-0.615523932	0	0.248	-0.0029	0.248	0	0	
1	1	30	0	0	0	1.4	154.26	0.23	10	-0.532580866	0	0.248	-0.0029	0.248	0	0	
1	2	0	0	0	0	1.4	148.18	0.23	9.6	-0.43993917	0	0.248	-0.0029	0.248	0	0	
1	2	30	0	0	0	1.4	141.98	0.23	9.3	-0.34037955	0	0.248	-0.0029	0.29353	0	0	
1	3	0	0	0	0	1.4	135.73	0.23	9	-0.235990219	0	0.248	-0.0029	0.2944	0	0	
1	3	30	0	0	0	1.5	129.48	0.23	8.7	-0.128795597	0	0.248	-0.0029	0.29527	0	0	
1	4	0	0	0	0	1.6	123.25	0.23	8.5	-0.020418933	0	0.248	-0.0029	0.29585	0	0	
1	4	30	0	0	0	1.6	117.08	0.23	8.3	0.087155743	0	0.248	-0.0029	0.248	0	0	
1	5	0	0	0	0	1.6	110.97	0.23	8.1	0.192693231	0	0.248	-0.0029	0.248	0	0	
1	5	30	0	0	0	1.6	104.96	0.23	7.9	0.294373942	0	0.248	-0.0029	0.248	0	0	
1	6	0	0	0	0	1.6	99.08	0.23	7.7	0.390731128	0	0.248	-0.0029	0.248	0	0	
1	6	30	0	0	0	1.8	93.34	0.23	8.8	0.480835744	0	0.248	-0.0029	0.248	0	0	
1	7	0	17	253	28	2.1	87.53	0.23	9.8	0.567125207	159.6764602	0.248	-0.0029	0.248	159.6764602	102.2961647	
1	7	30	71	15	73	2.8	82.36	0.23	11.5	0.63903635	76.44681132	0.248	-0.0029	0.28715	76.44681132	56.70677776	
1	8	0	124	94	145	3.5	77.37	0.23	13.2	0.70351875	183.2099687	0.248	-0.0029	0.28222	183.2099687	133.5683812	
1	8	30	60	752	283	3.5	72.69	0.23	14.7	0.759157714	631.2752039	0.248	-0.0029	0.27787	631.2752039	453.1345388	
1	9	0	67	812	365	3.4	68.43	0.23	16.2	0.805411346	722.2880834	0.248	-0.0029	0.27352	722.2880834	510.3478763	
1	9	30	72	855	438	3.3	64.66	0.23	17.9	0.842640412	794.6517456	0.248	-0.0029	0.248	794.6517456	509.0908564	
1	10	0	77	884	499	3.3	61.48	0.23	19.7	0.871213811	850.0366095	0.248	-0.0029	0.248	850.0366095	544.5729753	
1	10	30	80	904	545	3.2	59	0.23	21	0.891639546	889.5044549	0.248	-0.0029	0.248	889.5044549	569.8579122	
1	11	0	81	918	577	3	57.31	0.23	22.3	0.904603991	915.3743318	0.248	-0.0029	0.248	915.3743318	586.4313582	
1	11	30	82	924	592	2.9	56.47	0.23	23.1	0.910755747	927.6732271	0.248	-0.0029	0.248	927.6732271	594.3106024	
1	12	0	82	921	590	2.8	56.53	0.23	23.9	0.910322812	924.5071076	0.248	-0.0029	0.248	924.5071076	592.282239	
1	12	30	166	653	517	2.6	57.49	0.23	24.1	0.903260416	752.2339034	0.248	-0.0029	0.25061	752.2339034	486.9877918	
1	13	0	137	764	527	2.5	59.29	0.23	24.4	0.889336581	815.2476396	0.248	-0.0029	0.24974	815.2476396	525.9499664	
1	13	30	79	867	488	2.5	61.87	0.23	24.2	0.867852178	833.9655904	0.248	-0.0029	0.25032	833.9655904	539.2752097	
1	14	0	74	835	425	2.4	65.13	0.23	24.1	0.838194961	775.7060179	0.248	-0.0029	0.25061	775.7060179	502.1833754	
1	14	30	69	788	352	1.9	68.97	0.23	22.9	0.799789439	700.1471802	0.248	-0.0029	0.248	700.1471802	448.5468377	
1	15	0	61	723	269	1.4	73.29	0.23	21.8	0.752299934	604.9792739	0.248	-0.0029	0.248	604.9792739	387.577852	
1	15	30	112	135	140	1.4	78.01	0.23	19.6	0.695536691	199.8050171	0.248	-0.0029	0.248	199.8050171	128.0043841	
1	16	0	61	16	63	1.4	83.04	0.26	17.5	0.629862788	67.67123187	0.248	-0.0029	0.248	67.67123187	43.35333758	
1	16	30	12	0	12	1.4	88.21	0.26	16.7	0.557310439	11.32204469	0.248	-0.0029	0.248	11.32204469	7.253428259	
1	17	0	0	0	0	1.5	94.09	0.26	15.9	0.469317452	0	0.248	-0.0029	0.248	0	0	
1	17	30	0	0	0	1.5	99.85	0.26	15.5	0.37832552	0	0.248	-0.0029	0.27555	0	0	
1	18	0	0	0	0	1.5	105.75	0.26	15	0.281169223	0	0.248	-0.0029	0.277	0	0	
1	18	30	0	0	0	1.6	111.78	0.26	14.5	0.178802215	0	0.248	-0.0029	0.27845	0	0	
1	19	0	0	0	0	1.6	117.89	0.26	14.1	0.073064132	0	0.248	-0.0029	0.27961	0	0	
1	19	30	0	0	0	1.6	124.08	0.26	13.5	-0.034899497	0	0.248	-0.0029	0.248	0	0	
1	20	0	0	0	0	1.6	130.31	0.26	12.9	-0.14314716	0	0.248	-0.0029	0.248	0	0	

Results

- From 2018 to 2024
  - 316.76 GWh for All Panels
  - 2018: 44672 MWh
  - 2019: 45275 MWh
  - 2020: 45813 MWh
  - 2021: 44366 MWh
  - 2022: 45719 MWh
  - 2023: 45289 MWh
  - 2024: 45622 MWh
  - Average: 45251 MWh
  - For 1 Panel: 1.76 MWh per year
  - Capacity Factor: 27.2 %
  - Average Efficiency: 0.2325

- Highest Month: May
- Lowest Months: January and December
- Nighttime produces 0 MW
- Daytime: Generation hour 14/24 equivalent to roughly above 50 %
- Day time Peak: 11 Am
- Average Daytime Power: 409.73 W for 1 Panel





Morning Ramp (5–9 AM)

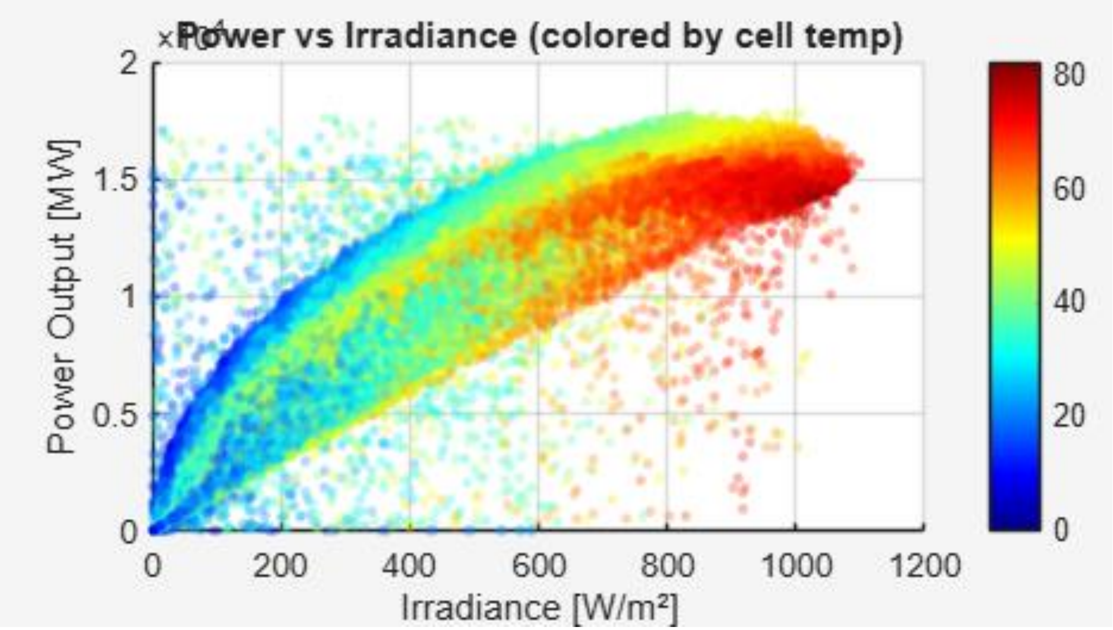
Plant ramps from near zero at 5 AM to over 4,700 MWh by 9 AM as the sun rises and angles improve. This 4-hour ramp represents the panel coming online for the day.

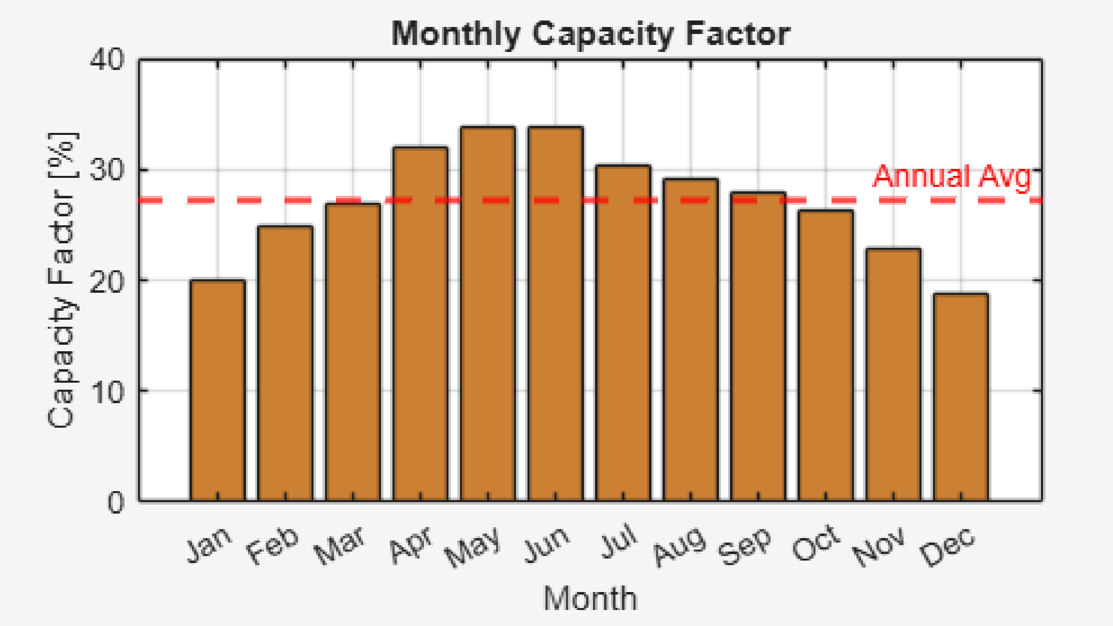
Peak Window (10 AM–1 PM)

Maximum generation occurs around 11 AM when sun angles are steepest relative to the 32.7° tilted panels. The plant sustains near-peak output for ~4 hours in the middle of the day.

Evening Decline (2–7 PM)

Output drops steadily after 1 PM as the sun moves west and zenith angle increases. Generation ceases entirely by 7 PM — this is precisely when the LFP battery storage system dispatches stored energy.


Power vs Irradiance (colored by cell temp)
Power Output [MW]
Irradiance [W/m²]
0
0.5
1
1.5
2
0
200
400
600
800
1000
1200
0
20
40
60
80


Monthly Capacity Factor
Capacity Factor [%]
Annual Avg
Month
0
10
20
30
40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Metric	Fixed-tilt (32.7°)	Single-axis tracker	Comment
Annual energy	100% (baseline)	**≈125%**	About **+25%** more kWh in a high-DNI site like Yuma.
Capacity factor	~23–24%	~28–30%	Higher because we produce more hours near rated power.
Upfront cost (CAPEX)	Lower	Higher (extra steel, motors, controls)	Trackers add roughly 10–20% to array cost.
O&M complexity	Low	Moderate	Moving parts and motors need maintenance.
Land use per MW	Slightly better	Slightly worse	Trackers need more row spacing to avoid shading.
Best climate	Cloudy / diffuse	Sunny desert, high DNI	Yuma falls here, so trackers shine.

1. Single-Axis Trackers - A single-axis tracker slowly rotates the solar panels east-to-west during the day so they follow the sun's path and capture more energy than a fixed-tilt array. Yuma has some of the highest DNI in the U.S. (>6.5 kWh/m²/day), so single-axis trackers add about **25% more annual energy** here compared to fixed-tilt.

Energy Storage slide

LFP Battery Storage

Design spec for my project	Great Power utility LFP BESS capability	Meets my spec?
Use LFP ($LiFePO_4$) chemistry for safety in desert heat	Great Power's utility-scale systems are based on LFP cells with high thermal stability and no NMC, which reduces thermal-runaway risk in hot conditions.	Yes
Utility-scale rating around 20 MW / 80 MWh	Their containerized LFP systems are modular and designed for multi-MWh to 100+ MWh projects, so configuring a 20 MW / 80 MWh system is within their normal range.	Yes
Target round-trip efficiency ≈ 94%	Vendor literature shows DC efficiencies above 95%; once PCS and auxiliaries are included, the overall AC round-trip efficiency falls in roughly the 92–95% band, matching my 94% target.	Yes
Cycle life of at least 6,000 cycles	The LFP cells used in their utility products specify 6,000–8,000+ cycles to 80% capacity, depending on depth of discharge and operating conditions.	Yes
Reliable operation in high-temperature desert environments	The systems are designed with liquid cooling and wide operating-temperature limits, and are marketed specifically for harsh climates and renewable-plus-storage applications.	Yes
Containerized, utility-grade package	Great Power supplies standard 20-ft/40-ft containers with integrated BMS, HVAC, fire suppression and grid-scale protections, suitable for a utility solar plant.	Yes
Ability to shift solar from midday to 5–9 PM	By combining enough LFP containers to provide roughly 80 MWh of usable energy, I can discharge at 20 MW for four hours and move generation into the evening peak window.	Yes

Cost Category	Description	Estimated Cost
Panels & Modules	29,851 × Jinko 670W @ $230 + racking + wiring	$9,665,730
Inverters & Electrical	4 × 5MW central inverters, transformers, cabling	$3,050,000
Substation & Grid	34.5→115 kV substation, transmission interconnect	$4,635,000
Civil & Site Work	Grading, roads, fencing, pile driving (65 acres)	$2,170,000
SCADA & Controls	Monitoring system, weather stations, communications	$560,000
Soft Costs	EPC management, permits, legal, insurance	$2,490,000
SAT Tracker Upgrade	Replaces fixed racking with rotating single-axis system	$2,500,000
LFP BESS System	20 MW / 80 MWh Tesla Megapack or equivalent	$24,000,000
BESS Integration	Inverter, controls, civil work for BESS pad	$2,200,000
Contingency (5%)	Engineering and construction contingency reserve	$2,620,000
TOTAL	Complete installed plant cost	$55,020,000
Cost per Watt (DC)	Industry benchmark: $0.90–$1.30/W solar, $1.50+ with BESS	$2.75/W

Budget breakdown

- The upgrades cost 2.32 times the base plant, generating approximately $555,000 in additional revenue per year — resulting in a 56-year payback on incremental revenue alone. However, the real financial case for the BESS is not extra energy but access to higher Power Purchase Agreement rates, where a peak-dispatch PPA at $55/MWh versus a flat $35/MWh rate makes the economics significantly more favorable. The single-axis trackers at $2.5 million for a 25% energy gain have an estimated 4 to 5 year payback and are justified on energy economics alone. The BESS is best justified by grid reliability requirements and the premium contract rates available to dispatchable solar assets rather than energy volume alone.

Metric	Value
Annual energy (with SAT + BESS)	56,768 MWh
PPA price	$38 / MWh
Gross annual revenue	≈ $2.16 M
Annual O&M	$0.20 M
Net cash flow (before debt, tax)	≈ $1.96 M
Total CAPEX	$55.0 M
Simple payback time	~ 28 years
25-year cumulative net revenue	≈ $45.2 M

At a $38/MWh PPA, this project in Yuma, Arizona generates about $2.16M in gross revenue and $1.96M net cash flow per year, leading to ~28-year simple payback and ~$45M cumulative net revenue over 25 years (before financing and taxes).

Revenue, O&M, payback

Conclusion

- Yuma, Arizona provides an exceptionally stable, high-DNI solar resource, allowing our 20 MW plant to achieve about **27%** capacity factor with less than 3% year-to-year variability.
- Using Jinko Tiger Neo N-type TOPCon 635 W modules keeps efficiency high and limits thermal losses in 60–70°C summer cell temperatures, while single-axis trackers boost annual energy by roughly **25%** to 56,768 MWh and raise capacity factor to **32.4%**.
- Integrating a 20 MW / 80 MWh LFP BESS shifts energy into 5–9 PM peak hours, increases effective revenue per MWh, and supports grid reliability, bringing total installed cost to about **$55M** (~$2.75/W).
- Over 25 years, accounting for 0.4–0.55%/yr panel degradation, $200k/yr O&M, and a blended **$38/MWh** PPA price, the project generates roughly **$45.2M** in cumulative net revenue against the $55M cost—leaving us **still in debt** after 25 years on a simple payback basis (≈28 years), though full DCF analysis with 30% ITC, MACRS depreciation, and residual value improves the picture.