Design of Non-Conventional Energy System (Solar Energy System) for Block 56, LPU, Jalandhar, Punjab, India

Submitted in partial fulfillment of the requirements

of the degree of

MASTER OF TECHNOLOGY

in

CIVIL ENGINEERING

by

AMBIKA THAKUR

(41400037)

Supervisor

Miss Alka Yadav

Transforming Education Transforming India

School of Civil Engineering

LOVELY PROFESSIONAL UNIVERSITY, PHAGWARA

2017

DECLARATION

I, Ambika Thakur (41400037), hereby declare that this thesis report entitled **"Design of Non-Conventional Energy System (Solar Energy System) for 56 Block, LPU, Jalandhar, Punjab, India"** submitted in the partial fulfillment of the requirements for the award of degree of Master of Civil Engineering, in the School of Civil Engineering, Lovely Professional University, Phagwara, is my own work. This matter embodied in this report has not been submitted in part or full to any other university or institute for the award of any degree.

Date: **Ambika Thakur**

Place: Lovely Professional University

CERTIFICATE

Certified that this project report entitled "**Design of non-conventional energy system (Solar Energy System) for 56 Block, LPU, Jalandhar, Punjab, India**" submitted individually by student of School of Civil Engineering, Lovely Professional University, Phagwara , carried out the work under my supervision for the Award of Degree. This report has not been submitted to any other university or institution for the award of any degree.

Supervisor

Miss Alka Yadav

(Assistant Professor)

ACKNOWLEDGEMENT

This is a great chance or opportunity for me to work on the topic **“Design of non-conventional energy system (solar energy) for 56 Block, LPU, Jalandhar, and Punjab, India”** and I am very thankful to all those people who helped me during this project report.

I would like to thank my mentor and the other fellow mates who helped me a lot to understand the topic and guide me for the project.

I would also like to thank my friends who gave their support for the completion of the project report. Really it gave me a wide experience and I have learned a lot during this time period.

Special thanks to:-

Mr. Suhas Shrivastav,

Mr. Murari Kumar,

Ms. Deepti Singh Jadon

Mr. Jitin Vasudeva

Mr. Gagan Luthra

Signature of Student

AMBIKA THAKUR

ABSTRACT

The power requirements of the world including India are at alarming rate and demand for electricity was executed before the supply. It is also now widely recognized that fossil fuels (c, coal, oil and natural gas) and other resources conventional, currently used for the generation of electrical energy, cannot be sufficient or appropriate to keep pace with the ever-increasing demand for electric power in the world. In the generation of electricity by Central steam based in cold or nuclear power plants causes pollution, which will probably be more acute in the future because of production capacity important on one side and greater awareness of citizens in this regard.

The serious recent energy crisis has forced the world to develop new methods and electricity generation, which could not be adopted so far due to various reasons. The magneto-hydro-dynamic (MHD) power generation is one of the examples of a single method new energy production. Conventional methods of production of energy can be like solar cells, fuel cells, thermoelectric generator, thermo-convertors, the production of solar energy, wind energy, the production of thermal energy-geographic, the production of tidal energy etc.

This project is based on non-conventional energy, use of solar energy, and conversion of solar energy into electrical energy and design of non-conventional energy system for LPU.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviation

UNDP	United Nations Development Programme
kWh	Kilo watt hour
TPES	Total primary energy supply
TWh	terawatt-hours
UNFCCC	United Nations Framework Convention on Climate Change
UNCED	United Nations Conference on Environment and Development
GHG's	Green house gases
FY	Fiscal year
CAGR	Compound annual growth rate
MTOE	Million tonnes of oil equivalent
FDI	Foreign direct investment
PV	Photo voltaic
GDP	Gross domestic product
DSSC	Dye sanitized solar cell
MNRE	Ministry of new renewable energy
AC	Alternating current
DC	Direct current
PSI	Peak solar intensity
V_D	Voltage drop
kVA	Kilo volt ampere
DNI	Direct Normal Radiance
GHI	Global horizontal Irradiance
DHI	Diffuse horizontal irradiance

CHAPTER 1

INTRODUCTION TO ENERGY

1.1 Basic of energy

Energy is the capacity of the physical system to do the work, plays a significant role in our day-to-day activities. It has become one of the necessities of our modern life. Energy is consumed in the form of electricity for lightening, cooling, heating, transportation etc. our activities depend so much on energy availability that is now become an integral part of our life and an indispensible tool for the development and growth of the company.

It is well observed fact that the development of the given region or country is directly proportional to the amount of energy consumption. Countries where the per capita energy consumption is high are at a higher stage of social and economical development. Higher energy consumption is not only tool for improving living standards but also results in high literacy rates and better health. Today the major energy sources are fossil fuel based. These sources are not only limited in nature but also cause bad impacts on environment. Global warming is the live example of environmental impact due to use of conventional energy sources.

The use of energy plays an important role in human life. The availability and accessibility of sufficient amount of energy accelerate individual and national development. The relationship between social development and use of energy is very clear. Nation with more consumption of energy is more developed. The illiteracy rate is plotted against consumption [1].

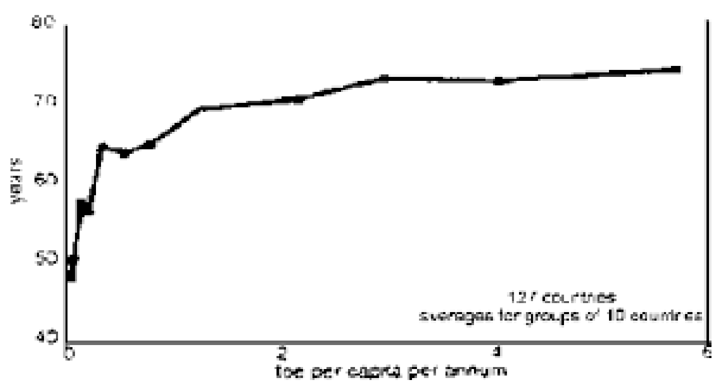


Fig no 1.1 Illiteracy and energy consumption of world (Data: UNDP)

1.2 Energy and Power-

Energy is defined as the capacity of the body to do work. A moving object is doing work. If object is placed at certain height then it possesses energy. Thus energy has many forms like heat energy, electrical energy, potential energy, kinetic energy, mechanical energy, nuclear energy and light energy.

People have always used energy to do work for them. Thousand years ago, human burned words to provide light, to heat their living spaces and to cook their food [2]. After that flowing water is used for generation of electricity. Today people are using more energy from variety of sources for multiple tasks. During the application of energy it changes from one form to another. This implies that energy converted from one form to another and total energy remains constant or conserved. The energy is measured in joules. One joules of energy is equal to 1 Newton- meter. It is also represented in other units like kilowatt-hour, calorie etc.

Power is the rate at which energy is used. Generally power is expressed in joules/ sec. in general power plants capacities are mentioned in megawatt and the energy content generated from fuel like coal, petrol, diesel etc are mentioned in terms of kWh.

1.3 Energy consumption world wise

World energy is the total energy used by the entire human civilization. The rule per year, it includes all energy applied from all sources of energy used on the efforts of the humanity in each industrial and technological sector in every country. It contains no energy from the food, and the extent to which the direct combustion of biomass is poorly documented. As the source of civilization, World Energy Consumption has deep impact on socio-economic-political sphere of humanity.

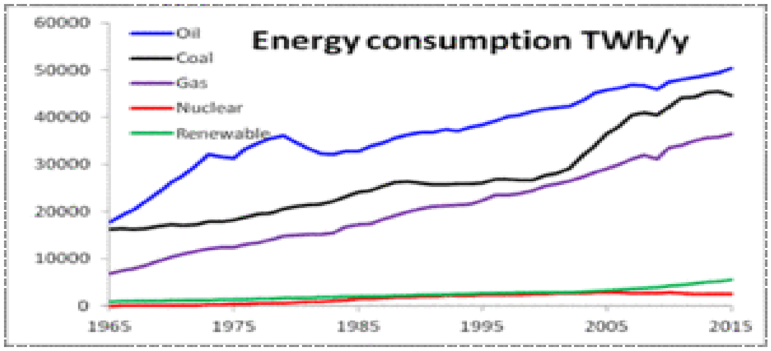


Fig. no. 1.2 World energy consumption (data: 2016)

World total primary energy supply (TPES), or "primary energy" differs from the world final energy consumption because much of the energy that is acquisition by humans is lost as other forms of energy during the process of its refinement into usable forms of energy and its transport from its ' initial place of supply to consumers. For instance, when oil is extracted from the ground it must be having into gasoline, so that it can be used and transported over long distances to gas stations where it can be used by consumers. World final energy consumption refers to the fraction of the world's primary energy that is used in its final form by humanity.

In 2012, world energy supply primary amounted to 155,505 terawatt-hours (TWh), while the world final energy consumption was 104,426 TWh or about 32% less than the supply total. World final energy consumption includes products as lubricants, asphalt and Petrochemical which have chemical energy content purpose are not used as fuel. This Non-use amounted to 9,404 TWh in 2012. By the end of 2014, the total installed global power generating capacity is nearly 6.142 TW (million MW) which does not include the DG sets not connected to local electricity grids In 2014, world energy consumption for electricity generation was coal 40.8%, natural gas 21.6%, nuclear 10.6%, hydro 16.4%, 'other' (solar, wind, geothermal, biomass, etc.) 6.3% and oil 4.3%. Coal and natural gas were the most popular energy fuels for generating electricity. The world's electricity consumption was 18,608 TWh in 2012. This figure is about 18% smaller than the generated electricity, grid losses duo, storage losses and self-consumption from power plants (gross generation). Cogeneration power stations use some of the energy otherwise that is wasted for heating or buildings in industrial processes [3].

1.4 Energy sources

The world around us has changed in the last 20 years. Technology is one of the key drivers of economic and social development. The rapid progress of information technology (IT) all over the world, not just the way we think, transformed the way we act. All aspects of human life have been affected by IT and the Internet, in particular. Of course that virtually all Technologies on electrically operated and thus the proportion of electricity rise rapidly, faster than Total Primary Energy Supply (TPES).The main energy sources from where electrical energy can be extracted are two types of energy sources.

1) Conventional energy sources
2) Non conventional energy sources.

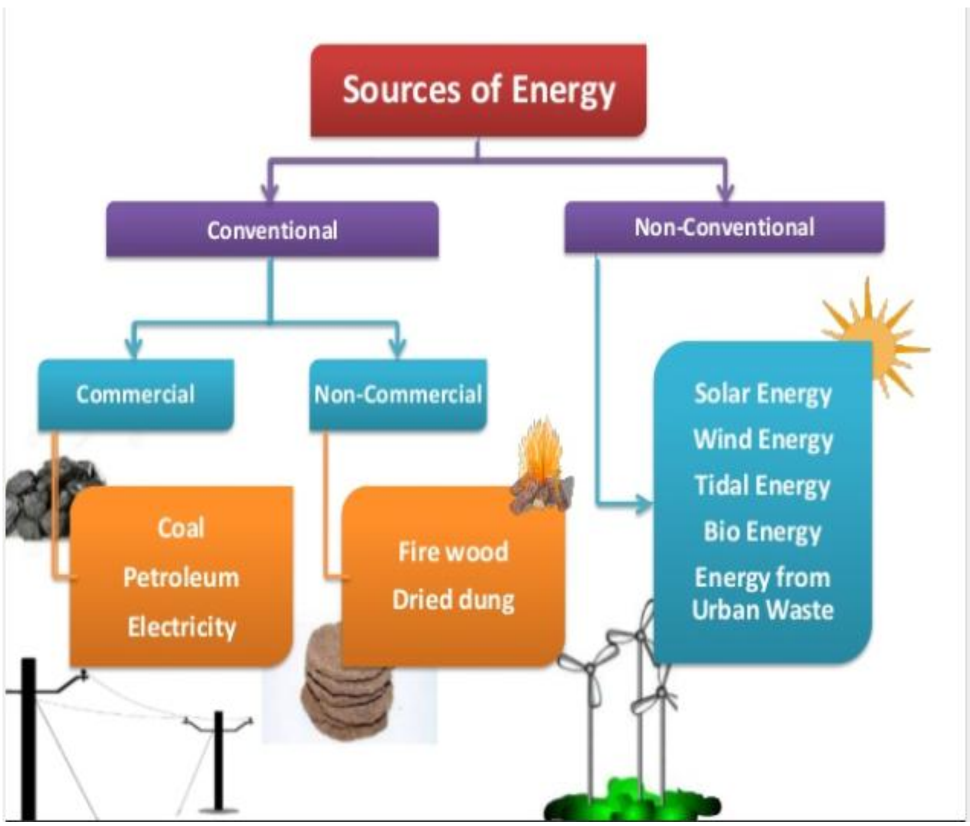


Fig. no. 1.3 Sources of energy

(Source: Google)

1.4.1Conventional energy sources

In ancient times, Wood was the most common source of heat energy. The energy of the flowing water and wind was also used for limited activities. The use of coal as a source of energy in the industrial revolution made it possible. Increasing industrialization has led to a better quality of life all over the world. It also has the global demand for energy grow at a tremendous pace. The rising demand for energy was largely met by fossil fuels-coal and oil. Our technologies have also been developed for the use of these energy sources. But these fuels were formed over millions of years and there are only limited reserves. The fossil fuels are renewable energy sources, so we have to. If we continue to consume these energy sources to these alarming proportions, we would soon be out of the running! To avoid this, alternative energy sources have been searched. But we are still heavily dependent on fossil fuels for most of our energy needs [4].

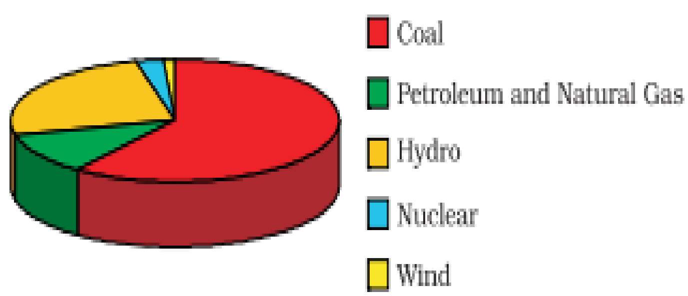


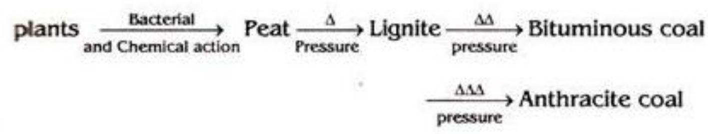
Fig. no 1.4 Major sources of energy in India

(Source: http://www.ncert.nic.in/ncerts/l/jesc114.pdf)

The energy sources which cannot be compensated, once these are used (after their exploitation) are termed as conventional energy sources. Conventional sources of energy are listed below-

1.4.1.1 Coal

Coal is a major conventional energy sources. It was formed from the remains of the trees and ferns grew in swamps around 500 millions year ago. The bacterial and chemical decomposition of such plant debris (which remained buried under water or clay) produced an intermediate product known as peat which is mainly cellulose $(C_6H_{10}O_5)_n$. Due to progressive decomposition by heat and pressure, the cellulose lost moisture H_2 and O_z and got converted in to coal as per the given equation.



Out of the 6000 billion tons coal stocks under earth crust, 200 tons have been exploited the present society. The coal reserves are found in the states like Jharkhand, Orissa, West Bengal, M.P. and A.P. Some important coal fields are: Talcher, Raniganj, Jharia, Bokaro, Panch Konkam, Signoulli, Chanda etc [5].

1.4.1.2 Petroleum and natural gases

Oil and Gas are natural resources of enormous economic importance. Together they provide about 60% of all the energy used by society today. They provide fuel for transport and are vital for heating, lighting and cooking. In addition they are used in the manufacture of synthetic fabrics, plastics, fertilizers, detergent as well as for many other purposes. In short, it is hard to imagine how our society could function without oil and gas. Oil and gas are complicated mixtures of different hydrocarbons. A hydrocarbon is a large organic molecule. As the name suggests it is composed of hydrogen atoms attached to a backbone, or chain, of carbon atoms. Short chain hydrocarbons like methane are gases. Medium chain hydrocarbons like paraffin are liquids. Long chain hydrocarbons like bitumen are solids. When crude oil is extracted from the earth it may be a mixture of hydrocarbons in solid, liquid and gas states.

1.4.1.3 Fuel woods

The rural peoples require fuel wood or fire Wood for their day to day cooking which are obtained from natural forests and plantations. Due to rapid deforestation, the availability of fire wood or fuel wood becomes difficult. This problem can be avoided by massive afforestation (plantation) on degraded forest land, culturable waste land, barren land grazing land etc.

1.4.2 Non conventional energy sources

Energy generated by wind, tides, solar, geothermal heat and biomass including farm and animal waste is known as non conventional energy. All these sources are renewable or inexhaustible and do not cause environmental pollution. More over these sources don't require heavy expenditure.

1.5 Impact of conventional energy sources on environment

Conventional energy sources include oil, gas and coal. This conventional energy is typically associated with fossil fuels. Their application leads to increased greenhouse gas emissions and other environmental damage. Consumption of fossil resources causes global warming and climate change. In most regions of the world few changes have been made to slow these changes. If the theory of peak oil is true, and more explorations of alternative sources of energy are viable, our impact could be less hostile to our environment.

1.6 Energy alternatives

The alternative energy is a source of energy that is an alternative to fossil fuels. These options are designed to meet concerns about these fossil fuels, such as emissions of carbon dioxide high, an important factor in global warming. In the marine energy, hydro, wind, geothermal energy and solar are all alternative energy sources.

The nature of what constitutes a source of alternative energy has considerably changed over time, as have the controversies regarding the use of energy. Because of the variety of energy choices and different objectives of their defenders, defining certain types of energy as "alternative" is considered very controversial.

1.6.1 Wind energy

Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of nonrenewable power sources. Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations [6].

Fig. no 1.5 Wind energy systems (Source: Google)

1.6.2 Solar Energy

Solar energy is the energy associated to the solar radiation and it represents the primary source of energy on the Earth. From the energetic point of view it is an energy alternative to traditional fossil fuels, renewable and clean (green energy) and one of the strengths that supports of the so-called green economy in modern society. It can be properly exploited through different technologies and different purposes although several of its technologies exploitation suffers from variability and intermittency of production that is not fully programmable due to day-night cycles and cloud cover.

Fig. no. 1.6 Solar energy systems (Source: Google)

Solar energy can be used to generate electricity (photovoltaic) or to generate heat (solar thermal). There are two main technologies that transform solar energy into usable energy.

- The solar thermal panel transfers the solar rays, to heat a liquid with special characteristics, contained in its interior, which transfers heat, via a heat exchanger, to the water contained in a storage tank.

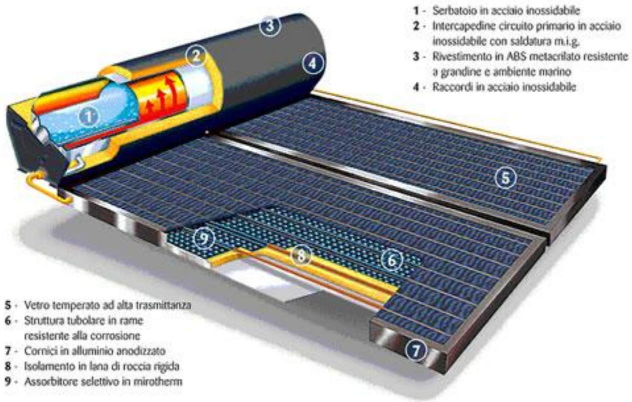


Fig. no. 1.7 Water heating through solar energy (Source: Google)

- The photovoltaic panel transfers the properties of particular semiconductor elements to produce electrical energy when stimulated by light**.**

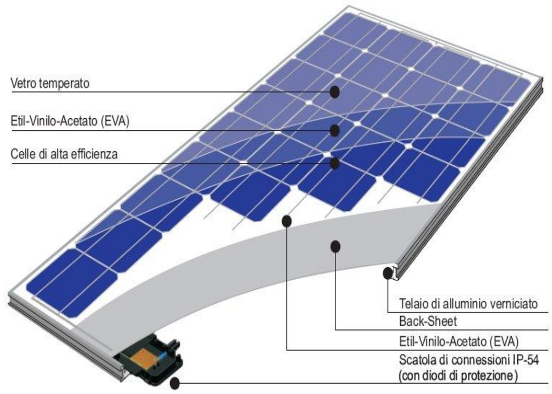


Fig. no. 1.8 Photovoltaic panel (Source: Google)

The photovoltaic panels are used in isolated systems for powering devices away from the grid (space probes, telephone repeater in the high mountains, etc.) or with reduced energy requirements so that a connection to the grid uneconomic (road signs light, parking meters, etc.) and inconvenient from an organizational standpoint. Obviously, these devices must be equipped with an accumulator capable of accumulating the electric current produced in excess during the day to power the equipment during the night and during cloudy periods. Solar energy has advantages and disadvantages. The advantages are mainly concentrated in the least environmental impact and the possibility of exploitation of the perennial source of solar energy. The disadvantages are, however, concentrated in the typical discontinuity that characterizes almost all the renewable energy and solar energy in the dispersion.

The main advantages of solar energy are:

- **Huge amounts of energy.** The energy from the Sun is very high. Taking advantage of the 6% of the solar energy at the surface it could meet the entire energy needs.
- **Clean Energy.** Unlike fossil fuels and nuclear energy, solar energy produces no pollution, waste or greenhouse gases. The environmental impact of solar energy is limited to the recycling of technological components (solar panels) and the impact of solar plants on the landscape.
- **Poor concentration.** While being in direct function of the latitude, the solar energy is available virtually anywhere on the planet.

The disadvantages of solar energy are:

- **Dispersion.** But arrived a huge amount of solar energy, this is spread on a wide surface. To meet this challenge it is necessary to build solar installations on a considerable area of territory.
- **Discontinuities.** Like other renewable energy sources also it has a solar energy power inconstant, variable and discontinuous as a result of the alternation of day and night, the weather conditions and the cycle of the seasons.
- **Intensity variable.** The intensity of solar energy is maximum in equatorial and sub-equatorial, decreases in temperate zones up to touch the minimum in the polar zones.

1.6.2.1 Solar power plant- The solar power plants uses photovoltaic modules to convert sunlight into electricity, it uses the turbine-alternator. It can have an efficient between 10 and 15 % (depends on the component that you use). [7]

Fig. no 1.9 Solar Power Plants (Source: Google)

1.6.3 Tidal energy- Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into useful forms of power - mainly electricity. This is the only form of energy whose source is the moon.

The first tidal power station was the Rance tidal power plant built over a period of 6 years from 1960 to 1966 at La Rance, France. It has 240 MW installed capacity and the worlds second biggest tidal power station.

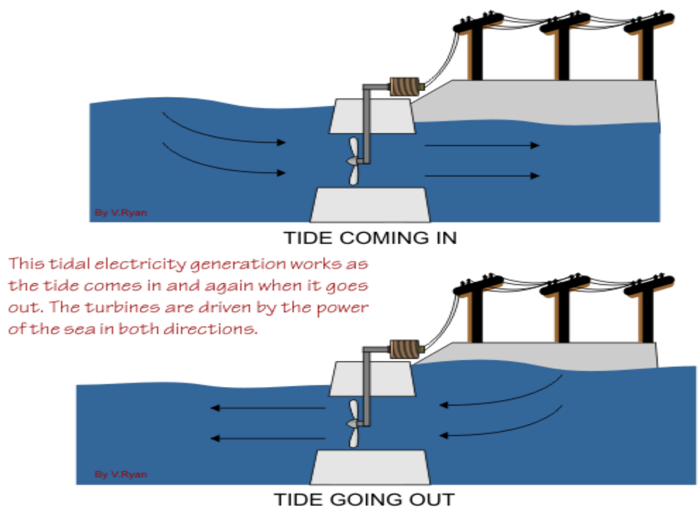


Fig. no.1.10 Tidal Energy (Source: Google)

1.6.4 Geothermal energy

Geothermal energy is the heat from the earth. It is clean and sustainable. Resources of geothermal energy range from flat ground hot water and hot rocks a few miles below the surface of the Earth, and even deeper to the extremely high temperatures below liquid rock called magma.

Fig. no.1.11 Geo-thermal power plant (Source: Google)

Advantages of non-conventional energy sources-

- **Cheaper and renewable-** most of non conventional power resources are cheaper and renewable as compared to the conventional sources.
- **Scarcity of fossil fuels-** the overall limitation and scarcity of fossil fuels has been given rise to the urgent need of exploiting alternative energy sources.
- **Rural energy need**- locally available non- conventional power sources can meet localized rural energy needs with minimum trasportional cost.
- **Inexhaustible and environment friendly**- power form nonconventional and renewable is must in order to reduce carbon dioxide emission of coal based power plants. It is inexhaustible in nature and environment friendly.

1.7 Carbon credit

Unlimited use of fossil fuel and conventional energy sources increase the environmental issue and global warming is one of them. An initiatives taken by countries to reduce the carbon emission (which is the main green house gas) convention was signed by many countries. UNFCCC is negotiated at the **United Nations Conference on Environment and Development (UNCED).** The Kyoto Protocol is an international treaty that extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC), obliges the parties to the reduction of greenhouse gases, even on the fact that (a) the global warming exists and (b) anthropogenic CO_2 emissions have caused it**.** A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another greenhouse gas with carbon dioxide equivalent (CO_2) equivalent to one tonne of carbon dioxide.

The new low-carbon economy provides a new market for Indian Forest hosts, ranchers and farmers to develop and sell carbon credits, as well as reduction of the gas offset and credits. Carbon credits are rural conservation and renewable energy projects, the amount of carbon dioxide (CO2) - or "reduce greenhouse gas emissions released into the air or remove existing CO2 from the air. Projects often include the use of terrestrial sequestration. [8] The emission of greenhouse gases (GHG) management and carbon credit projects are good for the environment, but they also provide an economic opportunity for those who develop them. Investors, who are often large businesses or industries, buy carbon credits to compensate for their CO_2 emissions.

1.8 **Energy sector in India-**

Power is one of the main components of the infrastructure for economic growth and the well-being of the peoples is of vital importance. The existence and development of appropriate infrastructure is essential for a sustainable growth of the Indian economy.

Indian power sector is one of the most diverse in the world. Energy production from conventional sources such as coal, lignite, gas, oil, and nuclear power is more costly than un-conventional sources such as wind, solar and agricultural and municipal waste. The electricity demand in the country has increased rapidly and is expected to continue to rise in the coming years. To meet the rising demand for electricity in the country, massive addition to the installed power generation capacity is required. India is one of 40 countries in the EY Renewable energy country attractiveness index at the rear of the center of gravity of the Government for the promotion of renewable energy and the implementation of projects in a time bound. With electricity production of 1,107.8 BU in India in FY16, the country witnessed growth of around 5.64 per cent over the previous fiscal year. Over FY10–16, electricity production expanded at a CAGR of 6.21 per cent. During April-September 2016, electricity production in India reached 584.22 BU. [9] The 12th Five Year Plan projects that, by 2016–17, total domestic energy production would reach 669.6 million tonnes of oil equivalent (MTOE) and would further increase to 844 MTOE by 2021–22.

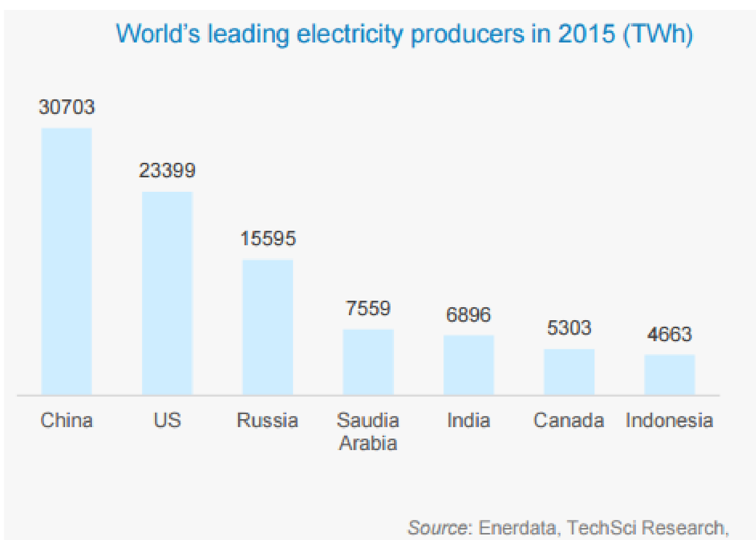


Fig. no. 1.12 Different countries energy production in 2015

1.8.1 Evolution of the Indian Power sector

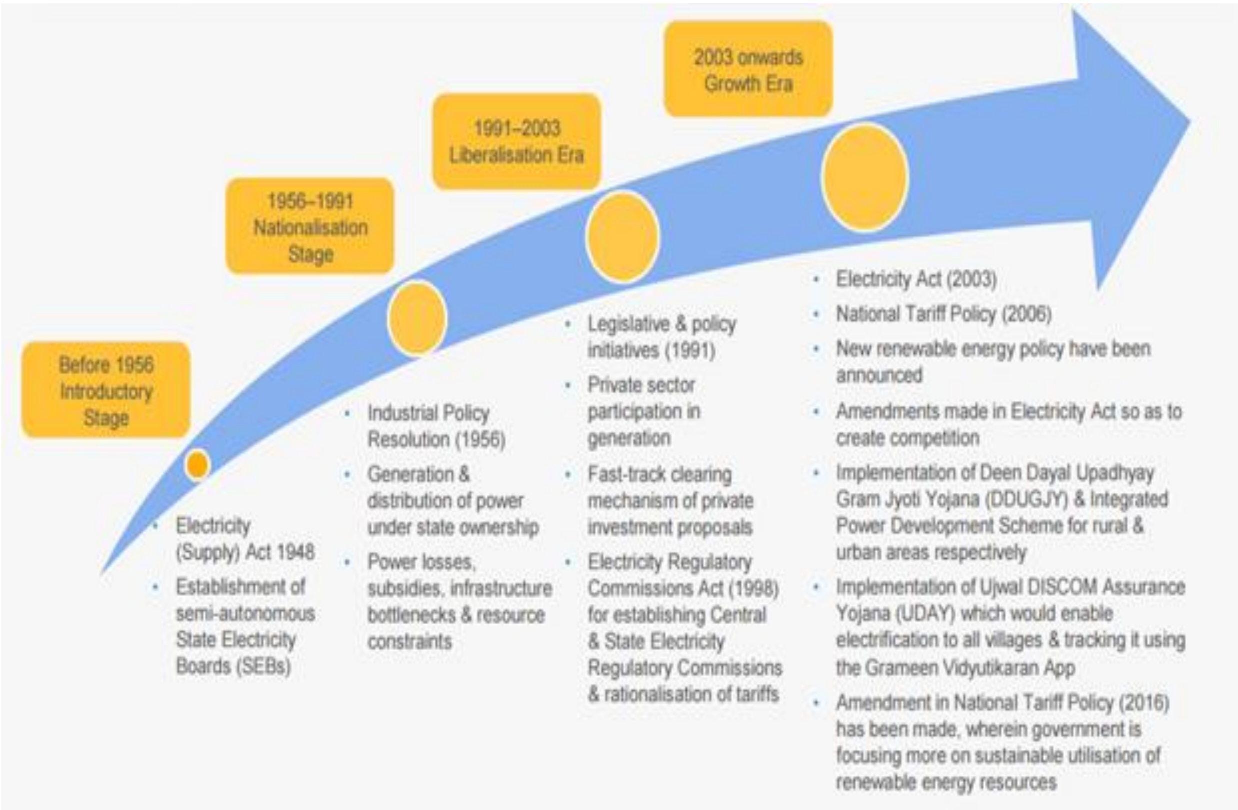


Fig. no. 1.13 Evolution stages of power sector in India (Source: Google)

The power sector in India has the fifth generation of the ability of electricity in the world, and it is among the main sectors of the country with an installed capacity of 253.39 gigawatts (GW) as soon as August 2014 (thermal power plants constitute 69.50% of the installed capacity, hydroelectric about 16.10% and remains a combination of wind, small hydro, biomass, waste-electricity, and nuclear. In addition, the captive power plants generate an additional 39.38 GW). It facilitates development in various other sectors such as agriculture, manufacturing, construction and services. Between April 2000 and January 2014, he drew 404 billion rupees of foreign direct investment (FDI) entries.

The rapid pace of economic growth in India and its increasing rate of industrialization has fuelled the demand for energy. During the eleventh five-year plan (2007-12), approximately 55 GW of production capacity has been added, which was about twice more capacity during the tenth five-year plan (2002-07) and a target of 88537 MW has been defined for the twelfth period plan that was reached 46766 MW until August 14. This underlines the important development adding capacity. The distribution sector which is mainly dominated by the state ownership of utilities has been dealing with losses. [10] Moreover, even after more than actual capacity exceeds targets in recent years, the country still faces significant electricity shortages throughout the year due to losses in the distribution (of global power deficit of FY2013 was 8.7% and the deficit record was 9.0%).

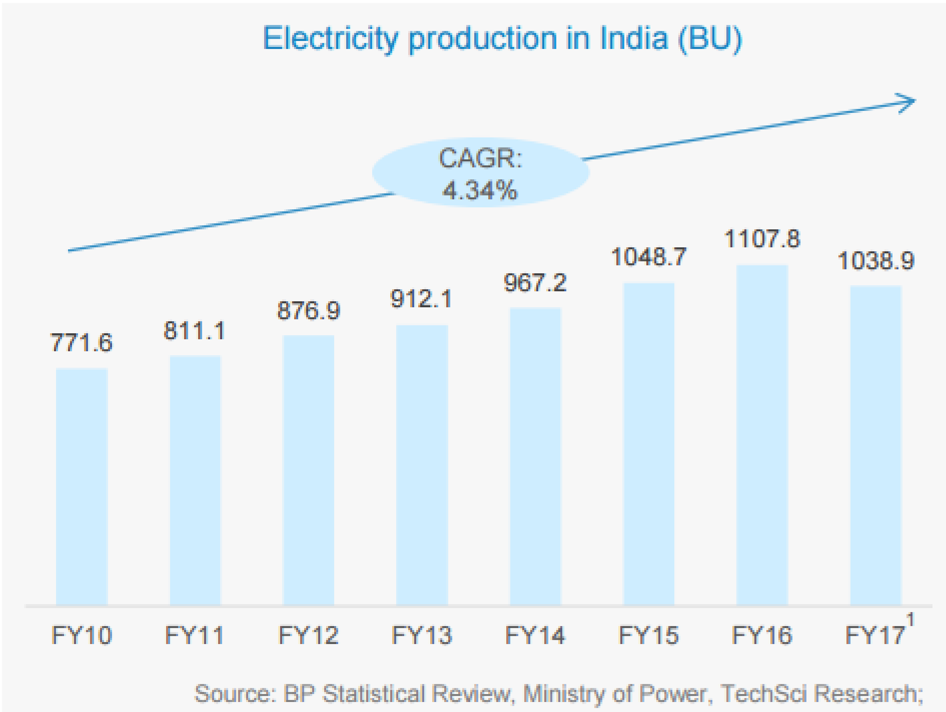


Fig. no. 1.14 Energy production in India

1.8.2 Total world energy consumption a statistical view

Table no. 1.1 Total world energy consumption in 2010 (stastical review)

(Source: https://en.wikipedia.org/wiki/World_energy_consumption)

Non-renewable		*Renewable*	
Energy Sources	**MTOE**	**Energy Sources**	**MTOE**
Oil	3,882	Ethanol	44
Coal	3,278	Biodiesel	14
Gas	2,653	Wind	89
Hydroelectricity	740	Geothermal	13
Nuclear	610	Solar	4

At the end of 2013, the installed capacity worldwide photovoltaic capacity reached 139 GW, about 1% Electricity demand. By 2050, solar energy is expected to become the Electricity, with solar PV and solar thermal contributing 16% and 11%, respectively. This will require PV capacity to grow to 4,600 GW, of which more than half will be deployed in China and India.

1.9 **Need of the project**

As energy is highly in demand we are consuming conventional sources for energy production and utilizing it for domestic purpose and for other commercial use. Consumption of conventional sources giving rise to environmental issue as it is releasing many pollutants into environment. The other problem is that these sources are in limited amount and it will finish soon as its consumption rate is high. The main alternative to this issue is that we can change the source of energy from conventional to non-conventional so that it will not pollute the environment and easily available in abundant amount too. The non conventional energy sources like sun light, wind energy, Tidal energy and thermal power energy. My study area is falling under **Lovely Professional University**. This university is situated in Phagwara, Punjab, India. In institution, energy requirement is more as it required energy for domestics and for education purpose. LPU is having total population more than 40,000 and spread over 600 acres area. Its energy consumption rate is very high. University is purchasing energy from electricity board and paying high amount for its transport arrangements. These are the following points which leads to needs of the project are given below-

- High expenditure on purchasing electricity and for its transport arrangement system
- High setup cost of electric sub stations
- Emission of pollutants from the electric appliances.
- Increase in global warming

So these are the main issues which are considerable and to overcome these issue non-conventional energy system setup is required so that university can generate its own energy can save the cost for other useful purposes. In this project report solar energy system is taken as alternative to reduce the expenditure of energy from outside source, resource allocation, non conventional energy system design and its payback period will be calculated.

1.10 Scope of the project

Project main focus is based on non-conventional energy system design for LPU which is solar energy based. In this system electricity will produce with the help of photovoltaic solar system and it can be utilize for many purposes within the university. Resource allocation and design will be done for many locations within university and total cost will be calculated. The main discussion will be on payback period. The scope of the project are listed below-

- Solar power provided by photovoltaic systems lower our utility bills and insulates us from utility rate hikes and price volatility due to fluctuating energy prices.
- Installing a solar system increases property value and resale opportunities.
- Purchase of a solar power system allows us to take advantage of available tax and financial incentives.
- Because they don't rely on miles of exposed wires, PV systems are more reliable than utilities, particularly when the weather gets nasty.
- PV modules have no moving parts, degrade very, very slowly, and boast a life span that isn't fully known yet, but will be measured in decades.
- Solar electric systems are quiet, reliable, fossil-fuel free.
- Unlike mobile power generators, avoids greenhouse gas emissions.

CHAPTER 2

LITERATURE REVIEW

Nonconventional energy system for various cities and towns has been widely studied throughout the world. As we know that due to exponential increase in population the consumption of energy is also increasing in exponential manner. The uses of conventional sources are increased up to maximum level and most probably in future it will over. This is Major problem and majority of researchers concentrated on this issue. Numbers of researchers have tried to find out new techniques for reducing the consumption of conventional sources and to replace it with non conventional sources which are available in abundant amount on earth. This report represents a review of the available literature on non –conventional energy system and their designs in India and in other different countries.

J.P Painuly, et.al (2000) [11] had review on "Barriers to renewable energy penetration; a framework analysis". It has been discussed that renewable energy has potential to provide clean energy and sustainability to the developing countries. A frame work has been developed in this paper to identify the barriers like technical barrier, market barrier, cost-effectiveness, political barriers etc to renewable energy and measures are suggested to overcome them.

Agustin Perez Barahona, et.al (2008) [12] had done core discussion on "The problem of non-renewable energy sources in the production of physical capital". This paper deals with the growth of usage of non renewable energy sources which are related with physical capital production. His work represents the energy saving techniques that can make sustainable growth for long run and the basic mechanism is to improve the efficiency of energy system. He developed a model which shows that physical production and consumption rates are same.

Akinboro F.G, et.al (2008) [13] had done research on "Solar energy installation in Nigeria: Observation, prospect, problem and solution". In this paper solar energy system in Nigeria, including its prospect, associated problems and possible solutions were discussed. it had been discussed that Nigeria is a developing country and it is having lot of problem related to electricity production and its supply. At present time the level of research and development in

Nigeria is at very low level and energy system is not designed properly. It was discussed that continuous uncontrolled use of non-renewable energy sources decreasing the amount of energy 9sources, so they are moving towards renewable sources and solar energy is one of them, solar energy can be used in two forms solar thermal and solar PV.

Pragya Nema, et.al (2009) [14] had research on "A current and future state of art development of hybrid energy system using wind and PV-Solar: A review". This paper is having review on combined utilization of wind and solar energy which is having tremendous results as compare the energy produce by oil. In this study a hybrid energy system is designed which consist of two or more renewable sources, power conditioning equipment, controller and power storage system. This paper is consisting of review related to PV solar-wind hybrid energy system, its design, operation and control requirements.

V.B.Omubo-Pepple, et.al (2009)[15] had done work on "Effect of Temperature, solar flux and relative humidity on the efficient conversion of solar energy to electricity, Port Harcourt, Nigeria". In this study B-K precision Model 615 digital light instrument was used to check the effect of temperature, relative humidity and solar flux on PV conversion of solar into electrical energy by using PV module. After experiment it was analyzed that output current and solar flux are directly proportional and relative humidity have negligible impact on output voltage.

Bhubaneswari Parida, et.al (2010) [16] had "review on Photovoltaic technologies". It has been discussed that global environmental concerns and huge demand of energy with increase demand of renewable energy are giving chances for utilization of non conventional sources. Solar energy is the most pure form of renewable energy which is most abundant and clean. Photovoltaic technology is the technique in which sunlight is converted into electricity by means of using different light absorbing materials. This paper is having discussion on different existing performance and reliability evaluation models, their sizing and control, grid connection and distribution.

Yuvika Gupta, et.al (2011) [17] had research on "Carbon credit: A step towards Green Environment". It was discussed that green environmentalist aim was to promote policy and business that work for environment. So trade of carbon credits taking place in both within regulated area and outside the regulated area. its giving rise in the carbon market, the main purpose is to control the emission of green house gases like carbon dioxide etc. this paper is having basic discussion on methods used for reducing pollution and on carbon market.

Deepak Kumar, et.al (2012) [18] had research **"**On the Optimum Utilization and Promotion of Renewable Energy Sources in India". This study is mainly focused on to increase the renewable technology and to make the sustainable growth. It was stated that 8-9% of GDP rate and 17% of the world population, India is the one of the biggest consumer of energy. Discussion was done on present renewable energy scenario in India and various legislative initiatives were discussed to improve the energy sector. At last other all sectors like residential, transportation and industrial sectors are discussed in detailed in which energy consumption is increased due to change in technology. At last recommendation was mentioned that replacement of the old machinery/equipment by new efficient technology can enhance the production and increase the efficiency of the system. Proper maintenance, monitoring, auditing can increase the productivity and the efficiency of the projects.

M.S. Jamel, et.al (2012) [19] had research on "Advances in the integration of solar thermal energy with conventional and non conventional power plants". The main discussion is on rising price of fuel and the pollution created by fossil fuel used for electricity generation. The main alternative for these problems are renewable energy sources and solar energy is one of them which is proven best for overcoming the pollution problem. A review is done on hybrid solar power plants and best option is discussed with its advantages and disadvantages.

Swapnil Dubey, et.al (2012) [20] has research on "Temperature Dependent Photovoltaic Efficiency and Its effect on Photovoltaic production in the world-A review"**.** It was discussed that temperature plays an important roles in power generation from PV system. As temperature increases, solar cell performance starts decreasing. Operating temperature is having important role in PV system. Generall1y in high temp region PV module with less sensitivity to temperature are provided to increase the efficiency of PV system and vice versa for low temperature region. This paper is having main discussion of ambient temperature and geographical distribution of energy distribution of solar irradiance on PV module efficiency.

Vivek Birla, et.al (2012) [21] had research on “carbon trading- the future money venture for India”. This paper is having discussion that carbon trading is advance format where firms buy or sell carbon permit for reduction of carbon emission. Each country who signed the international Kyoto Protocol of United Nation is advised to cut the emission of carbon dia-oxide to avoid the future climate related problems. India also has signed this convention and using advance technologies for reduction of generation of carbon dia-oxide. This paper is having discussion of carbon trading In India.

Dayal Singh Rajput, et.al (2013) [22] has research on “Effect of dust on the performance of solar panel, Bhopal, India”. It has been discussed in this paper that now a day research developments in PV system has given more concern on radiation availability, PV sizing, and operating strategies but dust influence is not considered for the design. This paper is representing the experimental data and results which show that dust having significant effect on PV cell efficiency.

Ishaq M., et.al (2013) [23] had research on “Design of an off grid PV system: A case study of govt. technical college, Wudil, Kano state, Nigeria”. Solar System was designed for an off-grid system for this research load was estimated for the govt. technical college. On the basis of load estimation no of PV modules, battery, inverter, voltage regulator and wires are calculated. Approximate cost estimation was done for the project which includes the maintenance cost too. Al last payback period is calculated which was 3 years and that was less than the life span of PV system.

Miss L.Raja Rajeswari, et.al (2013) [24] had reviewed on “Design of Stand Alone PV system – A case study”. In this paper two methods are discussed for the design of standalone PV system. One method is based on data collection related to solar irradiance for the location and load calculation, the second was only on the basis of load calculation. For the design part other constraints are also discussed in this case study.

Mohd Tariq, et.al (2013) [25] had research on “Effective battery charging system by solar energy using C programming and microcontroller**”.** This paper is having discussion on fossil fuels which are the main reason for releasing the pollutants into the atmosphere and increasing the green house effect. Increased demand of energy and to protect the environment form pollutants.

Country is moving towards renewable sources. In this paper a solar energy system is used for generating electricity and used for charging the devices. This was most reliable and effective tool for generating electricity which consists of three modules like DC to AC convertors, Microcontroller and charging outputs. Microcontroller is used for programming the input of energy during night and non available periods of light.

Pranita pranjale, et.al (2013) **[26]** had research on “Non Conventional Sources of Energy-Applications of Solar Energy in Architectural Buildings”. It has been discussed that electric energy play important role in human life and used for many purposes. At Present time Conventional and non-conventional energy sources are utilized for energy production but non-conventional sources are having more significance rather than conventional sources. In this paper all the non conventional energy sources are discussed in detail and their applications in day today life. Solar energy is having so many applications in architecture use, building use and agriculture uses etc. these sources having high potential to generate electricity due to large availability of sun light in tropical region. Solar energy is much beneficial for building elements.

Varun Kumar Singh, et.al (2013) **[27]** had research on “Photovoltaic-A Review of the Solar Cell generation”. This paper has discussion on past and present solar cell modules technologies. In this paper advantages and disadvantages of mono-crystalline, polycrystalline and amorphous technologies are discussed in detail. A new technology (DSSC) Dye sanitized solar cell a low cost technology is discussed in detail. This technology is high lightened for its good performance and stability.

Ashok upadhyay, et.al (2014) [28] had done research on “Solar Energy Fundamentals and Challenges in Indian restructured power sector”. In this paper a review is taken and present condition of solar energy production is described for Indian cities. Solar energy has huge phenomenal growth in recent year due to cost reduction and technology developments. There are so many policies which are supportive for solar energy production like Electricity act 2003, National electricity policy 2005, Tariff policy 2006 and National action plan of climate change. The basic two methods are discussed solar thermal and photovoltaic cells method. Advance technology was discussed that if nanopillars are used instead of old design then it can absorb

99% of visible light. Other advance technology like powerful solar cell, nano-wire cells, flexible solar cells, solar collectors and nano nets are discussed in detailed.

C. Marimuthu, et.al (2014) [29] had research on "A Critical Review of Factors Affecting Wind-turbine and Solar Cell System Power Production". It has been discussed in the paper that power sector is contributing for global warming and it's a critical issue. Renewable energy sources are the alternatives for reducing carbon emission and to reduce the environmental impact. Solar and wind energy are the best methods for energy production and more efficient. This paper discussed the effects of radiation and temperature on solar power generation. He has also developed the mathematical model for studying the parameter which impacts the power generation through wind turbines.

Manoj Kumar Panjwani, et.al (2014) **[30]** had research on "Effect of altitude on the efficiency of solar panel". It was discussed that efficiency of solar panel is decreased by many factors like humidity, temperature, dust, clouds and elevation. In this paper Altitude is particular parameter whose impact is determined experimentally. It was found that altitude is having 7-12% power accession due to placement of solar panel at a height of 27 m from ground level. This paper suggests that if solar panels are placed at higher altitude then it can give more power as compare to ground level.

Sachi Sharma, et.al (2014) **[31]** had research on "Non Conventional Energy's Overview Sources of India". It has been discussed that energy is required of doing work. Everything in world is happens in form of energy from its one form to another form. Broadly we have two sources of energy for windrowing energy i.e. conventional and non-conventional sources. Initially conventional sources were used for energy production but due to limit availability its start finishing. Due to energy crisis we shifted towards other alternatives of energy production and these are non conventional energy sources. These sources are more environment friendly as compare to conventional sources. This paper is having discussion on non conventional energy sources and their applications.

Hina Fathima, et.al (2014) **[32]** had research on "Problem in conventional energy sources and subsequent shift to green energy". This paper is consisting of study related to problems existing in conventional methods of generating electricity and a brief insight is taken into Indian Power sector. Power generation statistics is discussed for conventional and non conventional sources. Thermal power generation is the major source of electricity which contributes to power sector. The fuels used in thermal power plant are coal, natural gases and diesel etc. use of these conventional sources giving rise to green house gases like CO_2, SO_2, and NO_2 which contributes towards global warming. This shows that we required alternate sources for replacement of conventional sources with non conventional sources.

Md. Niaz Murshed Chowdhury, et.al (2014) [33] had research on "Present scenario of renewable and non- renewable sources in Bangladesh: A compact Analysis". This research is focused on present condition of renewable and non renewable sources and there effective management in Bangladesh. It was discussed that Bangladesh economy can be increased when govt. and private sector will work together on renewable energy sources. Bangladesh is having lot of natural resources like natural gases, coal, forest, fisheries and there protection can save country from budget deficiency. Laws and rules implementation should be imposed so that natural sources can be reserved and renewable sources utilization can be increased for energy production.

Wentao Feng, et.al (2014) [34] had done work on project "Off grid PV system design for Haiti School Project Lowell, USA". This work consist of design of off grid Photovoltaic system which consist of PV panels, battery, inverter and transformer etc. the sizing of system was done to fit the system on roof and energy production data was calculated and compared with data given from NASA website. This system was most effective and it reduced the electrical energy requirement for the school.

Abdeen Mustafa Omer, et.al (2015) [35] had review on "non conventional energy system and environment pollution control". It has been discussed that the huge rise in price over the last few years changing the choice of energy sources which are having more advantages and easily available for use. The main alternative of energy sources is renewable sources like water, wind and thermal energy. The main motive of these sources is to reduce the emission of CO_2 which contributes for global warming. This paper is having discussion regarding the potential of stationary and portable power market and cleaner technology. The main environmental issues are discussed like green house effect, ozone depletion, acid rain etc.

Ahmed Hossam Eldin, et.al (2015) [36] had "A Review on Photovoltaic Solar Energy Technology and its Efficiency". It has been discussed that sun is the main source of all types of energy. It can be converted into electricity by different method. Photovoltaic cell is the common method for converting sun light into electricity. This paper is having reviewed that how photovoltaic cell can be used in solar energy system and used as effective system for energy generation. In this paper PV technology is discussed with its new characteristics and comparison is done.

Dr. Ashish K. Desai, et.al (2015) [37] had research on "The concept of Carbon credit and comparison of co_2 emission of India with selected developing countries". The main discussion is on carbon credit accounting. Data is analyzed for emission of carbon dioxide for per country for selected period of 1990 to 2013. At last it is concluded that financial accounting standard should be established for carbon credit.

Dr. Meenu Maheshwari, et.al (2015) [38] had research on "carbon credit accounting: A case study of Delhi Metro Rail corporation". The main discussion is done on present condition of changing climate and emission of green house gases. International treaty Kyoto Protocol has taken initiative to reduce the emission of GHG'S through carbon trading business. Carbon credits are the certificates which are issued for certifying emission reduction of GHG'S. A case study of Delhi metro rail corporation, Delhi has been discussed here which was the first world project who wins the carbon credit certificate for representative braking system which reduce the energy consumption and pollutant emissions.

Dr. Shurveer Singh Bhanawat, et.al (2015) [39] had "An analysis of carbon credit revenue practice in Indian Corporate Sector". He had discussion that many developed countries are taking initiative to borrow carbon credit from developing countries through international market. New CDM projects have given revenue to the country and its also making the environment clean. This paper is having more discussion on revenue generated through carbon crediting in corporate sector.

Fabio Veronesi, et.al (2015) [40] had research on "Evaluating the use of open data to estimate the global solar energy potential"**.** It was discussed that due to increased demand of energy and due to global efforts to reduce carbon dia-oxide emission solar energy is playing an important role in energy sector. The main motive is to aware the people that how much electricity can be generated from solar. For this open data was used to produce interactive web map that is showing the potential of generation of electricity for each country. Advancements were made in the previous technology including mean annual temperature data to adjust the performance ratio of solar panels.

Prakash Kumar sen, et.al (2015) **[41]** had “A review of major non-conventional energy sources”. The main discussion is on energy that it’s an important element of life. The demand of the energy is directly related to the progress of mankind. The primary sources of energy are in limited amount and having bad impact on environment and it is changing the modern trend towards non-conventional energy sources. Numbers of non-conventional energy systems are discussed in details which are present in huge amount and having less environmental impact. Wind energy, solar energy, tidal energy, thermal energy and biomass energy are the main focus area for the review.

Karan sahni, et.al (2015) **[42]** had review on “Future energy non-conventional energy resources”. It has been studied that energy demand is increased in rapid manner and to meet the demand is the major concern of all nations. Due to excessive use of fossil fuel and coal and petroleum environment is degraded badly and it is giving rise to move towards non-conventional energy sources. In the hunt to sustain galloping economic activity, the dependence on coal and oil has soared at a phenomenal rate over the years. There are abundant renewable sources of energy such as wind, sun, water, sea, biomass apart from even daily wastes. These all sources are discussed which include the principle of energy conversion, site selection criteria, energy production and storage and its advantages.

Sathyanarayana P., et.al (2015) **[43]** had research on “Effect of shading on the performance of solar PV panel”. This report says that non conventional energy sources are gaining more importance as compare to other conventional sources. Solar energy systems are one of them. The use of PV modules is increased now a day because of its easy installment and less maintenance expenditure and it is eco friendly too. This paper is having systematic approach to study the effect of shading due to buildings and tress on solar panel efficiency. A direct relationship was discussed between short circuit current and solar irradiance under uniform shading approaches.

Anyanime Tim Umoette, et.al (2017) [44] has recently published his paper on "Design of standalone floating PV system for lbeno Health center, Nigeria". In this paper it was discussed that for designing PV system load estimation is required. On the basis of load estimated no of PV modules, battery, voltage regulator and inverter are estimated. There was offshore temperature and wind speeds were affecting the efficiency of panel, so its selection was done on the basis of that factors. The day of autonomy was selected 3 days for the design of solar energy system.

CHAPTER 3

LOCATION DETAILS

3.1 General

The growing energy consumption in the country has always dependent on fossil fuels such as coal, oil and gas. Cumulate prices for oil and gas, as well as their potential bottlenecks have uncertainty about the security of energy supply in the future, which have had a grave impact on the growth of the economy. Increased use of fossil fuels also causes serious environmental problems. So is a primary need for renewable energy sources such as solar, wind, tidal, Biomass and energy from waste. My study area is in Punjab region, India. The Jawaharlal Nehru National Solar Mission, also known as the National Solar Mission, is an initiative of the Government of India and State Governments to promote solar power. The mission is one of the several initiatives that are part of the National Action Plan on Climate Change. The program was inaugurated by former Prime Minister Manmohan Singh on 11 January 2010 with a target of 20GW by 2022 which was later increased to 100 GW by the Narendra Modi government in the 2015 Union budget of India. India increased its solar power generation capacity by nearly 5 times from 2,650 MW on 26th May 2014 to 12,288.83 MW on 31st March 2017. The country added 5,525.98 MW in 2016-17, the highest of any year [45].

3.2 Geographic details

Punjab is in northwestern India and has a total area of 50,362 square kilometers (19,445 sq mi). Punjab is bounded by Pakistan on the west, Jammu and Kashmir on the north, Himachal Pradesh on the northeast and Haryana and Rajasthan on the south. The geography and subtropical latitudes location of Punjab result in large fluctuations from month to month. Even though only limited regions experiencing temperatures below 0^0C, frost often is found in the majority of Punjab in the winter. The temperature rises gradually with high humidity and overcast skies. However, the rise in temperature is steep, if the sky is clear and the humidity is low. Maximum temperatures usually occur in May and June. The temperature is above 40 ° C throughout the region during this period. Ludhiana recorded the highest maximum temperature of 46.1 ° C with Patiala and Amritsar recording 45.5 °C. The maximum temperature during the summer in Ludhiana remains above 41 ° C for a period of a year and a half months. These areas experience low temperatures in January. The solar rays are oblique during these months and cold winds control the temperature in the day. [46]

Figure no. 3.1 Punjab Location map (source: http://www.mapsofindia.com)

My study area is Lovely **Professional University**. LPU is situated in Phagwara, Punjab, India. Its latitude and longitude is 31.2556° N, 75.7055° E. Lovely professional university is educational institute which is situated in Phagwara Tehsil in Kapurthala district of Punjab State, India. The total area covered by LPU is 600 acres which is semi urban. The total population of the University is more than 40,000.

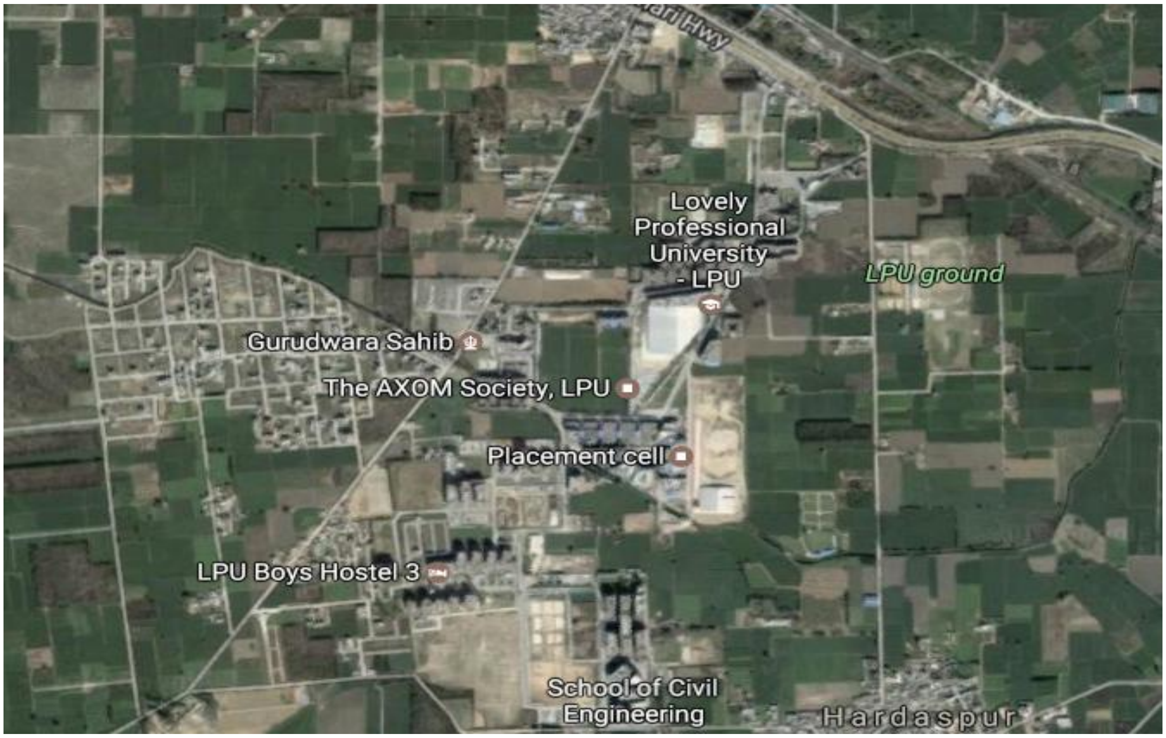


Figure no. 3.2 LPU location on map. (Source: Google map)

Fig. no 3.3 LPU detailed Map (source: LPU design cell)

3.4 Source of electricity in Punjab

There are two main sources of electricity generation in Punjab. These are given below.

Coal based thermal power plant

- Guru Nanak Dev Thermal Plant, Bhatinda. It is a 460 MW (110x2 + 120x2 MW) coal-based thermal power plant.
- Guru Gobind Singh Super Thermal Power Plant, Ropar. It is a 1260 MW (6x210 MW) coal-based thermal power plant.
- Guru Hargobind Thermal Plant, Lehra Mohabbat, Bhatinda. It is a 920 MW (2x210 MW, 2x250 MW) coal-based thermal power plant.

Hydel base power plant

- Ranjit Sagar Dam, 600 MW
- Shanan Power House. It is a **110 MW** hydro power plant.
- Anandpur Sahib Hydel Channel, 67 MW
- Mukerian Hydel, 207 MW
- UBDC Hydroelectric Power House, 45 MW
- Bhakra Nangal Project
- Gangual Power house
- Pong Dam Project
- Dehar Power House
- Thein Dam Project
- Shahpur Kandi Project

3.5 Renewable Energy Potential in Punjab

In March 2015, the installed capacity of Punjab to renewable energy consists of solar energy (200 MW), biomass (63 MW), and small hydro power (135 MW), waste to energy (1 MW), and of the Cogeneration (410 MW). It has also received an award by the' MNRE to be one of the members of the most efficient in terms of capacity more renewable energy. The Punjab has also set the objective of increasing the percentage of renewable energy in the energy mix to a total of

15 per cent in 2022. It aims for a total installed capacity of 5 400 MW of capacity for renewable energy by 2022 which includes 300 MW from biomass, 680 MW from the co-generation, 4 200 MW of solar energy, small hydroelectric plants of 200 MW and 20 MW from waste to energy. [47] The Punjab has great potential of solar energy and biomass as shown in Figure 3.3 below.

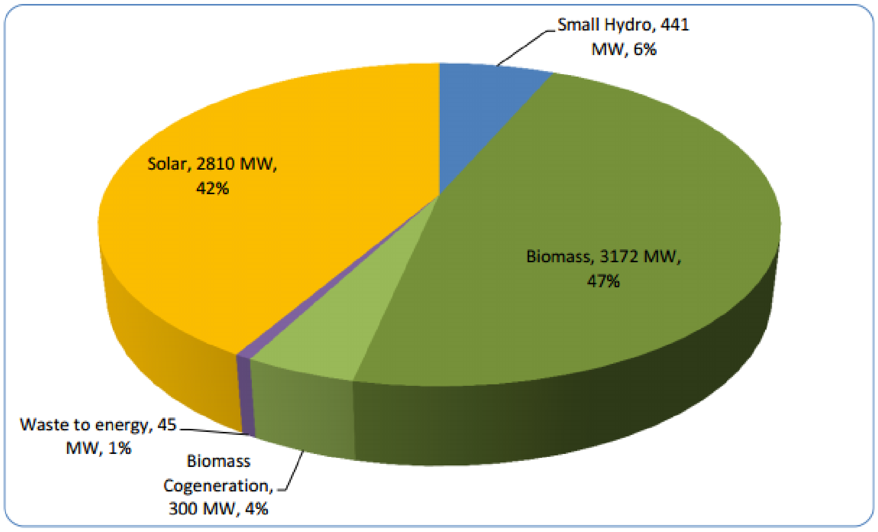


Fig. no. 3.3 Renewable Energy Potential in Punjab (source: MNRE Annual Report 2014)

3.6 Solar irradiance of Punjab

The radiation coming directly from the Sun received at the Earth's surface is called direct solar radiation. The amount of scattered radiation coming from all other directions is called diffuse solar radiation. The sum of both components as received on a horizontal surface is called global solar radiation. A significant fraction of the incoming solar radiation is reflected back by the surface. The surface albedo, defined as the ratio of the reflected over the incoming radiation, depends on the nature of the surface, solar zenith angle, and wavelength. For a water surface the albedo is about 0.06, whereas for snow the albedo is about 0.6–0.8. The albedo of bare sea ice is about 0.4–0.6. Since large areas of earth are covered by water, snow and sea ice, changes in the snow and sea ice cover can have a significant impact on the global albedo. Bare land surfaces have typical surface albedo of 0.1–0.35, with the highest value for the desert sand. Albedo of most vegetation surfaces fall in the range 0.1–0.25. The albedo for green vegetation depends greatly on wavelength, reflecting strongly in the near infrared but absorbing in the ultraviolet and visible regions.

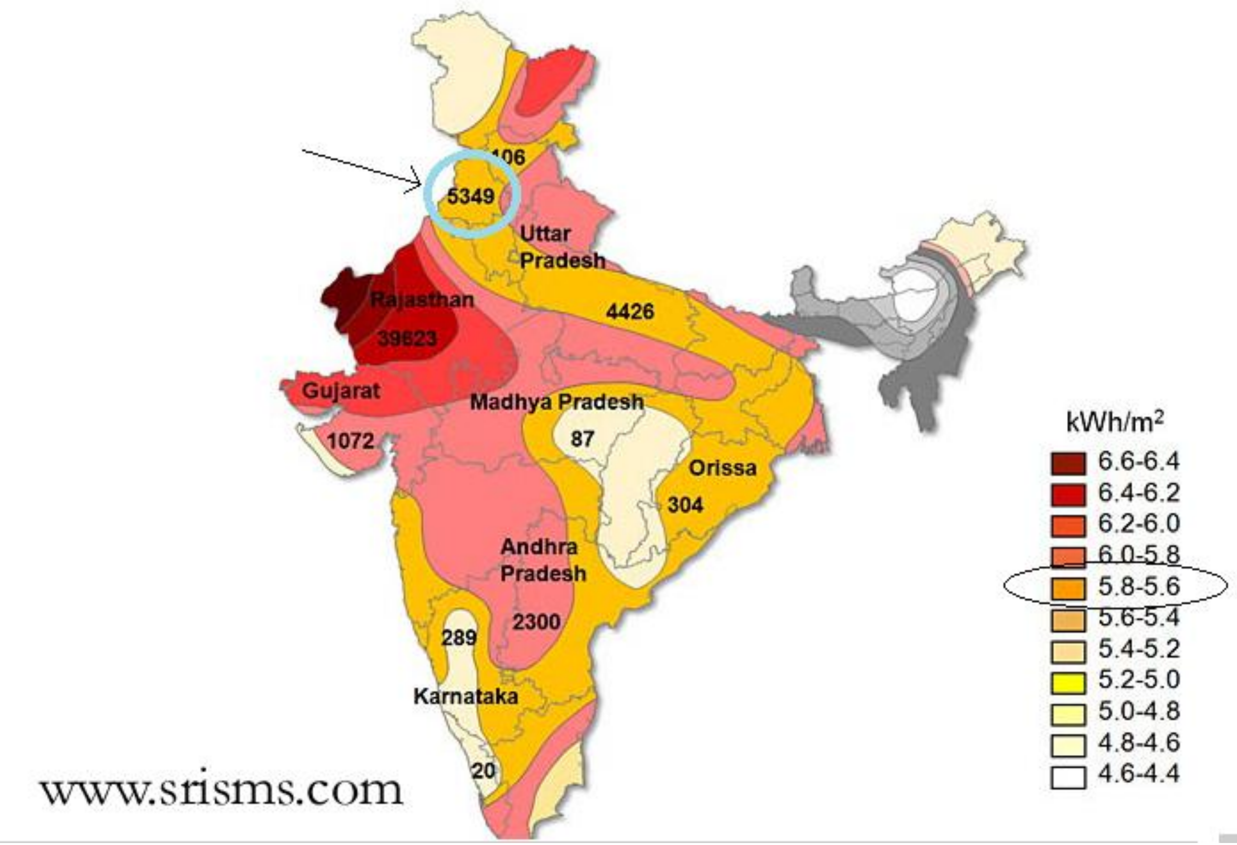


Fig. no 3.4 Solar irradiance of Punjab (source: www.srisms.com)

This value gives us idea that Punjab is receiving good amount of solar radiation which can be used for generation of electricity which is renewable in nature and eco friendly. In this report suggestion is made for the solar energy system which will be used for generation of electricity. This method is very useful and economic too. University can generate its own electricity with solar energy system and can save the energy cost and can give contribution towards energy saving mission.

CHAPTER 4

MATERIAL AND METHODOLOGY

4.1 General

This project report is based on non conventional energy system which includes solar energy. Solar energy is the radiant heat coming from sun that converted into useful work by using technologies like photovoltaic's, solar heating, solar thermal energy etc. it is important source of non conventional energy system and its technology as classifies as passive solar or active solar depends upon how energy is captured and distributed and converted into solar power. Photovoltaic and solar water heating comes under active solar techniques while orienting building towards sun, selecting material with thermal mass etc are coming under passive solar techniques. Techniques are given below in the figure.

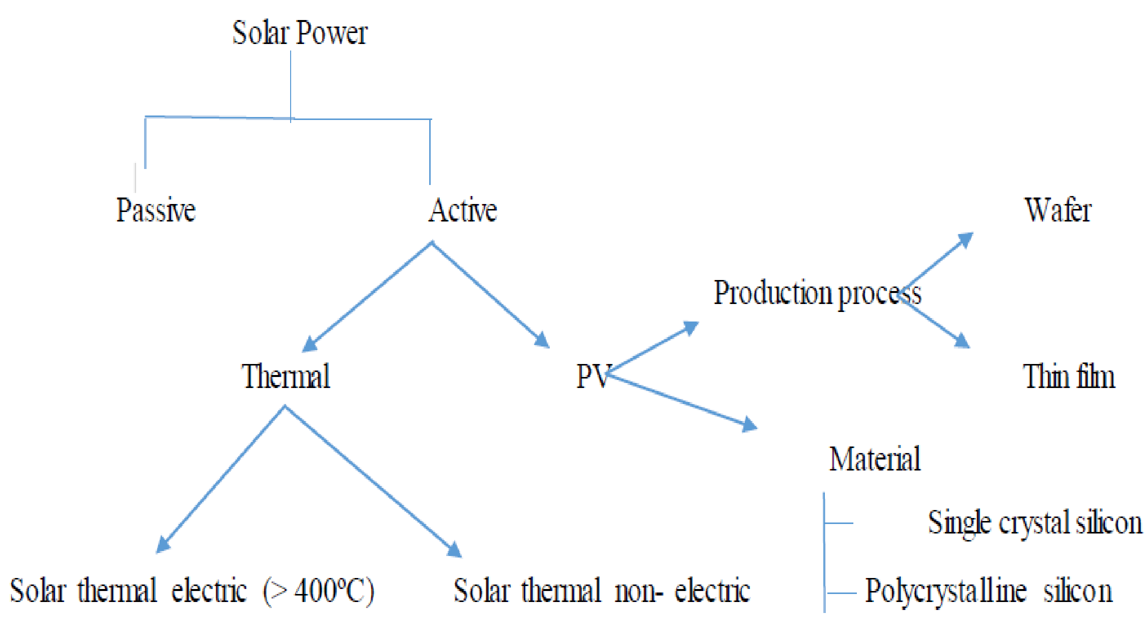


Fig. no. 4.1 Types of solar power techniques.

In this project active solar technique i.e. photovoltaic technique is used to convert solar energy into solar power.

4.1.1 Photovoltaic technology

Photovoltaic is the term which converts light into electricity by using semiconducting material that is having photovoltaic effect. A photovoltaic system consist of solar panels, each consist of number of solar cells, which generate electricity. This installation can be done in many ways like roof mounted, wall mounted and ground mounted. The main advantages of solar PV is that its operation is generating electricity which is pollution free and no GHG's emission [48]. Silicon is the best material which is used in solar cell to convert solar light into electrical energy. The main disadvantage of this system is that it is operational only in the presence of sunlight. The direct sunlight contact is useful for electricity generation. Other factors like clouds, dust, shades and indirect light are the factors which decrease the output of the system. Photovoltaic technology is of following types -

1. Crystalline technology
2. Thin film technology
3. Concentrated photovoltaic technology (in this project discussion is only about crystalline technology which consist of mono crystalline and poly crystalline structure)

Fig. no. 4.2 Photovoltaic systems (source: Google)

4.1.2 Principle of photovoltaic cell

Solar module is consisting of number of layers. These are given below

1. **Protection layer**- usually made of glass or transparent plastic
2. **Front contact**- the front contact should be transparent so that light would get in touch with cell.
3. **Absorption material**- the layer where absorbed light is converted into electric current, semiconducting material is used like silicon.
4. **Metal back contact**- a conductor at the back which completes the electric circuit.
5. **Laminate film-** the structure which is water proof and insolated from heat.
6. **Back glass-** back side protection of the module with glass material.
7. **Connectors-** module is fitted with connector's points and cable.

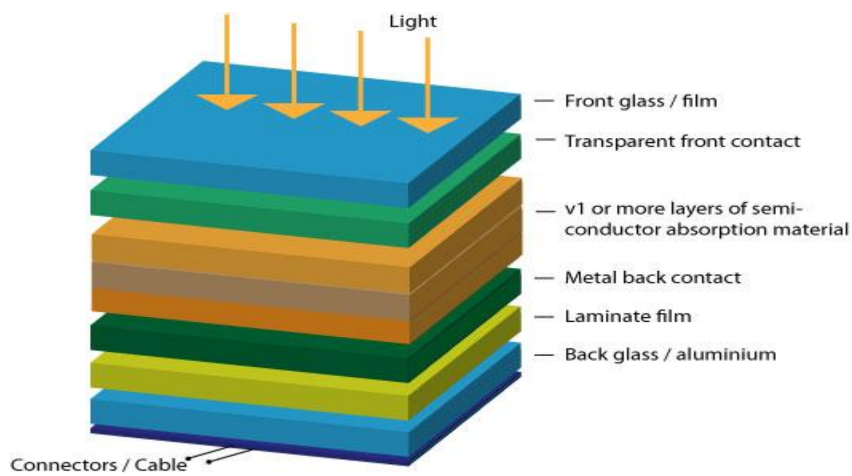


Fig. no. 4.3 PV Module cross section
(Source: http://www.greenrhinoenergy.com/solar/technologies/pv_cells.php)

4.1.2.1 The photo-effect

The light coming from sun consists of photons which carry quantum energy. Each photon is having one particular wavelength and frequency. Photon having high frequency having more energy as compare to low frequency [49].

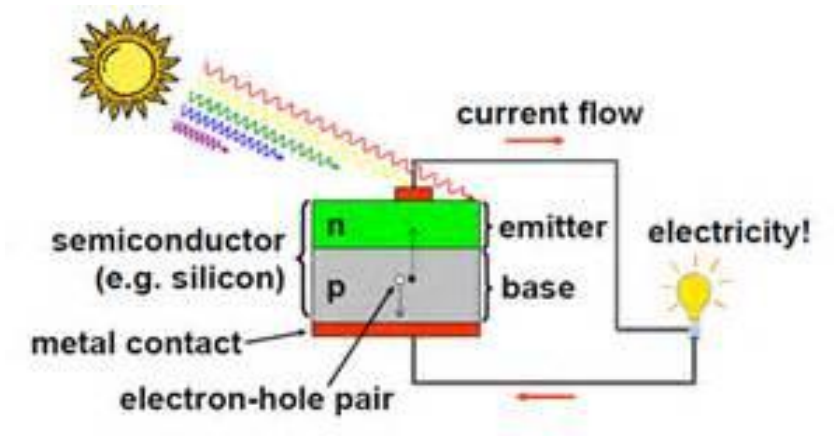


Fig. no. 4.4 The photo-effect (Source: Google)

4.1.3 Types of crystal structure

The structure of semiconducting material is having impact on efficiency of photovoltaic cell. Generally there are two types of crystal structure.

1. Mono-crystalline
2. Polly crystalline

Mono-crystalline structure- The atoms form a regular lattice. Due to the regular structure, mono-crystalline has a better response rate. Its Purity is > 99.99999%. It consists of silicon in which the crystalline grid of the whole solid is continuous, without breaking to its edges, and free of any grain boundary. Mono-Si can be prepared intrinsically, consisting only of excessively pure or doped silicon, containing very small amounts of other elements added to change its semiconductor properties.

Polly crystalline structure – This is in effect a series of crystals rather than one crystal. Its Purity is 99.999%.The polysilicon is composed of small crystals, also known as crystallites, which give the material its typical effect of metallic scales. While polysilicon and multisilicon are often used synonymously, multi-crystalline generally refers to crystals larger than 1 mm. Multi-crystalline solar cells are the most common type of solar cells in the fast growing PV market and consume most of the polysilicon produced worldwide.

4.1.4 Typical arrangement of photovoltaic system

Photovoltaic system requires different units for its setup. These are Photovoltaic module, Charge controller, Battery (optional), Inverters and Loads.

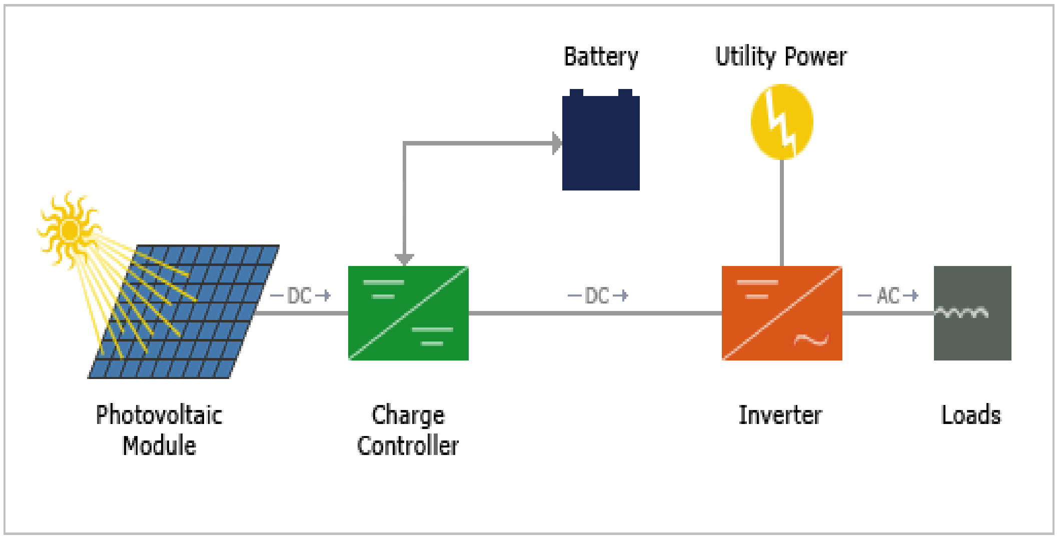


Fig. no. 4.5 Systematic arrangement of photovoltaic system (Source: Google)

4.1.4.1 Photovoltaic module

A PV module consists of many PV cells wired in parallel to increase current and in series to produce a higher voltage. 36 cell modules are the industry standard for large power production.

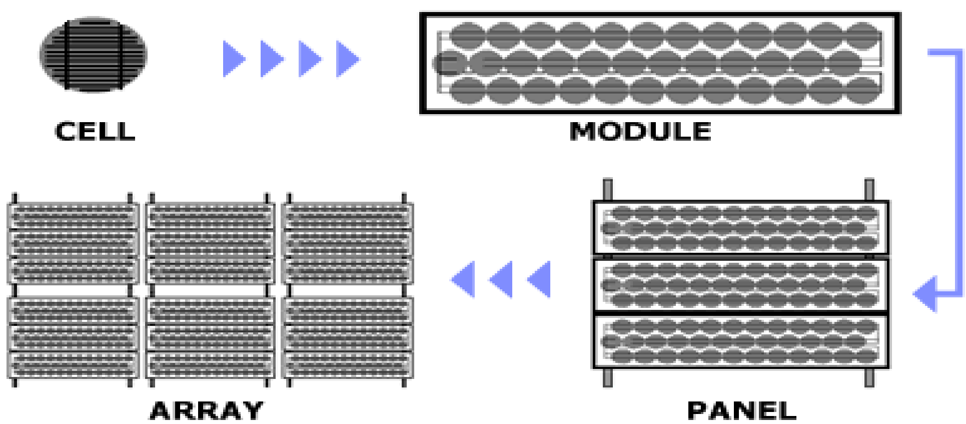


Fig. no. 4.6 basic arrangement of module

(Source: http://www.solardirect.com/pv/pvlist/pvlist.htm#url)

- **Cells-**Semiconductor device that converts sunlight into direct current (DC) electricity
- **Modules-**PV modules consist of PV cell circuits sealed in an environmentally protective laminate and are the fundamental building block of PV systems
- **Panels-**PV panels include one or more PV modules assembled as a pre-wired, field-installable unit.
- **Array-**A PV array is the complete power-generating unit, consisting of any number of PV modules and panels.

Photovoltaic modules are hold with the help of mounting structures which are of the following types-

a) **Pole mounted**- Solar panels are fixed on poles.
b) **Ground mounted**- Solar panels are fixed on ground with supporting arrangement
c) **Roof mounted**- Solar panels are fixed with roof arrangement.
d) Tracking mount- solar panels are fixed with such a moveable arrangement so that panel with track the direction of sun. This one is expensive one.

Photovoltaic systems range from small systems mounted on the roof or integrated in buildings with capacities of a few tens of kilowatts to large power plants hundreds of megawatts. Today, most photovoltaic systems are connected to the grid, while off-grid or stand-alone systems represent only a small portion of the market**.** Grid connected system is the one in which no battery is provided while the off grid system is one in which battery is provided for storing the charge.

4.1.4.2 Charge controller

We will need a controller to extend the life of our photovoltaic system battery. The most basic function of a controller is to prevent overcharging the battery. If the batteries are allowed to overload routinely, their life expectancy will be reduced dramatically. A controller detects the battery voltage, and reduces or stops the charging current when the voltage is high enough. This is especially important with sealed batteries where we cannot replace water that is lost during overload. Charge controller is not required when the source of charge is very small and the battery is very large in comparison. If a photovoltaic module produces 1.5% of battery ampacity or less, then no load control is required [50].

4.1.4.3 Battery

The batteries accumulate the excess energy created by our PV system and store it to be used at night or when there is no other energy input. Batteries can discharge quickly and produce more current that the charge source can produce on its own, so pumps or motors can run intermittently. Battery is optional as we can directly take the supply from the system but it is DC in nature so invertors is required for converting current from DC to AC if building is equipped with AC loads. Generally lead acid batteries are used for solar projects.

4.1.4.4 Inverters

An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the resulting AC can be at any required voltage and frequency with the use of appropriate transformers, switching and control circuits. Inverters are required only if the building load is AC based, if building is equipped with DC load then no need to provide inverters.

4.1.4.5 Load

Load is simply anything which dissipates electrical energy. An electrical load is an electrical component or portion of a circuit that consumes (active) electric power. This is opposed to a power source, such as a battery or generator, which produces power. In electric power circuits examples of loads are appliances and lights. The term may also refer to the power consumed by a circuit. Line and load refer to the power connections coming into or out of electrical devices in the scheme of our electrical system. Few examples are tube light, fans, AC's and motors etc.

4.2 Methodology

After doing a review of many research papers the design of non conventional energy system follow the systematic approach. . It includes preliminary survey, resource assessment, resource assessment sources which includes metrological data collection related to solar irradiance, temperature and humidity data for particular area, estimation of sizing using resource assessment tools which includes load estimation and module estimation and determination of invertors size and cable size, cost estimation and payback period calculation. The flow chart diagram given below is showing the systematic approach for project work.

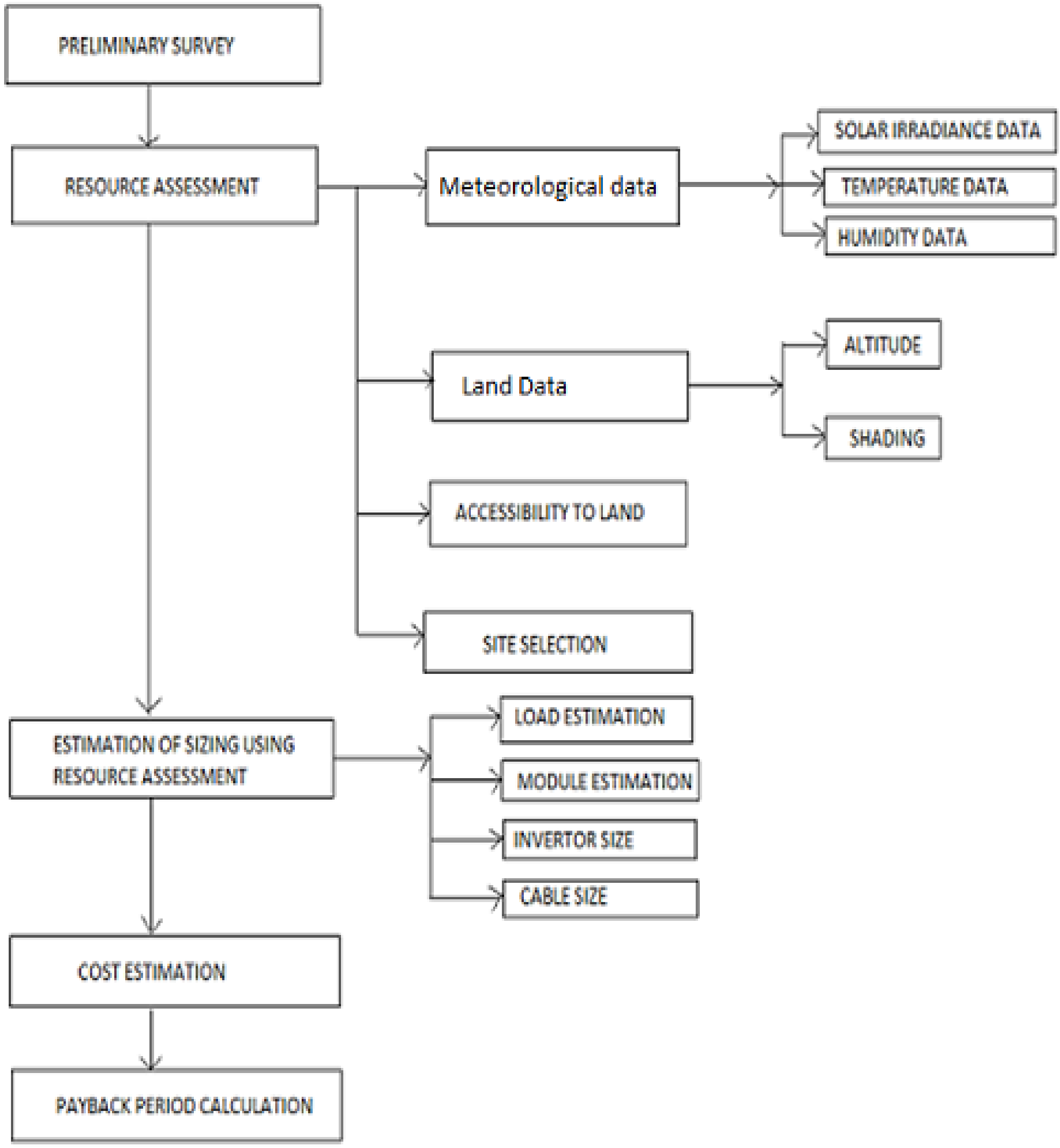


Fig. no. 4.7 flow chart diagram for systematic approach

4.2.1 Preliminary survey

The detail survey in which field is explored properly for gathering the data for best site selection is known as preliminary survey. The first step is to collect the site details and to analyze them for their best utilization. Basic data collection like site area, population, location detail, weather conditions, and existing expenditure all will be collected and utilized for project design.

4.2.2 Resource assessment

Information related to solar resources which include site-specific time series, as well as associated meteorological data, always been essential to the successful design and deployment of solar energy Systems. These systems (in particular photovoltaic and photovoltaic systems, and buildings Integrated Systems) should generally be installed near the load they are designed to Serve, reliable solar data must be available for the installation point. It is Pre-existing measurement data are unlikely to be available for calibration of these Systems or to predict their performance. Thus, site-time evaluation methods Specific data should be developed and applied. Requirements for quality and reliability Information on site-specific solar resources increases as more and more photovoltaic Linked to the grid in a distributed configuration. The need for future the resource is also increasing to help system operators integrate distributed PV Power in the most cost-effective way.

Solar Resource Assessment (SRA) refers to the analysis of a prospective solar energy production site with the end goal being an accurate estimate of that facility's annual energy production (AEP). As the designer, "SRA" term reference to site-specific measurement. That is, the systematic collection of "ground truth" meteorological data for the purpose of lowering the uncertainty of the annual energy production.

Resource assessment consist of following measurements

1. Meteorological data measurement
2. Land data
3. Accessibility to land
4. Site selection.

4.2.2.1 Meteorological data measurement

For the design of photovoltaic solar system meteorological data is measured over a certain period and satellite based data is corrected up to certain level. For this project solar irradiance, temperature and humidity will be measured on particular site with the help of one solar panel and data is collected for a period of month January to month June. The variation in the values according to the weather conditions noted down and average annual value, weekly and hourly value calculation will be done.

Generally three types of meteorological data is collected for particular proposed site

1) Solar irradiance
2) Temperature
3) Humidity

4.2.2.1.1 Solar insolation (solar irradiation)

Insolation is the total amount of solar radiation energy received on a given surface area during a given time (i.e., kWh/m2/day). It is determined by summing solar irradiance (power per unit area) over time. The results of the earth's motion and atmospheric effects at various locations have led to essentially two types of solar insolation data. These are daily and hourly.

The Earth receives a total amount of radiation determined by its cross section ($\pi \cdot RE^2$), but when rotating this energy is distributed along the entire surface ($4 \cdot \pi \cdot RE^2$). Therefore, the average incoming solar radiation, taking into account the angle at which the rays hit and that at any time half of the planet does not receive any solar radiation, is a quarter of the solar constant (approximately 340 W / m^2). The amount that reaches the surface of the Earth (as insolation) is further reduced by the atmospheric attenuation, which varies. At any given time, the amount of solar radiation received at a location on Earth's surface depends on the state of the atmosphere, the latitude of the location, and the time of day [51].

4.2.2.1.2 Solar constant

The solar constant is the amount of incoming solar electromagnetic radiation per unit area, measured on the outer surface of Earth's atmosphere on a plane perpendicular to the rays. The solar constant includes all types of solar radiation and is estimated to be roughly 1,366 W/m^2 according to satellite measurements, though this fluctuates by about 6.9 % during a year (from 1,412 W/m^2 in early January to 1,321 W/m^2 in early July) due to Earth's varying distance from the Sun (Charles Greeley Abbot between 1902 and 1957)54. For the entire planet the power is: 1366 x 1.274×1014(cross section area of earth) = 1.740×1017 W ± 3.5 % (Jules Violle, 1875).

The average value cited, 1,366 W/m², is equivalent to 1.96 cal/min/cm2 or 1.96 langleys (Ly) per minute (Samuel Pierpont Langley, 1884). [1 langleys = 1 gram calorie/cm2].

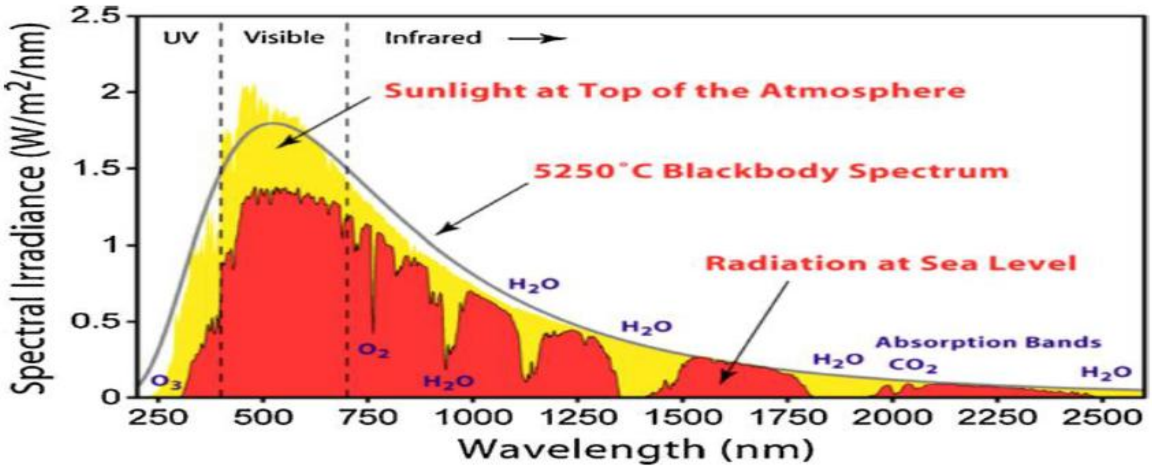


Fig. no. 4.8 Solar irradiation for the top of the atmosphere (source: Google)

4.2.2.1.3 Average Daily Solar Radiation

To provide long-term average daily solar radiation data, an average of daily solar radiation is calculated for each month over a period of typically 30 years. This data is useful both in predicting long-term performance and in analyzing the economics of solar energy systems. The actual average daily solar radiation for a given month may vary significantly from the long-term average for that month.

4.2.2.1.4 Peak Sun Hours

The number of peak sun hours per day at a given location is the equivalent number of hours at peak sun conditions (i.e., at 1 kW/m2) that produces the same total insolation as actual sun conditions.

4.2.2.1.5 Hourly Solar Radiation data for each month of a typical year

This data is useful for PV system analysis. The data consists of a selection of each of the 12 months, so that it best represents the average of that particular month over past years. A composite year with representative months selected from different years.

4.2.2.2 Temperature

Photovoltaic or solar panel that generate electricity is affected by their operating temperature, which is mainly the product of the ambient air temperature as well as the level of sunlight. Although the length and strength of sunlight are more important factors in the energy efficiency of a solar panel, temperature and other environmental factors can reduce efficiency and lower production of the solar panel [52].

4.2.2.2.1 The Effect of High Temperatures

The efficiency of the energy production of the solar panels falls when the panel reaches high temperatures. A field experiment in the UK revealed a fall of 1.1% of the maximum output for each increase in degrees Celsius of a solar photovoltaic panel at 42 degree Celsius. Laboratory experiments at Rivers State University of Science and Technology in Port Harcourt, Nigeria in 2008 found similar results; Solar panel output panel left panel Temperature constant at a temperature of 44 degrees Celsius. The temperature of the solar panels tested is average, about 20 degrees centigrade higher than the ambient air temperature. Consequently, the fall in efficiency starts at around 87 to 91 degrees Fahrenheit temperatures frequently during the summer day in temperate climates, and often exceeded in equatorial countries.

4.2.2.2.2 The Effect of Low Temperatures

Energy production of photovoltaic solar panels works more efficiently at cold temperatures. Cold and sunny environments provide optimum operating conditions for solar panels. Unfortunately, colder regions of the globe near the poles Are areas with weaker sun, Most of the year, shorter days The value of sunshine - the force of sunlight striking the ground in any particular area - decreases closer to the poles as the sun enters at a more angle Low radiance, or sunshine, Also decreases when the sun is at a low angle Solar tracking systems that adjust the angle of the photovoltaic panel to maximize the values of irradiance and sunshine can improve the ability to take advantage of the positive effects of the cold in The efficiency of the solar panel.

4.2.2.2.3 Heat sink and its impact on solar panel efficiency

There is a complex relationship at work between photovoltaic's (PV), heat and sunlight. Solar energy works best when the sun shines, But when the sun shines, everything gets warmer. Photovoltaic semiconductors offer more resistance in extreme heat, which makes them less effective when the modules should be the most efficient. Fortunately, this additional resistance is low, at most, reducing the efficiency by about 10 %. But more recent technologies, such as thin film PVs, which are not dependent on crystalline silicon to produce electricity, are less sensitive to heat losses [53].Semiconductor materials used in PVs, particularly crystalline silicon photovoltaic cells, lose efficiency as temperatures rise. The Hyper textbook of Physics explained that as the temperature increases in a conductive material, the quasi-particles, called phonons, are excited and move throughout the material, preventing the uniform movement of electrons. This impedance is what reduces the efficiency in PV when it gets too hot.

4.2.2.2.4 Average temperature calculation

Average temperature calculation is done on daily, weekly and monthly basis. This calculation will help us to know about the effect of the temperature on PV efficiency and the impact of heat sink. After an observation of few months average data is interpolated and site selection decision will be done on the basis of data. So temperature is one of the important parameter which affects the efficiency of the solar panel and its calculation is very much important. After calculation, Measures will be suggested to reduce the impact of heat sink as it decreases the efficiency of solar panel by 10 %.

4.2.2.3 Humidity

The high summer temperature is very often associated with very high humidity along the east and west coasts. Humidity affects solar PV in ways comparable to dust accumulation. Water vapor particles might reduce the irradiance level of sunlight that is required for PV panels to reach high efficiency. PV surface could be moist and light is scattered either by refraction, reflection or diffraction when it hits water droplets. If humidity penetrates into the solar panel frame, this can reduce the panel's performance producing less amount of power and worse can permanently deteriorate the performance of the modules. So humidity is an important parameter which affects the efficiency of the solar panel and its calculation is important for solar system design. Average value of humidity on the basis of weekly and monthly data will be calculated and its impact will be analyzed for solar panel efficiency. Rather than these factors we have other factors too which should be consider for design of solar energy system like wind speed, dust, clouds, snow fall, precipitation, number of sunny days in a year etc. but these are the three main important factors which should be covered for experiment part.

4.2.2.4 Land

Sunlight is at its maximum intensity when it strikes directly on a surface. Under these conditions, solar panels generate more energy than when the sun is incident at indirect angles. Therefore, the ideal angle for a solar panel is perpendicular to incoming sunlight. This angle varies by time of day, time of year and location [54].

4.2.2.4.1 Angle of Sunlight and Solar-Panel Power Output

As the angle of sunlight in a solar panel deviates from the perpendicular, the power of the solar panel starts decreasing. This is because the average intensity of light incident on a flat surface decreases as the angle decreases by 90 degrees.

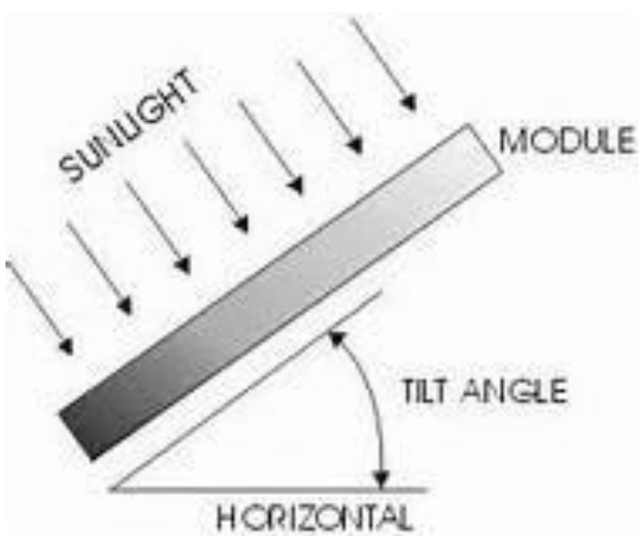


Fig. no. 4.9 angle of tilt for solar power output (source: Google)

4.2.2.4.2 Latitude and Angle of Sunlight

The maximum elevation of the sun in the sky changes depending on the latitude. As we get closer to the equator, the maximum angle of the sun from the equatorial horizon increases. For example, if we travel south in the northern hemisphere, the sun will reach an ever-higher peak in the sky. Consequently, the optimum angle for a solar panel will vary depending on the latitude**.**

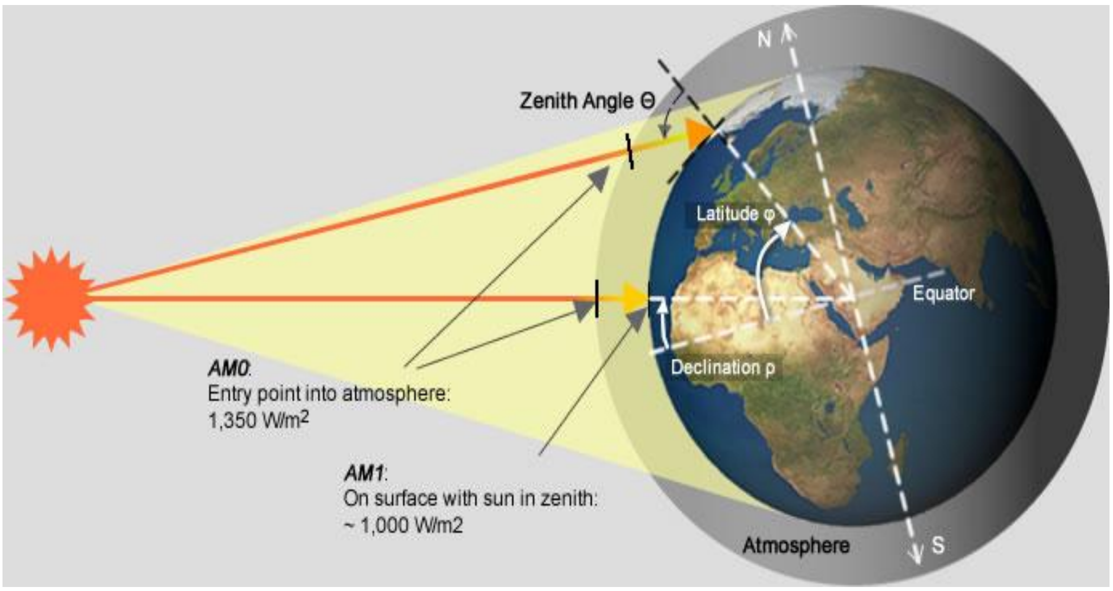


Fig. no. 4.10 latitude and angle of sunlight (source: Google)

4.2.2.4.3 Yearly movement of sun

The sun also changes its path through the sky depending on the season. Its maximum altitude is higher in the summer, lower in the winter. Due to this fluctuation, the optimal angle of inclination from the horizontal equals the latitude minus 15 degrees during the summer. In winter, the optimum angle of inclination from the horizontal position is equal to the latitude plus 15 degrees.

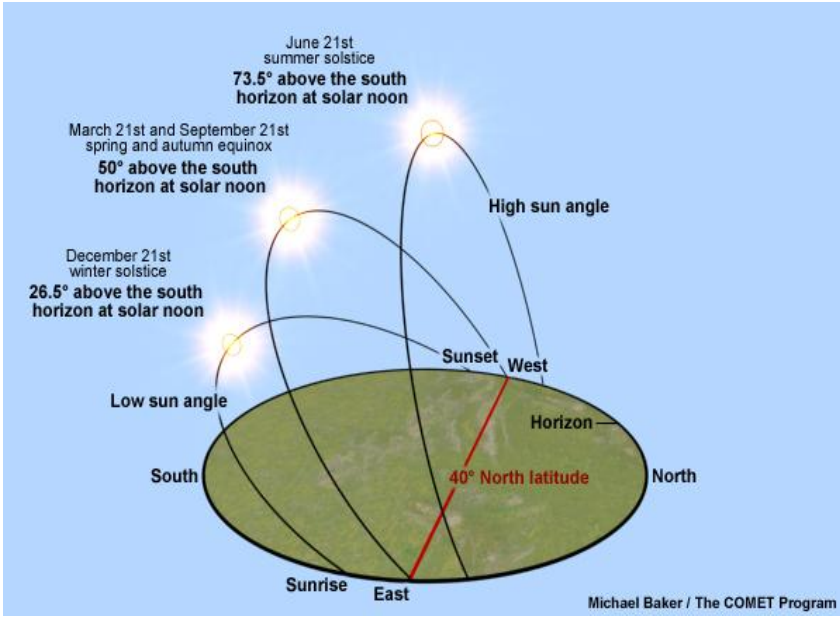


Fig. no. 4.11 Different path of sun in different season (Source: Google)

A tracking system can maximize the intensity of sunlight over the course of a day and a year. This system adjusts the angle of the panel according to the position of the sun in the sky. While this can be an expensive aspect of a small-scale solar panel system, it can increase power output by more than 20 percent. Large-scale solar farms with multiple matrices often use tracking systems to automatically adjust the angles for peak performance. Some tracking systems tilt panels along a single axis, east-west. Other systems have two axes to adjust both the east-west movement of the sun and changes in the altitude of the sun.

4.2.2.5 Land accessibility

Land accessibility is one of the parameter used for optimum and economic design of solar energy system. Land accessibility is the term used for accessing the location with minimum obstruction and where shading is less. As project main motive is to generate the electricity so it site location should be easily accessible and there should be less objects or building for decreasing the number of obstructions. Shading is one of the factors which decrease the efficiency of the solar panel. So site accessibility should be easy so that we can get the maximum output.

4.2.2.6 Site selection

After checking the status of all above parameter the last step is to select the best site for the project work. The selection of the location for fitting the solar panel should be done on the basis of above results, so that it can give maximum output at that point.

4.2.3 Estimation of sizing by using resource assessment

On the basis of resource assessment measurements the next step is to estimate the sizing of these four elements [55]

1) Estimation of load
2) Selection of system voltage
3) Determination of PV array size
    a) In series
    b) In parallel
4) Determination of battery bank capacity
5) Determination of invertors
6) Determination of voltage regulator size
7) Determination of cable size

4.2.3.1 Estimation of load

For the design of solar energy system for a particular building the first estimation is done for total electric load. Data is collected for a particular period and average estimate is taken for the design purpose. Generally Institutional building is consisting of electrical appliances like tubes, bulbs, fan, air conditioner, motor and machinery for lab works. Data will have fluctuation in load because of using and non using hours for different periods. These all electric appliances are run by Alternative currents. A calculated load in electrical terminology is the sum of all of the loads that are connected to a system. To size a service distribution for a home all of the connected loads have to be calculated in. Some loads can be de-rated as per the electrical code. When the total amperage is calculated from the sum of all of the loads, the wire size and distribution can be sized to handle the calculated load.

4.2.3.2 Selection of system voltage

AC is an electric current that periodically reverses direction, while direct current (DC) flows in only one direction. Alternating current is the form in which electric power is supplied to businesses and homes, and is the form of electric power that consumers usually use when connecting kitchen appliances, televisions and electric lamps to a wall outlet. A common DC power supply is a battery cell in a flashlight. The abbreviations of AC and DC are often used to mean simply alternating and direct, as when they modify current or voltage. The electricity generated by alternative energy sources, such as solar panels and fuel cells, is DC. Electricity in India is 240 Volts, alternating at 50 cycles per second. Solar panel generates DC which can be directly converted into AC by using convertor or it can store in batteries. DC can directly used if DC appliances are fixed in building.

4.2.3.3 Selection of PV module

In selecting a PV module for PV system, the main criteria are the performance warranty in case of any problems, module replacement ease; compliance with natural electrical and building codes and manual should be available to see the quality and characteristics of the module.

4.2.3.4 Determination of PV array size

The PV array output power (P_{PV} array) can be determined by equation [56]:

$$\mathbf{P_{PV}\ array = [E_L / (\eta_{b.o.} \times K_{loss} \times H_{Tilt})] \times PSI} \qquad \text{Eq. (1)}$$

Where,

E_L = Estimated average daily load energy consumption in kWh/day

H_{tilt} = Average solar radiation in peak sun hour's incident for specified tilt angle

PSI = Peak solar intensity at the earth surface = 1 kW/m2

$\eta_{b.o}$ = Efficiency of balance of system

K_{Loss}= A factor determined by different losses such as module temperature losses,

Dust, etc.

Here

$$\eta_{b.o} = \eta_{inverter} \times \eta_{wire\ losses}$$

Generally for design $\eta_{inverter}$ and $\eta_{wire\ losses}$ are taken as 95% and 90% respectively.
Thus,
$\eta_{b.o}$ =0.95×0.90
$\eta_{b.o}$ =0.855

Also,

$$K_{loss}=f_{man} \times f_{temp} \times f_{dirt}$$

Where,

F_{man} = Manufacturer's tolerance

F_{temp}= Temperature de-rating factor

F_{dirt} = De-rating due to dirt if in doubt, an acceptable de-rating would be 5%

Again, $f_{temp}=1- [Y\ (T_{cell.eff}-T_{STC})]$

Where,

γ = Power temperature co-efficient

= 0.4383 %/ºC

$T_{cell.eff}$= Average daily temperature in ºC

Now, $T_{cell.eff}$ can be determined by equation

$T_{cell.eff}$=Ta.day+25

Where,

Ta.day= Day time average ambient temperature in ºC

Based on the manufacturer specification for the selected module, $T_{cell.eff}$=45ºC, TSTC = 25ºC and f_{man}=97%

4.2.3.5 Number of modules

Photovoltaic system is consisting of solar array in which solar modules are laid down in series and parallel connections. These are calculated as given below:

a) Module in series

The number of modules in series (N_{ms}) is determined by dividing the designed system voltage, i.e., V_{System} (usually determined by the battery bank or the inverter) by the nominal module voltage (V_{Module}) at standard condition,

i.e., $$N_{ms} = V_{System} / V_{Module}$$

b) Module in parallel

The number of modules in parallel (N_{mp}) is determined by dividing the designed array output (P_{PV} array) by the selected module output power (P_{Module}) and the number of modules in series (N_{ms})

i.e., $$N_{mp} = P_{PV} \text{ array} / (N_{ms} \times P_{Module})$$

Then the total numbers of modules are calculated as

$$Nmt = Nms \times Nmp$$

4.2.3.6 Determination of battery bank capacity

Battery used in all solar systems is sized in Ah under standard test conditions of 25ºC. Battery manufacturers usually specify the maximum allowable depth of discharge for their batteries. The depth of the discharge is a measure of how much of the total battery capacity has been consumed. The minimum number of autonomy that should be considered for even the sunniest locations on earth is 5 days.

The storage battery capacity can be calculated using equation as given below

$$C_X = (N_C \times E_L) / (DOD_{max} \times V_{system} \times \eta_{out})$$

Where,

C_x= Required battery capacity

N_C= Number of days of autonomy = 1

E_L= Estimated load energy in Wh

DOD_{max}= Maximum depth of discharge = 75%

η_{out}= Battery loss

Number of batteries required (N_{breq}) is,

$$N_{breq}=C_x / C\ selected$$

Number of batteries in series (N_{bs}) is,

$$N_{bs}=V_{system}/V_{battery}$$

Number of batteries in parallel (N_{bp}) is,

$$N_{bp}=N_{breq} / N_{bs}$$

4.2.3.7 Determination of inverter size

In sizing the inverter, the actual power drawn from the appliance that will run at the same time must be determined as first step. Secondly, we must consider the starting current of large motors by multiplying their power by a factor of 3. Also to the system to expand, we multiply the sum of the two previous values by 1.25 as a safety factor.

Thus, $$P_{total} = (P_{RS}+P_{LSC}) \times 1.25$$

P_{total}= Inverter power rating (size)

P_{RS} = Power of appliances running simultaneously

P_{LSC}= Power of large surge current appliances

The input rating of the inverter should never be lower than the total watt of appliances.

4.2.3.8 Determination of voltage regulator size

The voltage regulator is typically rated against amperage and voltage capacities. The voltage regulator is selected to match the voltage of PV array and batteries. A good voltage regulator must have enough capacity to handle the current from PV array.

The rated current of the regulator (I_{rated}) is given by

$$I_{rated}=N_{mp}\times I_{sc}\times f_{safety}$$

The number of voltage regulators required (N_{vreq}) is given by

$$N_{vreq}=I_{rated}/I_{selected}$$

4.2.3.9 Determination of the system cables sizes

Selecting the correct size and type of wire will enhance the performance and reliability of PV system. The dc-wires between the PV modules and batteries through the voltage regulator must withstand the maximum current produced by these modules. This current (Irated) is given by

$$\mathbf{I_{rated} = N_{mp} \times I_{sc} \times f_{safety}}$$

The cross sectional area of the cable is given by

$$\mathbf{A = (\rho \times L \times I_{rated} / V_D) \times 2}$$

Where L is the length of cable

ρ= Resistivity of copper wire = $1.724 \times 10^{-8}\ \Omega m$

In both AC and DC wiring for PV system, the voltage drop ≯ 4% value.

4.2.3.9.1 Determination of cable size for PV modules through the batteries voltage regulators

Maximum voltage drop,

$$V_D = (4/100) \times 24$$

$$V_D = 0.96V$$

Calculate the area of copper wire required by above formula.

4.2.3.9.2 Determination of cable size between the battery bank and the inverter

The maximum current from battery at full load supply (I_{max}) is given by

$$\mathbf{I_{max} = [I_{inverter}\ kVA / \eta_{inverter} \times V_{system}]}$$

Maximum voltage drop,

$V_D = (4/100) \times 48$

$V_D = 1.92V$ Calculate area of copper wire on the basis of above data.

4.2.3.9.3 Determination of cable size between the inverter and the load

The maximum current from inverter at full load on the phase (line) is given by

$$\mathbf{I_{phase} = [Inverter\ kVA/V_{output} \times \sqrt{3}]}$$

Maximum voltage drop,

V_D= (4/100) ×220, V_D=8.8 V

Calculate area of copper wire required on the basis of above data.

4.2.4 Cost estimation

The total cost of the system is calculated on the basis of provided elements. Data is given in table no.4.1

Table 4.1 Cost estimation of solar energy system

Component	Model	Quantity	Unit price (Rs.)	Total Cost (Rs.)
Module				
Batteries				
Voltage regulator				
Inverter				
Subtotal				

Other BOS costs (wires, fuses, circuit breakers, etc) = 20% of subtotal.

The operational costs for solar PV installation are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system.

All the cost will be calculated on the basis of current uses of electricity and fuel for generator.

4.2.5 Payback period calculation

The initial setup cost of the photovoltaic system is high, but after certain period it will be cost free. Payback period calculation is done on the basis of these data.

$$\textbf{Payback period} = \frac{\textbf{Overall cost of the PV solar}}{\textbf{Total estimated cost of the fuel generator for the first year}}$$

CHAPTER 5

DATA COLLECTION AND RESULTS

5.1 General

As per discussion in the previous chapter "Design of non-conventional energy system" required data collection for different parameter, on the basis of which design will proceed. According to the methodology followed the following data is collected for the project.

5.2 Preliminary survey data

The detail survey in which field is explored properly for gathering the data for best site selection is known as preliminary survey. The first step is to collect the site details and to analyze them for their best utilization. The first step is the collection of site map and its location detail and topography details.

Fig. no. 5.1 LPU detail map (source: LPU design cell)

Fig. no. 5.2 LPU Front gate (Source: LPU Gallery)

Fig. no. 5.3 LPU campus (Source: LPU Gallery)

5.2.1Location data

Table no. 5.1 Location detail for LPU, Punjab

(Source: Global positioning system)

Place name	Latitude	Longitude	Elevation
LPU, Phagwara, Punjab, India	31.253603^0 N	75.7055° E	228 m from mean sea level

Total area covered by LPU= 600 Acre (2.4 sq. km)

Total population of LPU= 48,500 person

5.2.2 Topography and climate details

Punjab is located in the fertile plain of northern India; the state of Punjab has a combined area of 50,362 km sq. The state shares its borders with Pakistan in the west, on its northern border by Jammu and Kashmir, Himachal Pradesh on the east as the south is bordered by Rajasthan and Haryana.

The climatic conditions of Punjab are identified as an extreme of summers and winters. On average, the temperature in the state of Punjab varies from -4 degrees and rises to 48 degrees, which explains the extremity of its climate. Places that are close to the ranges of the Himalayas are often penetrated by heavy rains, while the southern parts of the state are high in temperature and considerably low in the rain[57].

The city has a humid subtropical climate with a cold winter and a long hot summer. Summer start from April to June and winters from November to February. In summer, the temperature varies from a maximum average of about 48 ° C to an average low of about 25 ° C .Maximum winter temperatures from 19 ° C at low -7 ° C .The climate is generally dry except for a brief Southwest monsoon season in July and August. The annual rainfall is about 70 cm.

The average data for climate is given below in table no. 5.2. It consists of the average high temperature and average low temperature and the average precipitation for Punjab region.

Table no. 5.2 Climate data for Phagwara, Punjab [58]

(Source: https://weather.com/weather/monthly/l/INXX0060:1:IN**)**

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Avg.
Avg. high temp.(^{0}C)	19	22	26	35	40	44	34	33	33	32	27	22	30.58
Avg. low temp. (^{0}C)	6.2	8.6	13	19	24	26	25	26	22	18	12	7.2	17.25
Avg. ppt. (mm)	11	17	33	15	20	70	155	183	60	2	6	15	48.91

5.3 Resource Assessment – on the basis of following data

5.3.1Meteorological data The Meteorological data required for the project is -

- Solar irradiance (solar insolation)
- Temperature
- Humidity

5.3.1.1 Solar irradiance data

Solar irradiance is measured in two terms.

1) Average direct normal irradiance
2) Average global horizontal irradiance

5.3.1.1.1 Average direct normal irradiance for Phagwara, LPU

Normal Direct Radiance (DNI) is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays coming in a straight line from the direction of the sun at its current position in the sky.

Table no. 5.3 Monthly average direct normal irradiance for Phagwara [59]

(Source: http://www.synergyenviron.com/tools/solar-irradiance**)**

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Avg.
Solar irradiance (kWh/m2/ day)	3.62	4.5	5.5	5.94	6.21	4.48	3.6	4.2	5.1	4.5	4.1	3.4	4.61

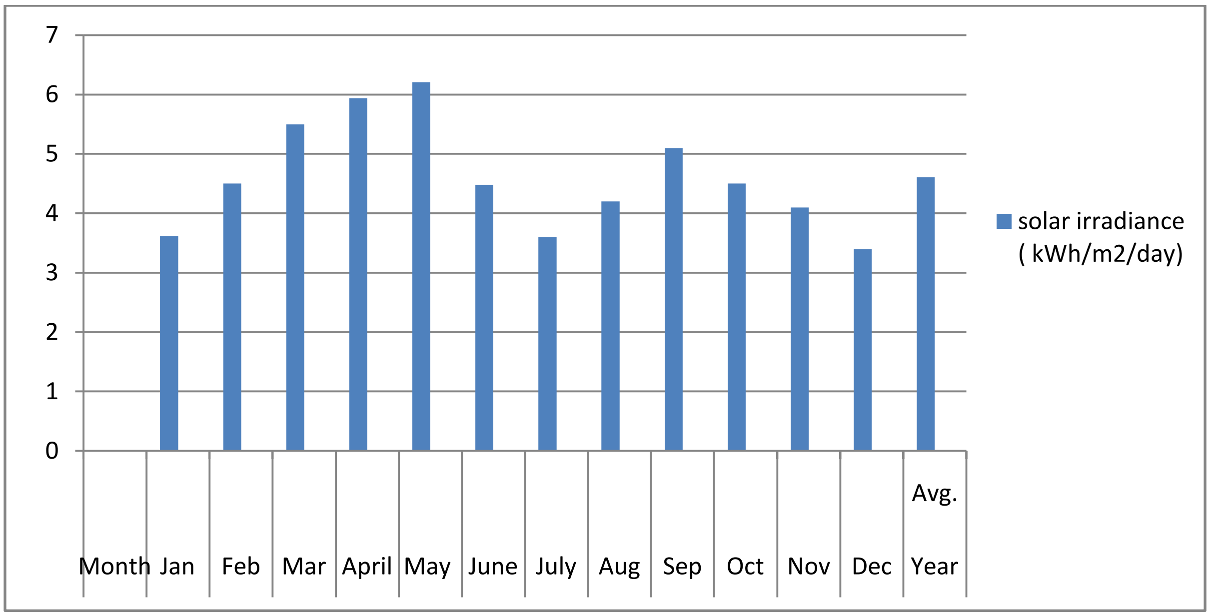


Fig. no. 5.4 Bar char for direct normal irradiance for Phagwara

5.3.1.1.2 Average global horizontal irradiance for Phagwara, LPU

The radiation that reaches the surface of the Earth can be represented in different ways. Global Horizontal Irradiation (GHI) is the total amount of shortwave radiation received from above by a horizontal surface to the ground. This value is of particular interest for photovoltaic installations and includes both direct normal irradiation (DNI) and diffuse horizontal irradiance (DHI).

Table no. 5.4 Monthly average global horizontal irradiance for Phagwara

(Source: http://www.synergyenviron.com/tools/solar-irradiance)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Avg.
Solar irradiance (kWh/m2/ day)	3.21	4.2	5.5	6.72	7.31	6.54	5.9	5.6	5.5	4.9	3.8	3.0	5.19

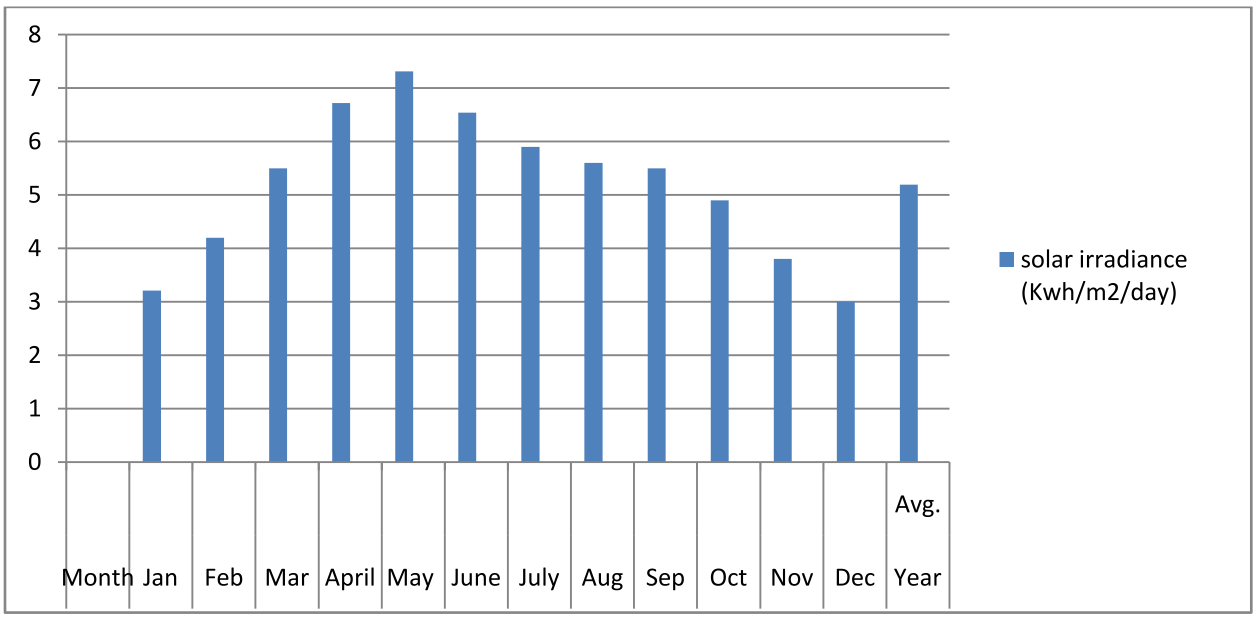


Fig. no. 5.5 Bar chart for average global horizontal irradiance for Phagwara

5.3.1.2 Annual average Temperature data for Phagwara, LPU

Determination of temperature is the main aspect for design of photovoltaic system. Generally 12 months average temperature data is collected from meteorological department or from meteorological sites for particular location for getting the idea of the effect of temperature on solar panel efficiency of the photovoltaic system.

Table 5.5 Average temperature for Phagwara, LPU

(Source: https://weather.com/weather/monthly/l/INXX0060:1:IN)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Avg.
Avg. high temp.(^{0}C)	19	22	26	35	40	44	34	33	33	32	27	22	30.58
Avg. low temp. (^{0}C)	6.2	8.6	13	19	24	26	25	26	22	18	12	7.2	17.25

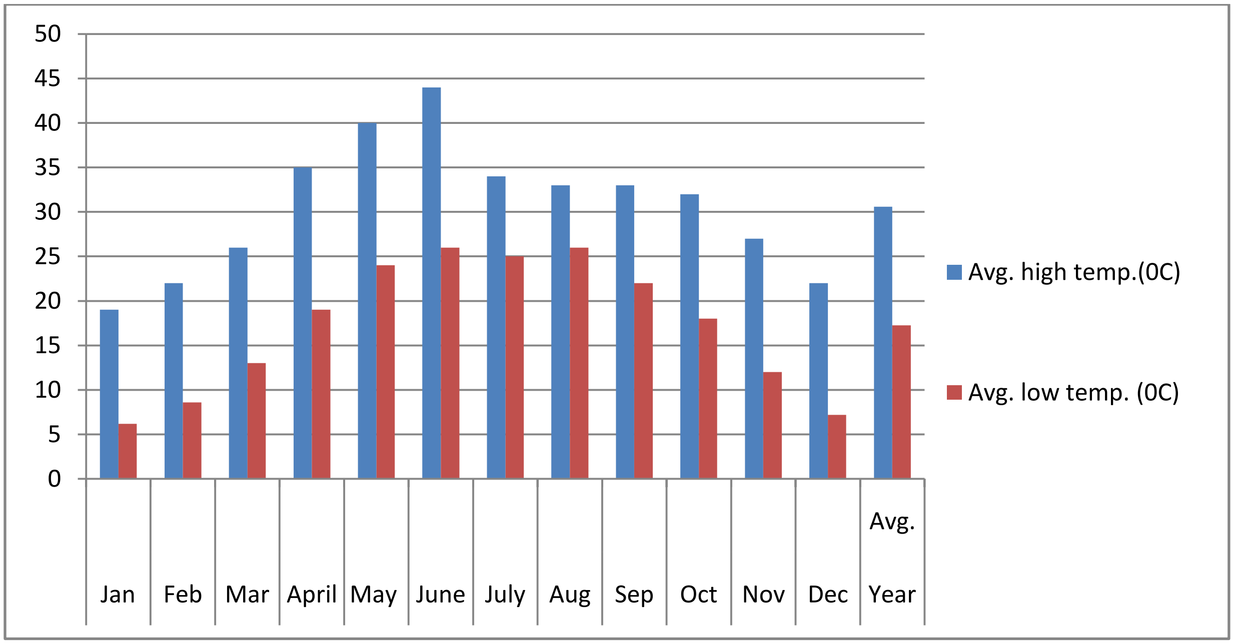


Fig. no. 5.6 Average annual temperature for Phagwara, LPU

5.3.1.3 Average Humidity Data for Phagwara LPU

Relative humidity measures the actual amount of moisture in the air as a percentage of the maximum amount of moisture the air can hold. For Punjab region average relative humidity is given below in table no 5.6.

Table no. 5.6 Average annual humidity for Phagwara, Punjab [60]

(Source: https://www.currentresults.com/Weather/India/humidity-december.php)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Avg.
Relative humidity (%)	74	70	64	47	38	48	72	77	69	67	73	76	64.58

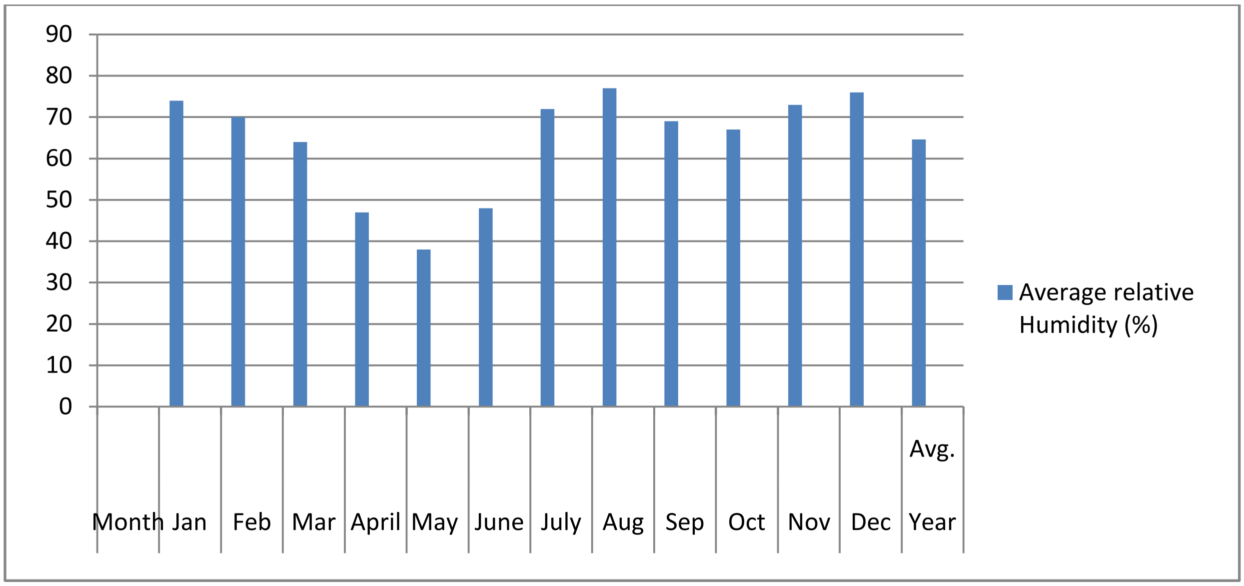


Fig. no. 5.7 Bar chart for average relative humidity for Phagwara

5.3.1.3.1 Relationship between temperature and relative humidity

Temperature and relative humidity have a relationship between them. The collective result for average temperature which includes maximum average and minimum average temperature and average relative humidity for the area is represents by graphs in figure no. 5.7. The tabular data is shown below:

Table no 5.7 Collective results for average temperature and average humidity

(Source: Same as table number 5.5 and 5.6)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Avg. high temp.(^{0}C)	19	22	26	35	40	44	34	33	33	32	27	22
Avg. low temp. (^{0}C)	6.2	8.6	13	19	24	26	25	26	22	18	12	7.2
Avg. humidity (%)	74	70	64	47	38	48	72	77	69	67	73	76

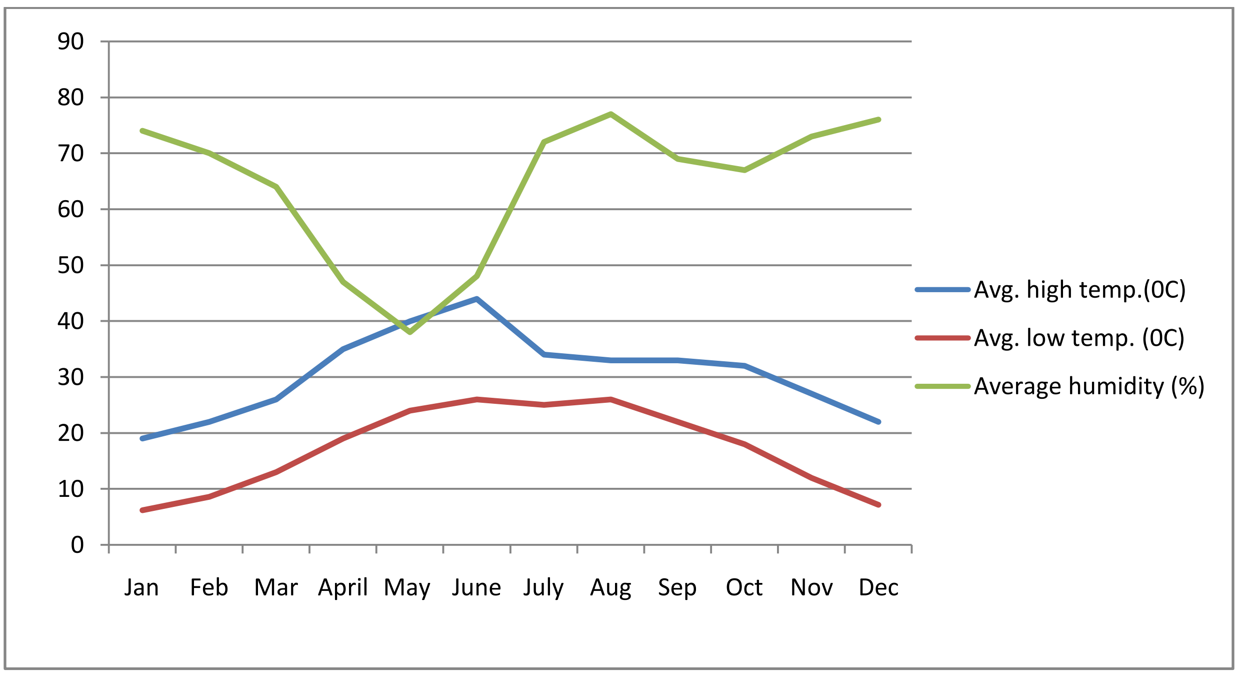


Fig. no. 5.8 Relationship between temperature and humidity

5.3.1.4 Experimentation Methodology

An experiment is conducted by using two 6 Watt solar panel mounted on a temporary stand. The electrical parameters like voltage & current have been measured to study the effect of environmental heat sink and dust and shadow. The net effect of heat sink, dust and shadow on the power reduction was evaluated & analyzed. The effect of heat sink, dust and shadow can be quantified by comparing the efficiency of panel exposed to these parameters and without exposing. In this work, the system of measurements is consists of a silicon solar panel of area value, a DC multimeter for measurement of producing current, and also a suitable lead acid battery for storage of current. The experimental study was done near 56 Block parking and on the top roof of Block 56. The latitude and longitude of the location are 31.253603^{0}N and 75.7055° E. The ambient temperature fluctuates in the range of 5 to 48 ºC during a year in Punjab, India. The solar photovoltaic panel was tested and the parameters like voltage, current solar irradiance, and ambient temperature etc. needed for the evaluation of the systems were measured at interval of one hour between 9.00 and 4:00 PM. The ambient temperature and the incident solar radiation intensity were noted from weather forecasting sites and apps·

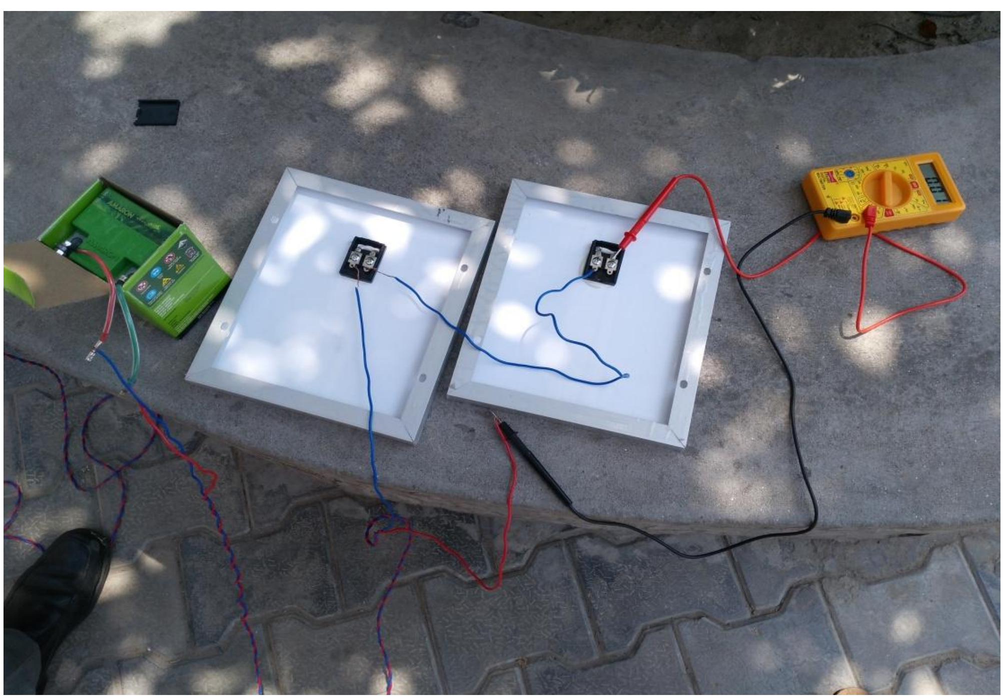


Fig. no. 5.9 Two solar panel of 6 watt connected in series with multimeter and battery

Fig. no.5.10 Parking area near 55, 56 and 57 block, LPU.

Fig. no. 5.11 Measurement of current with two 6 watt solar panels in 56 Block

Table no 5.8 Specification of PV module for experimentation

Model Name	SAVERA Solar Panel
Model no.	SS0605
Serial number	0416010605
Maximum power	6 watt
No of cell	36
Material	Mono-crystalline

Table no. 5.9 Data collected for current measurement, on 24th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	30	32	33	36	38	40	41	39
Angle of tilt (23^0)	0.3	0.35	0.43	0.45	0.47	0.41	0.4	0.38
Angle of tilt = 45^0	0.2	0.3	0.4	0.43	0.45	0.4	0.39	0.37
Angle of tilt = 60^0	0.2	0.22	0.3	0.4	0.44	0.39	0.35	0.3

Average ambient temperature = 32^0 C, Relative humidity= 29 %

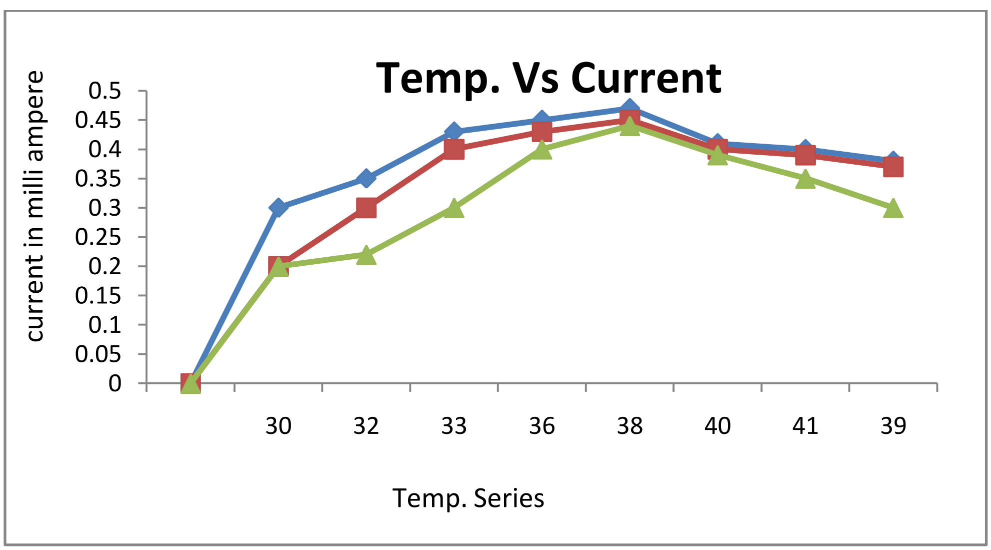


Fig. no 5.12 Current reading at hourly interval, near 56 block parking area

Table no. 5.10 Data collected for current measurement, on 25th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	31	32	33	38	40	42	41	39
Angle of tilt (23^0)	0.33	0.50	0.60	0.60	0.50	0.40	0.35	0.29
Angle of tilt = 45^0	0.20	0.45	0.50	0.55	0.35	0.30	0.32	0.30
Angle of tilt = 60^0	0.30	0.45	0.50	0.54	0.40	0.30	0.30	0.32

Average ambient temperature = 34^0 C, Relative humidity=49%

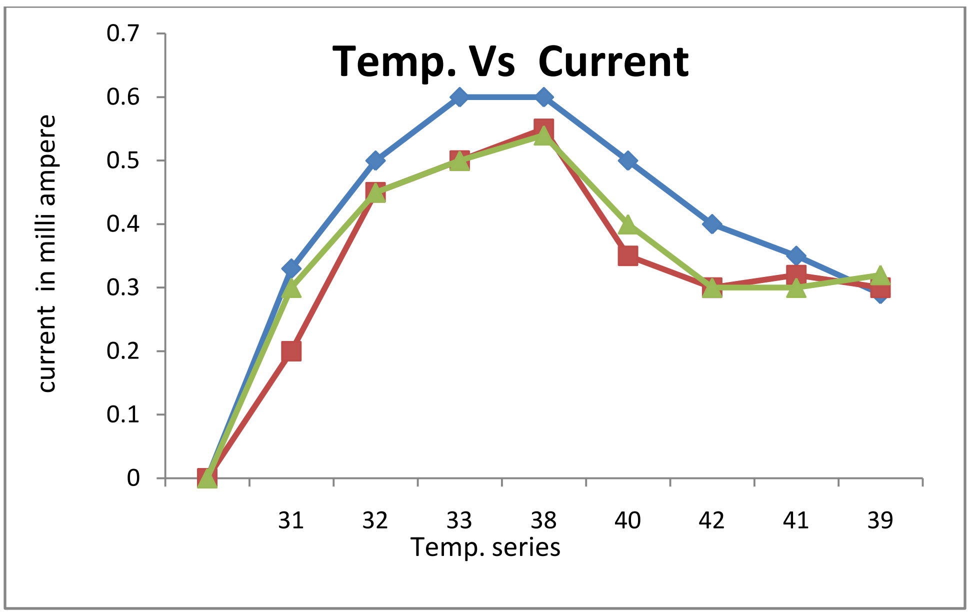


Fig. no. 5.13 Current reading taken in 56 block top floor, 25th May,2017

Table no. 5.11 Data collected for current measurement, on 26th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	31	32	33	41	42	43	41	38
Angle of tilt (23^0)	0.30	0.40	0.50	0.60	0.50	0.40	0.35	0.20

Angle of tilt = 45^0	0.20	0.32	0.40	0.50	0.60	0.50	0.40	0.30
Angle of tilt = 60^0	0.10	0.30	0.45	0.50	0.58	0.40	0.35	0.30

Average ambient temperature = 36^0 C Relative humidity=49%

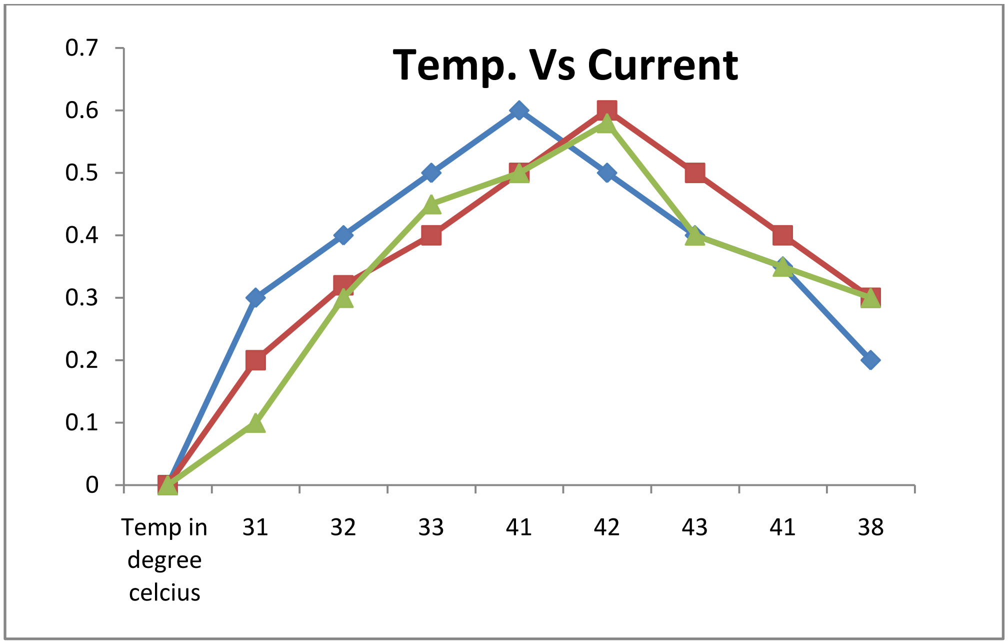


Fig. no. 5.14 Current reading taken in 56 block top floor, 26th May, 2017

Table no. 5.12 Data collected for current measurement, on 27th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	32	34	35	38	40	41	40	38
Angle of tilt (23^0)	0.25	0.34	0.36	0.39	0.45	0.36	0.27	0.19
Angle of tilt = 45^0	0.21	0.32	0.34	0.36	0.43	0.34	0.24	0.15
Angle of tilt = 60^0	0.2	0.26	0.30	0.34	0.40	0.32	0.22	0.1

Average ambient temperature =32^0 C Relative humidity=43%

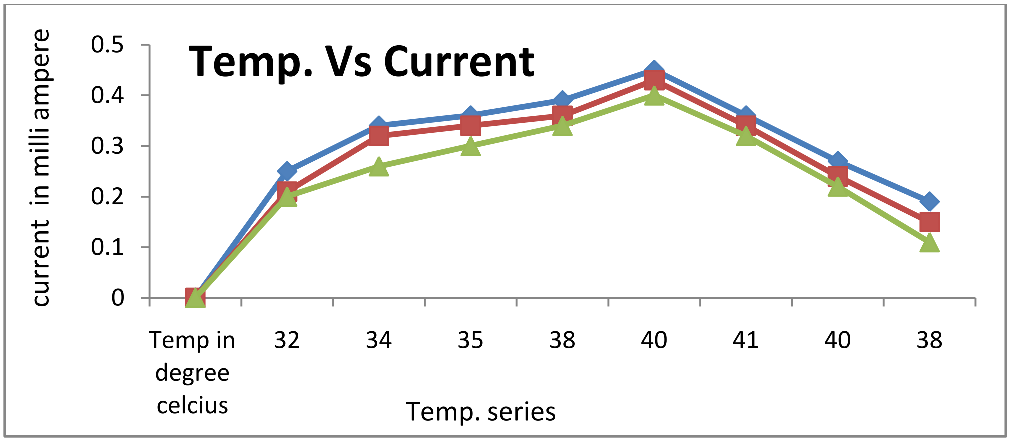


Fig. no. 5.15 Current reading taken in 56 block top floor, 27th May, 2017

Table no. 5.13 Data collected for current measurement, on 29th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	25	26	26	30	34	38	36	34
Angle of tilt (23^0)	0	0	0	0	0.4	0.3	0.25	0.2
Angle of tilt = 45^0	0	0	0	0	0.3	0.2	0.15	0.1
Angle of tilt = 60^0	0	0	0	0	0.2	0.1	0.1	0.1

Average ambient temperature =31^{0}C, Relative humidity=42%

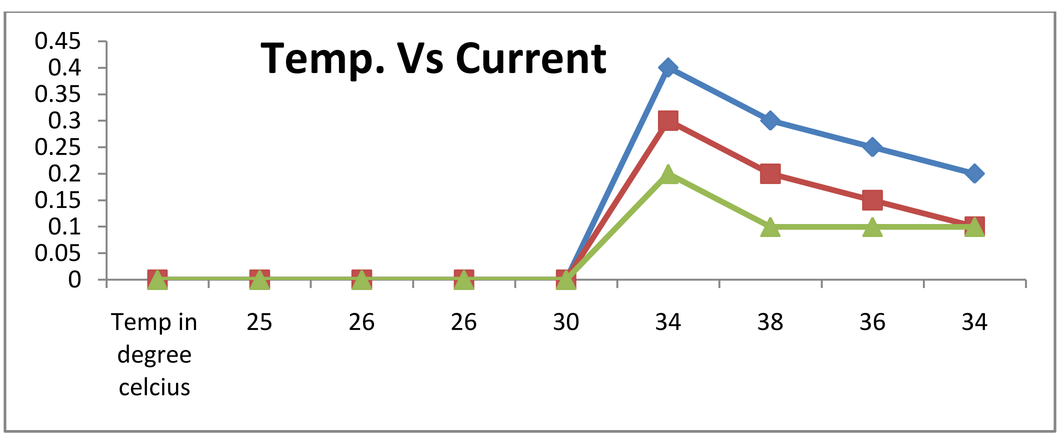


Fig. no. 5.16 Current reading taken in 56 block top floor, 29th May, 2017

Table no. 5.14 Data collected for current measurement, on 30th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	25	26	28	30	35	38	36	34
Angle of tilt (23^0)	0.2	0.33	0.45	0.51	0.55	0.45	0.42	0.36
Angle of tilt = 45^0	0.1	0.31	0.42	0.43	0.50	0.40	0.41	0.34
Angle of tilt = 60^0	0.1	0.3	0.4	0.41	0.45	0.41	0.39	0.31

Average ambient temperature= 32^{0}C, Relative humidity= 42%

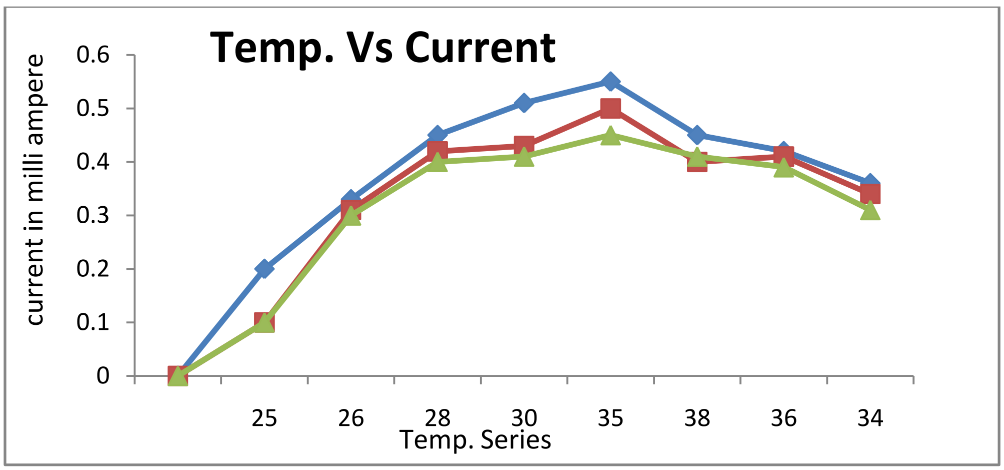


Fig. no. 5.17 Current reading taken in 56 block top floor, 30th May, 2017

Table no. 5.15 Data collected for current measurement, on 31th of May, 2017

	Current produce in (milli ampere)							
Time	9AM	10AM	11AM	12PM	1PM	2PM	3PM	4PM
Temperature (^{0}C)	25	25	26	30	32	33	32	31
Angle of tilt (23^0)	0	0	0	0.40	0.50	0.50	0.45	0.39
Angle of tilt = 45^0	0	0	0	0.40	0.45	0.43	0.42	0.37
Angle of tilt = 60^0	0	0	0	0.30	0.40	0.40	0.38	0.31

Average ambient temperature= 28^{0}C, Relative humidity= 51%

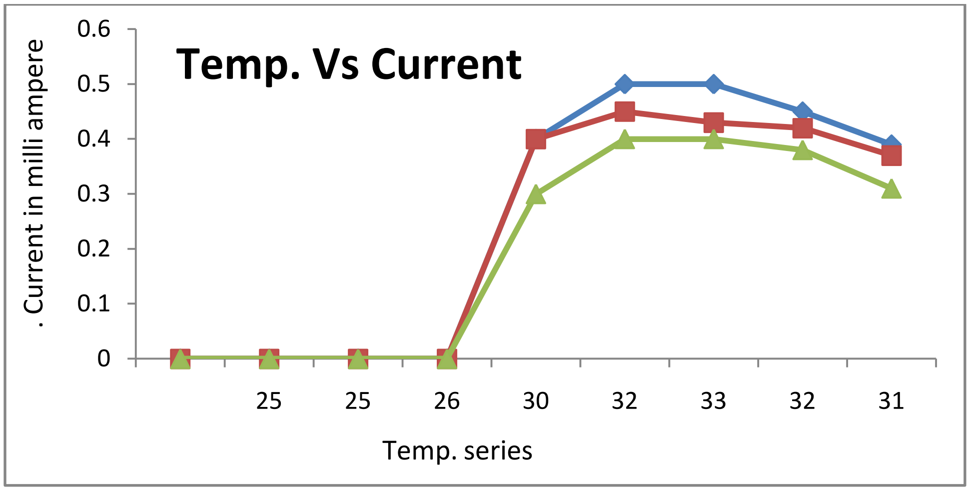


Fig. no. 5.18 Current reading taken in 56 block top floor, 31st May, 2017

5.3.2 Land data

Land data consist of determination for two types of data altitude and Shading. After site exploration it was identified that maximum area of LPU is covered by official and residential buildings, roads, parking, playgrounds and open land. The vegetation cover for LPU is average. The maximum space is covered by buildings and it is having shading cover on ground level. At top level there is less shading cover.

Fig. no. 5.19 Area covered by closely spaced buildings

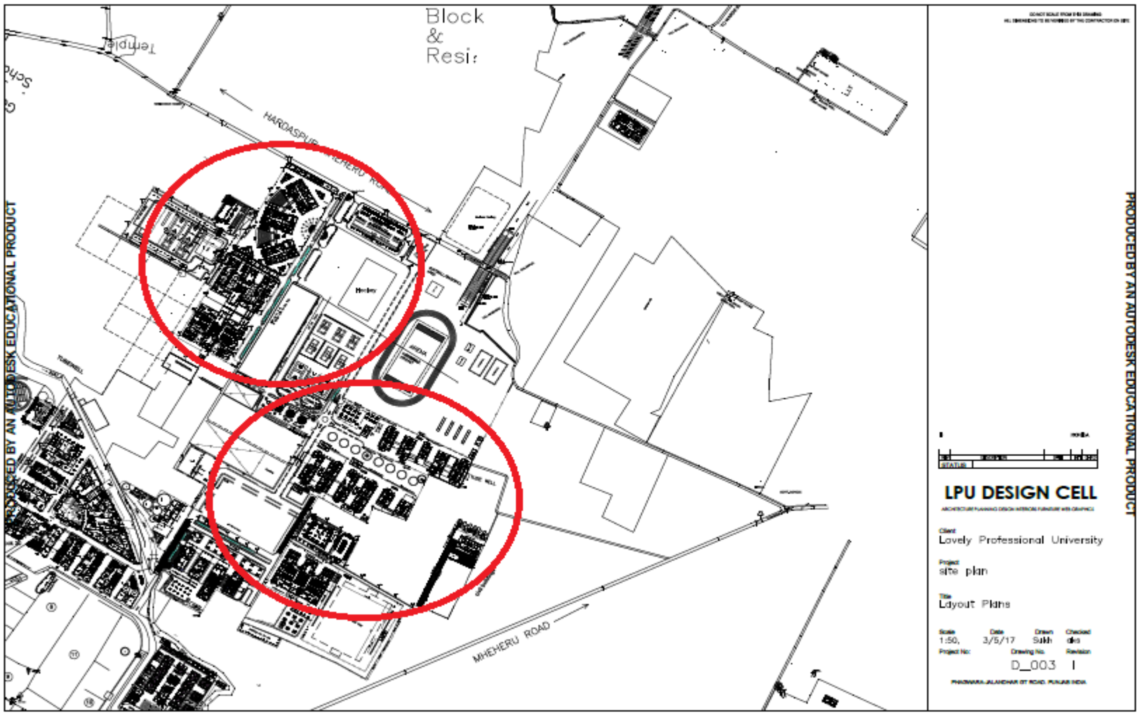


Fig. no. 5.20 Area covered by closely spaced buildings and parking

Buildings having altitude of 30-35m approximate from ground level. Other area like parking and playground are continuously in use so such area is not suitable for placing the solar panels. Building top floor and roof are most suitable for pacing the solar panel so that it will not create obstruction for public and it should safe. Altitude and shading has its impact on solar panel efficiency. According to the facts when the light consisting of energy / photon strikes the layer of water / unwanted gases which in fact appears denser in the Ground level, refraction appears resulting in the decrease in light intensity that in fact appears to be the cause decreased efficiency. There are also minimal elements of Reflection that also appear on the site and where, there appearing light striking is subject to further losses. If the placement of solar panels appears at a certain height, less effect of these factors on efficiency as it appears less moisture and less gas quantity than indirectly restrict the process reflection and refraction have less effect on the use of energy that comes from the Sun[62].

5.3.3Accessibility to land

LPU is having total population of 48500 Person and we can imagine that maximum space is utilized for traveling purpose. So the parking area and playground area are restricted for solar panel fixing. Rest of the space is covered by official and residential building and food courts. So the last option is left the building terrace which is at high altitude and more easily accessible and away from public place.

5.3.4 Site selection

After considering all the parameters building terrace is the most safe and accessible place for solar panel fixing where shading and other obstruction are less as compared to ground level. As LPU is spread over a large area and it is having total 58 building blocks. So I am selecting block 56 for design of non convention energy system i.e. solar energy system.

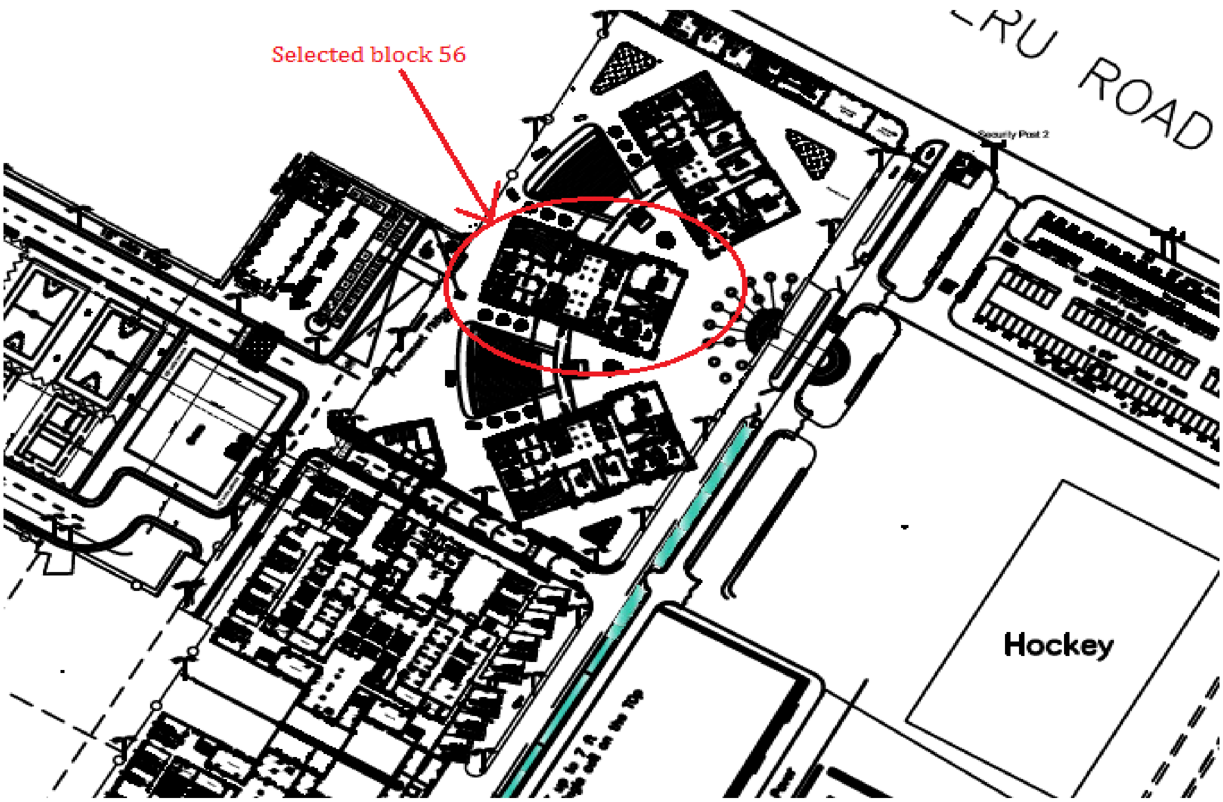


Fig. no. 5.21 Selected block for design of non conventional energy system

5.4 Results

From experiment following results are shown through graphs are given below-

5.4.1 Heat sink Effect

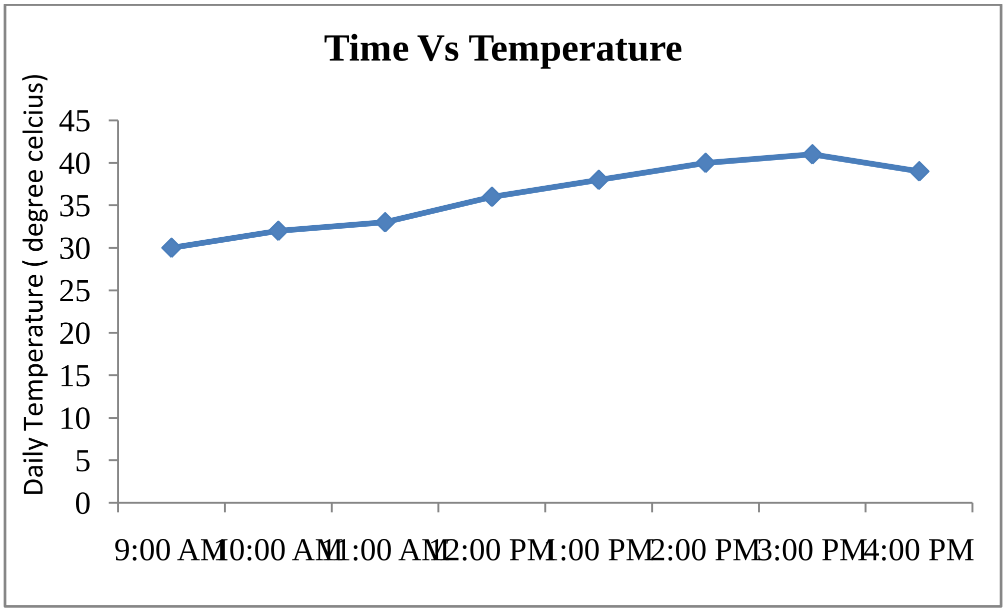


Fig. no. 5.22 Increase in temperature with respect to time

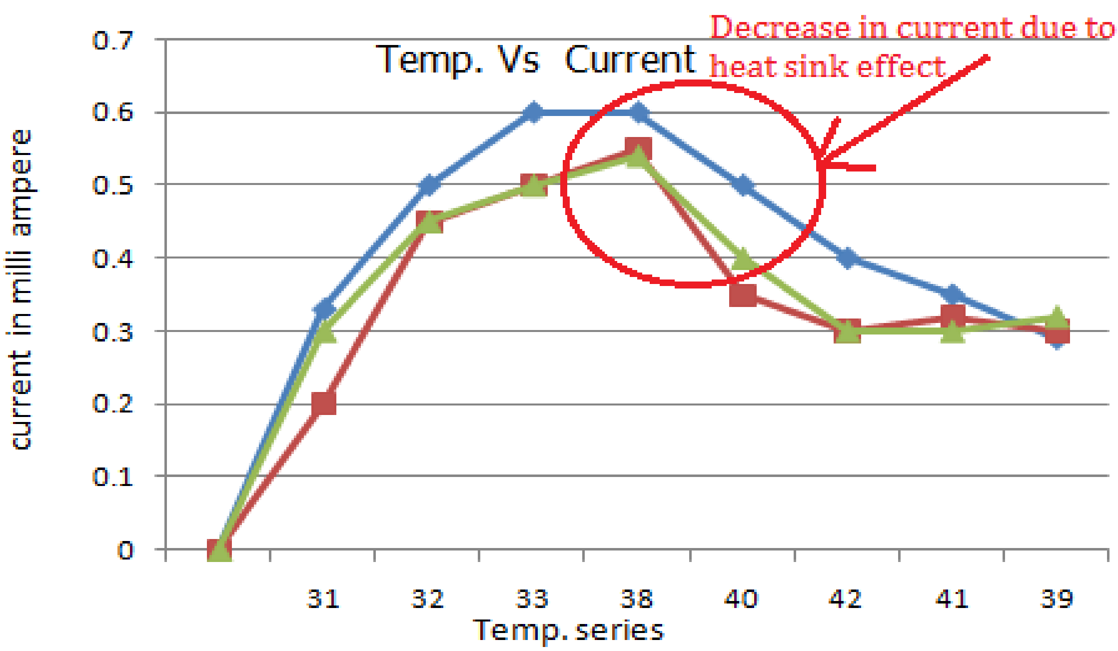


Fig. no. 5.23 Heat sink effect on PV Solar panel, Reading taken on 25th may, 2017.

5.4.2 Effect of rain on PV solar Panel

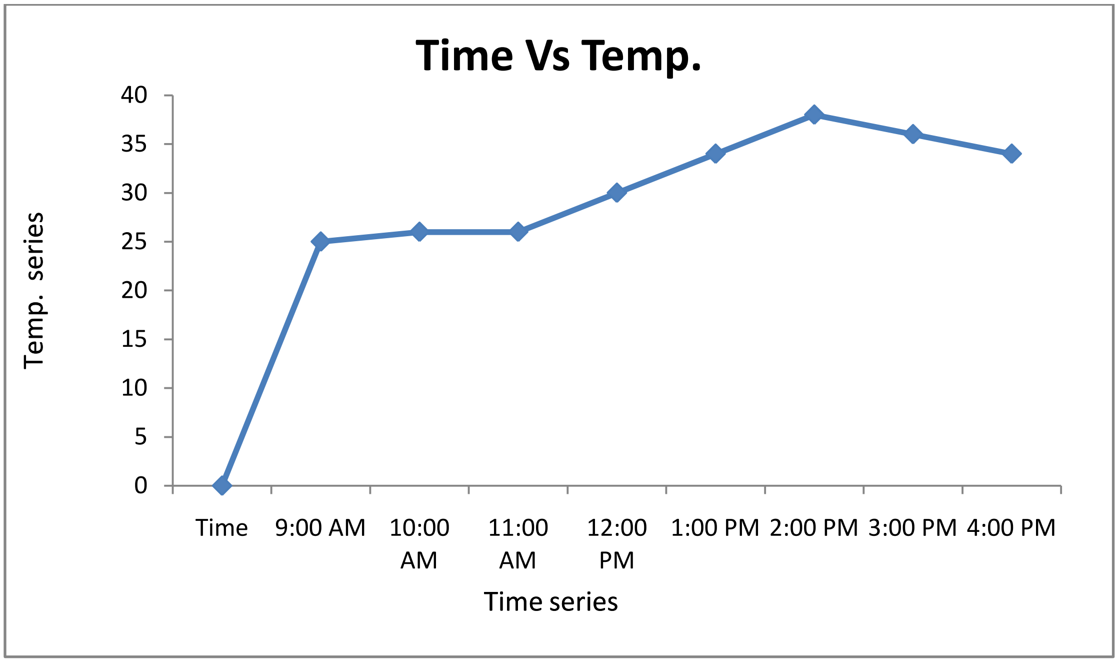


Fig. no.5.24 Temperature variations during Rainy period on 29th May, 2017

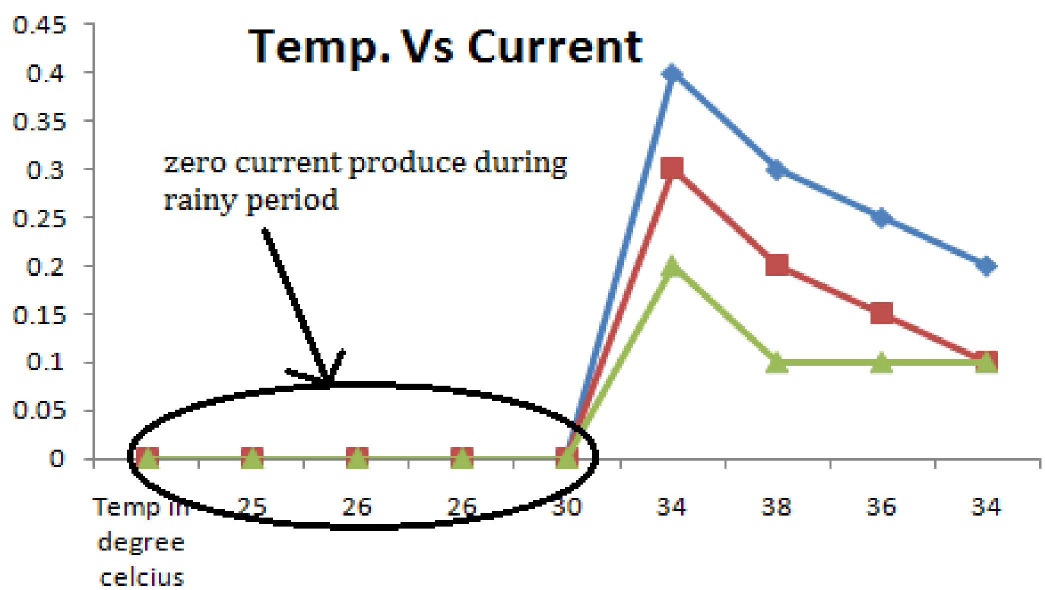


Fig. no. 5.25 Effect of rain on PV solar panel, reading taken on 29th May, 2017

5.4.3 Effect of altitude on PV solar Panel

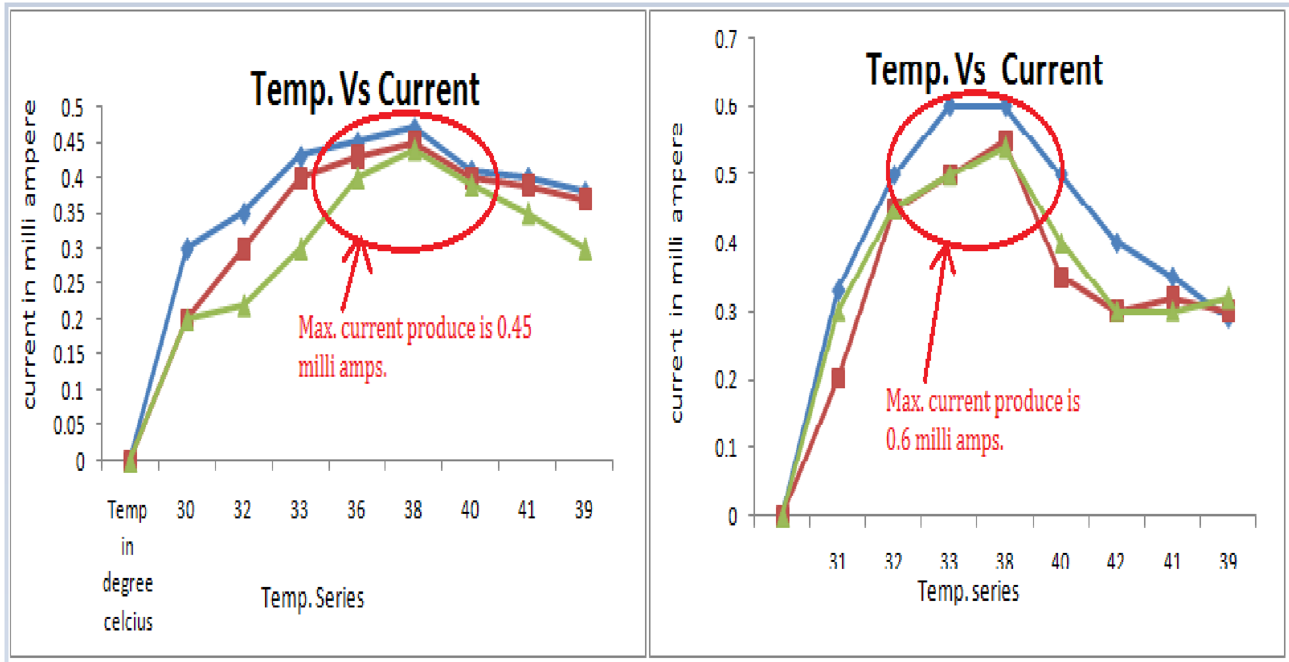


Fig. no. 5.26 Graph 1 solar placed at ground level, graph 2 solar placed on building top floor

From above data we can see that one reading is taken at ground level and other is taken at high elevation. The maximum current produce at ground level was 0.45 milli ampere while the maximum current produce at higher elevation was 0.6 milli ampere. It shows that solar panel position should be at higher elevation so that maximum output/ efficiency can be achieved.

This experimentation part shows that efficiency of PV cell depends upon all these factors like location of solar positions, rainy season, humidity, shadow, Temp. And dust. Etc.

CHAPTER 6

DESIGN OF SOLAR ENERGY SYSTEM FOR BLOCK 56, LPU

6.1 General

On the basis of resource assessment estimation of sizing is done for design of solar energy system. In previous chapter one block was selected for designs of non conventional energy system i.e. block 56. The estimation of sizing includes various parameters like load estimation for particular building, module estimation, invertors size determination etc.

6.2 Designs for 56 -Block, LPU

The design of an off-grid power requires a number of steps. A basic design method follows:

a) Load estimation
b) Selection of system voltage
c) Determination of PV array size
d) Inverter size estimation
e) Cable size estimation

6.2.1 Load estimation for block-56

Table no 6.1 Detail of electrical appliances and their power consumption for 56 Block

S.No	Power consumption	Rated Power (watt)	Qty	Average hours used per day	Effective Qty	Load(Kw)	Kwh/day
1	Fan	75	796	6	382	28.650	171.900
2	Tube Light	40	686	6	275	11.000	66.000
3	AC	1500	115	5	45	67.500	337.500
4	Ductable AC	3500	4	3	1	3.500	10.500
5	Oven	750	6	4	6	4.500	18.000
6	Water cooler	1000	4	6	2	2.000	12.000

7	Exhaust Fan 18"	80	15	4	1	.080	.320
8	Exhaust Fan 12"	80	15	4	1	.080	.320
	Total Load	7025	1641	38	713	117.310	616.540

(Source: AO office civil department)

The total power consumed by electrical appliance in block 56 = 616.5 kWh/d

6.2.2 Selection of system Voltage

System voltages are generally 12, 24 or 48 volts. The actual voltage is determined by the requirements of the system. For example, if the batteries and inverter are too far from the power source, a voltage may be required to minimize the loss of power in the cables. In larger system, where load is more, 120V and 240V DC used. I am designing for 56 Block and it is having maximum demand of 616.5 units per day so system voltage should be 48 Vdc.

6.2.3 Selection of PV module

In selecting a photovoltaic module for the photovoltaic system, the main criteria are performance assurance in case of any problem; ease of module replacement, compliance with electrical and building codes and manual should be available to view the quality and characteristics of the module. After considering all the factors like material, efficiency and atmospheric impact, poly-crystalline solar panel module type JJ- M660 is selected for the design purpose.

Fig. no.6.1 Poly-crystalline solar panel JJ- M660

Table no. 6.2 Electrical and Thermal specification of JJ- M660 Solar panel module

Module type	**JJ-M660**
Maximum Power [pm (Wp)]	250
Power tolerance (%)	+-3
Maximum Power voltage [V_{mp} (V)]	29.77
Maximum Power current [I_{mp}(A)]	8.40
Open circuit voltage [V_{oc} (V)]	37.04
Short circuit current [I_{SC} (A)]	8.96
Module efficiency (%)	15.22
Size	1643mm x 996 mm x40 mm (+-1 mm)
weight	20 Kg
Cable size	1000mm/ 4mm^2
Max. system voltage	1000 V_{DC}
NOCT	45^0 C
Temp. coefficient of P_{max}	-0.43%/^{0} c
Temp. coefficient of I_{sc}	0.046%/^{0} c
Temp. coefficient of V_{oc}	-0.33% /^{0} c
Operating Temp.	45^{0}c to + 85^{0}c

(Source: http://jisl.co.in/PDF/Catalogue_2015/solar/photovoltaic_module/Catlgm_JJ_M660.pdf)

6.2.4 Determination of PV array size

The PV array output power (P_{PV} array) can be determined by equation:

$$P_{PV}\ \text{array} = [E_L / (\eta_{b.o.} \times K_{loss} \times H_{Tilt})] \times PSI \qquad \text{eq. (1)}$$

From collected data

E_L = 616.6 kWh/day

H_{tilt} = 4.61 kWh/m2/day

PSI = Peak solar intensity at the earth surface = 1 kW/m2

$$\eta_{b.o} = \eta_{inverter} \times \eta_{wire\ losses}$$

Generally for design $\eta_{inverter}$ and $\eta_{wire\ losses}$ are taken as 95% and 90% respectively.
Thus,

$\eta_{b.o}$ =0.95×0.90

$\eta_{b.o}$ =0.855

$K_{Loss}=f_{man} \times f_{temp} \times f_{dirt}$ eq. (2)

F_{dirt} = De-rating due to dirt if in doubt, an acceptable de-rating would be 5%

$f_{temp}=1-[Y(T_{cell.eff}-T_{STC})]$

Where,

γ = Power temperature co-efficient for module= 0.4383 %/ºC

$T_{cell.eff}$=45ºC, T_{STC} = 25ºC and f_{man}=97%

Put values in $f_{temp}=1-[Y(T_{cell.eff}-T_{STC})] = 1-[0.43/100*(45^0-25^0)]$

f_{temp}=0.9123

Put this value in eq. 2

$K_{Loss}=f_{man} \times f_{temp} \times f_{dirt}$

$K_{Loss=}$ 0.97 x 0.9123 x 0.95

$K_{Loss=}$ 0.841

Put values in eq. (1)

P_{PV} array= $[E_L/(\eta_{b.o}. \times K_{loss} \times H_{Tilt})]$ x PSI

P_{PV} array= [616.6/ (0.855x0.841x4.61)] x 1Kw/m^2

P_{PV} array= 186.01 approximate

P_{PV} array= 186 Kw

6.2.4.1 Total number of module

Total number of module calculation based on combine module placed in series and parallel connections.

a) Number of module in series

b) Number of module in parallel

Number of module in series are given by $N_{ms} = V_{system}/V_{module}$

N_{ms} =48/29.77 =1.61 there for voltage of module is given in module specification table

N_{ms} =2 module

Number of module in parallel is given by

$N_{mp}= P_{Pv\ Array}/ N_{ms} \times P_{module}$

N_{mp}= 186000/ (2*250) = 372 modules

N_{mp}=372 module

Total no of module= $N_{ms} \times N_{mp}$= 744 module

6.2.5 Determination of battery bank capacity

The storage battery capacity can be calculated using equation as given below

$C_X = (N_C * E_L) / (DOD\ max * V_{system} * \eta_{out})$ eq no. (3)

Where

N_C is number of autonomy day. It is assumed as 1day.

E_L is the total load estimated for the building. I.e. 616.6Kwh/day

DOD max is assumed to be 75% Maximum depth of discharge.

η_{out}= Battery loss = 0.85 (Leonics, 2009)

V_{system}= 48 volt

Put values in this formula we will get

$C_X = (N_C * E_L) / (DOD\ max * V_{system} * \eta_{out})$

$C_X = (1*616.6*10^3) / (0.75* 48* 0.85)$

C_X = 20150 Ah.

So Battery selected L16RE-B which is having capacity of 370 Ah, standard rating of 20 hours and nominal voltage 6 volt.

No. of battery required is given by

$N_{breq}=C_x / C\ selected$ eq. no. (4)

N_{breq}= 20150/370 = 54.45=55 batteries

N_{breq}= 55 Batteries

Number of batteries required in series $\mathbf{N_{bs} = (V_{system}/V_{battery})}$

N_{bs}= 48/6=8

$\mathbf{N_{bs}=8}$

Number of batteries required in Parallel $\mathbf{N_{bp} = (N_{breq} / N_{bs})}$

N_{bp}= 55/8=6.8=7

$\mathbf{N_{bp}= 7}$

6.2.6 Determination of inverter size

Power drawn from inverter is given by

$$\mathbf{P_{total} = (P_{RS} + P_{LSC}) \times 1.25} \qquad \text{eq. no. (5)}$$

For design $\mathbf{P_{LSC}}$ is taken zero and P_{RS} taken from table 6.2.1

P_{total} = (117.3 +0)*(1.25)

$\mathbf{P_{total} = 146.625\ kVA}$

So inverter to be used should not be more than 146.625 kVA and nominal 48 vdc.

So selection of inverter Neowatt Energy 150 kVA is done for this design.

6.2.7 Determination of voltage regulator size

Rated current of regulator is given by

$$\mathbf{I_{rated}=N_{mp}\times I_{sc}\times f_{safety}} \qquad \text{eq. no. (6)}$$

Here I_{sc} is 8.96 from table 6.2.2 and factor of safety is 1.25

I_{rated}= 7 * 8.96 *1.25=78.4 A

$\mathbf{I_{rated}= 78\ A}$

So selection of PLASMATRONICS solar regulator PL80 which works on 12/24/32/36/48 volts and current 80 Amperes is done.

Number of voltage regulator required

$N_{vreq}=I_{rated}/I_{selected}$

$N_{vreq}=78/80=0.975=1$

N_{vreq}= 1 voltage regulator

6.2.8 Determination of the system cables sizes

The rated current is given by

$I_{rated}=N_{mp}\times I_{sc}\times f_{safety}$ from previous calculation

I_{rated}= 78 A

Cross sectional area is given by

$A= (\rho\times L\times I_{rated}/ V_D) \times 2$ eq. no. (7)

Here ρ= Resistivity of copper wire = 1.724×10^{-8} Ωm

In both AC and DC wiring for PV system, the voltage drop ≯ 4% value.

6.2.8.1 Determination of cable size for PV modules through the batteries voltage regulators

Maximum voltage drop, V_D= (4/100) ×24

V_D=0.96V

Assume the length of cable= 1m

Cable size for PV module = $(\rho\times L\times I_{rated}/ V_D) \times 2$

A= [(1.724×10^{-8}x 1x78)/ 0.96] x2

A= 2.8 mm^2

Copper wire of approximate 3mm^2, 78A and ρ = 1.724×10^{-8} Ωm can be used for modules through the batteries voltage regulators.

6.2.8.2 Determination of cable size between the battery bank and the inverter

The maximum current from battery at full load supply (I_{max}) is given by

$$\mathbf{I_{max} = [I_{inverter}\ kVA / \eta_{inverter} \times V_{system}]} \qquad \text{eq. no. (8)}$$

$I_{max} = [146.625 \times 10^3/0.85 \times 48]$

I_{max} = 3594 A

Maximum voltage drop

$V_D = (4/100) \times 48$

$V_D = 1.92V$

Assume cable size =5m

Cross sectional Area of cable is

$A = (\rho \times L \times I_{max} / V_D) \times 2$

$A = [(1.724 \times 10^{-8} \times 5 \times 3594) / 1.92] \times 2$

$A = 322\ mm^2$

So we can provide a copper cable which is having cross section area of 322 mm^2, 3593A current and $\rho = 1.724 \times 10^{-8}$ Ωm resistivity.

6.2.8.3Determination of cable size between the inverter and the load

The maximum current from inverter at full load on the phase (line) is given by

$$\mathbf{I_{phase} = [Inverter\ kVA / V_{output} \times \sqrt{3}]}$$

$I_{phase} = [147 \times 10^3 / 220 \times \sqrt{3}]$

$I_{phase} = 386$ A

Assume length of cable = 20m

Maximum voltage drop,

V_D= (4/100) ×220, V_D=8.8 V

Cable cross sectional area can be calculated as

A= (ρ× L×I_{Phase} / V_D) ×2

A= [(1.724×10^{-8}x 20 x386)/ 8.8] x2

A= 30.2 mm^2

So we can provide Copper wire with cross sectional area 30.2 mm^2 , 386 A Phase current and ρ = 1.724×10^{-8} Ωm resistivity.

6.3 Cost estimation

The total cost of the system is calculated on the basis of provided elements. Data is given in table no. 6.3

Table no. 6.3 Cost estimation of solar energy system for block 56, LPU

Component	Model	Quantity	Unit price (Rs.)	Total Cost (Rs.)
Module	JJ-M660, 250 watt	744	10000	74,40,000
Batteries	L16RE-B	55	25,000	13,75,000
Voltage regulator	PL80	1	40,000	40,000
inverter	Neowatt Energy 150 kVA	1	17,85,000	17,85,000
Subtotal				1,06,40,000

Other BOS costs (wires, fuses, circuit breakers, etc) = 20% of subtotal.

There for total cost = 1, 06, 40,000 + 0.2 (1, 06, 40,000) = 1, 27, 68,000 Rs.

The operational costs for solar PV installation are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system. Maintenance cost of the PV system = 0.5% of 1, 27, 68,000 = 6384,000

Overall total cost of the solar project = 1, 27, 68,000 + 6384,000 = 1, 91, 52,000 R.s

6.4 Payback period calculation

$$\textbf{Payback period} = \frac{\textbf{Overall cost of the PV solar}}{\textbf{Total estimated cost of the fuel generator for the first year}}$$

Here

The Average estimated time for which generator is in running mode= 1 hour /day

Therefore, total estimated hours used per annum = 1 × 365= 365 hours

Total estimated fuel (diesel) consumption per hour = 15 L/hr. (As per Load)

Total estimated fuel consumption per annum= 15 x 365= 5475 Liters

Cost of diesel = Rs 54.02 Rs/liter

Total estimated cost of fuel used per annum = 54.81 × 5475= 3, 00,084.75 Rs.

Total estimated cost of maintenance per annum assume= 10,000 Rs.

Total running cost per annum= 3, 00,084.75+ 10,000 = 3, 10,084.75 Rs.

Cost of purchase of the fuel generator= 55000 (Assumed)

Total estimated cost of the fuel generator = 3, 10,084.75 + 55000

=365084.75 Rs.

Total cost of energy expenditure by the university for block 56 per year=cost of energy used from the Himachal state electricity board + cost of energy used from the generator

Total cost of energy expenditure by the university for block 56 per year= [616.5 x 365 x 10] + [365084.75] = 2615309.75 Rs. [There for I unit price of electricity in Punjab= 10 Rs.]

Payback period = 1, 91, 52,000 / 2615309.75

Payback period = 7.32 years

Payback period = 7 years

6.5 Result Discussion

The following results are obtained from the design are given below in table no 6.4

Table no. 6.4 Results obtained from design

Components	Description of components	Results
Load estimation	Total peak load estimated	616.5 kWh/day
PV Array	Capacity of PV array	186 KW
	Number of modules in series	2
	Number of modules in parallels	372
	Total number of modules	744
Battery Bank	Battery bank capacity	20150 Ah
	Number of batteries in series	8
	Number of batteries in parallel	7
	Total number of batteries	55
Voltage regulator	Capacity of voltage regulator	78A
	No of voltage regulator required	1
Inverter	Capacity of inverter	146.625 KVA
Wire	Between PV modules and batteries through voltage regulators	78A, $3mm^2$
	Between battery bank and inverter	3594A, $322\ mm^2$
	Between inverter and load	386A, $30.2\ mm^2$

Table no. 6.5Approximate cost estimation of the system

Component	Model	Quantity	Unit price (Rs.)	Total Cost (Rs.)
Module	JJ-M660, 250 watt	744	10000	74,40,000
Batteries	L16RE-B	55	25,000	13,75,000
Voltage regulator	PL80	1	40,000	40,000
inverter	Neowatt Energy 150 kVA	1	17,85,000	17,85,000
Subtotal				1,06,40,000
Other balance of system (wires, fuse, circuit etc)				21,28,000
Total cost				1, 27, 68,000

The operational costs for solar PV installation are negligible, but the annual maintenance cost may amount to 0.5% to 1% of the capital cost of the system. Maintenance cost of the PV system = 0.5% of 1, 27, 68,000 = 6384,000

Overall total cost of the solar project = 1, 27, 68,000 + 6384,000 = 1, 91, 52,000 R.s

Payback period = 7 years

CONCLUSION

After experimentation part it is concluded that Punjab region is having maximum solar potential as it is receiving maximum sun energy. Solar system is having advantages as it is renewable source and free of cost, but having one disadvantage that it is functional only in sunny days. Efficiency of solar module depends upon many factors like type of crystal structure, cloudy weather, rainy season, dust, shadow and altitude etc. the initial setup cost is high for the non-conventional energy system, but it can recover back after certain period. LPU is under growing education sector and having largest infrastructure and facilities for students. As per high population, its energy demand is also high and energy expenditure cost is more. If university will established its own renewable energy sources, half of the expenditure cost can be reduce and the environment pollutants will reduce to certain extent. So design is for non conventional energy system only for one Block, but it can be designed for whole campus which includes hostels building too. This will reduce the energy expenditure from outside and this is eco friendly too.

The design of solar energy system for 56 Block, LPU has following design criteria

Type of system= off grid system

Maximum consumption of electricity = 616.5 kWh/ day

Capacity of PV array= 186 KW

Total number of module= 744

Capacity of battery bank= 20150 Ah

Total no. of batteries required= 55

Voltage regulator capacity= 78A

No. of voltage regulator required =1

Capacity of inverter = 146.625 KVA

Wire = 78 A and cross sectional area of 3mm^2, 3594A and cross sectional area of 322 mm^2 and 386A, 30.2 mm^2.

Total cost of non conventional energy system for 56 block, LPU=1, 91, 52,000 R.s

Payback period= 7 years

REFERENCES

[1] Solanki, Chetan singh, 2015, Renewable energy technologies: a practical guide for beginners, Ashoke K. Ghosh, Patparganj Industrial Estate, Delhi. 153

[2] http://www.need.org/Files/curriculum/infobook/IntroS.pdf

[3] https://en.wikipedia.org/wiki/World_energy_consumption

[4] http://www.ncert.nic.in/ncerts/l/jesc114.pdf

[5]http://www.environmentalpollution.in/energy/sources-of-energy-conventional-and nonconventional-sources-explained/292

[6] https://en.wikipedia.org/wiki/Wind_power

[7]www.slideshare.net/BiancaTeodora3/solar-energy-75975144?qid=51b9f70e-e089-4824-b83b-613bfe7641e6&v=&b=&from_search=11

[8] http://www.indiancarbon.org/the-carbon-credit-market.html

[9] https://www.ibef.org/industry/power-sector-india.aspx

[10] http://www.powersector.in/market-dynamics

[11] Painuly J.P, Barriers to renewable energy penetration; a framework analysis, Renewable Energy 24 (2001) 73–89, 2008

[12] Barahona A.P, The problem of non-renewable energy sources in the production of physical capital, core discussion paper, 2008

[13] Akinboro F.G, Solar energy installation in Nigeria: Observation, prospect, problem and solution, Transnational Journal of Science and Technology May edition vol. 2, No.4, 2008

[14] Nema Pragya, A current and future state of art development of hybrid energy system using wind and PV-Solar: A review, Renewable and Sustainable Energy Reviews, vol. 13, pp. 2096–2103, 2009

[15] Omubo-Pepple V.B, Effect of Temperature, solar flux and relative humidity on the efficient conversion of solar energy to electricity, Port Harcourt, Nigeria, European Journal of Scientific Research ,Vol.35 No.2, pp.173-180, 2009

[16] Parida Bhubaneswari, Review on Photovoltaic technologies, Renewable and Sustainable Energy Reviews, vol.15, pp.1625–1636, 2010

[17] Gupta Yuvika, Carbon credit: A step towards Green Environment, Global journal of management and business research, vol.11, Issue 5, 2011

[18] Kumar Deepak, The Optimum Utilization and Promotion of Renewable Energy Sources in India, International Journal of Engineering Research and Applications, Vol. 2, Issue 1, pp.571-578, 2012

[19] Jamel M.S, Advances in the integration of solar thermal energy with conventional and non conventional power plants, Renewable and Sustainable Energy Reviews, Issue 20, pp.71–81, 2012

[20] Dubey Swapnil, Temperature Dependent Photovoltaic Efficiency and Its effect on Photovoltaic production in the world-A review, PV Asia Pacific Conference, 2012

[21] Birla Vivek, Carbon trading- the future money venture for India, International Journal of Scientific Research Engineering &Technology, Vol. 1 Issue1 pp. 019-029, 2012

[22] Singh Rajput Dayal, Effect of dust on the performance of solar panel, Bhopal, India, International Journal of ChemTech Research, Vol.5, No.2, pp. 1083-1086, 2013

[23][56] Ishaq M, Design of an off grid PV system: A case study of govt. technical college, Wudil, Kano state, Nigeria, International Journal of Scientific & Technology Research, Vol.2, Issue 12, 2013

[24] L.Raja Rajeswari, Design of Stand Alone PV system –A case study, International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 2, pp. 510-515, 2013

[25] Tariq Mohd, Effective battery charging system by solar energy using C programming and microcontroller, American Journal of Electrical Power and Energy Systems, vol. 2 issue 2 , pp. 41-43, 2013

[26] Pranjale Pranita, Non Conventional Sources of Energy-Applications of Solar Energy in Architectural Buildings, International conference on Green Computing and Technology, 2013

[27] Kumar Singh Varun, Photovoltaic-A Review of the Solar Cell generation, Journal of Innovation in Electronics and Communication, Vol. 3, Issue 1, pp. 46-55, 2013

[28] Upadhyay Ashok, Solar Energy Fundamentals and Challenges in Indian restructured power sector, International Journal of Scientific and Research Publications, Vol. 4, Issue 10, 2014

[29] C. Marimuthu, A Critical Review of Factors Affecting Wind-turbine and Solar Cell System Power Production, International Journal of Advanced Engineering Research and Studies,vol.3, Issue 2, pp. 143-147, 2014

[30] Kumar Panjwani Manoj, 2014, Effect of altitude on the efficiency of solar panel, International Journal of Engineering Research and General Science, Vol. 2, Issue 4, 2014

[31] Sharma Sachi, Non Conventional Energy's Overview Sources of India, International Journal of Engineering Research and General Science, Vol. 2, Issue 4, 2014

[32] Fathima Hina, Problem in conventional energy sources and subsequent shift to green energy, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Special Issue 1, pp. 1618-1624, 2014.

[33] Chowdhury Md. Niaz Murshed, Present scenario of renewable and non- renewable sources in Bangladesh: A compact Analysis, International Journal of Sustainable and Green Energy, vol. 3, issue 6, pp.164-178, 2014

[34] Feng Wentao, off grid PV system design for Haiti School Project Lowell, USA, Journal of Power and Energy Engineering, vol. 2, pp. 24-32, 2014

[35] Omer Abdeen Mustafa, Non conventional energy system and environment pollution control, Journal of Soil Science and Environmental Management, Vol. 1, Issue 7, pp. 127-154, 2015

[36] Hossam Eldin Ahmed, A Review on Photovoltaic Solar Energy Technology and its Efficiency, 2015

[37] K. Desai Ashish, The concept of Carbon credit and comparison of co2 emission of India with selected developing countries, International Journal on Recent and Innovation Trends in Computing and Communication, vol-3, issue-10, 2015

[38] Maheshwari Meenu, Carbon credit accounting: A case study of Delhi Metro Rail Corporation, Pacific Business Review International Vol. 8, Issue 3, September 2015

[39] Singh Bhanawat Shurveer, An analysis of carbon credit revenue practice in Indian Corporate Sector, Pacific Business Review International, Vol. 8, issue 6, December 2015

[40] Veronesi Fabio, Evaluating the use of open data to estimate the global solar energy potential, 2nd International Conference on Energy and Environment: bringing together Engineering and Economics Guimaraes, Portugal, 18-19 June, 2015

[41] Kumar sen Prakash, A review of major non-conventional energy sources, International Conference on Emerging Trends in Technology, Science and Upcoming Research in Computer Science, DAVIM, Faridabad, 25th April, 2015

[42] Sahni Karan, Future energy non-conventional energy resources, IJRDO-Journal Of Mechanical And Civil Engineering, Vol.1, Issue-5, pp. 76-80, May,2015

[43] Sathyanarayana P, Effect of shading on the performance of solar PV panel, Energy and Power, vol.5, Issue (1A), pp. 1-4

[44] Tim Umoette Anyanime, Design of standalone floating PV system for lbeno Health center, Nigeria, Science Journal of Energy Engineering, vol. 4, issue 6, pp. 56-61

[45] https://en.wikipedia.org/wiki/Jawaharlal_Nehru_National_Solar_Mission

[46] https://en.wikipedia.org/wiki/Punjab,_India

[47] http://www.teriin.org/projects/green/pdf/Punjab-Renewables.pdf

[48] https://en.wikipedia.org/wiki/Photovoltaics

[49] http://www.greenrhinoenergy.com/solar/technologies/pv_cells.php

[50] http://www.solardirect.com/pv/pvlist/pvlist.htm#url

[51] https://en.wikipedia.org/wiki/Solar_constant

[52] http://homeguides.sfgate.com/effects-temperature-solar-panel-power-production-79764.html

[53] http://www.cleanenergyauthority.com/solar-energy-resources/heat-and-pv/

[54] http://oureverydaylife.com/effects-angle-sunlight-solar-panel-33180.html

[55] Clean Energy Council (CEC), "Grid Connected PV Systems Design Guidelines for Accredited Designers" Issue 3 July, Update November 2009.

[57] http://www.discoveredindia.com/punjab/the-green-granary-of-india/geography.htm

[58] https://weather.com/weather/monthly/l/INXX0060:1:IN

[59] http://www.synergyenviron.com/tools/solar-irradiance

[60] https://www.currentresults.com/Weather/India/humidity-december.php