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RELIABILITY ASSESSMENT OF ROOF TOP SOLAR / PV SYSTEM

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ABSTRACT

Today's world needed uninterrupted qualitative electrical power with high reliability. Electrical energy that is derived from fossil fuels produces high pollution one side and on the other side electrical energy demand is continuously increasing . To tackle this typical twin problem alternative resources such as wind, solar and bio mass energy sources are to be preferred. In order to reduce the utilization of fossil fuels that is to save the fossil fuel reserves {coal, diesel e.t.c} it is very essential to see towards the above mentioned alternative sources.

Solar/PV systems are one of the most promising methods of electrical power generation. PV- grid connected systems are worldwide installed because it allows consumer to reduce energy consumption from the electricity grid and to feed the additional energy back into the grid. A realistic cost benefit analysis requires evaluation models that can recognize the highly erratic nature of solar energy source and it's interdependence of random variables inherent in them.

The probabilistic reliability evaluation of solar photo voltaic systems is required for gaining a better insight in component sizes and location needed before they are built. Proper survey of solar radiation sources study may be carried over . In this paper a case study of a roof top solar power plant (100 KW) at **"Vidyut soudha, Somajiguda, Hyderabad , Telangana"** is considered for reliability assessment.

The reliability evaluation of solar PV energy system is promising technologies to justify their views in small scale grid assistant/standalone applications for rural or remote areas.

KEYWORDS: Renewable Energy, Reliability, Solar/ PV, LOEE, LOLE e.t.c.

INTRODUCTION

RENEWABLE ENERGY:

Renewable energy is reliable and plentiful and will potentially be very cheap once technology and infrastructure improve. It includes solar, wind, geothermal, hydropower and tidal energy, plus bio fuels that are grown and harvested without fossil fuels. Non-renewable energy, such as coal and petroleum, require costly explorations and potentially dangerous mining and drilling, and they will become more expensive as supplies dwindle and demand increases. Renewable energy produces only minute levels of carbon emissions and therefore helps combat climate change caused by fossil fuel usage.

Renewable energy can be locally produced and therefore is not vulnerable to distant political upheavals. Many of the safety concerns surrounding fossil fuels, such as explosions on oil platforms and collapsing coal mines do not exist with renewable energy.

Renewable energy is far cleaner than fossil fuels. Coal mining and petroleum exploration and refinement produce solid toxic wastes, such as mercury and other heavy metals. The burning of coal to produce electricity uses large quantities of water often discharges arsenic and lead into surface waters and releases carbon dioxide, sulphur dioxide, nitrogen oxides and mercury into the air . Gasoline and other petroleum products cause similar pollution. These pollutants cause respiratory illnesses and death in humans, produce acid rain that damages buildings and destroys fragile ecosystems, and deplete the ozone layer.

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Strong consensus in the scientific community states that climate change and global warming are occurring and are caused by human production of carbon dioxide and other greenhouse gases. Climate change may also damage agriculture, because widespread extinctions imperil clean water supplies and aid the spread of tropical diseases.

SOLAR ENERGY:

Solar energy is produced by the sun. It can be harnessed like any other type of energy and used to create electricity to run homes and businesses. Buildings can also be heated by the thermal energy produced by the sun. Best of all, solar energy is free and does not compromise the environment.

If you have ever gotten in a warm car on a sunny winter day, you have experienced the thermal energy of the sun. The sun's rays move through the glass of the car and warm the interior, although it may be quite chilly outside. Likewise, some people have actually baked cookies on the dashboard of their car on hot summer days. Again, thermal energy is being used.

In order to harness the energy from the sun and turn it into electricity, it is necessary to have solar cells to collect and transform solar energy into useable electricity. These cells are typically in the form of panels that face the direction of the sun to capture the most rays possible.

SIGNIFICANCE OF SOLAR ENERGY:

- Fossil fuels, like gas and oil, are not renewable energy. Once they are gone they can't be replenished. Someday these fuels will run out and then mankind will either need to come up with a new way to provide power or go back to life as it was prior to man's use of these things.
- Fossil fuels create massive pollution in the environment. This pollution affects waterways, the air you breathe, and even the meat and vegetables that you eat.
- These fuels are expensive to retrieve from the earth and they are expensive to use. Other, more Eco-friendly energy sources like wind and solar energies are relatively inexpensive and easy to produce.

NEED FOR RELIABILITY STUDY:

It is needed to get the information we need to cut operating costs, improve efficiency and reliability, and improve system maintenance . Risk analysis and reliability studies are essential tools in designing continuous process plant power systems. Emerson Network Power's power system reliability study provides the information we need to upgrade and maintain our power delivery infrastructure.

We engineers can conduct a thorough assessment of your system's design to identify points of failure within your system. We'll investigate the number of redundancies designed into your electrical system, and determine the likelihood of a power interruption under normal or compromised power conditions. Once the assessment is complete, we provide recommendations on how to improve your system design to ensure continuous operation under all foreseeable circumstances.

We must do an economic assessment in addition with the reliability assessment in determining suitable transmission facility to deliver solar power from the PV Arrays to a power grid system. The evaluation of sufficient system facilities is essential in providing adequate and acceptable continuity of supply.

POWER SYSTEM RELIABILITY EVALUATION

Modern electrical power systems have the responsibility of providing a reliable and economic supply of electrical energy to their customers. The economic and social effects of loss of electric service can have significant impacts on both the utility supplying electric energy and the end users of the service. Maintaining a reliable power supply is therefore a very important issue in power system design and operation.

The term "reliability" when associated with a power system is a measure of the ability of the system to meet the customer requirements for electrical energy. The general area of "reliability" is usually divided into the two aspects of system adequacy and system security [1, 2], as shown in the Fig1.1

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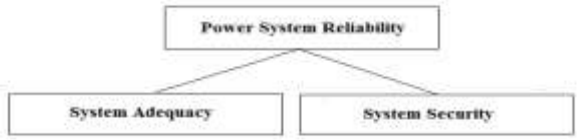

Figure 1.1: Attributes of power system reliability

CASE STUDY (VIDYUTH SOUDHA SOLAR POWER PLANT (100KW)

In the present paper a case study of a solar/ PV 100KW plant located on the roof of Vidyuth Soudha, Somaji guda, Hyderabad, Telangana is considered for Reliability study.
Arrangement of PV arrays on Vidyut Soudha is shown in fig 2.1

Fig 2.1 Arrangement of PV arrays at Vidyut Soudha

RELIABILITY ANALYSIS

Reliability analysis of a power system can be conducted using either deterministic or probabilistic techniques. The early techniques used in practical application were deterministic and some of them are still in use today. The essential weakness of deterministic criteria is that they do not respond to the stochastic nature of system behaviour, customer demands or component failures. System behaviour is stochastic in nature, and therefore it is logical to consider probabilistic methods that are able to respond to the actual factors that influence the reliability of the system [1]. Limited computational resources, lack of data and evaluation techniques have limited the use of probability methods in the past. These factors are not valid today, and there has been a wealth of publications dealing with the development and application of probabilistic techniques in power system reliability evaluation [2-8]. This paper extends the probabilistic evaluation of power systems incorporating solar energy.

RELIABILITY EVALUATION OF VIDYUTH SOUDHA SOLAR PLANT:

Table1. YEAR WISE AVERAGE GENERATION DATA

YEAR	INV1 (KWH)	INV2 (KWH)	CUM (KWH)
2011	42562.0368	44055.0255	86617.0623
2012	32111.0283	55859.8263	87970.8546
2013	27005.4375	6765.0518	88770.4893
2014	22408.299	66403.4499	88811.7489

INV 1: Inverter 1 Reading in KWH
INV 2: Inverter 1 Reading in KWH
CUM: Cumulative generation (INV 1+ INV 2) in KWH
The plant consists of two inverters of each capacity 50KW. The individual annual generations of inverters and cumulative generation is shown in table 1.

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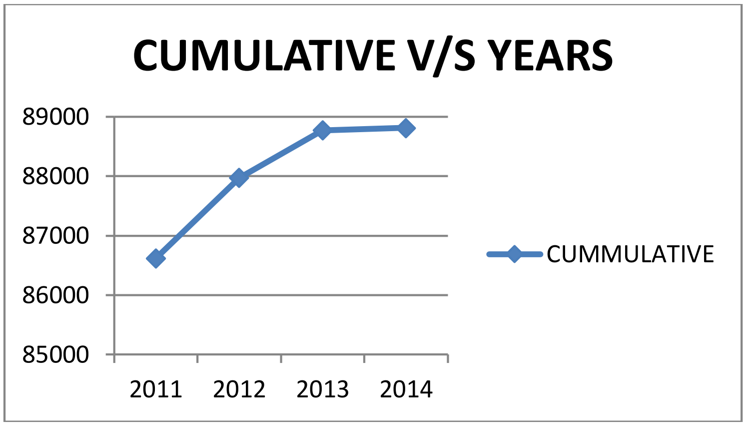

Fig 2.1 Cumulative VS Years

CAPACITY OUTAGE PROBABILITY TABLE:
For calculation of reliability indices it is assumed that
Availability (A) =0.98, Unavailability (U) =0.02
PANEL ARRANGEMENT ASSUMPTIONS :
12 Rows of PV Arrays= 1 UNIT
No of Units = 72/12 = 6
I Unit Capacity =16,800 W = 16.8 KW

Table 2:Capacity Outage Probability

STATE	CAPACITY IN	CAPACITY OUT	PROBABILITY
1 (0 UNIT OUT)	100.8 KW	0 KW	0.8858
2 (1 UNIT OUT)	84 KW	16.8 KW	0.01807
3 (2UNITS OUT)	67.2 KW	33.6 KW	$3.6894*10^{-4}$
4 (3UNITS OUT)	50.4 KW	50.4 KW	$7.5295*10^{-6}$
5 (4UNITS OUT)	33.6 KW	67.2 KW	$1.536*10^{-7}$
6 (5UNITS OUT)	16.8 KW	84 KW	$3.136*10^{-9}$
7 (6UNITS OUT)	0 KW	100.8 KW	$6.4*10^{-11}$

By using system annual generation data Capacity Outage Probability is evaluated and it is shown in Table 2. The probabilities of various outage states is shown in Fig 2.2

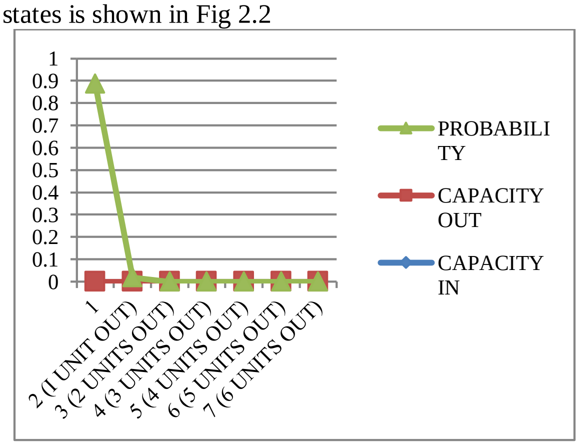

Fig 2.2 The probabilities of various states VS Capacity in & out.

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LOEE (LOSS OF EXPECTED ENERGY):

Table 3 : LOEE

STATE	CAPACITY IN	CAPACITY OUT	PROBABILITY	E_K KWH
1 (0 UNIT OUT)	100.8 KW	0 KW	0.8858	0
2 (I UNIT OUT)	84 KW	16.8 KW	0.01807	36792
3 (2 UNITS OUT)	67.2 KW	33.6 KW	$3.6894*10^{-4}$	73584
4 (3 UNITS OUT)	50.4 KW	50.4 KW	$7.5295*10^{-6}$	110376
5 (4 UNITS OUT)	33.6 KW	67.2 KW	$1.536*10^{-7}$	147168
6 (5 UNITS OUT)	16.8 KW	84 KW	$3.136*10^{-9}$	183960
7 (6 UNITS OUT)	0 KW	100.8 KW	$6.4*10^{-11}$	0

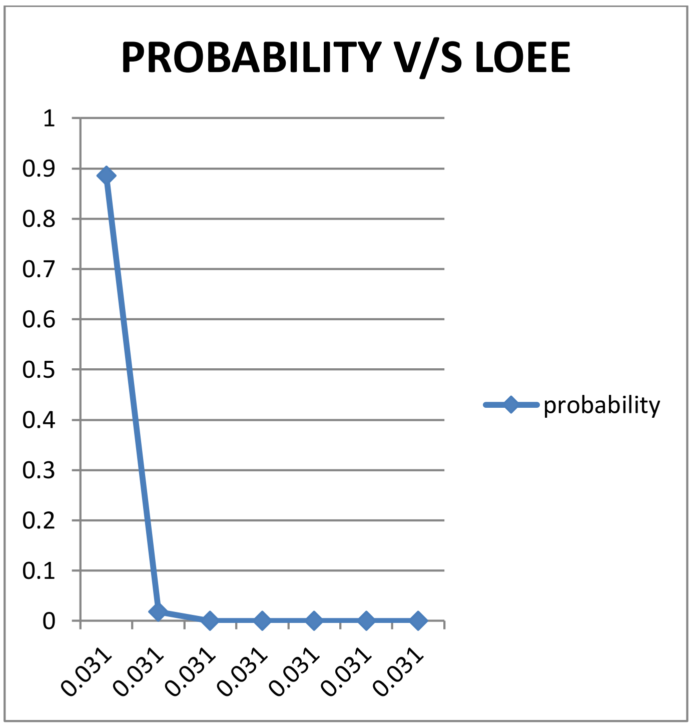

Fig 2.3 Probability VS LOEE graph

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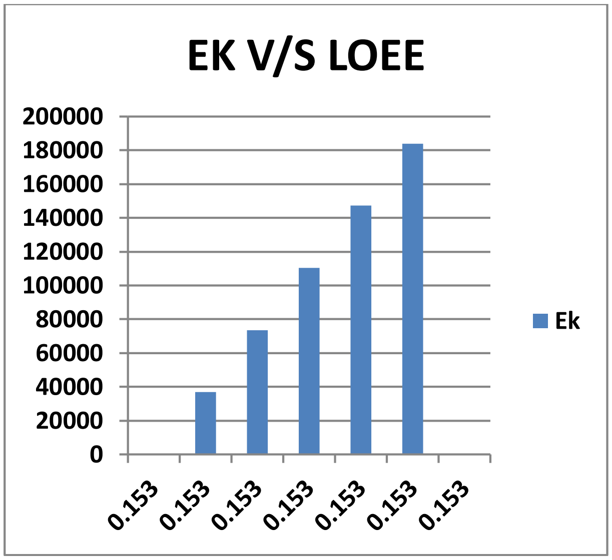

Fig 2.4 . Energy Curtailed (E_K) V/S LOEE graph

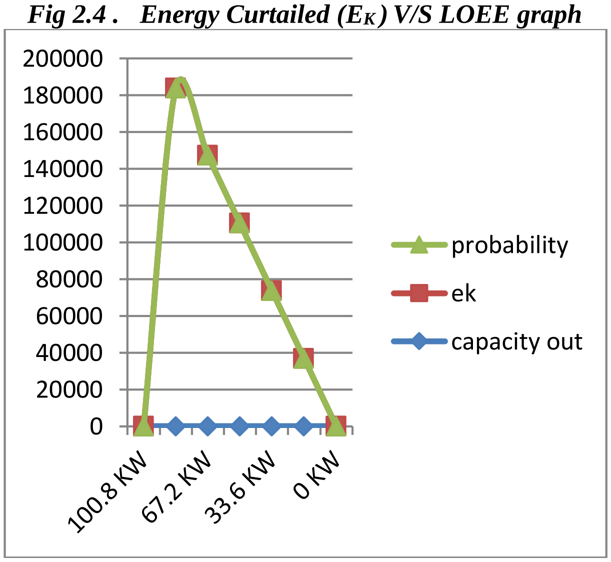

Fig 2.5. Cumulative graph for P_K, E_K, & Capacity Out.

LOLE (LOSS OF LOAD EXPECTATION):

Table 4: Evluation of LOLE

CAPACITY IN (KW)	CAPACITY OUT (KW)	PROBABILITY(P_K)	%T_K	LOLE=$\sum P_K T_K$
100.8	0	0.8858	0	0
84	16.8	0.01807	8.219	0.1485
67.2	33.6	$3.6894*10^{-4}$	31.232	0.0115
50.4	50.4	$7.5295*10^{-6}$	54.246	$4.08*10^{-4}$
33.6	67.2	$1.536*10^{-7}$	77.2600	$10186*10^{-5}$
16.8	84	$3.136*10^{-9}$	0	0

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				TOTAL =0.1604

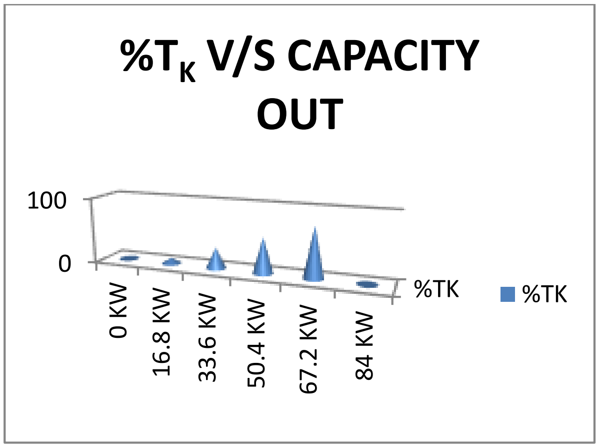

Fig 2.6. %T_K V/S CAPACITY OUT GRAPH

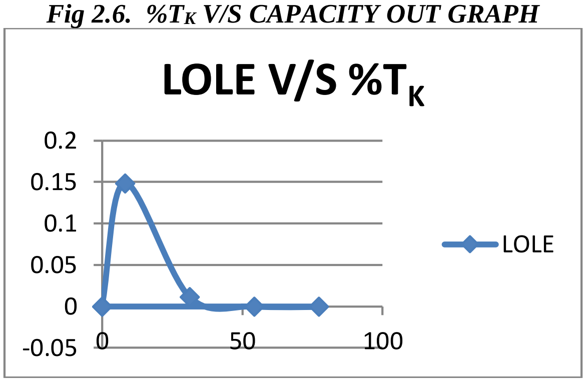

Fig :2.7. LOLE VS % T_K

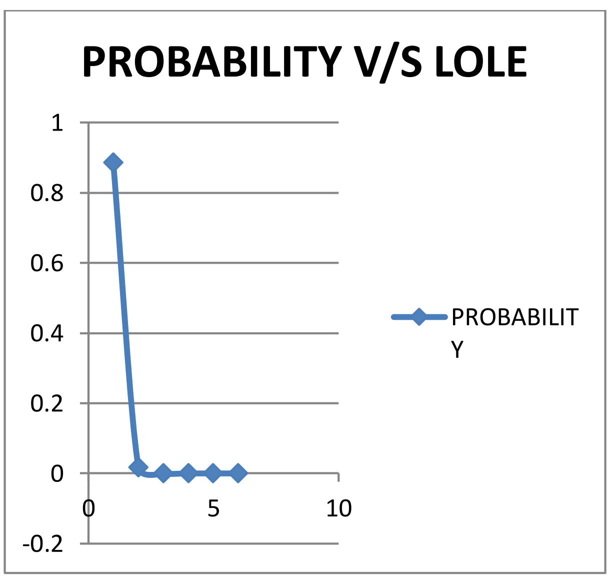

Fig 2.8. PROBABILITY V/S LOLE GRAPH

CONCLUSIONS

The principal objective of power system planner is to design reliable and economical system facilities. This objective becomes great challenging when considering transmission system facility to deliver solar power.

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A probabilistic method is presented for evaluating for contribution of solar system to overall system reliability using reliability evaluation of technique.

LOLE &LOEE are useful power and energy indices that can provide useful information on adequate transmission line size for solar power delivery.

IEEE RTS system reliability increases with the transmission line size when solar power is integrated to a conventional system .The incremental reliability benefits are however decreased with increasing in line capacity.

Solar power generation can contribute to overall system reliability and help in reducing costumer cost of electric power interruptions offsetting the conventional fuel consumption means reducing harm full emissions produced by fuel and therefore providing environmental benefits.

By the results the loss of load energy probability of Vidyuth soudha solar plant is 16.04%. It indicates better delivery of load and the interruption duration is very less.

For the simplistic reliability analysis it is assumed that 12 rows of PV module panels on roof (72) are considered as 1 unit .Hence the results presented in this paper provide approximate but with negligible error.

However the reliability study of vidyuth soudha PV plant is carried and its performance is checked with suitable indices.

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