Global Journal of Ecology, Environment and Alternate Energy Technologies
Vol 1, Issue 1 - 2018

A REVIEW ON INDIA'S POTENTIAL OF SOLAR ENERGY

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ABSTRACT

In few last decades Indian government has taken several steps to reduce the use of fossil fuels-based energy while promoting renewable generation. Solar energy constitutes the most abundant renewable energy resource available on earth. Solar energy, being a clean renewable energy resource, can be used for industrial as well as domestic purposes with added advantage of low maintenance cost. With the recent developments in technology solar energy harnessing equipments are easily available in the market. Most of the developed countries are switching over to solar energy as one of their primary renewable energy source. One of the major steps taken by the Government of India and State Governments in order to meet the growing needs of energy in India is National Solar Mission. The objective of this Mission is to establish India as global leader in solar energy, by creating the policy conditions for its diffusion across the country as soon as possible. The Mission is a major initiative to promote ecologically sustainable growth while addressing India's energy security challenge. This Mission also contributes to the global effort to meet the challenges of climate change. The objective of present study is concentrate on role, situation and developing solar energy in India to recognize the Investment and Potential Opportunities in social and economic field for achievements of sustainable energy.

KEYWORDS: Photovoltaic Cells, Concentrated Solar Power (CSP) System, Zero Emission, Solar India.

INTRODUCTION

In the world of electricity generation India is considered as the third largest country at present[22]. The country's power capacity generation mainly (about three-fifths) depends on vast indigenous reserves of coal and mineral oil resulting in greenhouse gases emission [1, 3]. Since the reserves of coal are limited, in last few decades the Indian government has taken steps towards reduction of use of non-renewable energy resources for electricity generation and at the same time it has promoted renewable electricity generation [3]. In the electricity sector renewable energy has accounted for 18.37% of the total power installed capacity, at present [3].

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Among the renewable resources of energy, solar energy is the most abundant renewable energy source available in most of the regions of the world [3]. Sun is a power house of unlimited energy that could give energy to us for many centuries [1]. The earth receives an unprecedented amount of solar energy [2].There are several techniques to store and use solar energy like solar cells, solar hot water, etc [1]. Solar energy is a scope that can be used for both large and small scale applications [1]. There is zero emission in case of solar energy and it is a clean renewable resource [4].The solar energy has the potential to satisfy the ever growing need of energy due to population boom [1]. The net energy delivered by the sun in a three days period is equivalent to energy supplied by all the fossil fuel in earth [2]. Solar energy is one of the most promising energy resources we can count on [2]. Solar energy is mainly produced by two methods, one is Solar PV i.e. through Photovoltaic Cells and other is Solar thermal i.e. through Concentrated Solar Power [3]. Most of the developed countries are switching over to renewable energy sources, primarily solar energy [4]. With the recent developments in technology during the past few years, the cost trend of solar energy technologies has declined and hence these technologies are easily available for domestic and industrial purposes [3, 4]. The trend shows that the solar power cost will likely to decline in future [3].

India's most of the regions are sunny parts and the country's location is in between the Tropic of cancer and the Equator [4]. India has an average annual temperature ranging from 25°C-27.5°C [4]. This shows that India has huge solar potential [4].

LITERATURE SURVEY

Apart from localized uses of solar power, industries and power plants are also taking advantage of our Sun's abundant energy resource and offering the power generated by solar cells to their users [1]. Our earth receives 174 potentials watts (PW) of solar radiation (insulation) at the upper atmosphere; about 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses [9].

A photovoltaic cell is made up of electrons and when the sun's rays hit it, some electrons absorb energy and leave the atom, these loose electrons begin to move around and it generates energy which is usable electricity [8].

Concentrating solar power systems allow power plants to produce electricity from the sun on a larger scale, allowing consumers to take advantage of solar power without making any investment in personal solar technology systems [1]. Solar power technologies, from individual home systems to large-scale concentrating solar power systems, have the potential to meet the growing needs and provide diversity and reliability in energy supplies [1].India is on course to emerge as a solar energy hub [4]. The demand for more energy is ever increasing in India [4].

Solar energy can satisfy this ever growing demand [4]. India has 300-330 sunny days in a year, which can generate an equivalent power of over 5000 trillion kWh in a year [4]. This is more than India's total energy requirement in a year [4]. India is one of the top 5 destinations worldwide for solar energy development as per Ernst & Young's renewable energy attractiveness index [4].

WORKING PRINCIPLE AND RELEVANT DISCUSSIONS

Solar energy is produced mainly by two methods,

1. Through Photovoltaic cells,
2. Through Concentrated Solar Power (C.S.P.) Systems [3].

SOLAR PHOTOVOLTAIC (PV)

Solar Photovoltaic (PV) is a technology that converts sunlight (solar radiation) into direct current electricity by using semiconductors [3, 4, 11]. Sunlight is made out of tiny energy particles called photons [3, 11, 12]. When the sunlight hits the semiconductor within the PV cell, photons are absorbed in the cell and their energy causes electrons to get free which creates flow of electrons [3, 11, 12, 15]. This generates electricity [3, 11, 12 ,15]. For the electron to get free it requires a threshold energy which depends on the semiconductor material. PV cells can be made from various semi-conductor materials [3, 11]. The most commonly used material is silicon [3, 12, 15]. Pure Si being a poor conductor of electricity requires doping (introducing impurities into an intrinsic semiconductor) to increase concentration of charge carriers (holes and electrons) [3].By absorbing photon energy electrons get excited and hence get detached from their atoms to move in the same direction creating holes [3, 12]. Thus a potential is generated [3]. The requirements for solar energy generation from Solar Photovoltaic cells are as follows:

1. High solar radiation at that particular site,
2. Techno-economic selection of solar panels [3].

Unlike C.S.P. Systems the amount of power generated by Solar PV cells mainly depends on the intensity of solar radiation [4, 15]. Hence productivity decreases if the sun does not shine bright [3, 12, 15].

Figure 1.Typical Rooftop PV System: http://greentomatoenergy.com/case-studies-2/solar-case-studies/

CONCENTRATING SOLAR POWER (CSP) SYSTEMS

Concentrating Solar Power (CSP) uses the principal of concentration of solar energy in a small area so as to generate heat which will in turn create steam and cause turbine to move thus creating current [1, 7, 11].Concentrating technologies exist in four optical types:

- Parabolic trough
- Dish engine
- Linear Fresnel reflector
- Solar power tower [1, 7, 11]

In most cases, CSP technologies cannot compete on price with PV solar panels, which have experienced huge growth in recent years due to falling prices and much smaller operating costs [1, 3, 11].

PARABOLIC TROUGH SYSTEM

A parabolic trough uses solar energy as its primary energy source. It consists of a linear parabolic reflector that concentrates light onto a receiver positioned along the reflector's focal line [1, 3, 7, 11]. The receiver is a tube positioned directly above the middle of the

parabolic mirror and filled with a working fluid (e.g. molten salt) [1, 3, 7, 11]. The reflector follows the sun during the daylight hours by tracking along a single axis [7, 11]. The working fluid is heated to 150–350 °C as it flows through the receiver and is then used as a heat source for power generation [1, 3, 7]. The heat is used to spin a turbine that drives a generator to produce electricity [1, 3, 7]. Trough systems are the most developed CSP technology [1, 3, 7].

DISH ENGINE SYSTEM

A dish engine system consists of two components; the solar dish, which is simply a parabolic mirror or set of mirrors, and a Stirling engine, a closed-cycle engine [1, 3, 7]. This system produces small amount of power in comparison to other CSP technologies, around 3 to 25 kilowatts [1, 7]. The solar dishconsists of parabolic reflectors that concentrate light onto a receiver positioned at the reflector's focal point [1, 3, 7]. The reflector tracks the Sun along two axes [1, 3, 7]. The working fluid in the receiver is heated and then used by a Stirling engine to generatepower. Land requirement for this system isfrom 3 to 4 acres per MW [3].

Figure 2.Dish Engine (CSP) System:http://www.koreatimes.co.kr/www/news/biz/2016/06/123_7372.html

LINEAR FRESNEL REFLECTOR SYSTEM

Fresnel reflectors consists of thin, flat mirror strips that focuses solar radiation in tubes through which the working fluid is pumped. The Fresnel reflectors are fixed on trackers put on the ground [1, 3]. Parabolic mirror may also be used to focus solar radiation from the top of the central tower structure to the receiver [1].They are very effective and the working principle of power generation of Concentrating Linear Fresnel reflectors is same as that of parabolic trough system [1, 3]. The reflector follows the sun with the help of trackers [1]. The working fluid is heated as it flows through the receiver and is then used to spin a turbine that drives a generator to produce electricity [1, 3].

SOLAR POWER TOWER SYSTEM

A solar power tower consists of tracking reflectors (heliostats) that focus sunlight at the top of a tower on a central receiver [1, 7, 11]. The receiver consists of molten salt which is heated by the sunlight (500-1000 °C) [7]. This heated molten salt then flows into a thermal storage tank which has a thermal efficiency of 98%, and then pumped to a steam generator [1, 3].The steam drives a standard turbine to generate electricity [3, 7, 11].This process is also called 'Rankine cycle' [1, 3]. The advantage

of this system over the parabolic trough design is the higher temperature [1]. Thermal energy at higher temperatures can produce electricity more efficiently [11]. The disadvantage of this system is that each mirror must have its own its dual-axis tracking system [1, 11]. But in case of the parabolic trough the only thing that is required is single axis tracking [1, 3, 7, 11].

Figure 3.Solar Tower (CSP) System: https://www.euwid-energie.de/solarreserve-baut-solar thermisches-kraftwerk-mit-fluessigsalzspeicher-in-suedaustralien/

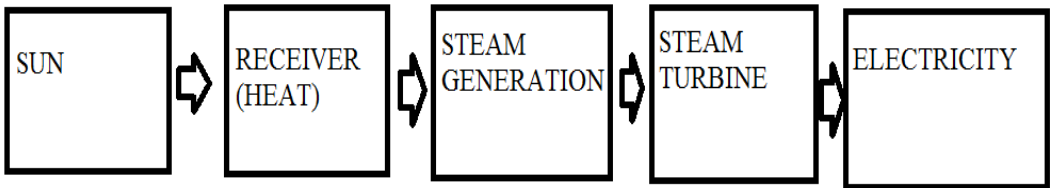

Figure 4.Typical Block Diagram of CSP Technology

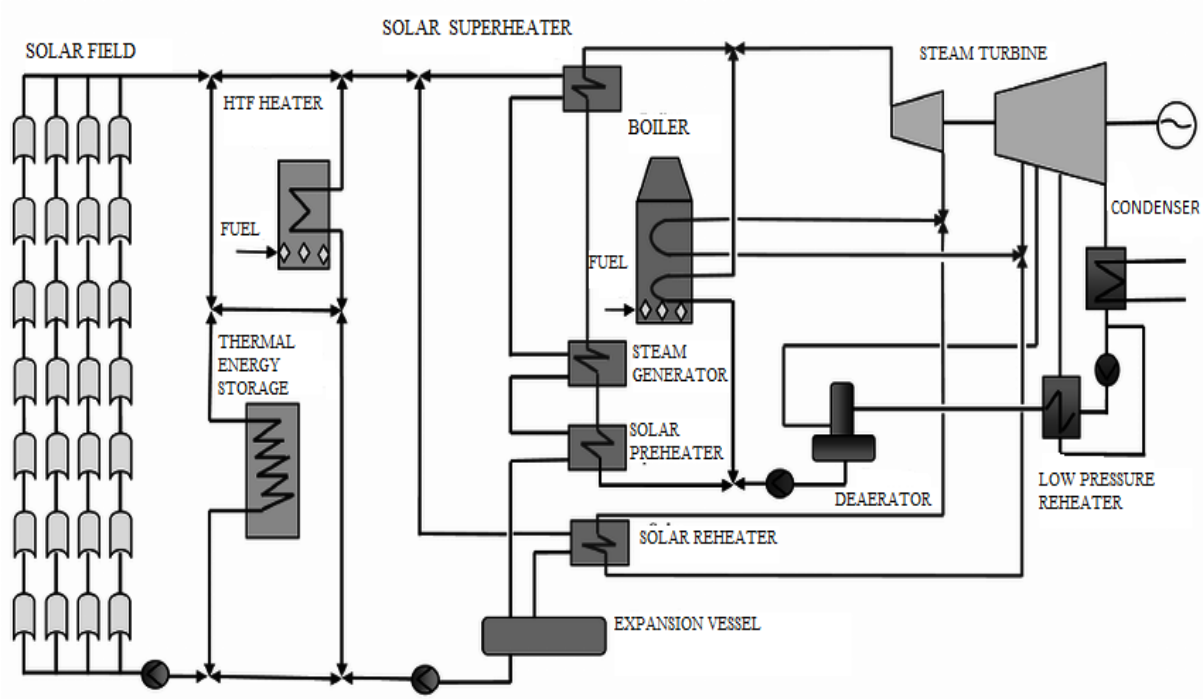

Figure 5.Parabolic Trough (CSP) System: https://www.researchgate.net/figure/ Parabolic-trough-solar-power-plant-schematic-flow-diagram-1_fig1_258402998

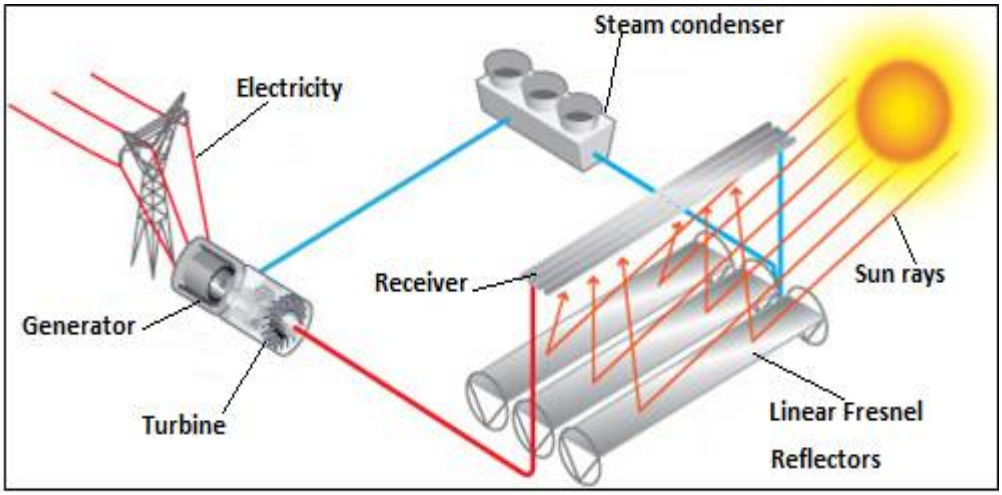

Figure 6.Linear Fresnel Reflector (CSP) System: https://shaikmohasin.wordpress.com/2012/08/28/linear-fresnel-reflector-system/

JAWAHARLAL NEHRU NATIONAL SOLAR MISSION

State Governments took initiative to promote solar power through Jawaharlal Nehru National Solar Mission, also kwon as National Solar Mission [4]. The mission is a part of National Acton Plan which deals with climate change [4, 6]. The program was inaugurated by Manmohan Singh (former Prime Minister) on 11 January 2010 and they had an initial goal of generating 20 GW by 2022 which was later Changed to 100 GW by the present Prime Minister Narendra Modi [4, 6, 14]. The main features of the National Solar Mission (NSM) are:

1. The mission visualizes an installed solar generation capacity of 20,000 MW by 2022, 100,000 MW by 2030 and of 200,000 MW by 2050 [4, 5, 6].
2. The total expected investment required for the 30-year period ranges from Rs. 85,000 crore to Rs. 105,000 crore [4].
3. Between 2017 and 2020, the target is to achieve tariff parity with conventional grid power and achieve an installed capacity of 20 GW by 2020 [4, 5, 6, 14].
4. 4-5GW of installed solar manufacturing capacity by 2017 [4, 5].
5. The scheme also aims at strengthening indigenous manufacturing capability as much as possible, and achieving 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022 [4, 5].

Figure 7.Jawaharlal Nehru National Solar Mission: http://www.erewise.com/current-affairs/jawaharlal-nehru-national-solar-mission-jnnsm_art52aec04d18aac.html#.Ws6CFi5ubIU

The National Solar Mission has the objective to establish India as a global leader in the field of solar energy, with the help of certain policy conditions that will help its diffusion and spread across the country quickly [4]. The Government set a new target of 100 GW from 20 GW on 1 July 2015 [5, 6]. In order to reach 100 GW by 2022, the yearly targets has been changed from 2015-16 onwards in order to achieve the target [5].

GROWTH OF SOLAR POWER IN INDIA

Solar power in India is a fast developing industry [1, 3, 4]. Prime Minister Manmohan Singh launched a National Solar Mission in 2010 [4, 5, 6]. Initial growth of solar power was high [4]. From less than 12 MW in 2009, solar-power generation in the country grew to 190 MW in 2011 [4, 5, 6]. In January 2015 the Indian government expanded its solar plans, targeting US$100 billion in investment and 100 GW of solar capacity by 2022 [5, 6]. The country added 3 GW of solar capacity in 2015-2016 and over 5 GW in 2016-2017, the highest of any year [5, 14].

DECREASING SOLAR COST IN INDIA

Solar PV cell's price has decreased in India, China, Brazil and in 55 other increasing market drastically to about one-third of its 2010 price, thus making solar energy the cheapest form of renewable energy available being way cheaper than fossil fuels such as coal and gas which are also non renewable [3, 4].The Cost of solar photovoltaic cells is falling drastically, the current price being 18% lower than the average price for electricity generated by coal fired plants[3, 4]. The current price now being a quarter of what they were in 2008 [4].

STRIKING CHALLENGES

ALTERNATIVE ENERGY SOURCES

Coal which is very cheap and serves as the closest competitor for alternate energy choices [7]. As India, USA, China and other industrializing nations are getting developed, they will hopefully stop using coal [7].

LAND REQUIREMENT

Another challenge towards Solar India is the availability of lands getting a consistent amount of direct sunlight [3, 4, 7, 11]. The current land requirement amount is approximately 1 km² for every 20-60 megawatts (MW) [7]. Land requirement for solar power installation would have to compromise with the other necessities that require land [5, 6]. The more suitable structure for solar power in India is a highly, distributed individual rooftop power generating system [3].

ATTENUATION

In general we need to concentrate the solar radiation in order to compensate for the attenuation of solar radiation in its way to earth's surface, which results in from 63.2 MW/ sq metre at the Sun to 1 kW/ sq metre at Earth´s surface [7]. The higher the concentration, the higher the temperatures we can achieve when converting solar radiation into thermal energy [7]. Also Solar energy is not uniform during cloudy weather and not available during the nights [7, 11].

COST

Large scale power generation will not be possible until solar power equipments are available at cheaper price at the market. Worldwide industry leaders intend to make it possible within a decade [7].

PRESENT STATUS AND INSTALLED CAPACITY OF SOLAR ENERGY IN INDIA

In February 2018, India's solar capacity had reached to 20 Giga Watts [5, 6]. India has increased its solar capacity over 8 times from

2,650 MW to 20 GW from 26 May 2014 to 31 January, 2018 [5, 6].

INDIA'S SOLAR ENERGY POTENTIAL

Solar energy intensity varies geographically. The Western Rajasthan receives the highest annual radiation energy, while the north-eastern regions receive the least. Most parts of India get 300 sunny days [4, 6]. India gets a good level of solar radiation. This radiation is equivalent to more than 5000 trillion kWh/year [4, 24]. The average solar incidence ranges from 4 to 7 kWh/sq metre/day [4, 6]. India is emerging as a global leader in solar energy [4]. The Indian government has taken steps towards reduction of use of non-renewable energy resources for electricity generation and at the same time it has promoted renewable electricity generation [3].

The strategy is administered through India's Ministry of New Renewable Energy (MNRE), Energy development agencies in the various States and the Indian Renewable Energy Development Agency Limited (IREDA) [5, 14]. With GDP growing in excess of 8%, the gap between supply and demand of energy will only widen [4]. Solar energy is the only source capable of bridging this gap, because of its abundance [4]. Hence India has great potential market of solar energy and is on course to emerge as a solar energy hub [4, 6].

ADVANTAGES OF SOLAR POWER

1. It does not cause emission of greenhouse gases [4]. Hence it is pollution free [11].
2. Solar energy conversion is noiseless and cheap [11].
3. It uses less land than coal mining [3, 4].
4. In case of fossil fuels and coal, there is an extra cost that is transport cost [3]. But in Solar power generating system there is no transport cost involved [3].
5. Maintenance cost is low [11].
6. It is quick to implement [11].
7. It has longevity [11].
8. It is highly reliable [11].

DISADVANTAGES OF SOLAR POWER

1. Maximum power delivered by solar cell decreases with increase in module temperature of the solar cell [5].
2. Installation is costly sometimes in rural area when it comes to solar cells [5].
3. A large area is required to collect solar energy [5].
4. In a cloudy day it may fail to deliver the required amount of power [5].

APPLICATION OF SOLAR PV CELLS

In Solar Thermal Electricity generating system also known as Solar Thermal Power plant which is an emerging renewable energy technology, we use solar energy to generate the thermal energy by focusing and converting the sunlight at medium/high temperature (300 – 800 °C) [7]. It can be used to heat up water bodies, hence useful for creating hot water and steam[5].Solar energy can be used to heat up greenhouses, homes, and other buildings [5]. It is used to power satellites in space [13].It can be used in low power solar bicycle as it reduces emission [10].

FUTURE SCOPES OF SOLAR ENERGY

The new generation technologies aim to enhance poor electrical performance of second generation (thin-film technologies) and maintain very low production costs [12]. A new material with a novel nanostructure has been developed at the University of California, Berkeley, this new material could lead to lower-cost solar cells and light detectors [3]. It absorbs light just as well as commercial thin-film solar cells and uses much less semiconductor material [3]. This new material is composed of an array of narrow pillars [3].

Solar tower can be built in India to capture solar radiation [11].

CONCLUSION

Solar energy is becoming a more reliable source of energy all over the planet. The aim of this study is to transform the basis of energy systems from fossil fuels to solar energy, a renewable source of energy. Due to the ever growing demand of energy in India, solar energy can play a serious role in sustainability of environmental issues as a renewable energy. The objective of this paper is to concentrate on role, situation and development of solar energy in India and to recognize the Investment and Potential Opportunities in social and economical field for achievements of sustainable energy. India is facing an energy crisis which is hampering its industrial growth and economic progress. In India's capital city, Delhi, citizens face hours without electricity. In some parts of India people can face days without electricity. The use of solar energy for the production of electricity reduces the price/unit cost. Hence for a better and more developed India we must switch to solar energy to meet the ever growing demand for energy.

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