Design of Solar PV system and Solar Potential Assessment Using PVSYST Software.

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Abstract- The performance of a photovoltaic system depends on the geographical location and type of PV modules used. PV systems are useful in areas having good amount of incident solar radiation. This study is aimed at developing a standard procedure for the design of 1 kW grid-connected solar PV systems using the PVSYST Software.The project began with a broad database of meteorological data including global daily horizontal solar irradiance and also a database of various renewable energy systems components from different manufacturers.The average global horizontal irradiation is 5.68 KWh/m^2/day. In this paper 1kW photovoltaic system is designed and simulated using PVSYST software for BGSB University rajouri, Jammu and Kashmir, India using meteo data of the location. The total amount of energy generated by the system and various losses occurring in the system are analyzed and presented. Performance ratio of the system over the whole year is estimated as 0.798. And it was found that, for a horizontal global irradiation of 1821.0 kWh/m2, the available energy at the inverter output which can be fed to the nearby grid is 1687 kWh with a specific power production about 1654 kWh/kWp/year.

Index Terms - ***Solar PV Module, Grid-Connected solar PV system, PVSYST Software, Meteorological data.***

I. INTRODUCTION

There are various number of factors behind the development of a nation, electricity is one of them. The biggest challenge for both the developing and developed countries is to cope up with the increasing demand. Energy is a vital requirement to sustain and improve the standard of our daily life. Energy demand is increasing day by day and now the electrical energy has become one of the basic need of the individual in present era. The load generation balance report (LGBR) 2018 by central electricity authority (CEA) portraits the existence of 8629 MU shortage in energy requirement and 3314 MW in peak power demand [1]. So the electricity production has to be increased in order to meet the increasing energy demand. Considering the depleting conventional power plants, uses of non-conventional sources of energy like solar, wind etc. are preferred. Non-conventional power generation from solar energy and wind energy are some of the promising electricity generation methods of the time. India has huge solar potential with almost about 250-300 sunny days in a year. in India almost all parts receive 4-7 kWh of solar radiation per sq. meter due to its geographical location[2]. As the power demand is increasing day by day and high solar potential, government of India aims a target of 100,000 MW grid connected solar power projects by 2021-22 under the national solar mission [3].

There are two types in PV system such as grid connected and standalone. Grid-connected photovoltaic systems feed electricity directly to the electrical network, operating parallel to the conventional energy source. Grid-connected systems generate clean electricity near the point of use, without the transmission and distribution losses or the need for the batteries. Its performance depends on the local climate, orientation and inclination of the PV array, and inverter performance. In case of standalone system there is no interaction with the utility grid, the power that is generated is directly connected to the load. if the PV array does not directly supply a load then a storage device is needed [4].

The aim of this paper is to design and simulate a photovoltaic system at BGSB University (Jammu and Kashmir), India using PVSYST software. In this paper we have imported the data from meteo database meteonorm7.1 as input to the software so that accurate results for the system design and performance analysis are obtained.

II. METHODOLOGY

The basic characteristics of a solar panel will depends upon type of solar cell, temperature of the cell and efficiency of PV system is important factor to be determined in the power generation technologies. In this paper we used to analysis the performance with the help of PVSYST software.

PVSYST software is used to design different types of solar application systems like DC grid, grid connected, standalone and DC pumping systems. Different solar PV module, battery and converter manufacture database for designing the system as it is included in the software package. Location details for the area of the experiment can be added with the help of software like NASA-SSE satellite data, Meteonorm, RETSCREEN etc. This software helps to design the system with respect to the load and available area. It also helps to analyze the annual, monthly and weekly production and performance of the designed system.

PVSYST is designed to be used by architects, engineer, and researchers. It is also a very useful educative tool. It includes a detailed contextual help menu that explains the procedures and models that are used, and offers a user-friendly approach with guide to develop a project. PVSYST is able to import meteor data from many different sources, as well as personal data.

2.1 GRID CONNECTED SOLAR PV SYSTEM

1 kW grid connected solar PV power plant is installing by comparing the energy production, economic feasibility at BGSB University(Jammu and Kashmir) using PVSYST Software. Figure 1 shows the proposed model of the grid connected PV system.

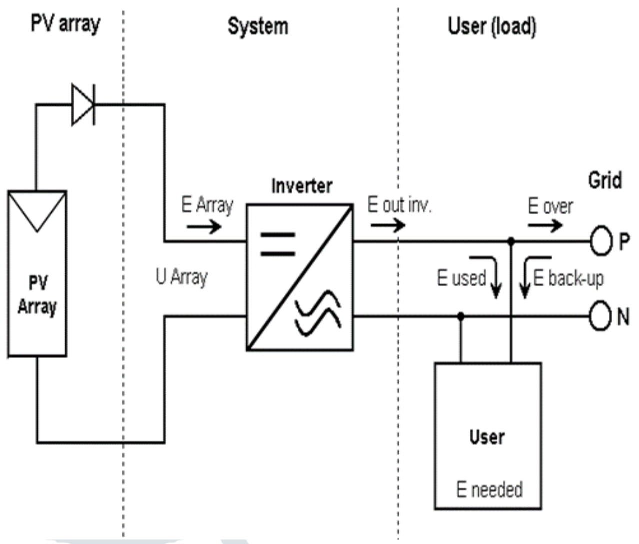

Fig 1. Grid connected PV system.

We are considering that all the power generated is directly supplied to the grid i.e. 1kW grid connected solar PV system.

III.SITE AND TECHNICAL DETAILS.

3.1 Site location and climatic resource.

The proposed site is located at BGSB University campus which is in village Dhanaur Gorsian of district rajouri (Jammu and Kashmir), India.

The site is located at Latitude of 33.40^0 N and Longitude 74.34^0 E at an altitude of 1187 meters.

Fig 2. Satellite view of BGSB University location .

To estimate the Irradiation, temperature and Horizon data of the location, meteo database meteonorm7.1 has been used via internet.

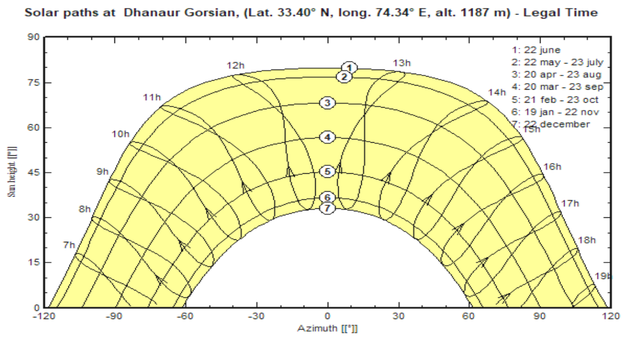

Chart 1. Trajectory of Sun at BGSB university with Horizon outline .

3.2 Solar PV technology

Solar PV Technology converts sun's natural energy to useful electrical energy. Photo Voltaic modules are made of mono crystalline / polycrystalline solar cells connected in series and parallel modes. Type of solar panel used in this project is polycrystalline. Overall efficiency on average is about 13-16%.

PV module of rating 60Wp 14 V is used for the simulation. Total number of modules connected in series are 17 in order to produce 1kWp power. Total area covered by PV modules is 9 m^2 as calculated after running the simulation in PVSYST software. The modules are connected in series in order to increase the voltage rating.

Table-1 Solar panel specification.

Characteristics of a PV module

Manufacturer, model :	Generic, Poly 60 Wp 36 cells				
Availability :	Prod. from 2015				
Data source :	Typical				
STC power (manufacturer)	**Pnom**	**60 Wp**	**Technology**		**Si-poly**
Module size (W x L)		0.502 x 1.109 m²	Rough module area	Amodule	0.56 m²
Number of cells		1 x 36	Sensitive area (cells)	Acells	0.47 m²
Specifications for the model (manufacturer or measurement data)					
Reference temperature	TRef	25 °C	Reference irradiance	GRef	1000 W/m²
Open circuit voltage	Voc	21.1 V	Short-circuit current	Isc	3.80 A
Max. power point voltage	Vmpp	17.1 V	Max. power point current	Impp	3.51 A
=> maximum power	Pmpp	60.0 W	Isc temperature coefficient	muIsc	3.0 mA/°C
One-diode model parameters					
Shunt resistance	Rshunt	300 ohm	Diode saturation current	IoRef	0.123 nA
Serie resistance	Rserie	0.45 ohm	Voc temp. coefficient	MuVoc	-79 mV/°C
			Diode quality factor	Gamma	0.95
Specified Pmax temper. coeff.	muPMaxR	-0.44 %/°C	Diode factor temper. coeff.	muGamma	0.000 1/°C
Reverse Bias Parameters, for use in behaviour of PV arrays under partial shadings or mismatch					
Reverse characteristics (dark)	BRev	3.20 mA/V²	(quadratic factor (per cell))		
Number of by-pass diodes per module		1	Direct voltage of by-pass diodes		-0.7 V
Model results for standard conditions (STC: T=25°C, G=1000 W/m², AM=1.5)					
Max. power point voltage	Vmpp	16.9 V	Max. power point current	Impp	3.55 A
Maximum power	Pmpp	60.1 Wc	Power temper. coefficient	muPmpp	-0.43 %/°C
Efficiency(/ Module area)	Eff_mod	10.8 %	Fill factor	FF	0.749
Efficiency(/ Cells area)	Eff_cells	12.8 %			

3.3 Inverter

The selection of the inverter or selected technology should best fit the overall requirement of the plant. Should be reliable and easy to handle, install, operate and maintain. It should have longest life and deliver highest performance levels and should have low cost; however it should not pose performance risk over the long run.

In our simulation in PVSYST software we are using 1kW solar inverter manufactured by AEG Industrial Solar GmbH. Total no of inverters for design purpose is 1.

Table-2 Inverter specification

Rating	1kW
Voltage rating	80-400 V
Nominal AC current	4.17 A
Output ac voltage	240V
Efficiency	93-96%
No of inverters	1

3.4 System orientation.

The inclination and orientation for the solar panel for BGSB University site is shown in FIG 3. The tilt angle for PV array is kept around the latitude of the corresponding location to get maximum solar irradiation . So that the optimum tilt angle for BGSB University site is kept as 30^0. The azimuth of the PV module is kept at 0^0.

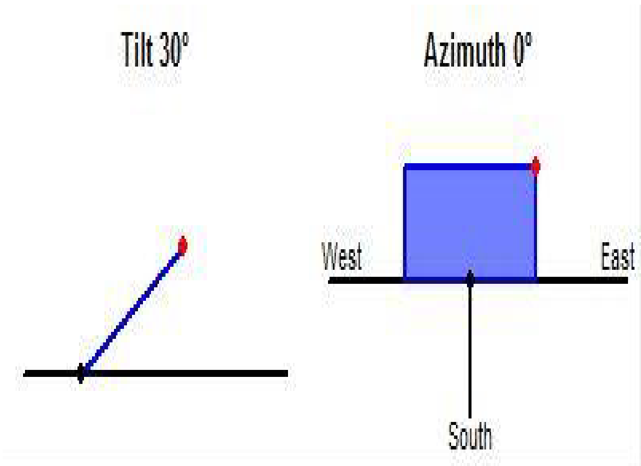

Fig-3: orientation

IV. DESIGN BASED ON SOFTWARE

Design and Estimate the results of 1kW solar power plant by using PVsyst software version 6.70. The total system performance and efficiency of each systems of plant are evaluated by entering the specifications of a particular design. Design the system according to the above specifications of all components.

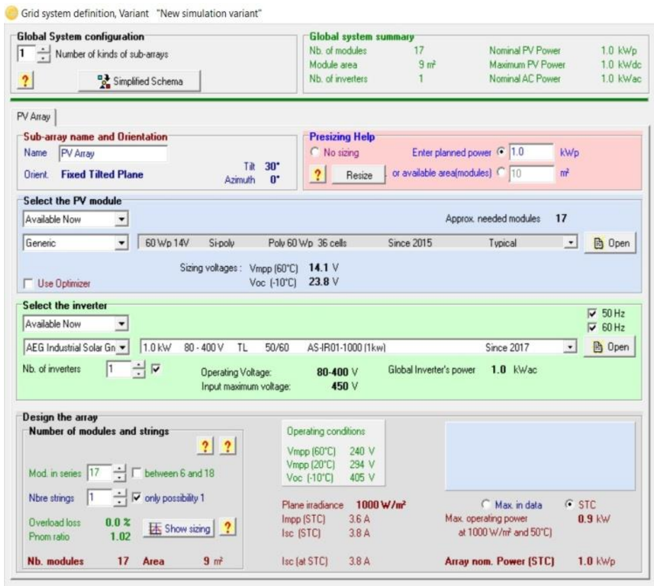

Fig-4: System Design (Solar module, inverter, array design).

The fig-4 shows the rating of all the components used for the simulation. After using the meteo database meteonorm7.1 for the given location i.e. BGSB university village Dhanaur Gorsian(Jammu and Kashmir), India and designing the system according to the above rating simulation is run..

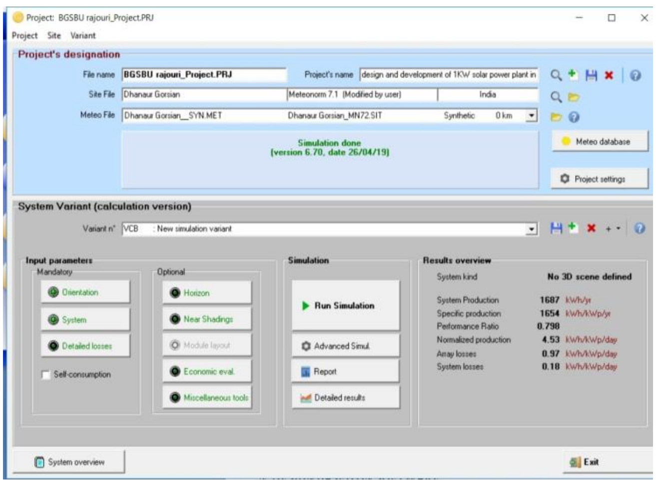

Fig-5: simulation in PVSYST software.

The final results are then obtained by running the simulation. Fig -5 shows the final simulation of 1kW PV system.

V. RESULTS AND DISCUSSIONS

This research work is totally based on the PVSYST software. We have used this software for modeling purpose. All the figures, tables are depicted here in the paper are generated during the simulation process for BGSB University site only.

TABLE -3: Energy injected into the grid.

	E_Grid kWh
January	117.9
February	102.6
March	148.4
April	145.2
May	158.5
June	149.7
July	139.3
August	135.6
September	157.6
October	164.5
November	148.0
December	119.4
Year	1686.7

Table 3 shows that the energy uses of the BGSB University site. It depicts the monthly average energy injected into the grid in kWh. The maximum energy injected into the grid at the month of October as 164.5 kWh. The minimum energy injected into the grid at the month of February as 102.6 kWh. The total energy injected into the grid is approximately 1687 kWh/year.

TABLE-4: Main result of system production

Main simulation results
System production = 1687 kWh/year Specific production = 1654 kWh/kWp/year Performance ratio = 79.8%

Specific production: The produced energy divided by the Nominal power of the array (Pnom at STC).

This is an indicator of the potential of the system, taking into account irradiance conditions (orientation, site location, meteorological conditions).

Specific Production= (Produced energy/Nominal Power of the array)=1654 kWh/kWp/year.

TABLE-5: BALANCES AND MAIN RESULTS.

New simulation variant

Balances and main results

	GlobHor	DiffHor	T Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	
January	90.9	35.20	4.18	134.4	131.0	122.6	117.9	0.860
February	93.5	44.20	7.04	119.8	116.7	106.8	102.6	0.839
March	149.8	54.30	12.29	178.5	173.9	154.1	148.4	0.815
April	172.4	65.40	16.65	179.8	174.7	151.3	145.2	0.792
May	212.4	75.50	21.00	202.0	195.8	165.2	158.5	0.769
June	208.9	75.20	23.71	190.6	184.2	155.5	149.7	0.770
July	191.3	83.00	25.38	178.4	172.4	145.3	139.3	0.766
August	175.2	77.20	24.50	174.1	168.6	141.9	135.6	0.764
September	173.9	53.80	20.78	199.2	194.0	163.3	157.6	0.776
October	152.3	35.10	15.65	203.5	198.8	170.5	164.5	0.793
November	114.5	25.70	9.17	175.8	172.0	153.3	148.0	0.825
December	85.9	28.40	5.52	137.0	133.6	123.9	119.4	0.854
Year	1821.0	653.00	15.54	2073.1	2015.8	1753.5	1686.7	0.798

Table 5 depicts the balances and main results of Gridconnected PV system. Yearly global horizontal irradiation is 1821.0 kWh/m2. The yearly global incident energy on the collector plane is 2073.1 kWh/m2. Energy available at the output of the PV array is 1753.5 kWh. The energy injected into the grid is 1686.7 kWh which is nearly equal to 1697kWh. The average ambient temperature is 15.54^0 C.

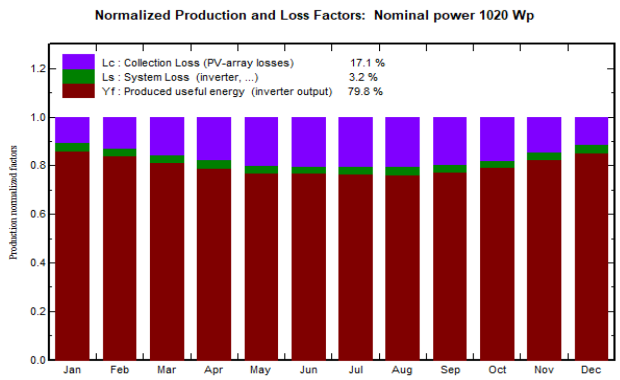

Chart-2: Normalized production and loss factors

From chart-2, gives the normalized power production and loss factor which is yield annually. Normalized power is 1020 Wp. System loss is 3.2%. collection loss (PV-array losses) is 17.1%.

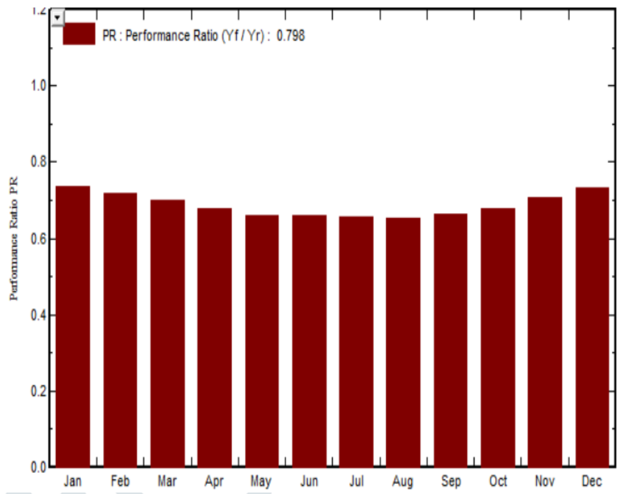

Chart-3 Performance Ratio

Performance ratio (PR) is the ratio of the final PV system yield (Yf) and the reference yield (Yr).From chart-3 ,shows the performance ratio of the PV system which for a given system is 0.798.

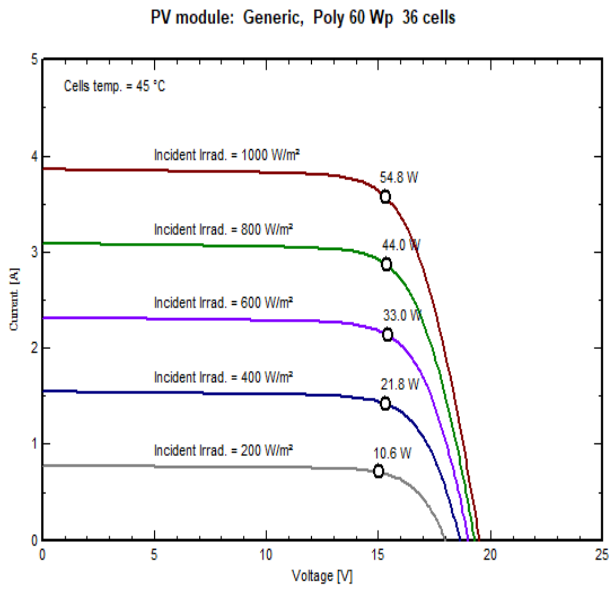

Chart-4 VI characteristics of solar panel

It is clear from the Chart-4, that as the incident solar radiation (INSOLATION) level increases, the maximum current for a PV array also increases and has no significant effect on voltage when the temperature remains constant.

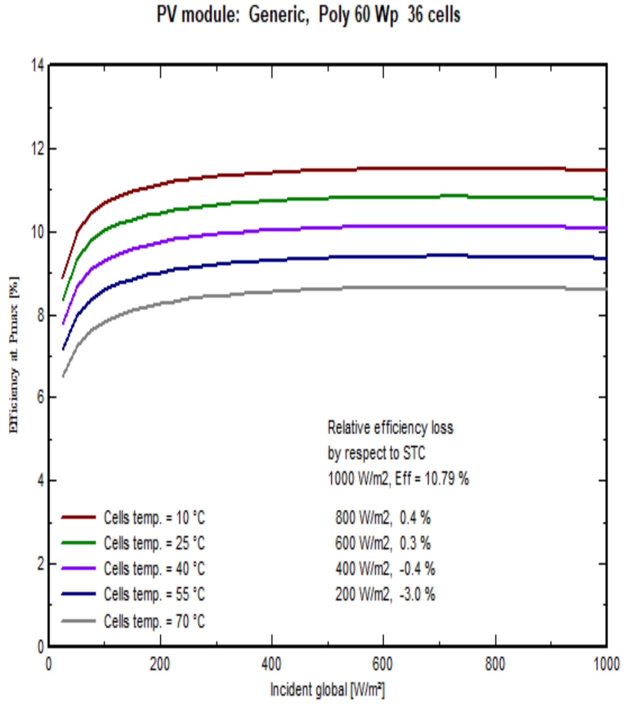

Chart-5: Efficiency vs. Incident radiation

The graph of efficiency versus the incident solar radiation under varying temperature condition is shown in Chart-5, which clearly demonstrates that as the temperature increases of PV module, the efficiency decreases at specific radiation level. The efficiency of the solar panel is 10.79 % at STC.

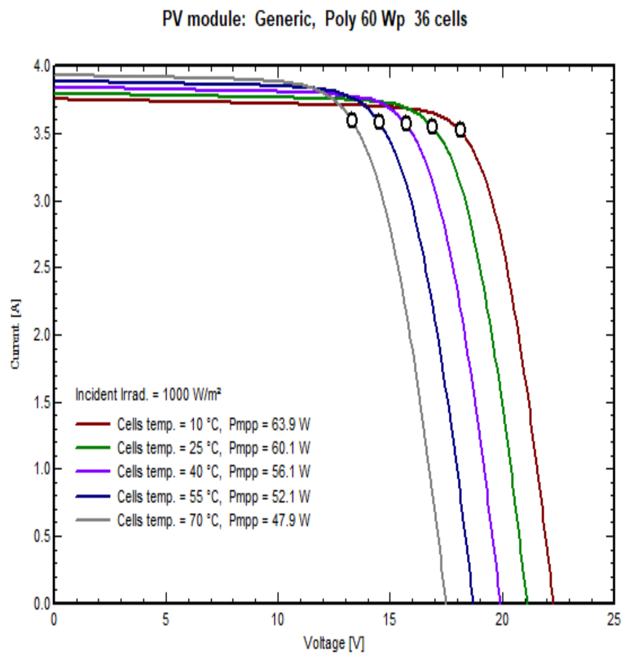

Chart-6: Voltage verses current with varying temperature

As shown in chart-6, voltage verses current graph is drawn with varying temperature.. Temperature is inversely proportional to power due to negative temperature coefficient of the material. It can be seen from the graph that the power output decreases due to increase in temp because of the fact that the PV panel is made up of a material which has negative temp coefficient of resistance.

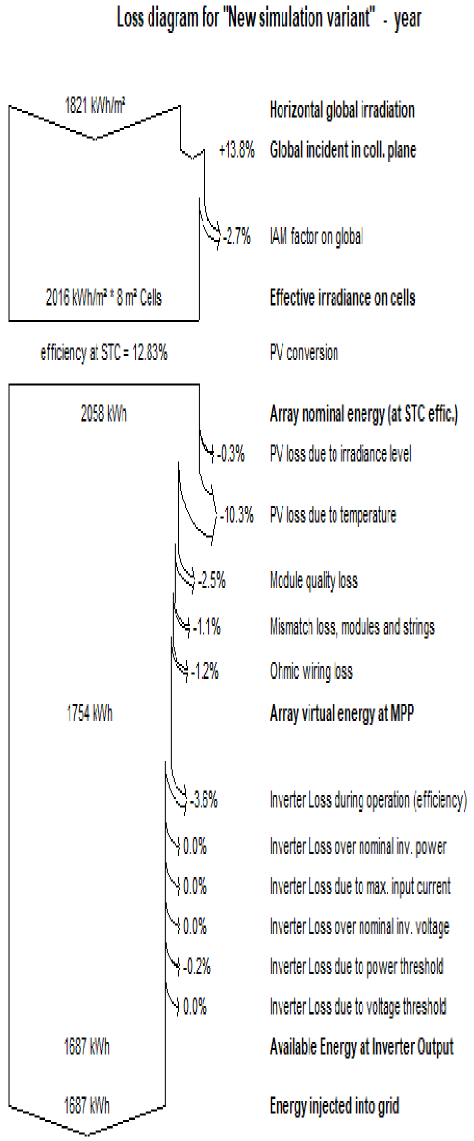

Chart 7. System Loss diagram.

The above chart 7 shows the system loss diagram. The net power injected into the grid is 1687 kWh after subtracting all the losses of the system. So we can the 1687 kWh energy from 1kWp PV system.

VI. CONCLUSION

Using PV SYST V6.70 simulation software, the energy yield analysis for 1kW PV Solar power generation was performed for geographical site BGSB University site Which is located at latitude of 33.40^0 N and Longitude 74.34^0 E at an altitude of 1187 meters .And it was found that, for a horizontal global irradiation of 1821.0 kWh/m2, performance ratio about 79.8%.The available energy at the inverter output which can be fed to the nearby grid is 1687 kWh with a specific power production about 1654 kWh/kWp/year. Hence the performance analysis is done using PVSYST software which gives solar radiation yield globally is 5.68 kwh/m2/day. This much of energy can be injected into the grid.

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