UNIVERSITY OF SOUTH FLORIDA

Design of 20 MW PV Solar Power Plant – Albany, New York

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COURSE: Design of Solar Power Plants

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Purpose of report:

To Commence this report illustrates the design of a 20MW Solar Photovoltaic Power plant system in Albany, New York. Albany is a humid continental climate zone located on the West bank of the Hudson River, the Mohawk River in the south, and New York City in the north. The average electricity charge is 19 cents per KWH, the average consumption of electricity per month is 1,025 KWH and the 12,300 kWh per year. This power plant produces 20MWs for residence and commercial purposes for Albany city.

Solar Insolation:

Albany is an Intermediate Solar radiation place for PV systems. The whole solar insolation is much better for Albany and the parameter values are calibrated in kwh/m^2 per day. The table below illustrates the value:

Place	**Albany, New York**
Global Horizontal	3.93 kWh/m^2/day
Direct Normal	4.25 kWh/m^2/day
Diffuse Horizontal	1.58 kWh/m^2/day

Business Model:

In our business model, the power producer organization as a partnership provides adequate Electricity supply to the Department of Public Service, Albany at a fixed rate of 0.1$ per kWh. In our project, we made Power Purchase Agreement for over 25 years. We have 1$ price escalation for a year in the contract.

Summary:

The table below illustrates the crystal-clear SAM software results. The federal income tax rate 21 %/year and the State income tax rate is 7 %/ year of the duration of the Power Purchase Agreement.

Metric	Value
Annual AC energy in Year 1	20,724,692 kWh
DC capacity factor in Year 1	11.8%
Energy yield in Year 1	1,036 kWh/kW
Performance ratio in Year 1	0.53
PPA price in Year 1	10.00 ¢/kWh
PPA price escalation	1.00 %/year
LPPA Levelized PPA price nominal	10.81 ¢/kWh
LPPA Levelized PPA price real	8.63 ¢/kWh
LCOE Levelized cost of energy nominal	9.81 ¢/kWh
LCOE Levelized cost of energy real	7.83 ¢/kWh
Investor IRR Internal rate of return	13.02 %
Flip year	10
Investor IRR at end of project	13.41 %
Investor NPV over project life	$626,166
Developer IRR at end of project	13.71 %
Developer NPV over project life	$2,121,954
Net capital cost	$17,545,446
Equity	$7,828,264
Debt	$9,717,182
Debt percent	55.38%

Energy Transition Act:

First, the total Electricity usage in Albany is 2,211,539 MWh and the usage per capita is 7.02 MWh. The energy-producing to Albany city is huge 5,304,789 MWh. But the drawback is the most energy is getting from the Non-Renewable resources that are 4,952,142 MWh. The energy is producing to Albany city by Renewable resources is much lesser than Non-Renewable resources. The energy produced by Renewable resources to Albany city is 352,647 MWh. The energy produced per capita is 16.85 MWh.

In addition, we acquire information about Solar energy production in Albany is 26,720 MWh. This is the reason why Albany County is standing in 8th position out of all 62 Counties for producing Megawatt hours of Solar energy production. However, the CO2 Emissions are also there, which is recorded as 782,453,515 kg and Emissions per capita is 2,485.18 kg. The Power Purchase Agreements of PNM only eligible for renewable energy credits for federal tax incentives. We will be getting credit for each, and every Megawatt hour produced by Solar energy Renewable resources.

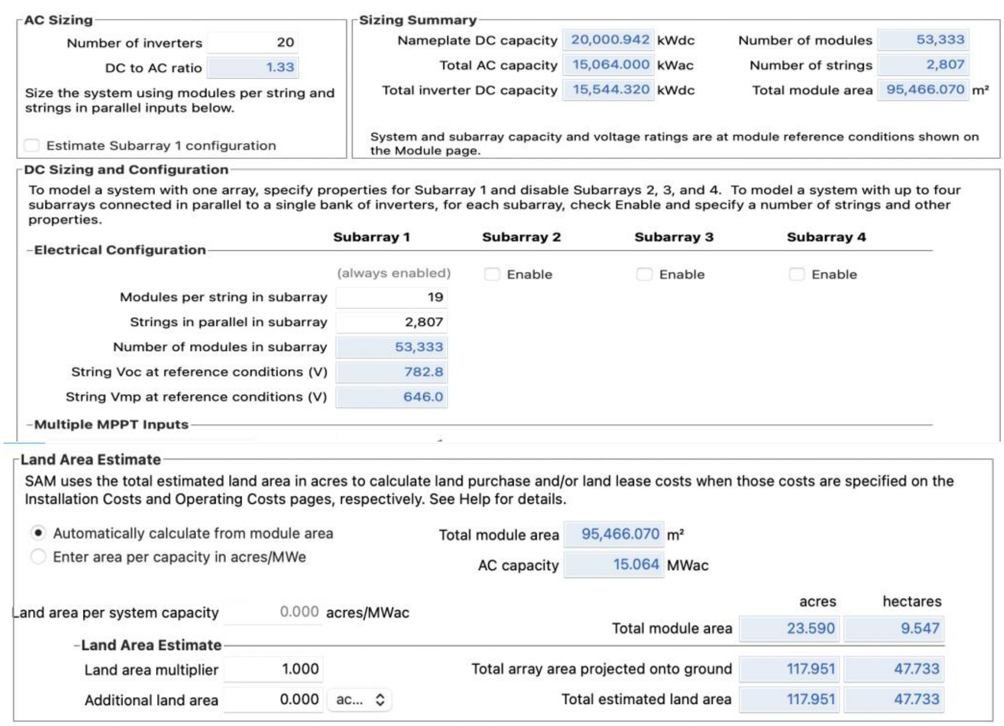
Developing a PV System:

We have found and listed out all the fundamental equipment required to develop a PV solar farm to produce 20MW DC power output and sell them to local utilities among Albany County of New York.

- Initially we started our investigation on geographical aspects around Albany to determine right location to build the solar farm both economically and statistically efficient for all the investors and consumers. to develop a 20 MW DC power output from PV systems, it will ideally require 24 acres of land for the placements of equipment alone and along with all the supporting equipment and spacings between PV systems, we have estimated a overall land capacity of 118 acres and we found that is Norman skill, a small county alongside Albany, the capital of New York, priced at 3600 USD per acre. The best price we could under the economic status in New York.
- Before establishing the PV system driven facility, we had to normalize our project with all the governing rules in the county to run the project legally. Having said that, first step was to get the approval from Albany County's Board of commission to set up the PV Module facility where the system being used is conditional. We reported environmental dependency as the source to facility and summarized all the impacts it could give to surrounding environmental substances by the virtue of solar facility. The impacts are both positive and negative, All the local consumers would have the benefit of consuming power from solar farm at lower costs compared to far consumers, and on the other hand, they are prone to hazardous impacts when the PV facility is prone to disaster which is more unlikely to happen as the facility is based at a elevation of 27m above land surface area.
- Being a solar producer, after generating ultra-capacity of power outputs, our next step is to sell the power produced to make some revenue out of the project. One way is to sign a contract with independent power producers and sell the produced power under power purchase agreement. While the other opportunity is to target all the mid scaled auto industries and sell the produced power for them to store in rechargeable batteries and make use of them in auto commercial products as well as commercial housing plannings. Essentially, either of the approach is a long and hard process, yet signing a power purchase agreement and selling the power output to independent power producers are more essential and business oriented on a long-term basis along.
- Since Albany, has a good statistical requirement for developing a solar plant, with direct normal beam of rays around 4.3 KWh/sq.m/day and diffusion horizontal of 1.6 KWh/sq.m/day, many independent ventures have placed their facilities in this region, making us more prone to competition. To keep us Amit all other competitors, we started off with getting an approval to conduct interconnection study to study the impact of PV facility across all other subsequent industries and households. This includes the study of transmission lines used to interconnect

between PV modules and also, between the plant and the substations. We have used underground transmission lines to interconnect PV Modules within the facility with core R, L, C ratings to withstand voltage ratings up to 820 V and overhead transmission lines to carry the power generated from the facility to solar grid stations. This is detailed more in the Interconnections portion of the report.

- Recent study on Power purchase agreement in Albany County of New York shows that, the average PPA price is $ 46.5 per MWH produced. While we have used 0.01 USD KWh in our PV Module System design with an escalation of 1 % for every year up to 25 years of the facility lifespan.
- It is beneficial to locate the PV Facility in the near premises of Substations to compromise on the power transmission charges from the facility to grid stations. on detailed study, we have found 2 substations which are at a distance of 10 miles and 15 miles from PV Facility namely, National Grid Substation and INDRIO Sub Station.
- The PV System is connected to inverter to generate AC voltage and then combined in a combiner box on the substation side and introduced to step up transformer to step up the 480 KWH power input to 792 KWH AC output from the step-up transformer using transmission wires. The facility will be prone to stable wiring losses due to transmission wires connecting equipment but using highly efficient transmission wires with more bandwidth to voltage capacity and Resistance, Capacitor, shunt resistance rating, this can be overcome.
- The target is to use the existing sub stations rather than establishing a new one for the sake for PV facility. Having chosen National Gris Substation located 10 miles from the PV Facility, eliminates the cost introduced to substation requirements. On the other hand, we will need necessary supporting equipment's like switch gear and circuit surge protection devices which are detailed in upcoming instances of the report.
- To summarize the System design and development, we must focus on getting approval from the board of commission, produce a analysis report, test the scenarios and get authorized from the board for commission and target to normalize the electricity purchase price to lower number as well as increase the power production with minimal impact to environment.



Tax Incentives:

The tax system practiced in New York commission denotes, State Income tax of 8% having a breakdown of 4 % to the New York state and 4% to the city and county taxes. The federal tax is subjected to vary between 20 % and 26 % of the total asset value. The inflation rate is 2.5% per year for the facility use and to reduce the IRR Returns under 20% we have set the discount rate to 6.5% annually.

Incentives are the returns that a producer or a partner gets based on his investment and revenue. So, it is basically the independent power producers who can make use of this benefits based on the PPA price they sign the power purchase agreement with.

The Solar Tax credit system in Albany allows the producer to reduce up to 5000 USD or 25% in sales tax as a credit to reduce the exposure of tax on himself, and for newer farms, federal tax credit returns fall under 10 % while the tax alone stays between 26- 30 % and the production energy tax credit lies between 10 to 15 % having highest possible returns for a newly set up plant compared to the plants established over 3 years.

By the virtue of Federal tax credit, the facility will receive 10 percent of net capital cost as their tax incentive which comes up to 0.9 cents per KWH with a bonus of 5 % overall from federal and state tax incentives.

Solar Insurance:

Insurance balances un-intended losses incurred for a solar farm due to environmental hazards as well as nominal accidents that can take place in a farm. After a detailed study on insurance, we have listed out few key elements that might be important from insurance perspective.

- Insurance for the property purchased: This policy will cover all damages, based on risk, for equipment's, infrastructure, and facilities.
- Business Insurance: Provides facility to cover the downtime income that might get affected due to the event being occurred. These include business income, lost production, additional expenses incurred to fix the hazardous event which will be mentioned in power purchase agreement.
- Liability Insurance for the employer: If any claim were raised by employees for any practice, it would be covered as part of the solar insurance.
- Solar Revenue Insurance: This policy covers energy production shortfalls, weather transition risk, losses that fall apart from manufacturer’s ability.

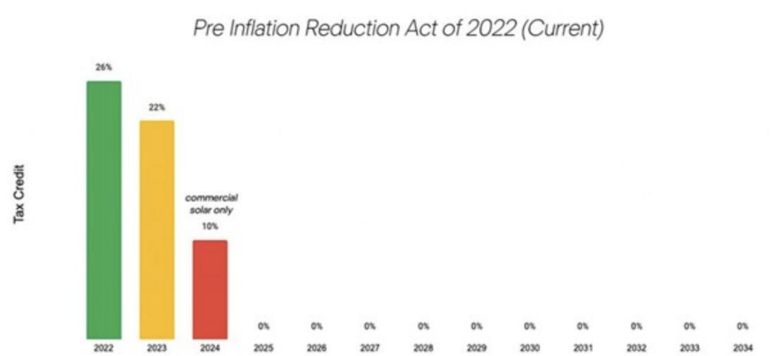
As mentioned in our presentation, we conducted small research on how the Solar Insurance was being used in Albany for the previous years. The table under this section defines the statistical overview of insurance history in Albany.

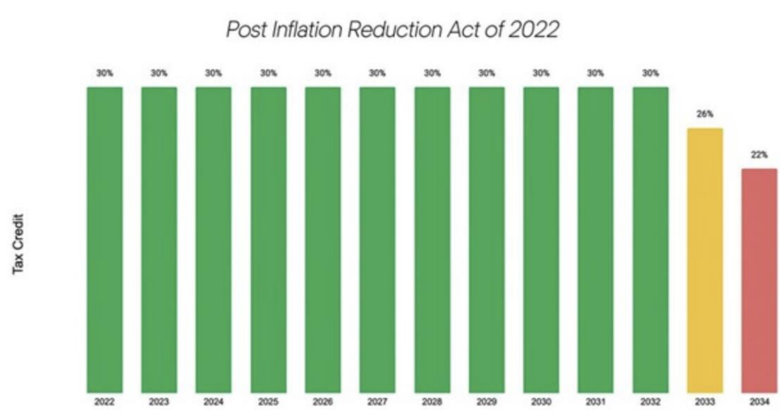
- It includes all the losses in terms of events and occurrences such as fire outburst, climate change, theft, environmental disasters.
- It also shows insurances covered due to non parameterized occurrences that includes losses beyond manufacturer’s abilities.
- The statistical representation is done with respect to total number of claims and its action items on an average along with maximum and minimum claimed value in USD.
- This study helps to take decision for considering solar insurance based on the region insurance and disastrous event history.

Solar Claims Total	Fire Group	Wind Group	Hail Group	Freeze Group	Lightning Group	Theft and Vandalism Group	Flood/ Water Group	Weather Otherwise Not Classified	Other Group	Unknown
Number of claims	1,282	4,784	7,979	79	222	144	197	55	364	22
Average solar claim value	$17,309	$2,641	$2,555	$5,288	$9,746	$5,770	$2,020	$3,702	$4,109	$3,852
Maximum	$281,428	$250,617	$180,529	$94,921	$82,481	$52,439	$26,103	$40,136	$86,157	$28,163
Median	$10,140	$1,098	$1,203	$2,358	$3,410	$2,383	$1,210	$1,340	$1,365	$1,249
Standard deviation	$22,631	$6,604	$5,027	$12,143	$14,561	$7,919	$2,839	$7,237	$8,440	$6,713

Investment Tax Credit:

If we sign the petition with New York Tax commission, The facility investors are prone to 30% of Investment tax returns on the total capital cost of 21M USD used to establish a smooth functioning Solar facility. A Solar ITC is a nonrefundable tax credit that can used to accumulate the returns on the following year tax systems. The Investment tax credit policy came into picture in 2005 under the Policy Act at a capital return of 2000 USD. This limit was then overcome in 2008 as a following act extension where the tax credit was brought down to 26% with no limit on capital return which was still extended to 30% by Reduction ACT in 2022.





Solar ITC covers for the portion of investments made on Solar Facility, namely,

- Equipment's: Solar PV Panels, combiners, inverters, transmission wires, connecting devices, Transformers, Surge Protection devices.
- Installation cost.
- Authorization and legal fees: Permission, Inspection, soft liable costs.
- Taxes: Sales and Federal

MACRS:

Modified Accelerated Cost Recovery Systems, MACRS, provides the benefit of recovering deprecated assets over 5 years after qualified adjustment fundament analysis of personal property as per the below attached picture from SAM simulation. Where the percentage of total revenue that would be qualified for the adjustment process is denoted under Allocation Tab. It is seen that 90% of the total revenue is subjected to MACRS basis recovery for first 5 years by the virtue of Federal and State Bonus depreciation followed by 1.5% Allocation for the 15 years MACRS tenure starting from the established year of Solar Facility.

Straight Line Depreciation denoted to depreciate the asset value uniformly over its period of use. It is marked as 2.5 % of total revenue for the first 15 years and then raised to 3% when it steps into 20-year tenure. This sums up to be 100 % of total internal revenue for Bonus depreciation.

Depreciation

		Bonus Depreciation		ITC Qualification	
Classes	**Allocations**	Federal	State	Federal	State
5-yr MACRS	90 %	☑	☑	☑	☑
15-yr MACRS	1.5 %	☑	☑	☐	☐
5-yr Straight Line	0 %	☐	☐	☐	☐
15-yr Straight Line	2.5 %	☐	☐	☐	☐
20-yr Straight Line	3 %	☐	☐	☐	☐
39-yr Straight Line	0 %	☐	☐	☐	☐
Custom Edit...	0 %	☐	☐	☐	☐
Non-depreciable assets	3 %	Bonus: 0 %	0 %		

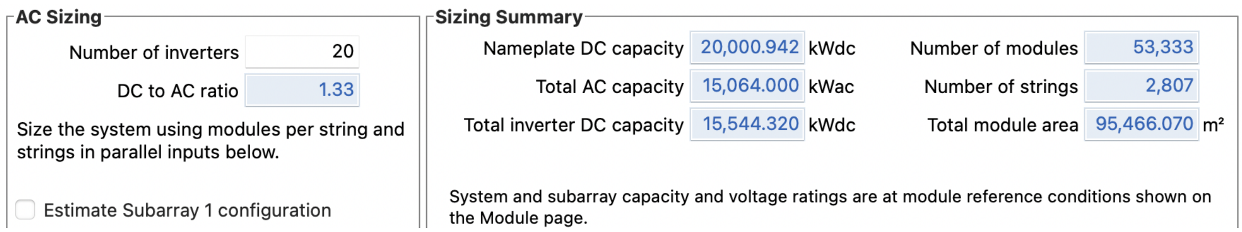
System Design:

System design gives overview of all the equipment's being used along with its number of components which is detailed in the section below:

Major Components of a PV System

Components	Count	Description
Solar Panels	53333	Poly PV, Highly efficient having nominal efficiency of 21.6%
Inverters	20	Central Inverters
Combiner Boxes	430	To combine all the PV outputs into the inverters

Solar Transformers	3	Step up transformer, to raise 480 V AC output to 792V AC output



Voltage Surge Protection devices:

Since the PV facility is produces on ultra-high voltages of up to 20 MW, it is expected to have sudden outburst of power under uncertain environmental circumstances either due to lightening or improper routing of generated power. For this reason, we have introduced surge protection devices on AC and DC side of the facility to prevent any uncertain situation due to sudden rise in voltages beyond transient voltage.

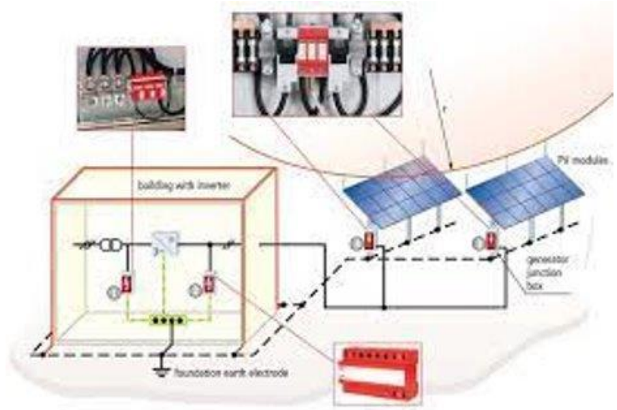
As the solar plant is producing 20MW of DC Power at different un-uniform magnitudes, it is possible for the panel to surge high voltage and damage the device when irregular voltage drop is experienced. It can either be due to a sudden lightening wave that incidences on the panel or the invertor or any of the equipment, or other environmental disasters leading to rise in open circuit voltage. Few of the problem statements can be as mentioned below:

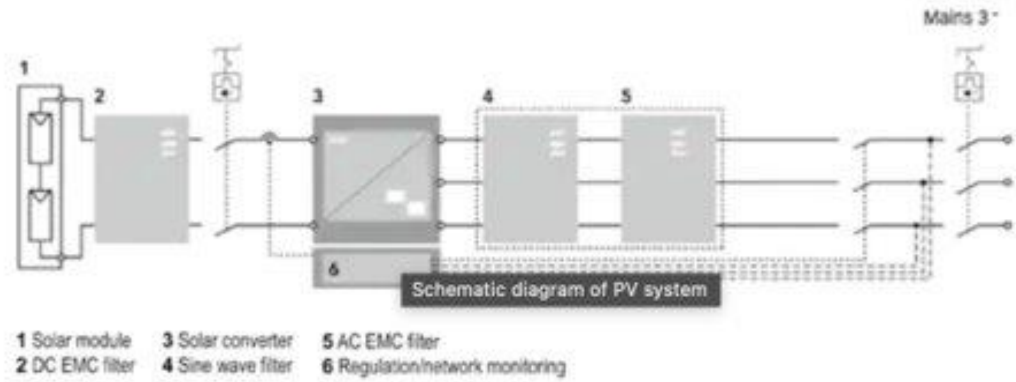
- If a lightening wave is incident on the PV Panel, it would damage the PV Array or the invertor leading to DC outburst.
- On the other hand, if the wave incidents on AC side, it would result in damaging The AC Filter, Step Down Transformers, and connection to the grid subsequently.
- To prevent these occurrences, we are using Transient Surge Protection devices on both the sides of Solar plant.

Let us see, how to choose right Surge Protection device. Mainly we have to consider to analyze the following requirements:

- Operating voltage of the system.
- Short circuit current rating.
- Wavelength of all the incident waves for which the system is operating. Such that, the threshold is set.
- Average discharge current and voltage.
- Reflection index of the light waves.
- Lightening flash density.

Type 2 SCD is installed alongside PV Module to hold the net voltage coming from various resources under threshold voltage ratings of the modules and the inverters. Since the energy signal coming from the device will have noise and fluctuations, we are using AC and DC Filters on either side of the PV Facility to eliminate the pulses, noises, and interferences like Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) coming out of the inverter and helps in producing pure electrical component to the devices to function prominently.





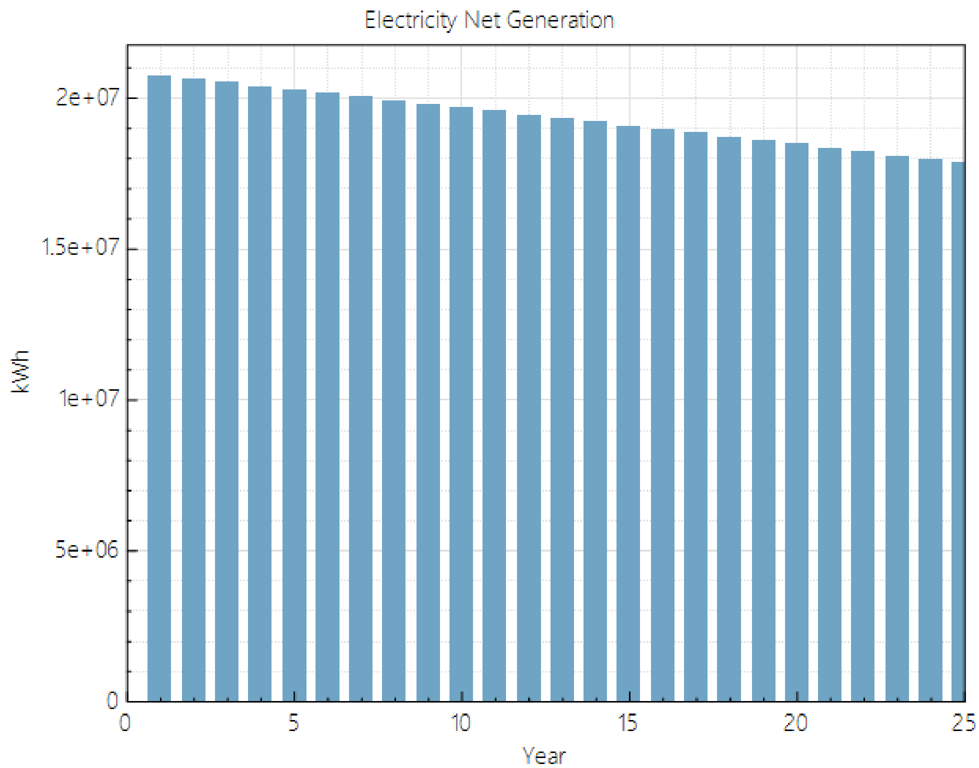
Power Purchase agreement:

Power purchase agreements are used signed with third party owners or developers who will be willing to purchase the Solar power produced at the solar facility. It is usually independent power producers who sign the PPA agreement. When a PPA is signed, the facility owners that the responsibility of housing all the maintenance and safe process of energy production in the facility along with wear and tear of equipment's placed in the facility, while the IPP developers house the maintenance and liabilities to consume the power energy from the farm and house it to substations and following consuming procedures. In this way, nobody will buy the solar facility at one go, while they sign an agreement to use the facility benefits for the proposed period of tenure.

Ideal PPA Price practiced in Albany, New York is 46.5 USD per MWH while we have used a PPA price of 0.01 USD per KWH in our power purchase agreement with a escalation of 1% for the period of 25 years annually.

Service Life:

The average lifespan of PV panels is 25 years before noticeable degradation starts to affect the performance of the solar panels, See Graph 1. Most of the components of our system have a manufacture warranty that can be utilized which guarantee electricity generation at the very least for the first five years. Please see Table 1 for a list of warranty dates. Since the break-even point of our system is 10 years, any generation after this point would provide adequate funding for any service replacement and/or repairs that would need to take place.



Graph 1: *Electricity Generation of PV System Over 25 Years*

System Component	*Warranty Coverage*
Inverter	5 years (60 Months)
Solar Panels	25 Years (300 Months)
Transformer	10 Years (120 Months)
Mounting Hardware	15 Years (180 Months)

Table 1: *Warranty Coverage Lengths of System Components*

Renewable energy production credit

Federal Renewable Energy Production Tax Credit (PTC):
The PTC is a per Kilowatt-hour tax credit (2.6¢/kWh) that is presented to qualifying entities for generating solar energy for the first 10 years of operation. It reduces overall federal tax liability and is adjusted annually for inflation. Our project qualifies for this benefit and can see more value in it rather than the Federal Renewable Energy Investment Tax Credit (ITC). Due to the efficiency of our system, the monetary value

of a per-KWh is more financially viable option, in addition to the annual 2.5% increase due to inflation. Excess tax credits can be carried backward up-to three years or carried forward up-to 22 years.

Calculation:
For Year 1, capacity factor set at 20%:
20,000 kW x 24 hours/day x 365 days/year x 20% = 35,040,000
35,040,00 x $0.026/kWh = $911,040 Tax credits in the first year.

Interconnection

Utility interconnection is at the heart of the revenue stream when it commercial solar energy systems. A system cannot be financially viable without proper interconnection and our system is no different! Our system will interconnect with Albany, NY's utility company, National Grid after a $750 application fee, there is a Complex Application process which involves a Full Study of our Electrical System in addition to a Coordinated Electric System Interconnection Review which analyzes the Impact our system will have to the grid. Since the size of our system, 20 MW, will have a large impact on the grid, we estimate to be charged the maximum amount for the review which carries a price tag of $25,000. All these requirements are in conjunction to New York Independent System Operator (NYISO) and New York State's Standard Interconnection Requirements (SIR). Further requirements include our system's satisfaction of various safety requirements based on IEEE 1547 and UL 1741 standards.

Solar Substations:

Switch Gear:

This is the major part of the substation, which also contains disconnect switches, circuit breakers, and other tools for managing and safeguarding the electrical equipment in the substation.
Circuit Breakers: Circuit breakers are essential parts of a solar power plant because they guard against overloads, short circuits, and other problems that might harm the system or endanger employees' safety.

Disconnect Switches:

Disconnect switches are employed in solar substations to open and close electrical circuits, therefore isolating or re-connecting the solar power plant to the electrical grid. The AC side and DC side of the solar power plant are two areas where these switches are commonly located throughout the solar substation.
To detach the solar panels out from inverter or charge controller, disconnect switches are utilized on the DC side portion of the solar power plant. To protect workers and also the solar power plant itself during maintenance or repairs, this is important. While performing maintenance or repairs, the solar power plant is disconnected from the grid using disconnect switches on the AC side.

Some of the other protective devices includes:

Surge protectors: Surge protectors are employed in solar power plants to safeguard delicate equipment against voltage spikes and surges that might harm or destroy the equipment, such as inverters.

Lightning arresters: Lightning arresters protect solar power plants prevent lightning strikes by diverting the high-voltage electrical discharge that results from a lightning strike aside from solar power plant and sending it to the ground.

Ground Fault Protection: Inside the solar power plant, ground faults are detected and stopped by ground fault prevention devices. They are intended to prevent individuals and assets against electrical shock and harm.

Overvoltage Protection: In order to shield solar power plant equipment against voltage levels that are greater than the rated voltage, overvoltage protection equipment is used. They are built to protect against equipment failure and damage.

Power Condition System: Systems for power conditioning are used to make sure the solar power station generates high-quality energy that meets with grid regulations. In order to control and manage the energy produced by the solar power plant, these power conditioning systems may include a variety of parts, including voltage regulators, filters and other devices.

Transformer:

The transformer is utilized to raise the voltage of the inverter's AC energy to a level acceptable for long-distance transmission.

A PV cell's output is DC, thus before it can be connected in parallel to the grid through a step-up transformer, it must be converted to AC by an inverter. The inverter brings DC and harmonic components into the system while converting the DC output of the PV panels into AC, which not only lowers the power quality but also raises the noise and vibration of the transformer. Dry-type transformers are used in solar power stations to generate photovoltaic electricity, which lowers total equipment costs and boosts efficiency. Nevertheless, in inverters without isolating transformers, the double split dry type of transformer is utilized to electrically isolate the two inverters from one another.

In general, the cost of 25MVA dry type transformer for 20 MW solar PV plant is $425000.

For 20MW solar PV plant the group will join the transmission line that is near the plant's intended location.

The total cost of interconnection: $425000.

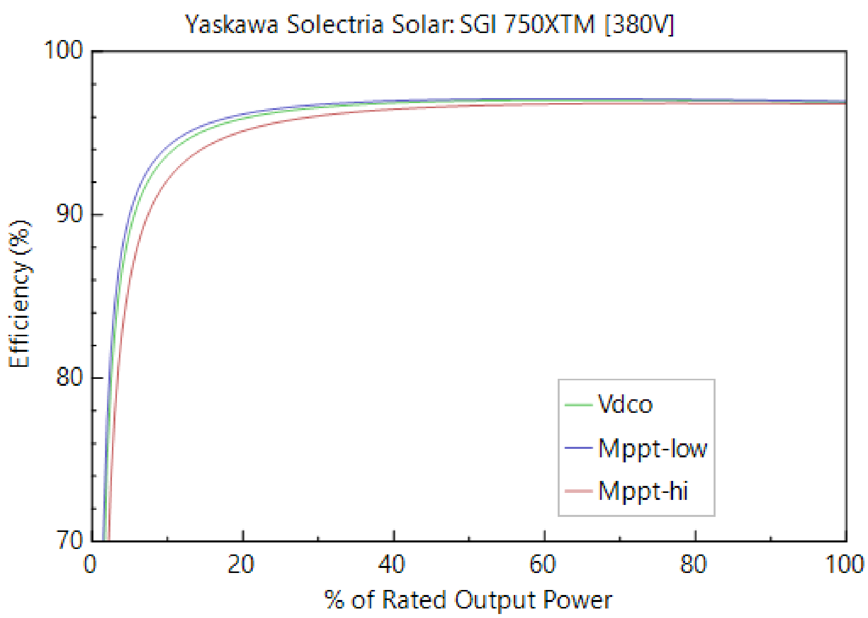
If the network expansion is required, then it will be cost around $212000.

Inverters:

We have used Central Inverters in our design.
Yaskawa Solectria Solar: SGI 750XTM is the company of the inverter.
The total number of Inverters used in this project are 20.
Below table gives the Datasheet parameters of the selected inverter:

Maximum AC power	753200	Wac
Maximum DC power	777216	Wdc
Power use during operation	3714.14	Wdc
Power use at night	122.55	Wac
Nominal AC voltage	380	Vac
Maximum DC voltage	820	Vdc
Maximum DC current	1263.77	Adc
Minimum MPPT DC voltage	545	Vdc
Nominal DC voltage	615	Vdc
Maximum MPPT DC voltage	820	Vdc

Efficiency curve and Characteristics:



Batteries:

Energy storage enables flexible energy usage at periods other than when it was created, yet it's never 100% efficient since energy is constantly wasted in the conversion and retrieval processes. Storage can thereby enhance power quality by balancing supply and demand, as well as system resilience and efficiency.

Energy capacity, or the total quantity of energy that can be stored, and power capacity, or the quantity of electricity that can be discharged at a certain moment, are two ways that storage facilities can be distinguished from one another (commonly measured in kilowatts or megawatts).

Rechargeable batteries classified as lithium-ion employ lithium ions as their primary charge carrier. Because to their high energy density, prolonged cycle life, and little maintenance needs, they are extensively utilized for energy storage in solar power plants. The battery system's size and capacity, the solar panels' efficiency, and the quantity of energy they produce during the day are only a few of the variables that affect the 20MW solar power plant's storage capacity.

In order to determine the storage capacity of such a lithium-ion battery system. First, we must determine the overall power output of the 53,333 solar panels, each generating 375 Watts.

Total output power: 375*53,333 = 20MW.
The storage capacity for the 10 hours is 200 MWh.

As Lithium-ion batteries typically have a capacity of 200 kWh, we would thus require about 1,000 batteries to attain a total storage capacity of 200 MWh.

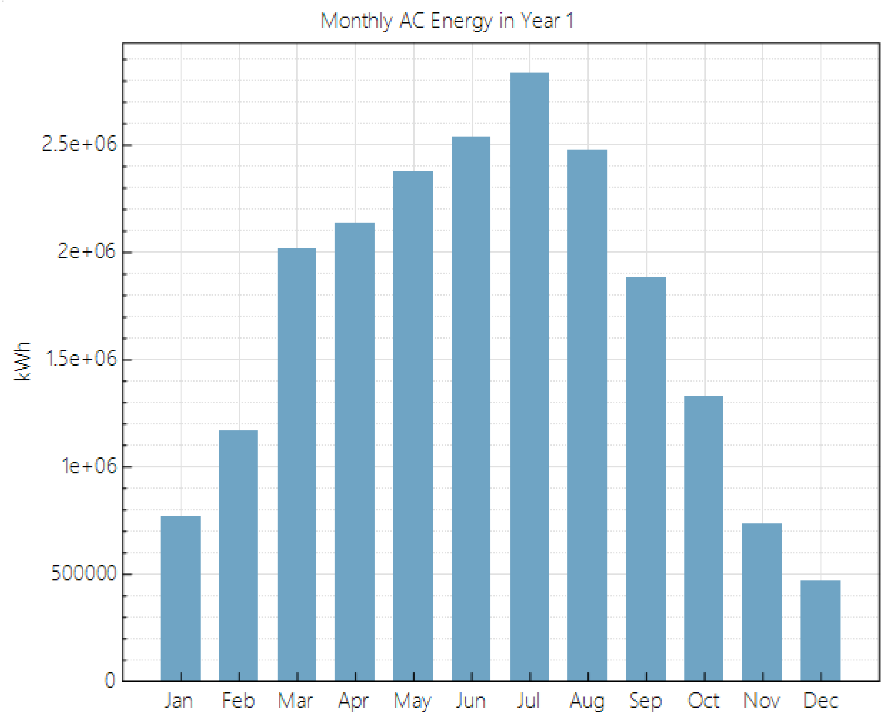
Assuming one battery costs $132 per MWh, the price of the batteries needed to reach entire storage capacity of 200 MWh would be approximately $26.4 million.

Simulation Software:

SAM:

From the below summary, the annual AC energy is 20.72MW. The Internal rate of return is 12.33%. The PPA price according to New York State Energy Research and Development Authority (NYSERDA) it should be in the range of 8 to 15 cents/kWh. From the SAM simulation we can see the PPA price is 10 c/kWh.

The below diagram shows the monthly AC Energy for 1 year. We can see that Peak power is generated in the months of May to August which is nearly 25MW. The lowest power is recorded in the months of January and December which is above 5MW.



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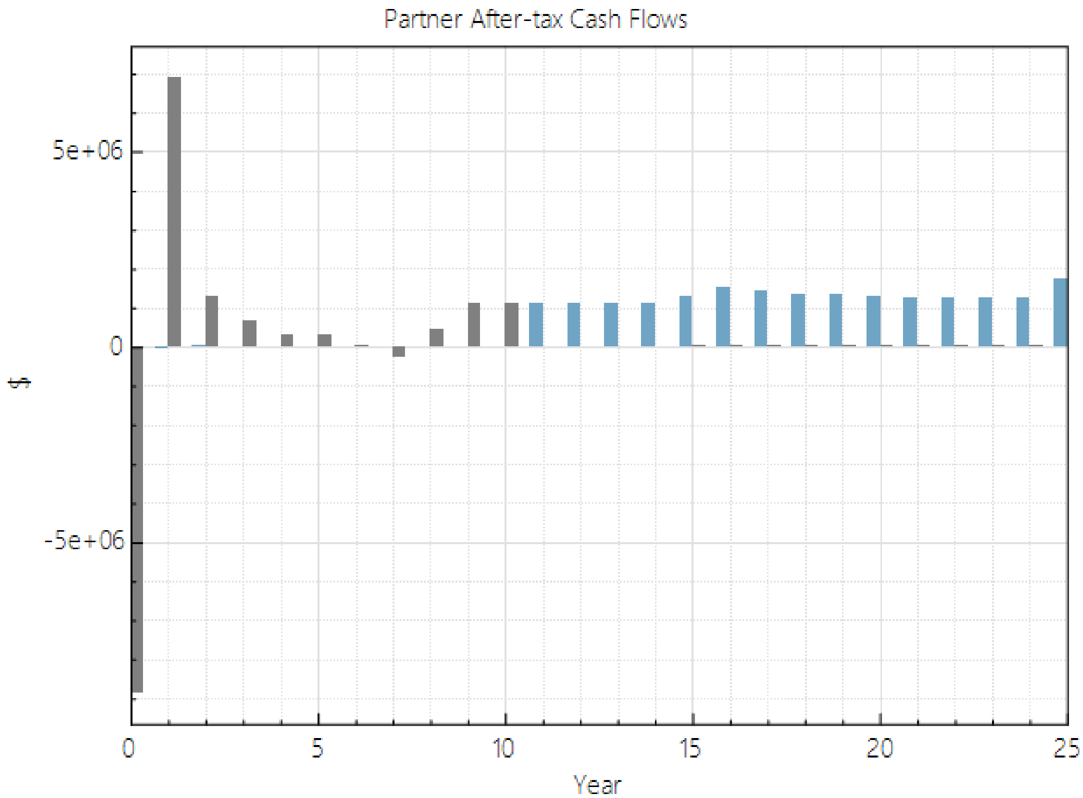
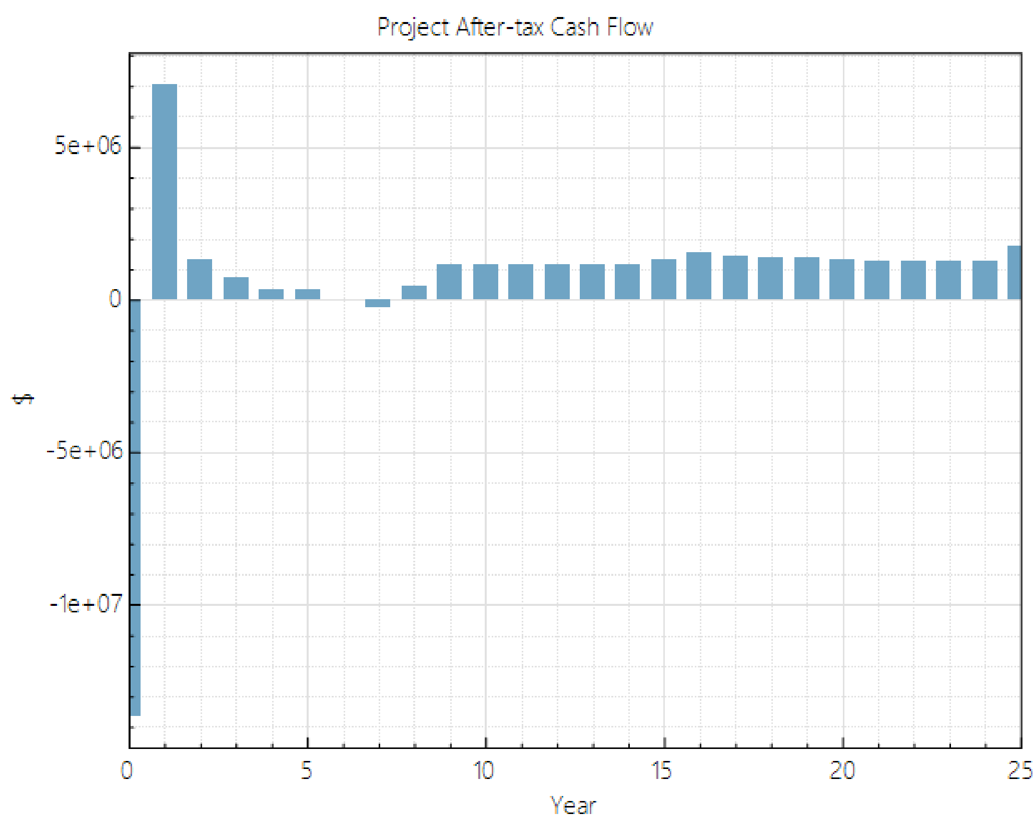
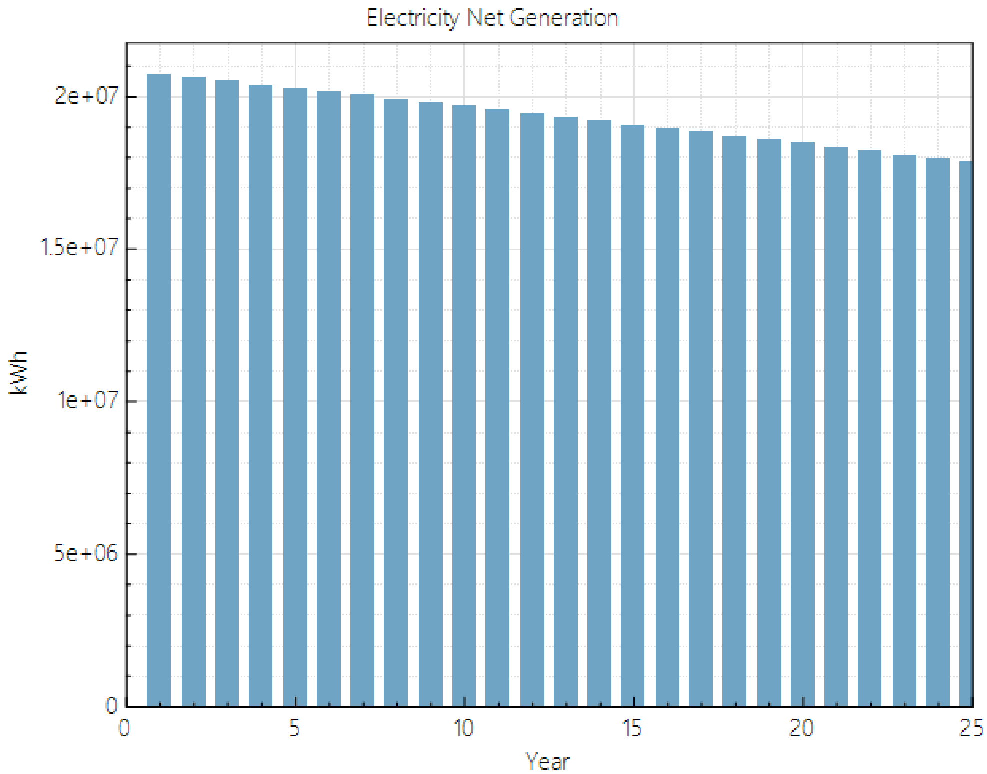
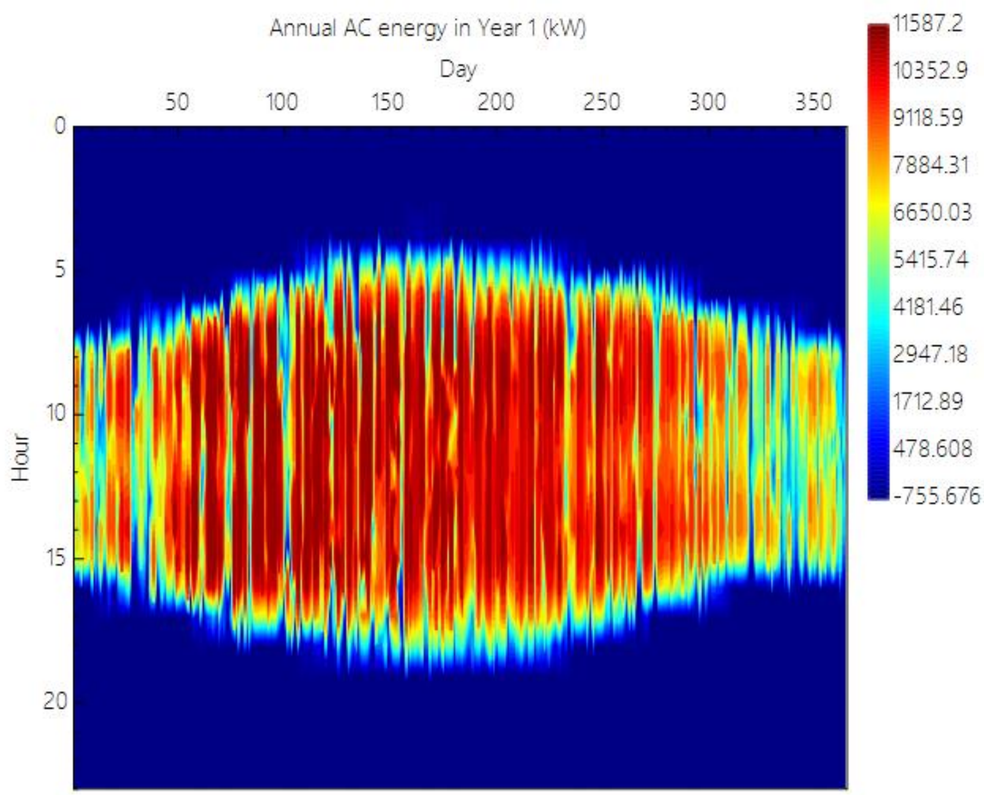
Investor IRR Internal rate of return	12.33 %
Flip year	10
Investor IRR at end of project	12.63 %
Investor NPV over project life	$698,995
Developer IRR at end of project	9.32 %
Developer NPV over project life	$169,612
Net capital cost	$23,357,844
Equity	$13,640,661
Debt	$9,717,182
Debt percent	41.60%

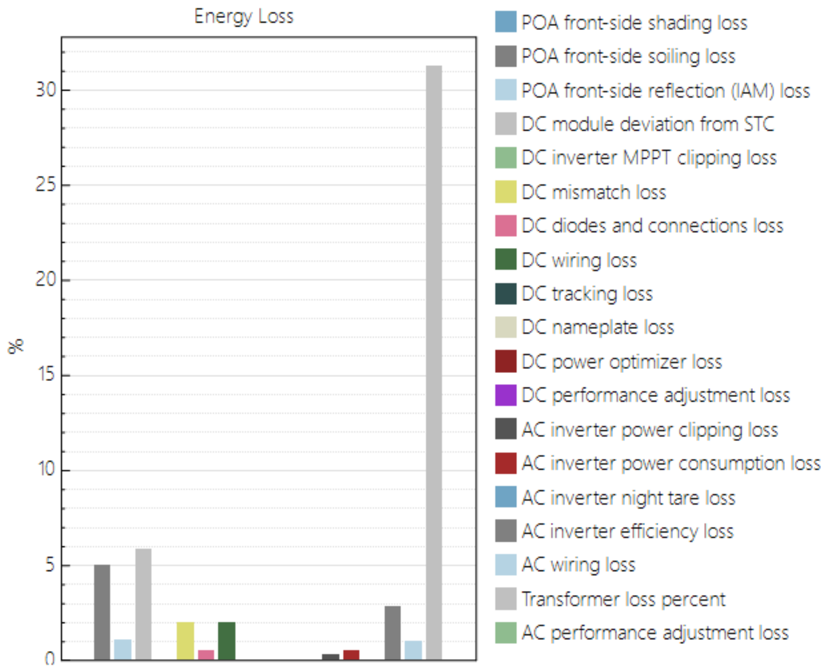
Fig: Summary


Partner After-tax Cash Flows
5e+06
0
-5e+06
$
0
5
10
15
20
25
Year


Project After-tax Cash Flow
5e+06
0
-5e+06
-1e+07
$
0
5
10
15
20
25
Year


Electricity Net Generation
kWh
2e+07
1.5e+07
1e+07
5e+06
0
0
5
10
15
20
25
Year


Annual AC energy in Year 1 (kW)
Day
50
100
150
200
250
300
350
Hour
0
5
10
15
20
11587.2
10352.9
9118.59
7884.31
6650.03
5415.74
4181.46
2947.18
1712.89
478.608
-755.676



The above plots shows the after tax cash flow, Energy Los, Electricity Net Generation and Annual AC Energy for hourly.

Costs:

Direct Capital costs:
The direct capital cost, which constitutes a sizeable portion of the overall expense of a solar power plant, is impacted by a number of variables, including the facility's size, its technological configuration, and its location.
Solar Panels and Inverters:

Below table gives the details about Solar PV modules and Inverters costs.

Parameters	Number of Units	$W/dc	Total cost ($)
PV modules	53,333	0.37	7.4 million
Inverters	20	0.03	600 K

The direct costs also include Balance of system equipment, Installation labor and Installer margin and overhead.
According to the above table and other parameters, the total direct cost of the project is @18.9 M.

Indirect Capital Cost:

Indirect capital costs are charges that are required for the proper implementation of the solar project while not directly related to its construction. These expenditures may consist of charges for finance, insurance, legal counsel, and permit fees.
The table gives the costs of the indirect expenditures.

Parameters	$W/dc	Total cost ($)
Permitting Fee	0.01	200 K
Legal Counsel	0.02	400 K
Grid Interconnection	0.02	400 K

Land:

The land for this project is in the place of Norman Skill, Albany New York.

The land required for this project is 117 acres. The cost of the land in Normanskill is $3800 per acre.
The total cost of the land is $400K.
Total Indirect capital cost for this 20MW solar project is $1.4M.

Installation cost:

The total installation cost which includes direct, sales and indirect which is around @20M.
Total installation cost per capacity is $1.02/Wdc.

Mounting Structure:

To increase the solar panels' energy production, single axis mounting systems are frequently utilized in large scale solar PV installations. A single-axis mounting system tracks the passage of sun throughout the day by putting the solar panels on a framework that really can rotate along one single axis, often an east-west axis.

When compared to fixed-tilt structures, single-axis tracking systems have the potential to produce much more energy since they are intended to maximize the elevation of the solar panels with respect to the sun's location. The design of the system and its placement determine how much energy a single-axis system can produce. Whereas tilted single axis trackers are installed on a tilting axis and move along a tilted axis, horizontal single-axis trackers spin along a horizontal axis and are supported by horizontal bearings.
Following are the some of the advantages of the single axis:

- High Energy production
- Less land requirements
- Easy maintenance
- Flexible-design

Conclusion:

The proposed 20 MW solar power system in Albany, New York is a smart investment that will benefit the environment and society. Thanks to the system's high efficiency and single axis tracking configuration, more energy can be produced, and the sun's rays can be used optimally. This provides significant savings and a faster return on investment.

After at least ten years of profitability, the system's long-term guarantee of up to 25 years ensures long-term profitability and stable income. The system is also eligible for the federal Renewable Energy Production Tax Credit, providing significant economic benefits during the first decade of operation. Ensure safe and reliable system integration into the network by connecting to the national grid and complying with NYISO and New York State standard interconnection requirements. Although the application process is complex and expensive, the interconnection process is necessary to ensure the smooth operation and long-term viability of the system.

Overall, the proposed 20 MW solar power system in Albany, New York is an economically sound and environmentally sound investment that will have a significant impact on the neighborhood and beyond. Due to the system's high efficiency, long life and connectivity and security requirements, the system is a smart investment for individuals and organizations looking to reduce their carbon footprint while generating income. Safety.

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