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Generation of Grid Connected Electricity using Solar System for Residential Area : An Analytical Approach

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Abstract - *In this paper authors analyze the electricity generation by solar panels installed at roof top of homes in the residential area of Mumbai city (India). The solar energy generation for grid connected homes reduces the CO2 emission as well as utilization of fossil fuels which help us to achieve constant equilibrium in the atmosphere. AT present MSEDCL (Maharashtra State Electricity Distribution Company Limited, Mumbai, Maharashtra, India) which provides single phase low tension electricity for single home in residential zone in Mumbai (Maharashtra, India) is 0.8KW. Unlike this conventional mechanism of power supply, here authors propose generation of 2KW electricity using solar panels for a single month and 3MW electricity for annual load in same residential area. With roof top solar panels using the poly crystalline PV panel with a fixed tilt and azimuth angle 2.0KW energy can be generated where as the requirement is 0.8KW (source: usage in 2016-17, MSEDCL). This generates a surplus of 1.2KW. The grid connected solar homes may contribute the energy and transfer it onto grid. Authors have developed prototype using various parameters of the Solar System using PVSYST tools. However authors also detail the comparison among mono, poly and thin film panel to understand the cost effectiveness of the project for the consumers/end users.*

Key Words: MSEDCL (Maharashtra State Electricity Distribution Company Limited); PV (Photo-voltaic); CO2 (Carbon dioxide); LPG (Liquefied Petroleum Gas).

1. INTRODUCTION

Sun gives large amount of energy to the earth in the form of radiation of light, radio wave, x- rays. Every morning time required to reach the sun ray on the surface of earth is 8 minute 17 second. It is estimated that just 30 minutes of radiation output from the sun could be equal to the world energy demand for one year. The major part of development is utilization of energy. Resources of energy are mostly divided in to two parts primary and secondary sources. Primary sources are fossil fuels which are non renewable. Fossil fuels are natural gas, coal, nuclear and oil that will convert in to the secondary sources for industry utilities. [1] By using non renewable energy it generates more CO2 emission which is harmful for atmosphere. Solar energy is renewable energy. Using renewable energy sources for generation of electricity which reduces the utilization of primary sources. In home for daily use products is LPG, colorful lamps, kerosene, charging device, which causes to emission of CO2 in environment. We avoid use of this produces by alternating solar products like solar cooker, solar oven etc. Using solar electricity we design a smart home which helps to make good climate. Generation of electricity using solar is being pollution free, silent, and limitless. [2-7] In INDIA the requirement of electricity is increases in city and village. To achieve the requirement of demanded electricity we are using the various kinds of generator for alternate electricity production which having high cost and maintenance. So we development grid connected Solar electricity for city and village area also. That will cost effective for consumer and also by reduces the fossil fuel utilization and takes an important role in the climate change. The Solar power covers 1% of global electricity current scenario. Here in this paper we have analysis the utilization of one year electricity provided by the MSEDCL for BADLAPUR in Mumbai geographical region and generate the grid connected electricity for the same geographical area.

2. ANALYSIS OF ELECTRICITY

2.1 Electricity Domestic Consumption in TWh

World demand of consumption of electricity increases every year linearity up to 2009 year. After 2009 the demand for electricity consumption is more and more. The consumption of electricity in INDIA is not constant every year it varies as per the requirement but after year 2010 electricity consumption is linearly proportional and in this decade electricity consumption is increases gradually.

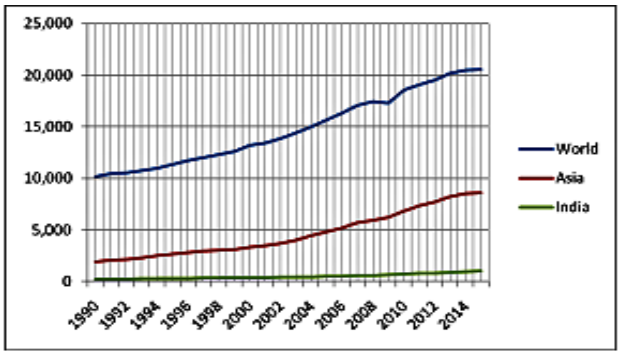

Chart. 1 Electricity Consumption in TWh

2.2 Electricity Production in TWh

World electricity production increased gradually up to 2009 but after 2009 the production was more and

more and it depends on the consumption of electricity overall the electricity production is linear in proportional. In INDIA the electricity production is constant and increases every year after the year 2009 the production is increases more and more.

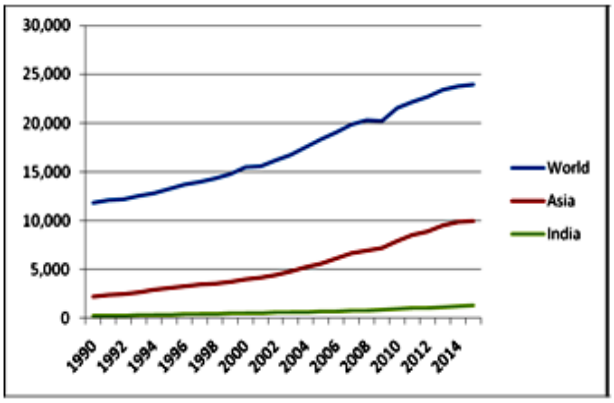

Chart. 2 Production of Electricity

From the analysis we observed that world having constant percentage for electricity consumption and production which makes the equilibrium. But In INDIA having 6.9 % of consumption of electricity and generates the 6.0% electricity so our aim is to generate the more and more energy to fulfill the consumer requirement [8].

Table 1. Consumption of Electricity %

	2014-2015(% Year)	2000-2015(% Year)
World	0.4	3.0
Asia	0.9	6.5
INDIA	5.6	6.9

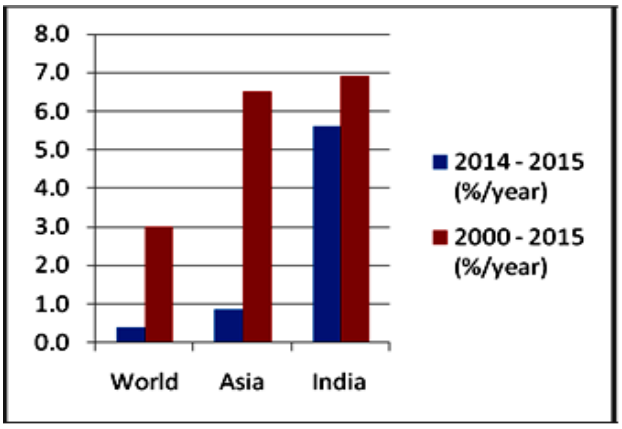

Fig 1. Consumption of Electricity

Table 2 Production of Electricity %

	2014-2015(% Year)	2000-2015(% Year)
World	0.8	3.0
Asia	0.7	6.3
INDIA	5.6	6.0

In INDIA demand for generation of electricity is more with respective to consumption for achieves the constant equilibrium in electricity. So our aim is to generate the electricity using the solar energy and use it for our own consumption. Here we generate the more electricity than required for single consumer and all the extra electricity send on grid which gives cost effective for single consumer. We design Smart Home using solar energy having low tension single phase electricity which is connected to grid for storing the electricity at BADLAPUR in Mumbai location.

3. DESIGN OF GRID CONNECTED ELECTRICITY

Following are the design parameters of grid connected electricity generation using PV.

3.1 Selection of Geographical Area

We design the grid connected solar power for low tension single phase at BADLAPUR location near Mumbai geographical area. The location of BADLAPUR is selected by the parameters are [9]

Table 3 for Selection of Location

Parameters	BADLAPUR Zone
Longitude	73.3°E
Latitude	19.2°N
Altitude	44m
Time Zone	UTC+05:30

3.2 Sun Position for the Badlapur zone

Sun impact on the building at BADLAPUR zone is shown by the sun chart path throughout the year. This chart is that surrounding buildings can be plotted and we can define exactly when the sun would go behind those obstructions. That causes the effect of shading like soft shading and hard shading. The shading effect also takes important role in the generation of electricity.

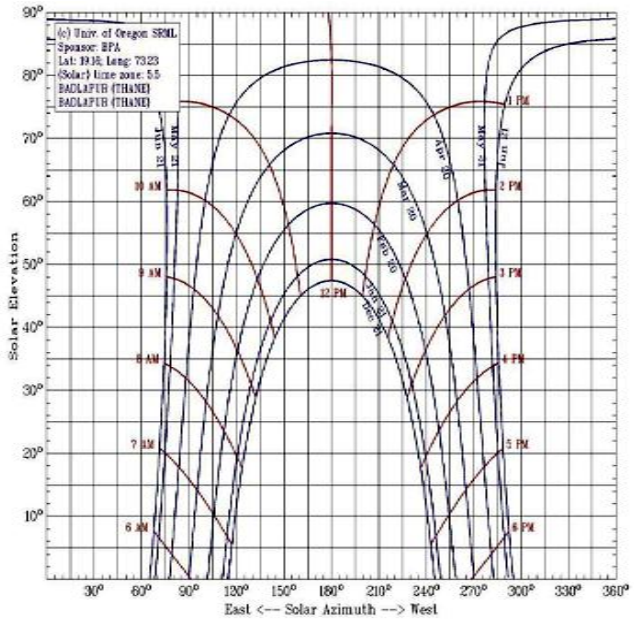

Fig. 2 Sun Chart Path for BADLAPUR [10]

3.3 PV Orientation

The standard PV panel is using here and it having tilt angle 19 degree and azimuth angle is 180 degree. By such orientation of various technology PV panel we observe the summer winter and Rainy season effect of sun on the panel.

3.4 Stand Alone Solar System

Stand alone Solar System is unique source for the PV generation. At the night mode battery is required store the electricity. [12]So in the day and night hours the total loads of the stand alone PV system is calculated. In case of the autonomous days batteries are required for such systems. This way the cost increases for such solar system. Further, efficiency depends on the storage mechanism few of them are:

1. Electro- Chemical Storage has efficiency approx. 70 % (batteries or fuel cell is required).
2. Pumped Hydro Storage has efficiency approx 70 %
3. Compressed AIR storage has efficiency 70%
4. Flywheel Storage has efficiency is 80 %

So as per the suitable for the designer and availability of the mechanism the system can be designed also the mathematical model for the same system is as.

$$Whpv = Whday\left(1 + \frac{na}{nB * nr}\right) + Whnight\ (\frac{nr + na}{nB * nr})r^2$$

Where, na = number of autonomous days

nr = number of recharge period

nB = efficiency of PV cells depends on technology

3.5 Grid Connected Electricity

PV generates the energy when sun shines in the autonomous days and hard shadow, soft shadow and in night mode. The generated electricity fed directly to the transmission line by net metering concept. In this electricity transmits continuously without any interrupt and hence beneficial for residential purpose use. Also this system is cost effective for consumers because it has no battery to store and initial electricity is driven by the MSCB. Any amount of electricity is generated is fed to the MSCB. One important aspect in this mechanism is that it requires maintenance of system only as there is no battery for storage which leads to cost effectiveness.

Net Cost = (Whload * Cload)-(Whpv * Cpv)

Where, Whload = available load

Cload = Cost required per watt hour

Whpv = generated load from the PV

Cpv = Cost required per watt hour

When,

Whpv = Whload

Cload = Cpv

Available load and generated load is same then the net energy generated is zero.

The main block diagram for grid connected solar power system for residential home at BADLAPUR is shown below in figure. Photovoltaic panel absorb the sun radiation (light wave) and convert them into the DC current (electricity). The DC from the panel is fed to inverter where the inverter converts the DC in to AC. This conversation is carried out because most of the

home appliances operate on the AC. The output of inverter is Fed in to AC distribution panel from where the current is fed to the AC load of the home appliances

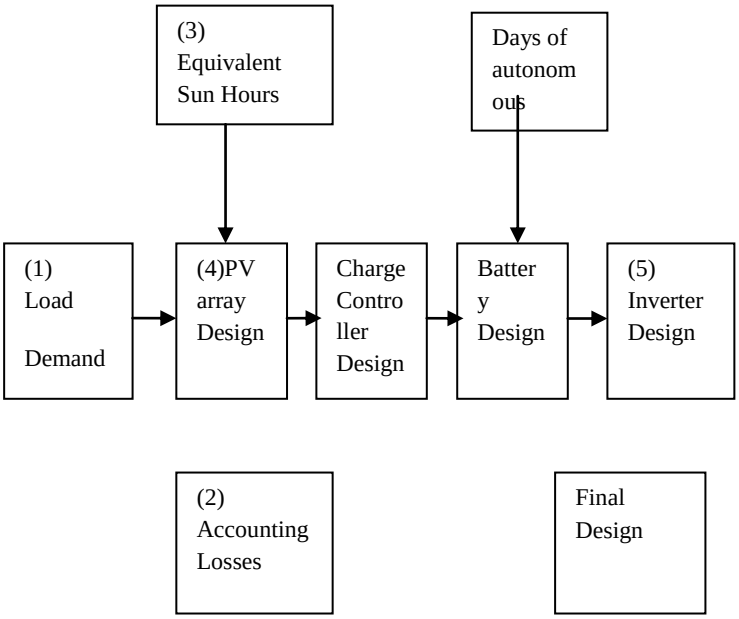

Fig. 3 Block Diagram for Residential Home Designs

The other part of AC distribution panel is connected to the meter which in turn is connected to the main transmission line. At the location BADLAPUR the available load for the single home in building is 0.8Kwh and using the PV System we generate the 2kWp electricity every month out of this 1.2kWp is store on grid and remaining is available load as per the MSEDCL. As per the sun path chart the generation of electricity is not constant and which depends on the sun position and season. Sometimes we generate the less electricity so in that case we get our store electricity from the grid and fulfill our requirement. The standard PV panel is using here and it having tilt angle 19 degree and azimuth angle is 180 degree. By such orientation of PV panel with different technology we observe

3. RESULTS

Using standard PV panel and various cells technology mounting on the Flat roof of building we generate electricity for low tension single phase grid connected residential home at BADLAPUR.

3.1 MSEDCL Energy Utilization

The available load is 0.8Kwh in building for single home at BADLAPUR Location. Every residential home having the following equipments as given

- ✓ Three Ceiling Fan
- ✓ Three Tube light
- ✓ One set of Refrigerator
- ✓ One set of Laptop
- ✓ One set of Television
- ✓ Mixer
- ✓ Iron

All this general purpose equipment required for every family in daily life so the MSEDC provides 0.8Kwh load for residential home.

Table 4 Consumption of electricity in Units as per MSEDCL [11]

Month	Consumption of units
March 2017	74
February 2017	67
January 2017	23
December 2016	39
November 2016	61
October 2016	35
September 2016	97
August 2016	88
July 2016	87
June 2016	120
May 2016	150
April 2016	110

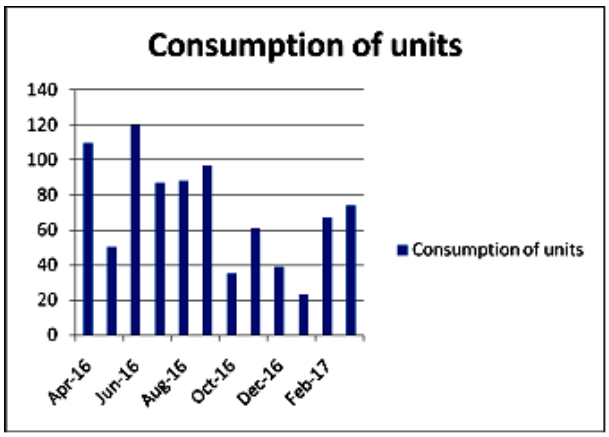

Fig. 4 Consumption of Electricity as per MSEDCL [11]

In the summer season (April, May and June) the maximum utilization of electricity is used as shown in table and graph. In the month December and January the minimum utilization of electricity is used so by generating constant 2kWp electricity using the PV panel we store the 1.2kWp electricity on the grid and fulfill our requirements when we generate the less energy than available load.

4.2 PVSYST Design

Using various technology cells we generate the power as per the requirement of end user

4.2.1 Monocrystalline cells

Geographical Site	**Mumbai**	Country **India**
Situation	Latitude 19.2°N	Longitude 73.3°E
	Time defined as Solar Time	Altitude 44 m
PV-field installation main features		
Module type	Standard	
Technology	Monocrystalline cells	
Mounting method	Flat roof	
Back ventilation properties	Free standing	
System characteristics and pre-sizing evaluation		
PV-field nominal power (STC)	Pnom	2.0 kWp
Collector area	Acoll	13 m^2
Annual energy yield	Eyear 2.74 MWh	Specific yield 1368 kWh/kWp
Economic gross evaluation	Investment 541443INR	Energy price 20.96 INR/kWh

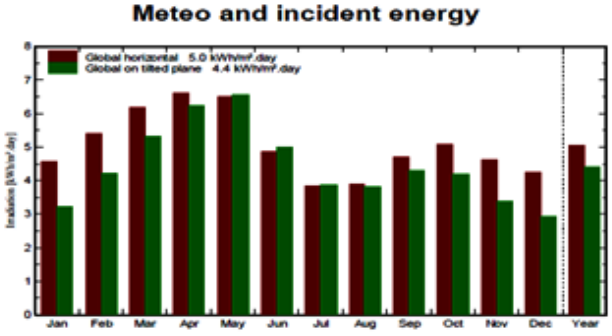

Fig. 5 Meteo and incident energy

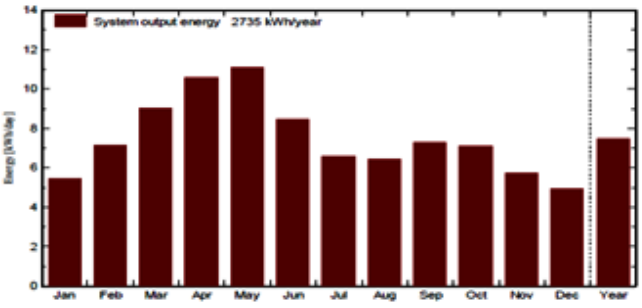

Fig. 6 System Output using Monocrystalline Cells

Table 5 Output Data using Monocrystalline Cells

	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	4.58	3.23	5.49	170
Feb.	5.40	4.21	7.15	200
Mar.	6.19	5.31	9.03	280
Apr.	6.60	6.24	10.59	318
May	6.50	6.54	11.11	344
June	4.87	4.98	8.46	254
July	3.84	3.87	6.57	204
Aug.	3.90	3.81	6.46	200
Sep.	4.70	4.29	7.29	219
Oct.	5.06	4.18	7.09	220
Nov.	4.63	3.39	5.76	173
Dec.	4.25	2.92	4.95	154
Year	5.04	4.41	7.49	2735

4.2.2 Polycrystalline cells

Geographical Site	**Mumbai**	Country **India**
Situation	Latitude 19.2°N	Longitude 73.3°E
	Time defined as Solar Time	Altitude 44 m
PV-field installation main features		
Module type	Standard	
Technology	Polycrystalline cells	
Mounting method	Flat roof	
Back ventilation properties	Free standing	
System characteristics and pre-sizing evaluation		
PV-field nominal power (STC)	Pnom	2.0 kWp
Collector area	Acoll	13 m^2
Annual energy yield	Eyear 2.74 MWh	Specific yield 1368 kWh/kWp
Economic gross evaluation	Investment 547697INR	Energy price 21.14 INR/kWh

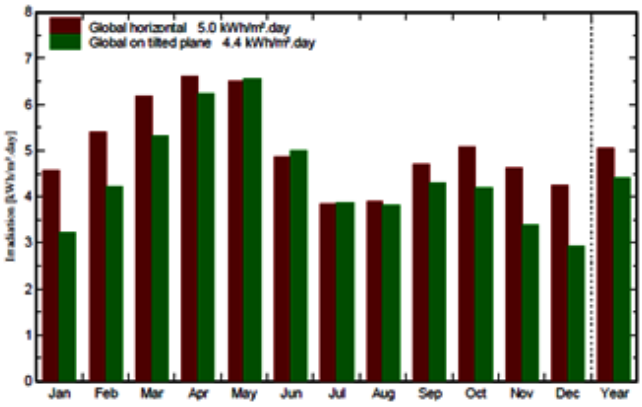

Fig. 7 Meteo and incident energy

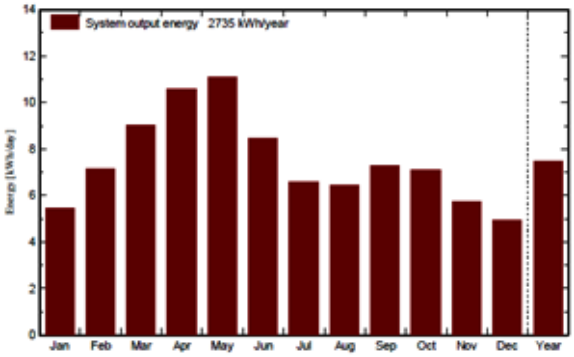

Fig. 8 System Output using Polycrystalline Cells

Table 6 Output Data using Polycrystalline Cells

	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	4.58	3.23	5.49	170
Feb.	5.40	4.21	7.15	200
Mar.	6.19	5.31	9.03	280
Apr.	6.60	6.24	10.59	318
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Dec.	4.25	2.92	4.95	154
Year	5.04	4.41	7.49	2735

4.2.3. Thin Film Cells

Geographical Site	**Mumbai**	Country **India**
Situation	Latitude 19.2°N	Longitude 73.3°E
	Time defined as Solar Time	Altitude 44 m
PV-field installation main features		
Module type	Standard	
Technology	Thin Film cells	
Mounting method	Flat roof	
Back ventilation properties	Free standing	
System characteristics and pre-sizing evaluation		
PV-field nominal power (STC)	Pnom	2.0 kWp
Collector area	Acoll	20 m^2
Annual energy yield	Eyear 2.74 MWh	Specific yield 1368 kWh/kWp
Economic gross evaluation	Investment 547697INR	Energy price 22.61INR/kWh

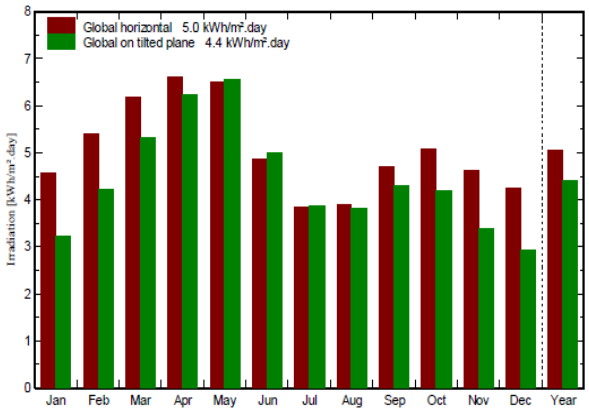

Fig. 9 Meteo and incident energy

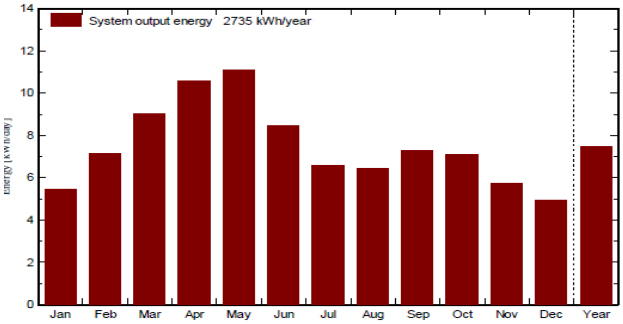

Fig. 10 System Output using Polycrystalline Cells

Table 7 Output Data using Thin Film Cells

	Gl. horiz. kWh/m².day	Coll. Plane kWh/m².day	System output kWh/day	System output kWh
Jan.	4.58	3.23	5.49	170
Feb.	5.40	4.21	7.15	200
Mar.	6.19	5.31	9.03	280
Apr.	6.60	6.24	10.59	318
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Dec.	4.25	2.92	4.95	154
Year	5.04	4.41	7.49	2735

5. CONCLUSIONS

In accordance with the MSEDCL available load for residential home is 0.8kWh. Generated electricity is more than the available load which is annually 2.8Mwh and is stored on the grid. In due course of time followings things have been observed:

5.1.1 Electricity Consumption

Consumption of electricity is more in the summer season (April, May and June) and relatively less in the winter season

(December & January). So in case of more requirements then the available load the electricity can be fetched from the grid to fulfill the requirement. In the winter season maximum energy can be stored on the grid which gives the benefit for the consumer in much cost effective way.

5.1.2 Effect of Shadow

Further, due to number of autonomous days and the shadow effect (hard and soft) responsible to degrade the generation of the power. In such case using the concept of net metering electricity can be fetched directly from the grid to fulfill requirement. Due to such system load shading is improved and the uninterruptable electricity cab ne made available.

5.1.3 Technology Uses

As per the data and reading, Polycrystalline cells technology plays an important role as compare to others. Thin film required more space as compare to other. All the technology generates the same amount of power but the manufacturing is expensive. So according to the PVSYST reading the Polycrystalline cells technology is recommended.

So in this way grid connected solar system plays an important role in the generation of pollution free electricity for residential homes.

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BIOGRAPHIES

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