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Economic Feasibility of Installing Poly Crystalline Technology Solar Plants in Andhra Pradesh, India.

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ABSTRACT:Renewable energy sector in India has emerged as a significant player in global market. A financially healthy and efficient power sector is necessary for the growth of overall economic development and poverty alleviation for a state like Andhra Pradesh. This study intends to investigate the financial feasibility of a 10 MW photovoltaics plant installation in Andhra Pradesh on a project level with poly crystalline silicon panel technology. The present market and legal frames of investment in Andhra are studied. Poly crystalline technology is regularly developed to improve its efficiency and capability. The research study includes net present values, internal rate of return, simple payback method and levelized cost of energy analysis for the implementation of the project plan proposed. The economic viability in photovoltaics installations are calculated for the considered project plan. The results illustrate the choice that a potential investor can look into and invest in the project. Large-scale photovoltaics installations can be sustainable in Andhra Pradesh but government should truly support by providing more incentives, infrastructures and substantial subsidies.

KEYWORDS:Levelized cost of energy, Net present values, Internal rate of return, Simple payback method, Andhra Pradesh, Poly crystalline, Feasibility.

I. INTRODUCTION

Solar energy economics plays a crucial role in the successful adoption of largescale solar systems around the world including India. There are important economies of scale in photovoltaic installations. [1] In India, through transparent auctions and with endowment of land and transmission, tariffs have become lower than thermal power cost. The government has launched a special program or scheme to encourage solar energy generation, reducing carbon footprint and increase investments. The special program is launched to develop the existing dedicated solar parks consisting large-scale solar power plants. [2]

CERC estimated the solar module price of U.S 0.48 \$/W for the projection of benchmark capital cost of photovoltaics for FY 2016 - 2017 which includes custom charges, unloading and transportation [3]. In order to make solar power competitive with conventional power plants economically, huge investments are required. For 96 GW additional installation by 2022, CERC recommended present benchmark photovoltaic power capital cost of \$ 107 billion is required. Solar energy projects are financed by many investors in addition to Indian government like banks, public and private firms. When compared to Indian energy challenge scale, the international finance levels for green energy remain insufficient [4]. To attract international investors to do their investment in solar installation, manufacturing components activities in India and some tactical measures should be undertaken. [4]

In the world, India is located in the sunny belt. For solar energy utilization, India is a favourable place with 300 sunshine days per year [5]. In India average solar incidence will vary by 4 - 7 kWh/m²/day and with 2300 - 3200 sunshine hours per year based on the location [4]. The barren lands available to setup solar power plants is higher in Andhra Pradesh that is 2056 ha [5].

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Crystalline structure is used in order to make first generation of photovoltaic technologies that uses silicon to manufacture solar PV cells that are incorporated to make photovoltaic modules. This technology is not outdated, instead it is being regularly developed to improve its efficiency and capability. EWT, mono and multi crystalline are the type of cells comes under structures of silicon crystalline and are reviewed in the coming sections. Poly crystalline/Multi crystalline cells are developed in order to increase production and to reduce cost. The efforts of photovoltaic industry have led to new advancements of crystallization techniques. In the beginning, multi crystalline was ruling the solar industry while the cost of silicon was \$340/kg. Even with the reduction of silicon price to \$50/kg, this technology is turning to be more attractive due to lower manufacturing costs even though these cells are lessefficient (15%) compared to that of mono crystalline. The advantage by converting the manufacturing of crystalline solar cells from mono to multi silicon is to reduce flaws in crystal structure and metal combination [6]. For this economic feasibility analysis work the standard indicators like net present values (NPV), internal rate of return (IRR), simple payback period and levelized cost of energy (LCOE) are considered. Each indicator is calculated with help of standard numerical data. For calculating payback period and levelized cost of energy undiscounted analysis is considered and calculated.

II. RELATED WORK

The literature covered most of the government policies in India and latest dated cost information on photovoltaic systems. The literature work was used for economic guidelines, assumptions and comparison of results. Two important related works are briefly described as follows.

Studies conducted by David and Muyiva [7] used financial and performance data from two thin film technologies for a region of hot-humid climate in Ghana and conducted a techno-economic analysis. They considered amorphous silicon and copper indium disulfide technologies and found that a-Si is superior to CIS in that location and can be similar to other hot humid climates. We can relate the similar conditions to India and consider two different technologies and perform an assessment to indicate the feasibility of technology using financial indicators.

Ganga et al., checked the feasibility of a 100 kW roof top solar power plant in India based on life cycle cost of energy. [8] Their results showed that positive internal rate of resulted favorable in both the cases of with and without battery. This shows that the plant can be installed with increase or decrease of 10% capital cost which shows that the project is feasible.

The objectives that were addressed in this study is to evaluate economic feasibility, indicators like NPV, IRR, Payback Period and LCOE for Crystalline silicon technology implementations on 10 MW solar project. Also, to help investors take investment decisions for which technology is more sustainable.

III. METHODOLOGY

In this work, Andhra Pradesh state is considered because it holds the rapid outrageous growth in solar power sector, mainly due to construction of ultra-mega solar power parks in Rayalaseema region of Andhra Pradesh. Project capacity is 10MW utility scale grid connected solar power plant with poly crystalline silicon technology panels.

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Table 1: Panel Description and Total Cost estimation of 10 MW solar plant with project plan [9][10][11]

Technology	Poly crystalline	Components	Project Plan
Nominal Maximum Power	250 W	Solar Modules Cost	□ 312,303,600.00
Efficiency	15.4 %	Inverter Cost (Power Conditioning Unit)	□ 42,848,564.00
Annual Efficiency Degradation Rate	0.1232 %	Mounting Structures Cost	□ 35,000,000.00
Number of Panels Required (Pieces)	40,000	Civil and General Works Cost	□ 35,000,000.00
		Land Cost	□ 25,000,000.00
		Evacuation Cost up to Interconnection Points (Transformers & Cables)	□ 44,000,000.00
		Accessories Cost	□ 2,287,804.00
		Preliminary & Pre-operative expenses including IDC and Contingency	□ 28,000,000.00
		Project Design and Management Cost	□ 10,000,000.00
		Total Project Cost in INR	□ 534,439,968.00

A. Energy and Revenue Generated

To estimate annual energy output generation from the solar plant, the global formula is given by [12].

$$E = A \times r \times H \times PR$$

Where E: Output energy, A: Total solar panel area (m²), r: Solar panel efficiency (%), H: Annual average solar radiation on tilted panels, PR: Performance ratio.

B. Net Present Values (NPV) and Internal Rate of Return (IRR)

NPV states the difference between the present value of all solar project cash inflows and outflows [13].

The formula used for NPV in Rupees is given by equation [14]

$$NPV = \left[\sum_{t=1}^T \left(\frac{C_t}{(1+r)^t} \right) \right] - C_0$$

Here, C_t = Solar project annual cash inflows, r = Discount rate, C₀ = Initial investment for the solar project and t = years.

IRR is the rate at which the sum of project cash inflows and outflows are equal.

Therefore, IRR is written as below equation in % [13].

$$NPV = \left[\sum_{t=1}^T \left(\frac{C_t}{(1+r)^t} \right) \right] - C_0 = 0$$

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C. Payback Period

It is used to determine the time taken by the solar project to return back the initial investment (cash outflow). We have used cash flow amounts by not taking time value of money into account.

The payback period is given by equation below in years[15]

$$\text{Payback period} = \left(\frac{\text{Initial investment}}{\text{Cash inflow per period}} \right)$$

D. Levelized Cost of Energy (LCOE)

LCOE signifies the operating and building cost (kWh) of the 10 MW solar power generation plant over a presumed financial life.

LCOE formula is calculated in Rupees by equation[16]

$$\text{LCOE} = \frac{\text{Sum of the costs over life time}}{\text{Sum of electricity produced over life time}}$$

Note: Undiscounted LCOE analysis is considered.

IV. EXPERIMENTAL RESULTS

The total energy and revenue generated from the plant with plant life of 25 years is calculated with the help of following input conditions: A: $1.6236 \times 40,000 = 64,944 \text{ m}^2$, PR: 75%, H: $2040.35 \text{ kWh/m}^2/\text{year}$ and power purchasing rate is 4 Rs/unit.

Total energy generated: 342825966.360 kW

Total revenue generated: ₹ 1,371,303,865.44

Table 2:NPV and IRR

Interest Rates	NPV A with actual capital cost	NPV B with 10% inflation of actual capital cost	NPV C with 10% deflation of actual capital cost
0%	₹ 836,893,897.43	₹ 783,449,900.63	₹ 890,337,894.23
2%	₹ 546,297,321.25	₹ 492,853,324.45	₹ 599,741,318.05
4%	₹ 337,849,495.14	₹ 284,405,498.34	₹ 391,293,491.94
6%	₹ 185,108,397.53	₹ 131,664,400.73	₹ 238,552,394.33
8%	₹ 70,850,210.74	₹ 17,406,213.94	₹ 124,294,207.54
9%	₹ 24,423,550.46	₹ -29,020,446.34	₹ 77,867,547.26
11%	₹ -52,277,537.41	₹ -105,721,534.21	₹ 1,166,459.39
13%	₹ -112,455,841.32	₹ -165,899,838.12	₹ -59,011,844.52
IRR	9.59	8.36	11.035

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Table3: Payback Period

	With actual capital cost	10% inflation in actual capital cost	10% deflation in actual capital cost
Year	Cumulative Cash Flow A	Cumulative cash flow B	Cumulative Cash flow C
0	□ -534,439,968.00	□ - 587,883,964.80	□ - 480,995,971.20
1	□ -473,710,796.82	□ - 527,154,793.62	□ - 420,266,800.02
7	□ -119,620,548.72	□ - 173,064,545.52	□ - 66,176,551.92
8	□ -62,319,637.20	□ - 115,763,634.00	□ - 8,875,640.40
9	□ -5,508,477.06	□ - 58,952,473.86	□ 47,935,519.74
10	□ 50,812,931.70	□ - 2,631,065.10	□ 104,256,928.50
11	□ 106,644,589.08	□ 53,200,592.28	□ 160,088,585.88
	9.1	10.1	8.2

For LCOE, with these following input conditions: Annual degradation: 0.50%, O&M Cost: 109 Rs/Unit, O&M escalator: 5.72%/year, Power purchasing rate: 4 RS/Unit. The total energy generated from the plant with 25 years plant life is 357,633,351 kWh and total operation cost of the plant with 25-year plan life is Rs. 57,496,547.57.

Table4: LCOE

LCOE Outputs	Actual capital cost/unit	10% inflation of actual capital cost/unit	10% deflation of actual capital cost/unit
25 Year	□ 1.655149	□ 1.804587	□ 1.505711

V. CONCLUSION

We have calculated all the financial indicators with the help of standard literature and real time input data and found that with the implementation of poly crystalline panels in 10MW solar plant in Andhra Pradesh state will yields financially better results to the investors who would like to invest their money in this state of India.

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