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DESIGN AND PROPOSAL OF SOLAR PHOTOVOLTAIC POWER PLANT FOR MEDIUM SCALE INDUSTRY

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ABSTRACT:

Energy is one of the major inputs for economic development of any country. In the case of developing countries like us, the energy sector assumes critical importance in view of the ever-increasing energy needs, widening of supply demand gaps and also huge investments required to meet them. The availability of energy is limited and known resources of energy are exhausting fast. In order to conserve the available resources, there is need to promote the Renewable Energy

India is blessed with rich solar energy and if exploited efficiently, the country has the potential of producing trillion-kilowatts of electricity.Photovoltaic power system, through direct conversion of solar irradiance into electricity, can be used as electrical power source for residential building, commercial building and industry to meet its daily energy requirement. In this paper detailed design and proposal of roof top solar pv power plant with grid connected and net metering for medium scale industry. Accomplishment of this process depends on a variety of factors, such as geographical location, weather condition, solar irradiance, and load consumption

Key Words: *Solar Energy, Solar Photovoltaic, Energy Conservation, Pay-back Period.*

1. INTRODUCTION

Solar energy is a very large, inexhaustible source. The power from the Sun intercepted by the Earth is approximately 2.9 x 1015 MW, which is many thousands of times larger than the present consumption rate on the earth of all commercial energy source. Thus in principal, solar energy could supply all the present and future energy needs of the world as a continuous basis. This makes it one of the most promising of the unconventional energy sources.

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The government started solar power adoption with subsidies. A consumer who installs a solar panel array on a house can sell surplus energy to the local utilities. The initial cost to install 1MW solar was 15 crores INR about 10 years ago, now at present it has come down to less than 4.5 crores INR, which would make solar Powered Electricity cost comparable with other types of fuel, is possible within the next decade. Photo-voltaic (PV) solar energy conversion is one of the most attractive non-conventional energy sources of proven reliability from micro watts to mega-watts level. The Photovoltaic system perform direct conversion of Sunlight to electricity, provide non-polluting conversion process, not depending on fossil or nuclear fuels[1].

2. SOLAR RADIATION AT THE EARTH'S SURFACE

Solar radiation is received at earth's surface in an attenuated form because it subject to the mechanisms of absorption & scattering as it passes through the earth's atmosphere, absorption occurs primarily because of the presence of ozone and water vapor in atmosphere, and lesser extent due to other gases and particulate matter. The scattered radiation is redistributed in all directions, some of them going back into space and some reaching the earth's surface. In fig clearly showing diffuse radiation, Absorption, Scattering, Beam or direct radiation etc.

Different equipment is used for measuring solar radiation like pyranometer, pyrheliometer, sunshine recorder. Pyranometer which measures either global or diffuse radiation.Pyrheliometer which measures beam radiation. Sunshine recorder which measures duration of bright sunshine in a day[2]

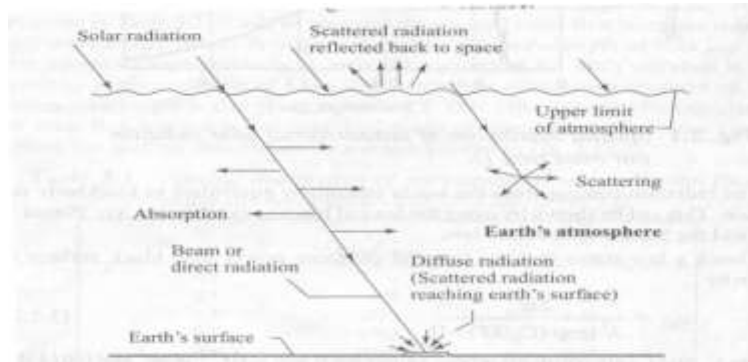

Figure2.1: Solar Radiation at the Earth's Surface

Table2.1.Estimated solar energy potential

State wise Estimated Solar Power Potential	
States / UTs	Solar potential(GWp)
Andhra Pradesh	38.44
Arunachal Pradesh	8.65
Assam	13.76
Bihar	11.2
Chhattisgarh	18.27
Delhi	2.05
Goa	0.88
Gujarat	35.77
Haryana	4.56
Himachal Pradesh	33.84
Jammu & Kashmir	111.05
Jharkhand	18.18
Karnataka	24.7
Kerala	6.11
Madhya Pradesh	61.66
Maharashtra	64.32
Manipur	10.63
Meghalaya	5.86
Mizoram	9.09
Nagaland	7.29
Orissa	25.78
Punjab	2.81
Rajasthan	142.31
Sikkim	4.94
Tamil Nadu	17.67
Telangana	20.41
Tripura	2.08
Uttar Pradesh	22.83
Uttarakhand	16.8
West Bengal	6.26
UT	0.79
Total	748.99

Source – MNRE[3]

3.SOLAR PHOTOVOLTAIC (PV)

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photo voltaic cells, when Sunshine is incident on solar cells, they generate DC electricity without the involvement of any mechanical generators i.e. there is direct conversion of solar radiation into electricity. In this system stage of conversion into thermo dynamic form is absent. The Photovoltaic effect is defined as the generation of electromotive forces as a result of the absorption of ionizing radiation. Energy conversion devices, which are used to convert Sun, light to electricity by use of the photovoltaic effect. Photovoltaic system employ energy conversion devices called solar cells[4].

3.1 SOLAR CELL

A solar cell is an electronic device that absorbs sunlight and turns it directly into electricity. The size of a solar cell is about an adult's palm, octagonal in shape, and colored bluish black. Solar cells are mainly bundled together to make larger units called solar modules, themselves coupled into even bigger units known as solar panels or chopped into chips (to provide power for small gadgets like pocket calculators and digital watches).

They are sometimes called photovoltaic (PV) cells because they use sunlight ("photo" comes from the Greek word for light) to make electricity (the word "voltaic" is a reference to Italian electricity pioneer Alessandro Volta, 1745–1827).

Semiconductors as basic solar cell, Solar Electric Systems- Photovoltaic (PV) systems convert light energy directly into electricity. Commonly known as “solar cells.” A solar cell, sometimes called a photovoltaic cell, is a device that converts light energy into electrical energy. A single solar cell creates a very small amount of energy (about 0.6 Volts DC), so they are usually grouped together in an (Series and Parallel integration under Kirchhoff’s Voltage and Current Law) integrated electrical panel called a solar panel. Sunlight is a somewhat diffuse form of energy and only a portion of the light captured by a solar cell is converted into electricity. The current generation of solar cells convert only 16 to 20 % of the sun's light into electricity. However in recent years there have been significant advances in their design. Some new cells on the market now are around 20% efficient and some laboratory prototypes are reaching as high as 30%. Given this it is likely that their efficiency will continue to improve over time[2].

3.2. DIFFERENT TYPE OF SOLAR PHOTOVOLTAIC PANEL

Mainly below type of panel is used[4]

Monocrystalline

- The technology that started it all, monocrystalline panels, originated in the 1950s. The cells are cut from silicon in a cylindrical fashion, and each cell looks like a wafer. Combined, tens of wafers make up a monocrystalline panel.
- Advantages: Monocrystalline panels are generally constructed from high-quality silicon, giving them the highest performance rates in the industry, usually up to 21 percent. By comparison, monocrystalline panels outperform thin film by

four to one. They also make wise use of space, so they offer a high power yield per square foot.

- Warranties often last for 25 years, and these panels perform better in low-light conditions than their poly-counterparts.
- Disadvantages: The disadvantages of this panel type are significant: Because they are high-quality, these panels are also costly. Circuit break down is common when the panel is obstructed or shaded .The manufacturing process produces significant waste. The panels perform best in warm weather, with performance decreasing as temperatures increase.
- Applications: solar power generation and utilization, Proven technology ,small to large installations
- Cell efficiency :14-18% (approximate)
- Area required for 1 kw: 7-9 square meter (approximate)
- Capacity :5 to 250W,270W

Polycrystalline

- While monocrystalline and polycrystalline panels are both manufactured from silicon, instead of cutting out wafer shapes, manufacturers pour silicon into a mold to form polycrystalline panels.
- Advantages: High temperature ratings are slightly lower than those for monocrystalline panels; however, the difference is minor, making these types of panels a good option for many homeowners. The manufacturing process produces little waste, and the technology allows for a cost-effective panel.
- Disadvantages: Efficiency is lower, typically between 13 and 16 percent, which is not nearly as high as the ratings for monocrystalline panels. The panels require more space when installed to produce the same electrical output as a panel constructed from monocrystalline.
- Applications: Solar power generation and utilization ,Proven technology ,Small to large installations
- Cell efficiency :13-17% (approximate)
- Area required for 1 kw: 8-10 square meter (approximate)
- Capacity :5 to 250W,270W

Thin film

- Manufacturers construct thin-film solar panels by putting down layer upon layer of a photovoltaic element, such as amorphous silicon or organic photovoltaic cells.
- Advantages: The advantages of thin-film panels are many but generally don't outweigh the disadvantages. These panels are lightweight, they are generally immune to problems from shading or obstructions and low-light conditions generally don't hinder their performance. These panels are easy to mass produce, so they are an affordable option.
- Disadvantages: On the other hand, thin-film solar panels come with a number of weighty downsides, including these:
- Efficiency: Most thin-film panels score very low in terms of performance, hovering between 7 and

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13 percent, with an average operating efficiency of about 9 percent.

- Space: These panels generally require a lot of space. For commercial applications, they often make sense. For most residential installations, where space is tight, they don't work.
- Cost: Due to the number of panels required for this type of system, associated costs are also higher because you'll need to purchase more support elements, cables and so forth to accommodate the system.
- Life span: In most cases, thin-film panels don't last long and quickly succumb to the effects of weatherization. You typically won't find a manufacturer offering a long warranty to go along with a thin-film panel.
- Applications: Watches calculators, solar power plants ,Suitable for large / grid sized installations, New technological developments offers immediate grid parity
- Cell efficiency :6-8 % (approximate)
- Area required for 1 kw: 16-20 square meter (approximate)

4. SOLAR PHOTOVOLTAIC SYSTEM

Two types of solar photovoltaic system [4]

4.1. STAND ALONE SYSTEM

These systems can generate, store and deliver power without depending on the electricity supply Small stand-alone SPV systems can power systems like: Home lighting and Street lights, Garden lights, Illuminated hoardings, Water pumps

Depending on the nature of the load, stand-alone SPV systems are designed with or without storage battery

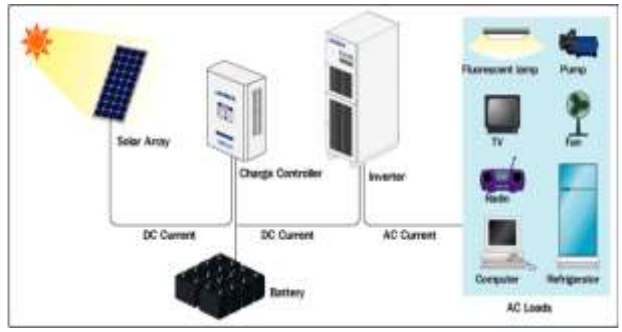

Figure4.1: stand lone system

4.2. GRID CONNECTED SYSTEM

These systems are connected to the electricity grid. DC electricity generated by the PV system is converted to AC electricity at the grid voltage through a specially designed inverter. Grid-interactive systems can be designed with or without battery storage. The main advantage of this system is that the power can be fed into the grid or can be drawn from the grid as required[7].

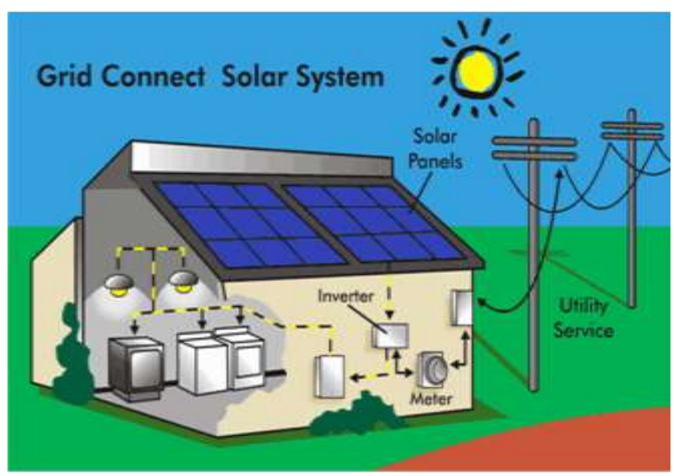

Figure4.2 : Grid Connected PV System

5.DIFFERENT COMPONENT USED IN SOLAR PV SYSTEM

Mainly below component used in solar pvsystem[5]

• Solar panel or pv module mounting systems

Solar panel mounting require either ground, roof or pole. These systems are mainly made of aluminum and are selected based on the specific model and number of modules in the array as well as the desired physical configuration. Solar Panels work best at lesser temperatures, and proper mounting allows for cooling airflow around the modules. For all locations, wind loading is an installation factor.

• Solar charge controllers

Every solar electric system with batteries should have a solar charge controller. The main function of the controller is to prevent overcharging of the batteries, but it also block battery bank current from leaking back into the photovoltaic array at night or on cloudy days, draining the battery bank. There are two main types of charge controllers PWM (Pulse Width Modulated) and MPPT (Tracking). PWM technology is older and more commonly used on smaller solar arrays. The controller must also have capacity (in rated Amps) to handle the total current of the array safely. MPPT charge controllers can track the maximum power point of a solar array and deliver 10-25% more power than a PWM controller could do for the same array. They do this by converting excess voltage into usable current. Another feature of MPPT charge controllers is their ability to accept higher voltage from the solar array for output to a lower voltage battery bank.

• Batteries for solar electric systems

Batteries chemically store electrical energy in renewable energy systems. They come in several voltages, but the most common varieties are 6 volt and 12 volt. Batteries are mainly classified into three types.

1. Lead acid batteries
2. Lithium ion batteries
3. Nickel cadmium batteries.

Types of batteries which are used in pv systems are:

1) Lead-acid batteries
   a.flooded(liquid vented)
   b.sealed(valve-regulated lead acid)
2) alkaline batteries

a. nickel-cadmium and b. nickel-iron.

Lead Acid Batteries-

Lead acid batteries are most common in PV systems in general and sealed lead acid batteries are most commonly used in grid-connected systems. Sealed batteries are spill proof and do not require periodic maintenance. Flooded lead acid batteries are usually the least expensive but require adding distilled water at least monthly to replenish water lost during the normal charging process.

There are two types of s sealed lead acid batteries: sealed absorbent glass mat(AGM) and gel cell.

AGM lead acid batteries have become the industry standard, as they are maintenance free and particularly suited for grid-tied systems where batteries are typically kept at a full stat eof charge.

Gel-cell batteries, designed for freeze-ressistance, are generally a poor choice because any over changing will permanently damage the battery.

Alkaline Batteries-

Because of their relatively high cost, alkaline batteries are only recommended where extremely cold temperatures(-50Ft or less) are anticipated or for certain commercial or industrial applications requiring their advantages over lead acid batteries. These advantages include tolerance of freezing or high temperatures, low temperatures, low maintenance requirments, and the ability to be fully discharged or over-charged without harm[5].

• Solar inverters

An inverter takes (DC) from batteries and turns it into (AC) which is used to run most common electricalloads. There are two main classes of inverters string invertor and central inventor .stringing vectors are easy to transport where the centering vectors are very heavy which require special crane to carry. Small quantity of dc cable is require for string invertor. Designing PV plant with central inventor is easier. String invertor is small and suitable for medium size installation were central inverter requires huge installation. Central inverters require huge space compare to string inverters[8].

• Miscellaneous components

This category includes everything which need to connect all the parts together safely and securely. As with most specialized technologies, there are many parts and tools involved in the proper installation of a safe and effective PV system. It is the responsibility of the installer to have a thorough understanding of them and of all the rules and regulations pertaining to solar electric installations . Gaining the knowledge needed to design and install a safe, efficient system not only ensures that your system will meet your needs effectively but also keeps you and your home safe and helps to promote the acceptance of renewable energy as a mainstream energy source

6. METHODOLOGY

6.1 REQUIREMENT FOR INSTALLING SOLAR PHOTOVOLTAIC PLANT

Below criteria must require for Implementing Solar PV Plant at any particular location

1 Availability of solar radiation

2 Availability of vacant land

3 Accessibility from national highways

4 Distance from existing transmission line

5 Variation in local climate

6 Use of nearby land

7 Topography of site

8 Geotechnical issues

9 Geotechnical political issues

10 Module soiling

6.2. FOR DESIGNING OF SOLAR PV FOR ANY INDUSTRIES OR ANY KIND OF BUILDING

We need some details of that Industries or building, like

- Total Available Area (without shading) for install pv panel
- Monthly energy Bill
- No of units consumed per by conventional energy sources as per energy bill
- Total installed capacity of UPS
- Total installed capacity of DG set , and how much diesel consumption
- Sanctioned load from the Energy Providing company

6.3. METHODOLOGY FOR PV SYSTEM DESIGN

Below step Should be consider to install solar pv plant

Step 1: Site inspection

Step 2: Radiation analysis

Step 3: Calculation of building load requirement

Step 4: Determine capacity of Inverter, battery .

Step 5: Sizing of dc cable .

Step 6: Solar PV array specification & design for particular layout.

Step 7: PV Module land requirement & orientation

Step 8: Analysis of Cost

6.4 WORK DONE

Paper proposed and design Grid connected solar pv system with net-metering for medium scale industry for batter understanding hear taken one medium scale industry which is located on Mysore. Industry's electricity consumption is 13252 unit per month and enrgy bill is 82162 Rs/month ,and also consuming 1000 Ltr/month diesel for power generation.

In the following tables it's shows design and proposal of solar photovoltaic power plant for particular medium scale industry which consumption is 13252 unit per month

Table6.1.GeographicalDetails

1	Location			
2	Latitude	12°15'50.32"N		
3	Longitude	76°39'44.47"E		
4	AMSL	2442	ft	
5	SOLAR RADITION	6.07	kWh/Sq.mtr/day	
6	Temperature		Deg C	
7	Wind Speed		KMPH	
8	Area	10000	Sq. ft	
9	Ground Mounting- SOUTH FACEING		Fixed type	
10	Tilt angle	0	Degree	39.000000°
11	Guranteed Energy		MU/ Annuam	

Table6.2.Roof Top Solar PV Power Plant with Grid Connected and Net Metering

Sl. No.	Deatails	Qty	Qty	Total (Average)	Units
1	**Diesel Generator Capacity**	**160**			**kVA**
	Diesel Consumption	1000			Litrs/Month
	Cost Per Litre	**60**			**Rs/Litre**
	Total Diesel Cost per Month	**60000**			**Rs/Month**
	Generation 3 Units per Litre	3000			Units/Month
	Generation Cost per Unit	**20.00**			**Rs/Unit**
2	Total Energy Required per month as per ESCOM	13252		13252	Units/Month
	Bill/Month@Rs.- /Unit	82162.4		82162.4	Rs/Month
	Tax			0	Rs/Month
	Total	82162.4		82162.4	Rs/Month
	Total Energy Requiremnt as per ESCOM and DG Energy	**16252**		16252	Units/Month
3	UPS Capacity	600	kVA	600	
	Total UPS Energy Loss per day for 8 Hours @ 15% loss	720	Units/day	720	
	Tariff	6.20	Rs/Unit	6.2	
	Total LOSS/ cost per day	4464	Rs/day	4464	
	Total Loss /cost per Month	133920	Rs/Month	133920	
4	**Toral Solar Rooftop PV Requirement as per Load**	120	kW	120	
	Total Solar Roof Top PV Capacity - Proposed	100	kW	100	
	Investment Cost of Solar PV Power Plant	0.70	Rs in Lakhs/kW		
	Total Investment	70	Rs in Lakhs	70	
	Total MNRE Subsidy @ 30%	21	Rs in Lakhs		
	User Investment	49	Rs in Lakhs	70	
	Generation per Day	4.5	Units/day / kW	4.5	
	Total Generation per day	450	Units/day	450	
	Total Generation/ Month AS PER PROPOSED CAPACITY	13500	Units/Month	13500	
5	Total Revenue				
	Revenue Using SPV Generation instead of Diesel	60000.00	Rs/Month	60000.00	3000
	Revenue Using SPV Generation after Diesel Account	65100	Rs/Month	65100.00	10500
	Revenue in the form of loss due to UPS	133920	Rs/Month	133920.00	
	Total Income	259020	Rs/Month	259020.00	
	Total Revenue /Income	31.08	Rs. Lakhs/Year	31.08	
6	Pay Back Period with UPS Loss	18.92	Months	27.02	
		1.58	Years	2.25	
	Pay Back Period without UPS Loss	**39.17**	**Month**	**55.96**	
		3.26	**Years**	**4.66**	
7	Additional Information				
	A. Tender among the MNRE approved Channel Parteners				
	B. Equipments as per MNRE and IEC Standards				
	C. Depending upon UPS / Clusters UPS system 10/15/20 Kw SPV Capacity may be considered for installation of SPV Power Plant				
	D. Area Required for 1 kW SPV System Maximum	10 X 10	Sq. ft	100	
	E. Total area Required	**10000**	**Sq. ft**		
	F. PROPOSED SPVPP	**100**	**kW**		
8	Equipments Required				
	SPV Modules				
	SPV Charge Controllers				
	Capables				
	Mounting Structures				
	Power Condoning Unit (PCU) - Optional and Bidirectioal (Grid Connection/Battery charging and Load Connection)				
	Sanctioned Load	150	KVA	150	
9	Total Energy Required per month as per ESCOM	13252	Units/Month	13252	
10	Total Generation/ Month AS PER PROPOSED CAPACITY	13500	Units/Month	13500	
11	Total Holidays	0	Days/Year	0	

Table6.3.Technical Details

Sl.No.	Details	Unit	Capacity	
1	Total Solar Roof Top PV Capacity - Proposed	100	kW	
	Total Generation/ Month AS PER PROPOSED CAPACITY	13500	Units/Month	
	Solar PV Module Capacity	250	Wp	12/24 V
	Total No. of Solar Pv Modules	400	Nos.	
	Technology - Crystalline	Mono	Poly	
2	Total Energy in Each Battery	2.4	kWh/EACH Battery	12V/ 200Ah
	Total Batterire Required	5625	Nos.	
3	Tariff	6.2	Rs/Unit	
4	E. Total area Required	10000	Sq. ft	

Table6.4.Highlights of Proposal

		With subsidy		Without subsidy
1	Total Solar Roof Top PV Capacity - Proposed	**100**	**kW**	100
2	Total Investment	70	Rs in Lakhs	70
3	Total MNRE Subsidy @ 30%	21	Rs in Lakhs	0
4	User Investment	49	Rs in Lakhs	70
5	Total Generation per day	450	Units/day	450
6	Total Generation/ Month AS PER PROPOSED CAPACITY	13500	Units/Month	13500
7	Sanctioned Load	150	KVA	150
8	Total Energy Required per month as per ESCOM	13252	Units/Month	13252
9	Total Energy Requiremnt as per ESCOM and DG Energy	16252	Units/Month	16252
10	Toral Solar Rooftop PV Requirement as per Load	120	kW	120
11	Pay Back Period with UPS Loss	18.92	Months	27.02
		1.58	Years	2.25
12	Pay Back Period without UPS Loss	39.17	Month	55.96
13		3.26	Years	4.66
14	E. Total area Required	10000	Sq. ft	10000
15	Total Holidays	0	Days/Year	0
16	Additional Revenue during Holidays @ Rs. -/Unit	0	Rs in Lakhs	0
17	Excess Revenue		Rs in Lakhs	
18	Total Solar Generation for 25 Years	4106250	Unit/ 25 Years	4106250
19	Solar Generation cost / unit for 25 Years (Average)	1.19	Rs./Unit	1.70
20	Tariff as per ESCOM	6.20	Rs/Unit	6.20
21	Average Cost Saving over life time of 25 Years Solar PV	5.01	Rs/day	4.50
22	Directly/Indirectly Cost saving over a period of 25 Years	205.59	Rs in Lakhs/ 25Years	184.59

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Table6.5Reduction of Socio Environment Impact

Reduction of socio environment impact after using SPV			
Monthly Energy Saving in KWh	Coal at 1kg per unit in kg	water saving Litre at 3.3Ltr/unit	Co2 +GHG at 1kg/unit
13500	13500	44550	13500

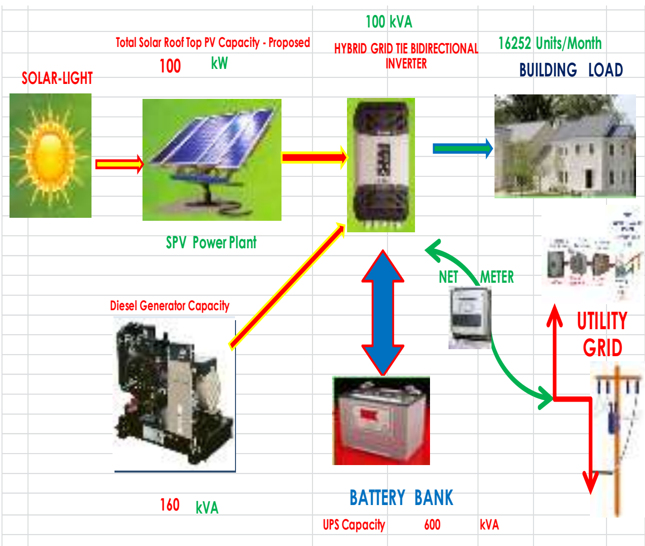

Figure6.1: Typical setup of a Solar rooftop PV Power Plant for Medium scale industry

7. CONCLUSION

- For particular location 100 kw plant suggested , 13500 unit per month can be generate from that plant and also indirect saving of water, green-house gases .
- for installing Solar photovoltaic power plant for particular location with subsidy 49 lakh Rs require, pay-back period with subsidy is 3.3 year
- And also diesel consumption can be eliminated for particular location 1000 ltr diesel require.
- Economic benefits such as reduction in monthly energy bill& UPS losses
- It is the responsibility of the society to conserve energy, energy resources and protect the environment and SAVE THE MOTHER LAND.
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