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ECONOMIC SCRUTINY OF PHOTOVOLTAIC SYSTEM FOR REMOTE AREA IN INDIA

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Abstract: In current power deficit era, the ever increasing global demand of energy during the last few decades had a significant impact on the climatic conditions such as pollution, global warming, and impact on ozone layer etc. Recently, a pact was signed by various countries (approx. 170) to reduce the global emissions and develop alternative resources of energy. Thereafter, significant efforts and funding were allotted by various countries throughout the world to implement several forms of renewable energy projects, especially solar and wind power projects. Most reliable type of the renewable energy i.e. Solar Energy is utilized for powering utility in the proposed work. Using Solar Photovoltaic Array as the primary source, a model is developed and optimize in the RETScreen software, extracting the solar energy in the form of electrical energy. In this proposed work evaluate prefeasibility analysis of grid connected PV system at fixed mode of solar tracker system and found system is more environments friendly.

I. INTRODUCTION

The Renewable energy which can be converted to electrical energy directly without any intermediate process is solar energy. Solar photovoltaic system is considered as one of the most reliable and matured technologies amongst various renewable energy sources [1]. With the rapid expansion of wind and solar power and a steady increase in hydropower, the position of renewable has been cemented as an indispensable part of the global energy mix; by 2035, renewable will account for almost one-third of the total electricity output [2]. Out of all kinds of renewable technology, solar power is growing more rapidly. Solar energy is clean, eco-friendly and is abundantly available. In recent years, the need for clean energy in an effort to reduce emissions and minimize reliance on fossil fuels has led to worldwide installation of large-scale renewable energy systems. In 2009, European Union Renewable Energy Directive has set a target of generating over 32% of total power from renewable energy by 2030, with a target of 100% by 2050. A research study has revealed that at each instant, the earth surface receives approximately 1.8 × 1011 MW of power from solar radiation which is much more than the total world wide consumption of power [3]. There are 2 distinct methods for solar power generation name as solar photovoltaic and concentrated solar thermal. Between the two, solar PV is the matured and financially viable choice for power generation. Solar (PV) plants (henceforth referred to as PV plants) directly converts sunlight into electricity without any type of rotating machine. The pleasing form of PV systems are modularity, light maintenance and operating cost, light weight, environmental cleanliness and easily.

Mostly, single capability of PV model ranges from 100W to 320W [3]. Several thousands of such PV modules want to be joined in a direction to get the MW order of power from PV system, thereby, demand important land region for the deployment of a huge-scale PV. Besides the important land region demand, higher setting up price compare to other renewable technologies, and alternating production with a light capability element are the other limitations of this generation technology. A solar PV module characteristic plays an important role for planning of designing system for power generation and transmission. Two PV modules with the same rated power, even with the same technology, will not provide the same output power and energy yield. Also, the different thermal characteristics play an important role in module efficiency as well as the output power; this is because the PV module is influenced by a variety of environmental factors and solar cell physics [4]. Hence, testing and modelling the PV module/system in the outdoor environment with specifying the influences of all significant factors, are very important to check the system performance and to facilitate efficient troubleshooting for photovoltaic module/system through considering hourly, daily and monthly or annual basis. Although, the efficiency of the PV system depends on several climatic factors such as the altitude, humidity, shadow, azimuthally angle, insolation, ambient temperature and the state of the solar PV modules like its cleanliness, etc [5].

Advantages of photovoltaic generation include:

- There is no moving part so that little maintenance is required,
- They utilize an infinitely renewable and pollution-free power source,
- The cells are reliable and long lasting with no harmful waste products,
- The cells are usually made of silicon which is one of earth most abundant and cheap materials, and they have a high power-to-weight ratio which is required in aerospace applications.

Despite all the above advantages they are still far too expensive for mass use but are viable for specialized applications such as spacecraft, isolated communication stations, and certain defense needs. However with worldwide concerns about fuel shortages and environmental issue the profile of using solar PV and other forms of renewable power generation systems has been raised significantly. Large financial investment is forthcoming, so mass consumption of electricity generated using PV panels will soon become reality. In considering the cost of solar cells a terminology "peak watt" of power is used. This means that the cell is required to generate 1 watt of power when the solar insulation is 1000 W/m2. With a typical efficiency of 10 %, 1 m2 of cell array area would generate 100 peak watts [7]. The quoted cost of electricity generated from solar cells varies widely, but the recent report quoted costs in the range $.0.25 /kWh to over 1.0 /kWh (2002) for a domestically managed system. Installed commercial systems, especially when retrofitted to existing buildings, are much more expensive. This price is not competitive with the conventional generation which is about $0.07 per kWh in the USA and £0.07 per kWh in the UK [6]. The general block diagram of VP system is shown in fig 1.

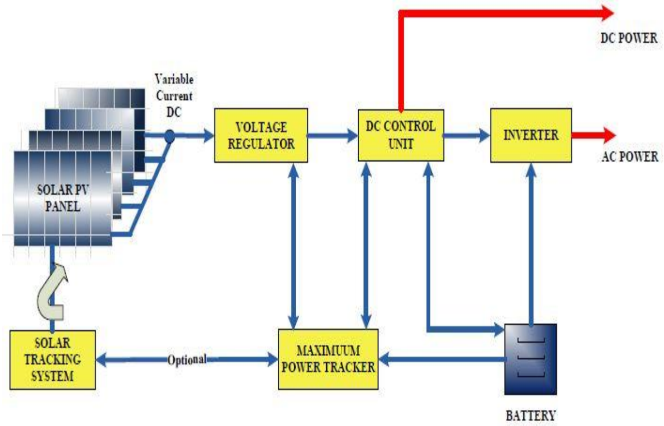

Fig. 1 Solar Photovoltaic System

II. RETSCREEN SOFTWARE

Introduction

The product coordinates various databases to help the client, including a worldwide database of climatic conditions, got from 6,700 ground-based stations and NASA's satellite information; benchmark database; venture database; hydrology database and item database[8]. The product additionally incorporates clean energy project and logical toolbox, and also a lot of multilingual and interactive media free preparing material, including an electronic textbook[9]. RETScreen is a product program created by Natural Resource Canada(a)what's more, accessible for open use for possibility investigation of clean energy project, including vitality effective advanced renewable energy systems, such as wind energy, minute hydro,photovoltaic, biomass heating, solar air heating, solar dihydrogen monoxide heating,passive solar heating, ground-source heat pump, and cumulated heat and power projects.

The product has been created in the Microsoft Excel program.Users can cull each technology project according to the purport of their feasibility study. Each technology project has a standard procedure with the same five-step analysis of the energy shape: price analysis, greenhouse vapor (GHG) analysis, fiscal concise, and sensitivity and jeopardizes analyses.figure 2. show the five-stage standard task investigation in the RETScreen model stream diagram. Each of the five stages in the standard technique is related to one or more Excel worksheet.In the Energy Model worksheet.What's more, sub-worksheets, parameters are utilized to depict the area of the task, the kind of system for the base and proposed cases, the heaps, for example, warming, cooling, and electrical burdens, and the renewable energy assets [10].

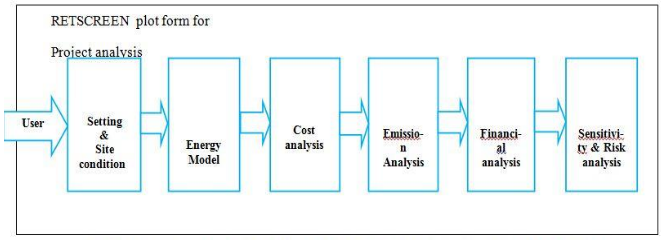

Figure. 2. RETScreen programming model stream graph: a five-stage standard examination

Size of PV System

Load

Electricity Load demand for design of solar photovoltaic system is on-grid (Central-grid & internal load) connected which utility supply system. On-grid applications cover both central grid and isolated grid systems without batteries. The reliability of central grid PV system is higher as compare to isolated grid application because if PV system output is not fulfilled the load requirement due to weather condition and etc no backup is available for supply system. Fig 3.. show the Base case load characteristics of PV system. System peak electricity load over max monthly average is 80% and Peak load – annual 5kW.

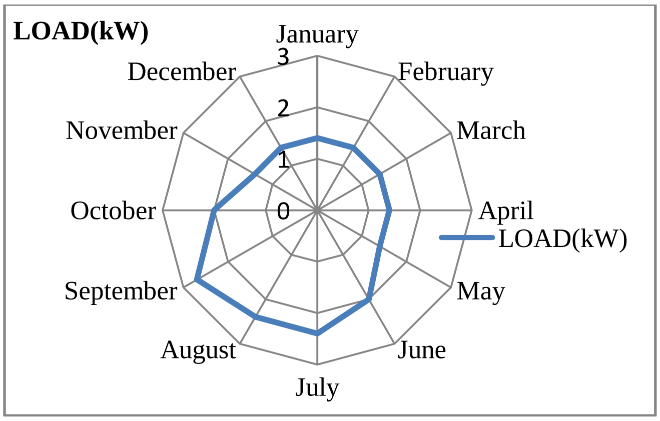

Fig 3. Base case load characteristics

PV

In this proposed work design location is Ujjain, Madhya Pradesh, India. This design location has great potential of solar photovoltaic system. The daily solar horizontal radiation is 5.15. The details of the project location are shown in table 1, 2.3.

Table: 1. Specification of location

Identification	Unit	Climate data location	Project location
Latitude	˚N	23.2	23.2
Longitude	˚E	75.8	75.8
Elevation	m	475	475
Heating design temperature	°C	14.0	_
Cooling design temperature	°C	36.7	_
Earth temperature amplitude	°C	21.5	_

Table: 2. Solar radiation data

Month	Air temperature °C	Relative humidity %	Daily solar radiation - horizontal kWh/m²/d	Atmospheric pressure kPa	Earth temperature °C	Cooling degree-days °C-d
January	19.5	41.8%	4.51	96.8	21.9	293
February	22.2	35.1%	5.27	96.6	26.0	340
March	27.7	26.0%	6.11	96.4	33.3	550
April	31.7	24.5%	6.67	96.1	38.2	651
May	32.5	35.3%	6.80	95.8	37.4	698
June	29.7	59.8%	5.73	95.5	32.9	591
July	26.8	75.8%	4.23	95.6	28.7	521
August	26.1	76.4%	3.85	95.7	27.7	500
September	26.9	64.3%	4.81	96.0	28.7	506
October	26.5	43.5%	5.10	96.4	28.6	511
November	23.6	36.1%	4.61	96.7	25.6	407
December	20.2	40.4%	4.20	96.9	21.9	316
Annual	26.1	46.7%	5.15	96.2	29.2	5,883

Table: 3. PV Specifications

PV SPECIFICATIONS		
Type	unit	Other
Power capacity	kW	14.72
Manufacturer	Sun power	
Model	Mono-Si-SPR-320E-WHT(46 unit(s))	
Efficiency	%	19.6%
Nominal operating cell temperature	°C	0
Temperature coefficient	% / °C	0.38%
Solar collector area	m²	75
Control method	Maximum power point tracker	
Miscellaneous losses	%	1.0%

Inverter
The charged of the inverter trust on the request it is usage for, the nature (waveform) of its output, its output capacity, and other integrated functions such as battery charging or gen set automatic starting. For on-grid PV systems, the cost of inverters is in the $800/kW AC to $1,500/kW AC range, where bigger units are on the lower end of this range and smaller units on the higher end. A high volume purchase of small units may bring the cost in the middle range. Note that some PV module manufacturers are offering "AC PV modules" for grid intertie systems. These modules have a short shape-in inverter. In this action, the user will not conclude an inverter cost here.

Inverter		
Efficiency	%	98.0%
Capacity	kW	15.0
Miscellaneous losses	%	0.0%

Table: 4. Specification of Inverter

III. RESULTS AND DISCUSSION

The analysis is followed by outcomes of the sensitivity analysis. Prefeasibility analysis of grid connected PV system for location Ujjain, Madhya Pradesh, INDIA evaluated through the RETSCREEN software. The software gives the result in form of net present value (NPV). RETSCREEN software also performs risk. The cumulative cash flow of fixed axis tracker of grid-connected PV system is shown in fig 3.

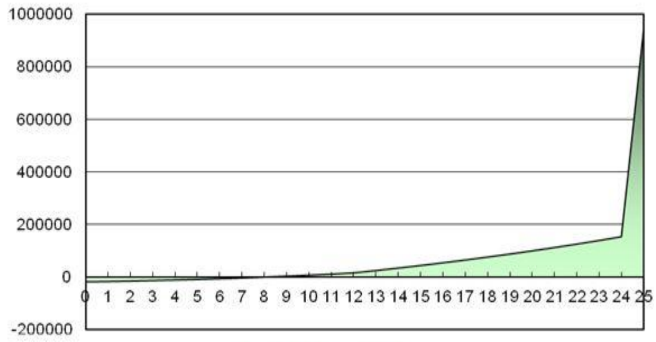

Fig 3.Cumulative cash flow

Net Present Value (NPV)
The shape counts the Net Present Value (NPV) of the scheme, which is the utility of all future cash flows, discounted at the discount rate, in today's currency. NPV is related to the interior charge of restore (IRR). NPV is thus calculated at a period 0 correspondents to the junction of the end of year 0 and the beginning of year 1. Under the NPV method, the present utility of all capital inflows is compared to against the instant utility of all capital outflows combined with an investment project. The difference between the present values of these cash flows, called the NPV, determines whether or not the scheme is commonly a financially agreeable investment. Positive NPV values are an indicator of a potentially feasible project. In using the net present value process, it is a requirement to follow a charge for deduction money overflow to present value. As a practical matter, organizations put much time and study into the choice of a deduction charge. The shape estimates the NPV using the cumulative after-duty money overflow. In cases where the user has selected not to conduct a tax analysis, the NPV calculated will be that of the pre-tax cash flows. In this thesis work, different axis tracker modes of the PV system is investigate and found the dual axis of PV system is has higher NPV as compare to other axis tracker modes which are shown in fig. 4.

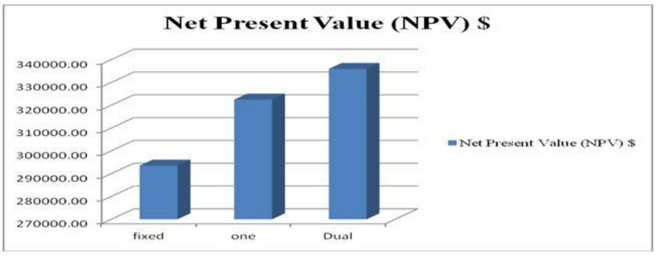

Fig: 4. Net Present Value

Risk analysis

The risk analysis is performed using a Monte Carlo simulation that concludes 500 likely combinations of input variables resulting in 500 values of after-tax IRR - equity, after-tax IRR - assets, equity payback or Net Present Value (NPV). The risk analysis allows the user to assess if the variability of the financial indicator is acceptable, or not, by looking at the distribution of the likely outcomes. An unacceptable variableness will be a mark of a want to put more effort into reducing the uncertainty associated with the input parameters that were identified as having the greatest impact on the financial indicator. The table 5 and fig. 5. show the variation of input parameters of the grid connected PV system and indicate the cost feasibility for the system installation.

Table 5 Risk analysis of PV system

Risk analysis				
Parameter	Value	Range (+/-)	Minimum	Maximum
Initial costs	61,658	20%	49,326	73,990
O&M	106	15%	90	121
Fuel cost - base case	2,507	5%	2,381	2,632
Electricity export rate	156.60	15%	133.11	180.09
Debt ratio	70%	5%	67%	74%
Debt interest rate	2.25%	30%	1.58%	2.93%
Debt term	12	0%	12	12

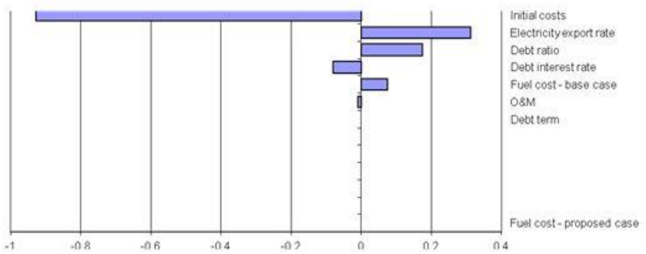

Fig.5. cost feasibility analysis of the system

IV. CONCLUSION

The RETScreen financial analysis accounts for all the design factors affecting the financial viability of a project, including initial costs, energy savings, operation and maintenance (O&M), fuel charged, taxation, greenhouse vapour (GHG) and renewable energy (RE) work belief. It automatically calculates important indicators of financial viability, permitting users to evaluate scheme supported on their own criteria. Then RETScreen can research the sensitivity of the key financial indicators to changes in the inputs. During this analysis, the author should keep in belief that indicators that observe profitability over the energy of the scheme, such as the IRR and the NPV, are preferable to the simple payback. In this proposed work evaluate prefeasibility analysis of grid connected PV system at fixed mode of solar tracker system. The net present value, and IIR etc are also higher during project life of system.

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