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A Comprehensive Study on Solar Power Plant at Educational Institute Level

P. V. Ramana
Assoc. Professor –Mechanical,
Nalla Malla Reddy Engg. College
(Research Scholar-JNTUA)-Hyderabad

B. Sudheerprem Kumar
Professor-Mechanical Engineering
Department–JNTU College of Engineering
Kukatpally-Hyderabad

D. Maheswar
Principal –Keshav Memorial Institute
of Technology- Hyderabad

***Abstract* – The conventional source of energy such as coal, oil, uranium etc., are depleting very fast and the demand of energy is increasing rapidly, so year to year energy need is exceeding the energy generation leading to acute shortage of energy Solar energy is a renewable from inexhaustible energy for all living creatures on the earth planet. This energy can be utilized by using thermal and photovoltaic conversion systems. Solar radiation known as solar constant is about is 1367 W/m^2 outside the atmosphere but the average energy received on the earth is 800 W/m$^{2.}$ It was worth to note that the earth continuously intercepts solar power of 178 billion MW daily which is about 10,000 times the world's demand of electricity but so far it has been harnessed in a very small percentage. It is estimated that if all the buildings of the world are covered with solar PV panels, the whole requirement of world's energy will be met. But, the solar PV power is till date very expensive.**

Intention of the study is to use solar power at educational institutes because it needs uninterrupted power supply for conducting Labs and Exams especially for professional colleges like engineering and medicine. So focus is given to study the power generation of solar plant and its cost production and also associated problems with it. Because of its high cost Government is encouraging for purchasing solar power plants, by giving subsidy so many users will purchase as a result of using solar power there will be a uninterrupted power supply ,eco friendly ,no pollution and reserves of conventional fuel will prolonged.

At present, the capital cost of solar PV system is Rs.10 crore/ MW as compared to Rs. 4 crore/ MW for coal based power plant. It is higher than the conventional fuel plant. So cost of solar power is higher .that is why many were not using solar power but due to recent research and developments the cost is slightly come down, because of power demand and power cuts, most of the user are ready to use solar power even it may costly. The intention is to get uninterrupted supply as like need of educational institution. By further researches if its cost of production reached equal to the conventional power plant then solar power become the main source power. .mostly it is expected that in near future with further researches in PV system, the cost of production may come down. It is already being used economically in many advanced countries for domestic and commercial purposes such as water heating, water distillation, refrigeration, dying, etc.

***Keywords* – Solar Panels, UPS, Solar Batteries, PCU.**

I. INTRODUCTION

Energy is defined as the capacity to do work and the rate of doing work is called power. The forms of energies are Heat energy and Work energy. The demand for energy and electricity increases steadily. Due to increased demand of energy consumption at various sectors like

Domestic sector (houses and offices): increased population growth, urbanization changing life style and civilization, more and more number of offices established to meet the requirement of public causing usage of more power

Transportation sector: increased road connectivity to the rural areas, transportation facilities are increased and fuel consumption increased. Now a day's rural villages are electrified and consuming power so usage from village side also increased. Due to increased population, to meet the requirement transportation also increased like more number of train's .due to increase demand drastically the transportation sector is really consuming more power.

Agriculture sector: due to in sufficient rains for cultivation, for crops water is required and it is to be lifted from wells and bore wells so number of agriculture pumps increased, consumption also increased

Industrial Sector: to meet the demand of increased population to supply essential commodities more industries are established and in other way creating employment to the public, energy consumption demand increased.

The international energy agency (IEA) has predicted that the energy and electricity demand in the world will increased by 1.7% to 2.4% per every year respectively from year 2000. In 2030 the IDA has forecasted that fossil fuels will still account for the largest part of the energy demand and most of the new power generating capacity will be natural gas fired combined gas/steam cycle as Natural gas is most environmentally friendly among the fossil fuels. As per the known reserve of fossil fuels, coal will decline after 250 years, oil and gas will decline after 50 years and 70 years. Due to greenhouse effect caused by the emission of CO_2 owing to burning of fossil fuels, the earth's temperature will increase if it increase by 4^0 C as a result many low lying areas near the sea will be drowned owing to melting of glaciers. So Efficient use of energy could be achieved on the basis of genuine energy strategies without releasing much CO_2 and the future of energy should be linked to the more efficiency less impact on environment.

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As a result many government and private agencies have initiated broad studies of projected energy consumption and the possibility of conserving energy while enhancing the quality of environment. But Educational Institutes are facing problems.

II. NEED FOR THE STUDY

Due to insufficient rains, low level of water level in dams and high consumption of energy due to the above reasons the energy supply is not meeting the customers demand and power cuts are increased drastically. Today it is difficult to say whether the whole day power is available or not .and we can't say if power goes means when again the power will come back. Educational Institutes will have fixed schedules of class work, laboratories and examinations. Especially for professional courses like Engineering, Medical colleges Uninterrupted electrical power supply is very essential to conduct laboratory Experiments and work shop exercises .Even one hour power cut also effects a lot in the academic curriculum. To overcome these difficulty colleges need to go for uninterrupted power supply to run the class work within a short period of semester system. So solar energy is one of the uninterrupted power sources of alternative energy

2.1. Objectives of the study

- To study current energy consumption
- To study Alternative source of energy
- To identify the gap of Energy consumption or source
- To propose suitable energy management solution
- To offer suggestion to improve energy management to meet the demand.

2.2. Significance of the study

By adding alternative sources of energy through solar it is going to complement existing power sources and would give full-fledged energy consumption

It is expected through this study that through uninterrupted energy supply the efficiency of the Institution may be reaching to the good heights.

At large through properly educated students through proper instructional methodology there will be efficient Engineer and Managers in the society who will be contributing to the nation's growth.

Now there is a need of sustainable energy which ensures constant supply of energy without or very less environmental pollution. Solar energy having the following merits because of

a) Plenty availability
b) No pollution
c) In exhaustible
d) Low gestation period

III. SOLAR ENERGY

India being a tropical country receives enough solar energy which can be harnessed. As per estimate India receives solar energy equivalent to 5000 trillion KWh per year which is more than the total energy consumption.

The daily global radiation is around 5 KWh/m^2 per day and the bright aspect with India is that sun shine during 2,300 to 3,200 hours per year in its most parts. As a result government of India has embarked upon to harness solar energy at a rapid rate. There are three methods to harness solar energy as given below;

a) Solar photovoltaic system
b) Solar thermal energy system
c) Space based solar power (new concept)

a) Solar photovoltaic system: solar photovoltaic system is a highly developed commercialized one and now it is so common that in remote villages also, the system has been installed. Indian government is promoting solar energy in the form of solar lanterns. Home lighting systems, street lighting systems, solar water pumps and power plants. The total SPV installed ill India is around 160 MW and as a result India ranks fourth in the world in harnessing SPV system after Japan, USA and Germany. 100 KW and 200KW SPV systems have been installed in some parts of country.

b) Solar thermal system: solar thermal power plant is harnessed by three methods namely solar concentrated system, distributed system and solar pond. In India, now use of solar energy for water heating, cooking, drying and space heating through various schemes are in common use. In order to promote the solar water heating system, Bangalore has declared as a solar thermal city.

It is worth to note that a project of 140 MW is under consideration under integrated solar combined cycle (ISCC) in Jodhpur district in Rajasthan. 35 MW will be generating by solar energy while rest 105 MW is to be generated by fossil fuel (natural gas) .A 100 MW solar power plants using solar concentrated system is under development. Reliance ADAG is going to install 500 MW of solar energy plants (PV and thermal systems) in India.

IV. A CASE STUDY ON SOLAR POWER PLANT

4.1 Solar Power Panels

The solar panels are erected on the Top of the college Building. The solar panels categorized as

a)Mono crystalline solar panel
b) Poly crystalline solar panels
c) Thin film technology panels:
as i) amorphous silicon ii) cadmium Telluride (C_dT_e)

These panels are having photo voltaic cell(Solar cells). photovoltaic cell is a device which converts solar energy in to direct electric energy

Solar cell (silicon cell): Modern solar cells make use of semiconductor based silicon. The general configuration of solar cell is to make p-n junction. p-n junction is obtained by diffusing n-type S_i (0.2µm thick)with p-type S_i of about 300µm thick. Metal electrode made of (T_i –A_g) alloy are attached to the top and bottom of the cell. The bottom is completely covered with metal electrodes while the top side electrode is made in the form of fine grid of narrow metal fingers which permits the sun light to go through an anti-reflection coating of 0.1 µm thick is applied on the

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top of the cell. The sun light strikes the upper surface of the cell; some photons are absorbed near the junction of two layers. This generates e.m.f and if the two electrodes are connected through the external circuit a current flow. Photo voltaic cell generates DC supply. However it can be converted to AC of required voltage by power conditioning unit (PCU). There are many companies are supplying solar panels but the institute installed Mono crystalline solar panels of "**solar semi-Conductor Company"**

Fig.1. Solar panels

Fig.2: Details of Solar panels

The approximate life of solar panel is 25 years.
The cost of solar panel is Rs. 11000 /-
Total No.of panels installed is: 112 Numbers

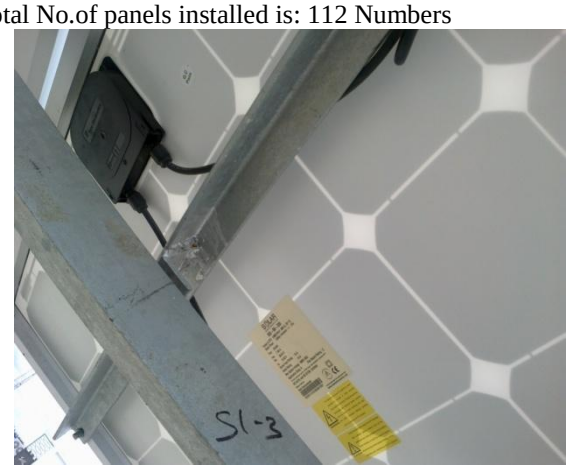

Fig.2a. Details of Solar panels

Name plate details of solar panel
Solar semi-conductors SSI-S6_230
Tested at STC (1000 W/m^2 AM 1.5, 25^0 C)
Rated power: 230 Wp(Tolerance ± 3%)
Vmp ; 29.04 VImp: 7.94 A
Voc: 36.5 VIsc: 8.54 A
Series fuse ratio: 15 A Diode rating: 15 A

Fig.2b. Details of Solar panels

Fig.2c. Details of Solar panels

The DC supply from solar panel through maximum power point track (MPPT) to the AJB1, AJB2, AJB3, AJ4 Junction boxes. These boxes are connected to the cable of supply terminal and DC supply from solar panels comes in to the power conditioning unit through the cable.

4.2 Power conditioning unit

Many companies are supplying power conditioning units but erected "Optimal power synergy India" (OPSI) Company power conditioning unit.

The cost of power conditioning unit is = Rs.600000/- (OPSI make)

Details of power conditioning unit as follows

Product type	: 3P-OD-25K-230-50-240-23KW
Model number	: GSC 25 KVA (900569-01)
Output power	: 25 KVA
Output AC voltage	: 415V, 3Ǿ, 50 HZ
Battery voltage	: 240 V DC
Series number	: 1563

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Fig.3. Power controlling unit

Fig.4. Power controlling unit details

Name Plate Details

Mfd. By optimal power synergy India Pvt.ltd
#197,12th Main,3rd phase, peenya Industrial Area
Bangalore-560058(India)

Other details of PCU

Battery Input Solar Input
Isolator CB-11 Isolator CB-12
3-phase GSC (DSP) Power Terminal Assignment
AC Power terminal strip (ACPTS)

Terminal No	Description
A1	Grid line 1 input
A2	Grid line 2 input
A3	Grid line 3 input
AN	Grid Neutral
LN	GSC system out put
L1	GSC System line 1 out put
L2	GSC System line 2 out put
L3	GSC System line 3 out put

GSC= grid support conditioner
DSP=Digital signal processor
DC power terminal strip

Terminal No	Description
B+	Battery positive
B-	Battery negative
S+	Solar positive
S-	Solar negative
E	Earth(PCU earth terminal)

Ps1= power source1 Ps2=power source2 INV = Inverter
The function of inverter is

1. Converting solar DC supply in to Ac supply which is required for the usage
2. To stabilize or to provide uniform uninterrupted power supply to the consumer without power fluctuations. It is achieved by energy storing devices (batteries)
3. Its function is when there is a excess solar energy then it allow the excess energy to store in the batteries and when there is a need to supply uniform energy when solar power is not availability then it draw the energy from batteries

V. SOLAR BATTERIES

Batteries are storing devices when there is no demand of energy by consumer the DC energy is stored in the batteries. When consumer requires uniform supply, to meet the demand of consumer, power controlling unit (PCU) supplies directly the solar energy by convert in to AC energy. In case if the direct solar energy not meeting required demand in such case PCU draw energy from stored batteries exactly to meet the demand (exactly how much is required to maintain uniform supply only that much it will draw from batteries) and supply as AC energy to the requirement of short fall of demand. So PCU is a Heart of solar system it balances the energy of the system when there is excess it will take in and when there is a demand it gives out. Energy stored in battery is depends upon storage capacity of the battery and number of batteries connected in the system.

There are many companies are supplying solar batteries but the institute using" AMARAJA BATTERIES LTD (AMRON)Made in India "company batteries.

Total No.of batteries used is 80 Number
The unit cost of battery =15000/-
Total no.of batteries =80 nos
Cost of batteries (80 x15000/-) = Rs 12, 00,000/-
Expected life of battery is 5 years

In general after every 4 years 25 % of batteries are to be replaced
i.e 25% of 80 batteries are 20 numbers (20x15000 = RS.300000/-)

Fig.5. Solar Batteries

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Fig.5a. Solar Batteries

5.1 Other Details

Apart from the above costs panel board costs, cable costs, erection costs and earth point costs are to be included. There are many earth points at different locations.

Inverter – earth point
Solar structure – earth point
Junction boxes – earth point
ACDB (AC distribution board) - having connected earth points
Switching control - earth point
Lighting arrester - earth point

Fig.6: Power cable from PCU to distribution board

Fig.7. Power Distribution board

Fig.8. Solar power Indicator

Fig.9. Solar power connected to Distribution boards

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Fig: 10: Solar and CPDCL power connections for distribution

Fig: 11: Solar and CPDCL power distribution

Fig: 12: Solar and CPDCL power connections for distribution

Fig: 13: Solar and CPDCL power distribution

Fig: 14: CPDCL to Solar power exchanger

VI. Cost of Solar Power Plant

On overall the cost of solar plant for 25 KVA is as under

a) Solar panels (112xRs 11000/-) = 12,32,000
b) Power conditioning unit = 6,00,000
c) Batteries cost (80x15000/-) = 12, 00,000
d) And other costs = 11,68,000
Total cost (a+b+c+d) Rs.42,00,000

Institute got 31% of Government subsidy which is equal to =Rs.13,00,000/-

Installing cost of 25 KVA solar plant is (approx.say) = Rs.29, 00,000/-

Due to usage of solar power the consumption of electricity consumption come down from 9638 units to 6638 units(KWh) so there is a saving of 3000 units power.

6.1 Saving of CPDCL power

Consumption cost 3000 units xRs.5.4 = Rs.16,200/-
Demand cost 25KVAxRs.200 = Rs. 5000/-
Cost of power saved (16200+5000) =Rs.21,200 per month

a) Cost is saved by usage of solar power =Rs.21, 200 per month

Due to usage of solar power generator and UPS are not at all using for power cuts

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So cost of generator running and UPS maintenance cost coming under power saving cost indirectly.
b) Generator running cost per month is =Rs.14, 790/-
c) UPS maintenance cost per month is = Rs.10,834/-
Total cost saved by usage of solar power =21,200+14,790+ 10,834= Rs.46824 /-per month
So consumption cost of CPDCL is reduced per Month as a follows
Before solar power usage cost = Rs. 96670 /-
Power cost saved by use of solar power = Rs. 46824/-
Reduced cost of CPDCL power = Rs.49846/-

6.2 Recovery of Investment cost

Power saving cost per year = 46824x12months =Rs.5,61,888/-
Power saving cost for 4years =5,61,888x4 years=Rs.22,47,552
Initial Investment cost = Rs.29, 00,000/-
Investment cost recovered at the of 4th years by usage of solar power =Rs. 22,47,552/-
Investment amount to be recovered after 4th years =29, 00,000- 22, 47,552=6, 52,448/-

Investment cost of Rs.6,52,448/- to be recovered after 4th year by solar plant operation
But after 4th year every year 25% of batteries are to be replaced.
That is in 5th year 25% of 80 batteries =20 batteries to be replaced
Cost of 20 batteries (20x15000/-) =Rs. 3, 00,000/-
So saving in 5th year is
(5, 61,888-3, 00,000) = Rs 2, 61,888/-
Balance investment cost Rs. 6,52,448/yearly saving Rs.2,61,888=2.5 years
Again in 6th year 25% of 80 batteries =20 batteries to be replaced
So saving in 6th year is
(5,61,888-3, 00,000) =Rs 2,61,888/-

Again in 7th year 25% of 80 batteries =20 batteries to be replaced
So saving in 7th year is
(5,61,888-3, 00,000) =Rs 2,61,888/-

At the end of 7th year(5th,6th,7th,years) total saving after replacing batteries =2,61,888 x3 =Rs.7,85,664/-
Investment amount to be recovered after 4th year =Rs.6, 52,448/-
At the end of 7th year profit is
(7,85,664-652,448) = 1,33,216/-

In 7th year the solar plant is reaching breakeven point and the Total cost is getting recovered at the end of 7th year with 1,33,216/- profit.

6.3 Result of Analysis:

The Interest on Investment @ 9%(750/- per lack) for 29 lacks is 21,750/- per month which gives Rs 2,61,000/- per year(10,44,000 per four years) not taken in to account and depreciation also not taken in to account for the above calculation because 20% batteries are replacing continuously after 4 years. In view of high cost of batteries and replacement of batteries at the rate of 20-25% every year after 4 years, this case study is showing for the period of 7 years the investment cost is recovered without interest.

However solar panels are giving a life of 20 to 25 years, and power controlling unit (PCU) maintenance also not so costly it may be covered in the profit amount of Rs1,33,216/-.so we can expect up to 7 years there is no profit .

Solar plant is at the end of 7th year it is on no gain and no loss .so it is economical in long run with proper care and maintenance to make profit.

Solar panels must be maintained to protect from environmental damage. The main Reasons for the panels to get ineffectiveness is

i) Due to wind blows dust accumulates over the panels
ii) Problem of Birds sitting on the panels and spoiling its effectiveness etc.,

VI. Precautionary Measures and Suggestions

Avoid the wastage of energy both at institution and Industrial level by suitable conservations methods, conducting energy audits to find out energy losses.

7.1 At Institutional level

1. Class rooms must be constructed with good ventilation of sun light (according to the direction of sun) to save power by avoiding usage of lights.
2. Avoid ideal running of fans and lights in the class rooms
3. Adopt latest technologies to save power. Use incandescent bulbs filled with keypton. Replace conventional GLS bulbs by CFL bulbs which save 80% of energy for the same light output same time CO_2 emissions reduces 80%.
4. Remote controlling devices /sensors to be provided for class Rooms for better control of power usage. When students are entering in to the class fan should switch ON. when students leaving the class fans should switch OFF automatically.

VIII. Limitations of the Study

Since the study is limited to Engineering colleges .It cannot be generalized and implemented to the similar Institutions.

Investing, Installing and Maintenance of Alternative source of energy involves huge investment which may not be feasible for the institutions of service nature.

This study is performed with researcher empirical views which may not be standardized and the views expressed by researcher s are personal and through various interviews performed. Hence those views can also not to be considered standard.

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IX. CONCLUSION

At present the capital cost of solar PV system is more as compared to coal based power plant. Solar power unit production cost is much higher than the production cost unit power by other sources. so it is not at all economical at present stage but in near future cost of conventional fuels will be raised due to non-availability of fuel because of increasing cost of petrol year to year. this is due to increasing the demand year to year and also due to faster rate of depleting conventional fuel sources .so in near future there is no way to get power other than renewable sources.

Renewable sources may be considered as a major source of power after depletion of the conventional (non-renewable) energy sources. Meanwhile latest technologies must be applied for further improvements by R&D to bring down the cost of solar production for common use.
Now it is a challenge to our scientists to bring down the manufacturing costs of solar panels and batteries to the acceptable level .we may expect in near future this cost may equal to hydroelectric cost and common man may also use solar power because of increasing the cost of conventional power and reducing the cost of non-conventional sources.

Solar energy is already being used economically in many advanced countries for both domestic and commercial purpose such as water heating, water, distillation refrigeration, dying etc,

At present lot of improvements are going on by research and development by adopting new technologies to bring down the cost to a reasonable level for the usage of common man.

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AUTHOR'S PROFILE

P. V. Ramana
Assoc. Professor, NMREC-Hyderabad (India)
Email: ramanapendu@gmail.com

Sudheer Prem Kumar
Professor –Mechanical -JNTUH –Hyderabad (India)

D. Maheswar
Principal and Professor –KMIT- Hyderabad

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