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Simulation and Cost Analysis of 42 kWp Solar PV Plant Using Homer Pro for Rural Village, Central India

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***Abstract*- Due to the rise in environmental pollution and ultimately leading to the climate change, we must look for renewable energy sources. Electricity generation using solar PV system is a sustainable, clean as well as climate friendly. In this paper, we are analysing and simulating 42 kWp solar photovoltaic systems at the site of Nandpur Village using simulation based software. The total energy installation in India is very high. However the availability of electricity in rural areas is often inconsistent. This can be improved by installing a solar power plant. In recent times, govt of India is also promoting the solar energy use by PM KUSUM Yojna. This plant is proposed for the village Nandpur, Madhya Pradesh. Site has the coordinates 21°54.1'N, 78°7.3'E. "HomerPro" software package is used to analyse and simulate the cost, efficiency and life cycle operation of the solar PV system.**

Keywords- Renewable, HomerPro Software, Cost Analysis, Life cycle, Initial rate of return(IRR).

I. INTRODUCTION

Electricity is needed in daily life. From smart phone charging to induction cooking to entertainment, electricity has made into all parts of our lives. India is a fast growing country with growing appetite for electricity. This demand has to be met in a way that it does not affect the environment. Therefore we must utilise renewable forms of electricity as much as possible. The most widely available renewable source of electricity is solar and wind power. Solar power is one such method to fulfil the ever increasing need of electricity. Solar cell based system has came out as the most suitable course of action to produce electricity at a large scale. For the most part of the year India receives sun light. 300 plus clear sunny days in India makes it one the most ideal place to build solar power plant. A study estimated that 5000 PWh/year (Petawatt-hour per year) solar radiance falls over the terrain of India. For per square meter it comes out as 4-7 kWh/ m^2/day. Here we are studying and simulating the performance of the proposed solar PV system, for the location at Nandpur Village in Betul District, Madhya Pradesh.

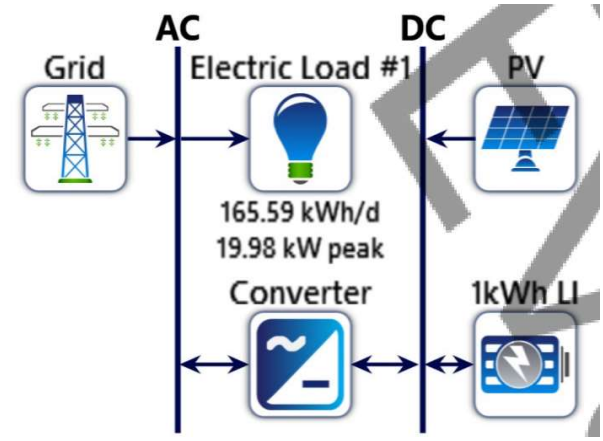
II. PREVIOUS RESEARCH

Earlier research has shown way for us to use softwares and simulation to perform the preplanning study, cost analysis and generation output of the PV plant over Homer Pro software. Abdul Munim Rehmani et. al. [1], explains the economic analyses of hybrid system of rural region installed in Pakistan. Development of hybrid system by Homer Pro is described by Swarnkar et. al. [2]. Sahil Mehta et al. [3] presented a case based study of solar system related to micro grid to obtain cost of electricity with respect to changes occurring in solar irradiance. Khan et al. [4] performed cost based research of a hybrid system on Homer Pro software in Pakistan. In South Africa, renewable energy availability of electricity in remote region is performed by O. M. Longe et al. [5]. Analytic evaluation design for rural places in Arunachal Pradesh for a low-cost model has been analyzed by Abhishek Sanyal et al [6]. Sanjay Kumar et al. [7] done performance analysis of solar electricity generation system using Homer Pro and PVsyst software. Yashwant Sawle et al. [8] did cost and sensitivity analysis of mixed renewable electricity generation units using Homer pro.

III. WORKING METHOD

In this, a software based cost analysis of 42 kWp solar grid connected system, proposed (not installed) at location of 21°54 (longitude), 78°7.3 (latitude) is studied. Study of the proposed system depends on geographical location, component material and making process, and climate parameters like flow of wind, solar incident irradiance, day time temperature of the location, shadow etc. Here simulation and analysis is done by HomerPro software. All calculation and data collection is done using software data readily available in the software. The load requirement is 242 kWh/day supplied by the MPPEB (Madhya Kshetra Vidyut Vitran Company Limited), a state owned company. Many performance indicators of the proposed plant are

Studied through HomerPro software. This vast amount of detail is described by various pictorial diagrams and tables for easy understanding of the system.



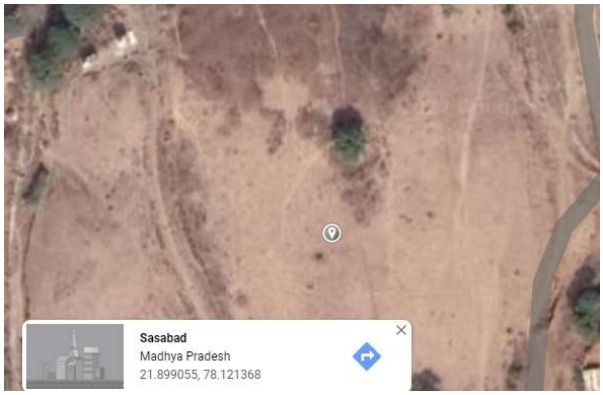


Fig-1 Site Location: Top View

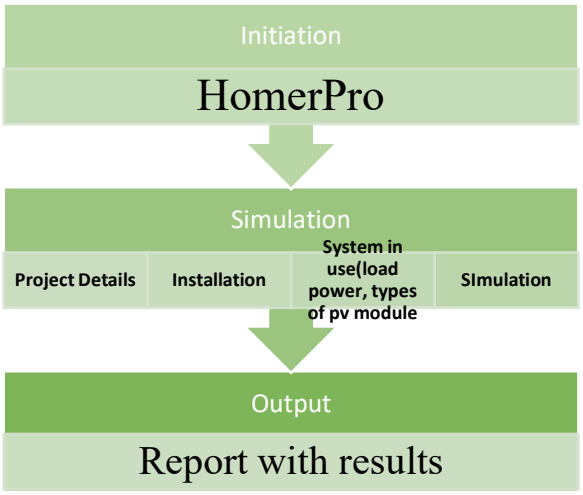
A. *HomerPro Software*

"HOMER® Pro simulates engineering and economic feasibility of micro grid or distributed energy systems that are off-grid or tied to an unreliable grid and enables the design of least-cost electrical systems and risk-mitigation strategies. The software provides insight into cost-effectively combining conventional and renewable energy, storage, grid resources (where available), and load management.

In a single data run, HOMER Pro simulates the operation of a hybrid micro grid or distributed energy system for an entire year, evaluating and optimizing the electrical system design, load profiles, components, fuel costs, and environmental variables. The simulation produces key information on technical performance, risk-mitigation, and projected cost-savings to inform system design and optimization. Results are presented in a succinct Micro grid Proposal. For more information, visit HomerEnergy.com." [9] .

B. *Inputs for the system*

A schematic diagram is shown here for easy explanation of the inputs of the system.

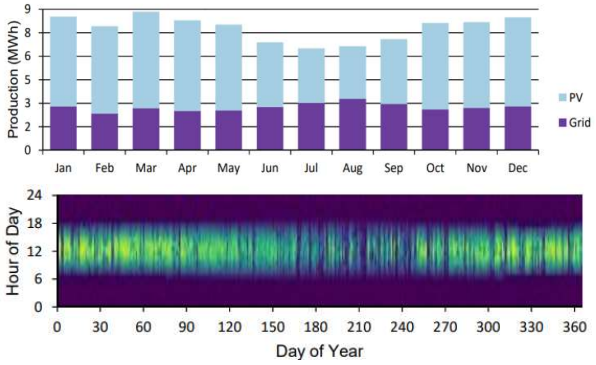


1. *Geographic Location*

Here the site selected is in Nandpur village in Betul district of Madhya Pradesh, India. The coordinates of the site are 21°54.1'N, 78°7.3'E.

2 *Load*

This micro grid requires 242 kWh/day and the maximum peak load of 24 kW. In the proposed system, the following generation source serves the electrical load.

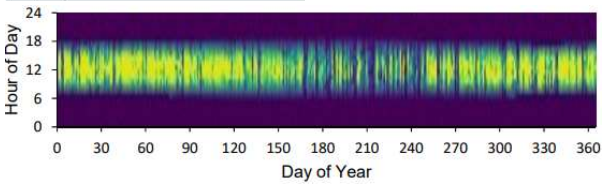


3 *Details of Inverter*

The proposed capacity of 42 kWp solar plant, we have taken Generic Inverters in the software simulation. The total maximum value of the inverter is 24 kWac. Details of Solar PV panels are given below.

Capacity	23.9 kW
Mean Output	6.33 kW
Minimum Output	0 kW
Maximum Output	23.9 kW
Capacity Factor	26.5 %

Hours of Operation	4,381 hrs/yr
Energy Out	55,421 kWh/yr
Energy In	58,338 kWh/yr
Losses	2,917 kWh/yr



Solar Inverter Electrical Summary

Quantity	Value	Units
Hours of Operation	4,381	hrs/yr
Energy Out	55,421	kWh/yr
Energy In	58,338	kWh/yr
Losses	2,917	kWh/yr

Solar Inverter Statistics

Quantity	Value	Units
Capacity	23.9	kW
Mean Output	6.33	kW
Minimum Output	0	kW
Maximum Output	23.9	kW
Capacity Factor	26.5	%

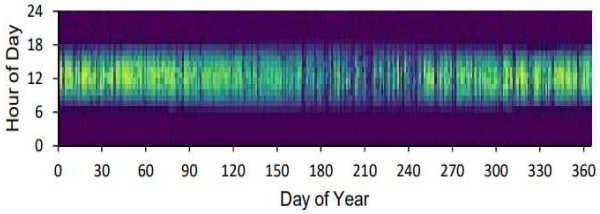
4 Solar Irradiance Effect

Solar irradiance diffusion is also very vital indicator that affects the simulation and design of any solar plant. It includes solar irradiance in atmosphere and after being scattered dust, various gases etc. It depends primarily on tilt angle, cloud presence and humid nature of the atmosphere as well as dust molecules. HomerPro software also takes wind and thermal temperature data as input for system simulation.

6 PV: Generic flat plate PV

The Generic PV system has a nominal capacity of 41.9 kW. The annual production is 60,479 kWh/yr.

Rated Capacity	41.9 kW	Total Production	60,479 kW
Capital Cost	₹1.68M	Maintenance Cost	41,892 ₹/yr
Specific Yield	1,444 kWh/kW	LCOE	2.84 ₹/kWh
PV Penetration	100 %		



IV. RESULTS AND DISCUSSION

1. Balance & Main Results

Month	Energy Purchased (kWh)	Energy Sold (kWh)	Net Energy Purchased (kWh)	Peak Load (kW)	Energy Charge	Demand Charge	Total
January	2,800	2,805	-5.10	19.9	-₹15.29	₹0.00	-₹15.29
February	2,346	2,796	-450	18.6	-₹1,349	₹0.00	-₹1,349
March	2,681	3,001	-321	18.4	-₹962.39	₹0.00	-₹962.39
April	2,509	2,888	-379	20.0	-₹1,137	₹0.00	-₹1,137
May	2,541	2,648	-107	18.8	-₹321.01	₹0.00	-₹321.01
June	2,762	1,643	1,119	19.0	₹6,490	₹0.00	₹6,490
July	3,021	1,208	1,813	18.8	₹10,517	₹0.00	₹10,517
August	3,279	1,116	2,163	18.0	₹12,544	₹0.00	₹12,544
September	2,943	1,753	1,190	17.7	₹6,902	₹0.00	₹6,902
October	2,614	2,651	-37.0	17.0	-₹110.98	₹0.00	-₹110.98
November	2,706	2,700	6.39	19.8	₹37.06	₹0.00	₹37.06
December	2,808	2,780	27.7	18.5	₹160.94	₹0.00	₹160.94
Annual	33,010	27,989	5,021	20.0	₹32,755	₹0.00	₹32,755

Cash Flows

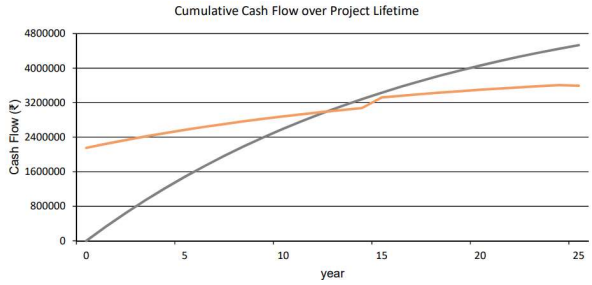
Project Lifetime 25 years — Expected Inflation Rate 2.0%

Nominal Discount Rate 8.0% — Real Interest Rate 5.9%

Year	1	2	3	4	5	6	7	8	9	10
Generic flat plate PV	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)
Grid	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)
Solar Inverter	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)

Year	11	12	13	14	15	16	17	18	19	20
Generic flat plate PV	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)
Grid	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)
Solar Inverter	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)

Year	21	22	23	24	25
Generic flat plate PV	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)	(₹41,892)
Grid	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)	(₹32,755)
Solar Inverter	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)	(₹23,882)



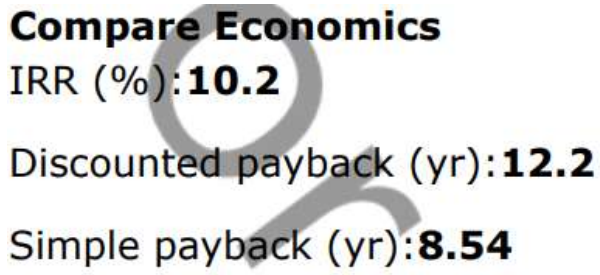
V. CONCLUSION

The HomerPro software based study of 42 kWp solar system was proposed and analysed for Nandpur Village in Betul District in state of Madhya Pradesh, India. The following conclusion is presented below.

Renewable Summary

Capacity-based metrics	Value	Unit
Nominal renewable capacity divided by total nominal capacity	100	%
Usable renewable capacity divided by total capacity	100	%
Energy-based metrics	**Value**	**Unit**
Total renewable production divided by load	68.4	%
Total renewable production divided by generation	64.7	%
One minus total nonrenewable production divided by load	100	%
Peak values	**Value**	**Unit**
Renewable output divided by load (HOMER standard)	145	%
Renewable output divided by total generation	100	%
One minus nonrenewable output divided by total load	100	%

	Base System	Proposed System
Net Present Cost	₹4.53M	₹3.59M
CAPEX	₹0.00	₹2.15M
OPEX	₹350,562	₹111,254
LCOE (per kWh)	₹5.80	₹3.14
CO2 Emitted (kg/yr)	38,199	20,862
Fuel Consumption (L/yr)	0	0



VI. ACKNOWLEDGMENT

This work is administered as performance analysis of the PV solar system installed at Nandpur Village in Betul District of Madhya Pradesh. I also acknowledge the support and assistance provided by Department of Electrical Engineering as well as my guide Professor Dr. Shailja Shukla.

VII. REFERENCES

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