Status of Conventional Energy Sources and Solar Energy in India: A Review

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Abstract

India's Power sector is expanding but due to increasing population energy demands are increasing day by day. Solar energy is infinite energy resources to meet up long term energy crunch. India is a tropical country, where sunshine is available for longer hours per day and in great intensity. India has great potential in solar energy. The government also runs various schemes on solar power to increase the energy production and supply. This study is focusing on current status of energy generation, solar energy, its potential, government schemes and importance of solar energy to meet the energy crisis This paper also discusses upon the various challenges faced in the efficient and effective utilization of solar power and gives recommendations.

Key Words: Solar Energy, Potential of solar energy, Energy scenario, Future of solar energy.

Introduction

India is a developing country and facing an acute energy scarcity which is obstructing its industrial growth and economic progress. Energy demand has been increasing gradually along with the development. Due to the limitation of conventional energy sources and increasing environmental pollution production of energy based on renewable energy sources is being given priority and promotion. The sources of electricity generation such as coal, oil, and natural gas have added to one-third of universal greenhouse gas emissions. It is crucial to raise the standard of living by providing cleaner and more consistent energy. (Kumar and Majid,2020).

India is generating 3,70,106 MW of energy by using both conventional and non-conventional sources. Among all the renewable energy resources, for example, wave energy, geothermal energy, solar energy, wind energy, and hydro energy, solar energy is becoming more popular in India. In financial year of 2019-20 energy production from renewable sources is 23.90% out of which 9.80% is contribution of solar energy. (CEA, MNRE & MERCOM, 2020). This is mainly due to the availability of plenty of sunlight in all the seasons and also at all the locations of India.

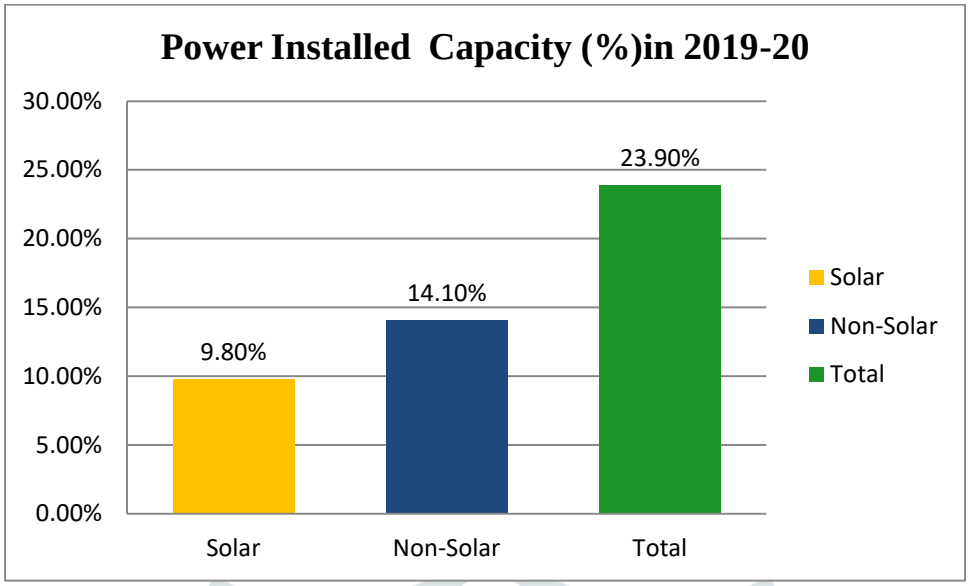

Fig-1 share of renewable energy in total installed capacity

The sun is Planet's most prevailing source of energy and one of the most unused source of energy India has a extreme potential for solar energy and it is projected several times of the energy requisite which is about 5000 trillion KWh per year. According to National Action Plan on Climate Change (NAPCC): "India is a tropical country, where sunshine is accessible for longer hours per day and in great intensity. The solar energy incident over India is equal to 4-7 kWh per square meter per day with an annual radiation ranging from 1200-2300 KWh per square meter. It has an average of 250-300 days with bright sunshine. India's electricity needs can be met on a entire land range of 3000km^2 which is equal to 0.1% of total land in the country.(Ministry of New and Renewable Energy, 2020) Though Solar energy is a superior choice for installation of new power in India with its environmental, social and financial benefits.

Energy generation in India

For the socio-economic development of a country access to affordable electricity for every household is important. India's projected population is 1,353,890,423 by end of year 2019 (World Bank, 2018) 68% of population of India lives in villages and 32% lives in cities and towns. According to Economic survey 2019, India's share in the world's primary energy consumption is only 6% though 18% of the world's population breathes in India. It's per capita energy consumption is one-third of the global per capita average of 1.8 tonnes of oil equivalent. To achieve energy access for all, government has been undertaking several initiatives for the past decade still people lacking access to electricity. 21.7% i.e. 3.9 crores out of a total of 18.1 crore rural households are still unelectrified (Rajya Sabha Data, 2018)

Table 1- India's total installed capacity as on 31.03.2020 (central electricity authority)

Sector	Installed Capacity(MW)	% of Total
Central Sector	93,477	25.2%
State Sector	103,322	27.9%
Private Sector	173,308	46.8%
Total	**3,70,106**	

India with more than1 billion populations is endorsing a huge demand for energy. The country ranks at fifth spot globally for the generation as well as the consumption of energy. Unquestionably, electricity generation has improved over the years; however, the population of the country is also increasing, resulting in an unbalance between demand and supply.

According to Ministry of Power total installed capacity of power in India is 3,70,106 MW The power produced in the country is mostly from coal (53.4%) and it is predicted that country's coal reserves won't last beyond 2040-50. It's high time that our nation should concentrate extra on energy efficiency, conservation and renewable energy. To meet this rising demand, solar energy is the greatest form of energy to satisfy the energy needs of India and tie the energy demand-supply gap.

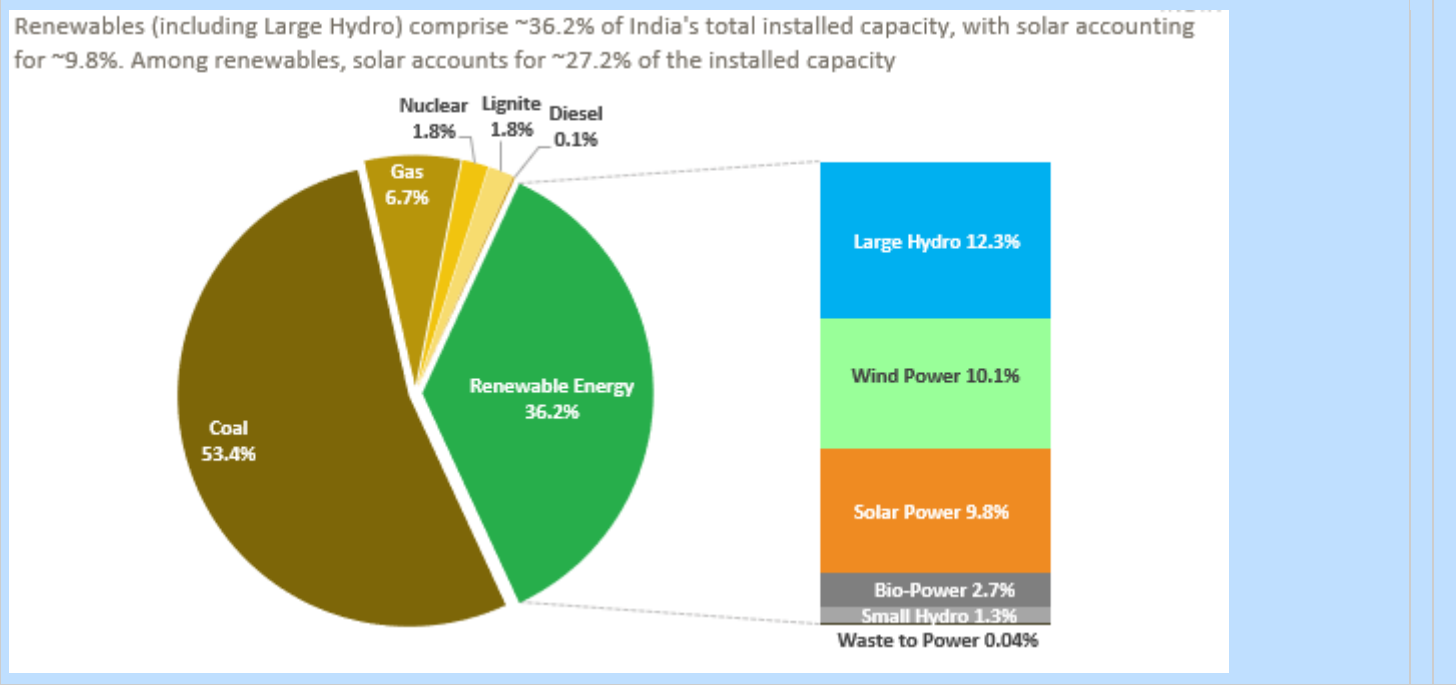

Fig-2 Cumulative installed capacity mix of India's Power Consumption (CEA, MNRE &MERCOM, 2020)

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Potential of India in Solar Power

Solar energy has ample availability in India and being environment friendly its significance increases multifold. The solar power can be utilized in different ways like after conversion into electrical energy with the aid of the semiconductors in the form of Photo Voltaic (PV) cells, as solar panels, or can be used in its natural form as a source of light and heat energy using the Concentrated Solar Power (CSP) or for heating and cooling purposes (Venkatkrishnan & Rengaraj, 2014). India is the fifth largest growing economy in the world and hence the demand for energy will increase and crucial for its development. Solar energy has immense potential in meeting the gap between the demand and supply of energy in the country. The estimated potential of renewable power in India as on March, 2018 was found to be highest in solar i.e. 68%, followed by wind power i.e. 28% and others (small hydropower, biomass power, cogeneration and waste to energy) is 4% (Ministry of statistics and program implementation, 2019).

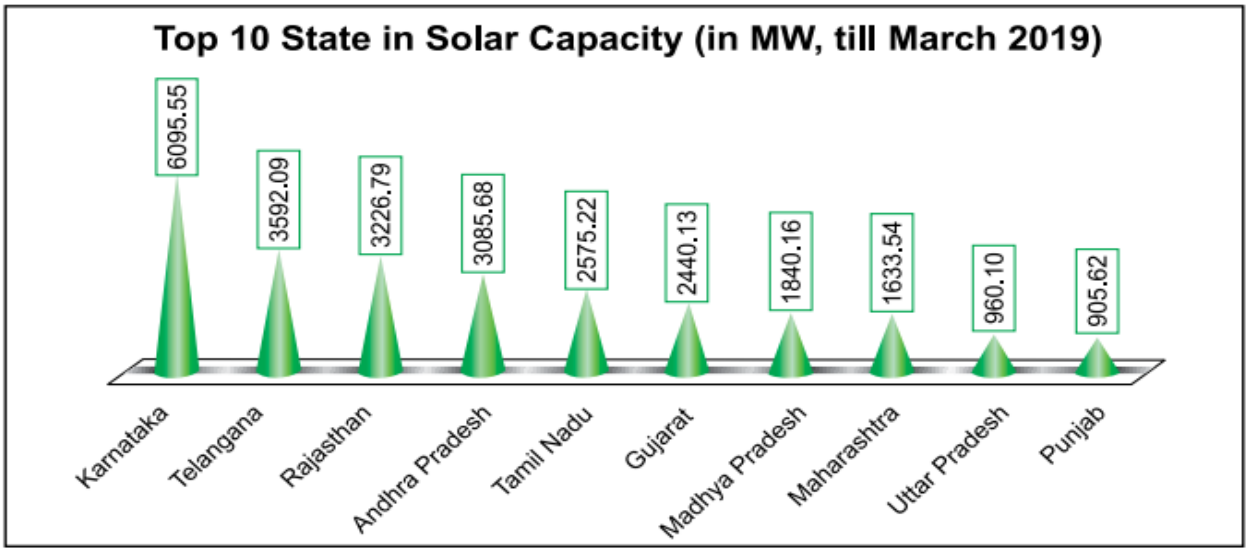

Fig-3: Top 10 States in Solar Installation capacity in MW (Ministry of Statistics and Program Implementation, 2019)

As per figure 3 the top ten states in solar power installation are Karnataka, Telangana, Rajasthan, Andhra Pradesh, Tamil Nadu, Gujarat, Madhya Pradesh, Maharashtra, followed by Uttar Pradesh and Punjab. As we compare the solar installation capacity of these states to their solar potential we can very clearly see in the figure 4 that there is a huge difference between the two and lot of scope in the development of solar installation capacity. This is for top ten states only and similar trend is seen in other states too. The largest difference is seen in the state of Rajasthan due to its very high solar potential because of various geographical and climatic factors.

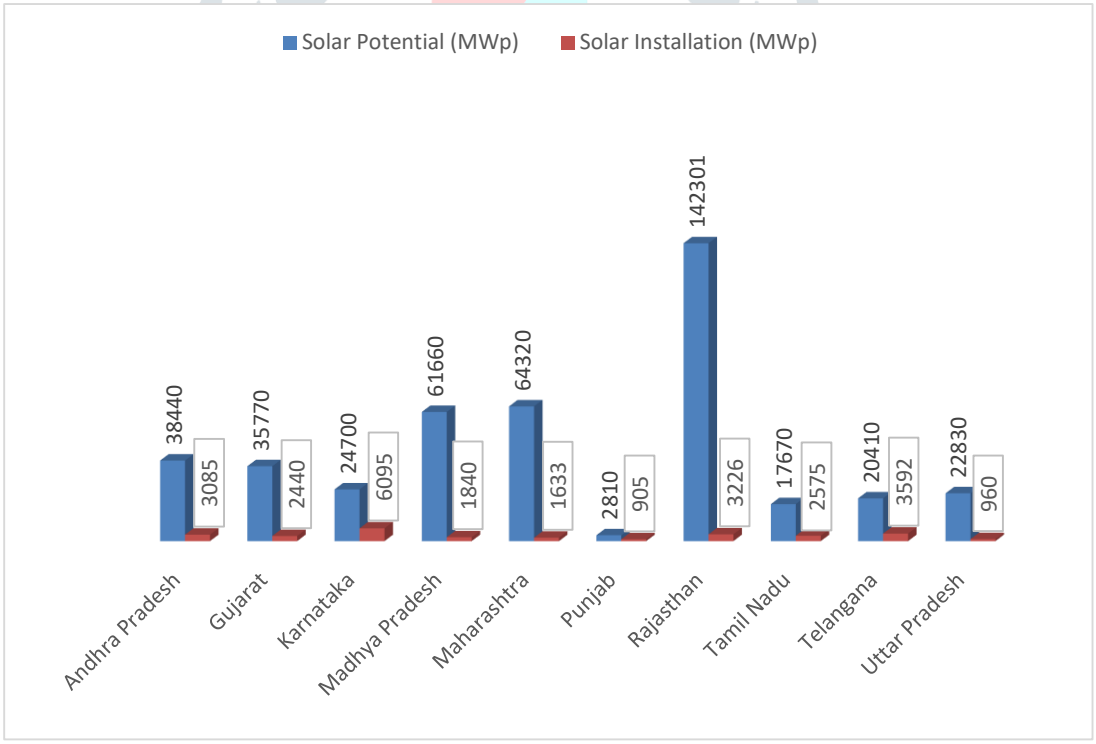

Fig-4: Comparison between solar potential and solar installation of few states (MNRE, 2019)

Government Targets

Government of India has set its target for solar power generation under Jawaharlal Nehru Solar Mission (JNNSM), this mission is one of the eight key National Mission's which comprise India's National Action Plan on Climate Change (NAPCC). JNNSM was launched on 11th January, 2010. It has been divided into three phases- Phase 1: upto 2012-13, phase 2: 2013-17, phase 3: 2017-22 (Rachit and Vinod, 2016). The mission had

the outlined target to achieve 20,000MW of connected solar power and 2000 MW of off grid solar power capacity. This included both solar thermal energy as well as photovoltaic (Raina and Sinha, 2019).
The mission aims to set up a conducive environment for solar technology penetration in the country both at a centralized and decentralized level. The target of 20,000 MW solar power by 2022 has been upgraded to 1,00,000 MW by 2022. The mission aims to create advantageous conditions for solar manufacturing capability (Vikaspedia, 2020).

Government schemes on solar power

GRID CONNECTED

Name of scheme	Features
Development Of Solar Parks And Ultra Mega Solar Power Projects	Under this scheme, it was proposed to set up at least 25 Solar Parks. The capacity of the Scheme has been enhanced from 20,000 MW to 40,000 MW in 2017. These parks are proposed to be set up by 2021-22.
Scheme of setting up of over 5000 MV grid connected SPV power project under IV of JNNSM Phase II	Scheme was launched on dated 14.03.2016, from FY 2015-16 to 2018-19. Viability Gap Funding (VGF) support of Rs. 5050 crore will be provided for setting up of at least 5000 MW Grid-connected Solar PV power projects by Solar Power Developers on Build-Own-Operate basis. Approximately 1,250 MW capacity is envisaged for bidding in each of the four Financial Years viz. 2015-16, 2016-17, 2017-18 and 2018-19.
Scheme for setting up of distributed grid connected solar PV power projects in andaman and nicobar and lakshadwep islands with capital subsidy from MnRE	To develop Carbon Free Islands by phasing out use of diesel for generation of electricity and to contribute to the National Action Plan on Climate Change and Greening of the Islands along with reduction in cost of electricity generation. Period- 2016-17 to 2019-20.
CPSU scheme phase II (government producer scheme) for setting up 12000 MW grid connected solar photovoltaic power projects by the government producers with viability gap funding support for self-use by government/ government entities , either directly or through distribution companies (DISCOMS).	To set up solar PV projects through Government Producers using domestic cells & modules in WTO compliant manner to facilitate national energy security and environment sustainability for Government purpose. Period: 2019-20 to 2022-23

SOLAR OFF GRID

Off-grid and decentralized solar PV applications program phase III	Installation of an additional off-grid solar capacity of 118 MWp by 2020 through following application-wise targets: 3,00,000 solar street lights, 25,00,000 solar study lamps , 100 MWp of off-grid solar power plants Till 31.03.2020
Pradhan mantri kisan urja suraksha evam utthan	The scheme aims to add solar and other renewable capacity of 25,750 MW by 2022 with total central

mahabhiyan	financial support of Rs. 34,422 Crore including service charges to the implementing agencies. Till 31.12.2022
Atal jyoti yojana phase II	Installation of 3,04,500 Solar Street Lights (SSLs) in the following states/ regions as per enclosed operational guidelines for implementation of the Scheme Till 31.03.2021
Scheme on scale up of access to clean energy for rural productive uses	The Scheme aims to enhance the use of reliable and affordable renewable energy for rural productive uses/livelihoods in un-served and under-served areas in 3 states; Assam, Madhya Pradesh and Odisha for strengthening rural livelihoods, improving income generation and reduce use of fossil fuels June, 2020
Seven million solar study lamp scheme for school going children	7 million solar study lamps to be distributed in identified block of the states of Assam, Bihar, Jharkhand, Odisha and Uttar Pradesh Period- 30.09.2019**(Closed)** • 60.61 Lakh Solar Study Lamps distributed to the School going Students • 1769 nos. of Solar Study Lamps repair maintenance centers were established • Around 1896 nos. people were trained in entrepreneurship development • 832 nos. of solar shops have been opened • 7436 nos. of women were trained as solar lighting technicians and Local women are involved in the scheme for Solar Study Lamps assembly
Off grid and decentralized concentrated solar thermal technologies for community cooking, process heat and space heating & cooling applications in industrial, institutional and commercial establishments	To promote off-grid applications of solar Thermal systems for meeting the targets set in the Jawaharlal Nehru National Solar Mission. Period- 2017-18 to 2019-20

Challenges faced in development of solar sector

The development in solar sector does not depend only on the presence of plenty of solar resource. Numerous factors prove to be hindrance in installing and functioning of solar PV plants at their full potential. The subsequent section of the study discusses the several challenges that need to be overcome in order to attain the additional targets.

i. **Economic barriers**- Solar PV is some years away from true cost attractiveness and from being able to compete on the same scale as other power generation technologies. Transmission & Distribution losses adding to the cost that approximately 40 percent solar energy generation sources are unfeasible. PV technologies also demands high initial investment which leads to discouragement among developers who refrain from investing in solar PV technologies. (EIA,2019)

ii. **Technological barriers** Although solar sector has done enormous progress when it comes to technology but it still hasn't proven to be enough. Researches suggested that low conversion efficiency of solar technologies is the biggest challenge in comparison to conventional systems of energy generation.

iii. **Environmental Impact**s-Many studies pointed out though solar energy is cleaner source compared to conventional energy sources, still it has some environmental impacts that can harm to the environment in the long run. According to Shahsavari et al. PV technology impacts environment during the process of manufacturing of PV panels. This is due to the use of poisonous compounds in the manufacturing lines. Studies have also indicated that environment is also getting harmed due to presence of selenium while using Cadmium telluride and copper indium selenide thin film technologies. Crystalline silicon panels' alignment mostly contains non-hazardous waste, which needs proper treatment. PV plants generate e-waste by using PV panels .E-waste recycling is a great way for reducing the effect of PV technology on the environment.

iv. **Social Awareness-** Lack of social awareness becomes a major barrier in full use of the benefits offered by solar PV technology It is a obstacle in the growth of solar power generation in developing countries like India. Acceptance of the solar PV systems due to lack of understanding about technology has proven to be an hindrance (Raina & Sinha 2019)

v. **Other barriers** Many studies register a number of challenges in the development of solar PV systems in the country. These challenges may be of small magnitude but some times their effects can be felt on a bigger scale. Dirt deposition and insufficient cleaning of solar panels may cause decrease in the efficiency of the panel as dust obstructs the incoming intensity from the sun Also uncertainties and inaccessibility of weather data leads to unsuitable design of the system for any assumed loads Lack of storage technologies, shortage of certain materials is another obstacle that must be dealt with to improve the status of PV installations in the country

Discussion and Recommendations India has plenty of solar energy due to its geographical location. Increasing demand for energy will be achieved well by using solar energy technologies for electricity generation with policy support and improvement in technology over the subsequent years.

Though many researches addressed challenges with solar power generation, but they did not disprove the ability of solar energy to address the issue of energy security and combat energy shortage in developing countries. Ample solar energy is used to generate electricity by using solar photovoltaic technology. Numerous reports stated that in the coming years energy demand is going to rise worldwide as well as for India. Cost effective investments are required for Indian policy fabricators at both national and state level with effective support between various levels of Government to meet high energy demands, Policy fabricators should target to achieve 100% renewable based system for energy generations in coming years.

Researches stated that compared to conventional systems achieving a 100% renewable based power system will be more cost effective over the last 20 years, to decrease the dependence on conventional sources of energy, numerous policies have been brought into effect to fast-track the development of solar energy development in the Nation. Policies for electrification of rural areas for providing adequate resources are developed in India as 68% population of India lives in Villages. Among all the policies no policy has focused on solar energy development as compared to Jawaharlal Nehru National Solar Mission. It has been the most successful policy in increasing the solar energy installations in the nation set for a decade with targets for solar energy development. The total installed capacity of solar energy generation in the nation has reached almost 26 GW as of October 2018. Many schemes have been implemented under JNNSM at central as well as state level with the aim of using the complete potential of solar energy available in India to achieve the target of 100 GW.

Various institutes focused on research and education is involved in R&D in the field of Photovoltaic to combat the technological barriers in solar technologies. A number of rivers flowing within Indian borders and it is surrounded with large water bodies, Floating Photovoltaic can be a good solution to raise the solar installed capacity in the nation. Floating Photovoltaic will help in overcoming the land unavailability and problem of temperature increase in Photovoltaic with the flow of water acting as a natural coolant providing a higher

energy output. The natural flow of water over the floating PV system can help in cleaning the panels which would otherwise have caused shading of the panel reducing its efficiency (Raina and Sinha, 2019).
All the above mentioned recommendations can help combat the challenges faced in development of solar energy in India. India's geographical location gives it an advantage where solar energy can be abundantly exploited for a major part of the year. States like New Delhi, Maharashtra, Gujarat, and Rajasthan with adequate solar radiation can develop policies that provide a helping hand in attaining the targets for 2022. Rooftop generation is also promising solution for achieving the 100 GW target of solar energy. Rooftop generation provides a solution for the land unavailability adds to the solar thermal generation in the country and provides consumers an opportunity to become self-sufficient, monetary benefits aside. Only with the implementation of strict policies for rooftop generation and adhering to those policies can solar energy rise as the best alternative to replace conventional fuels as the primary source of energy. Though solar power generation faces some challenges but it provides great opportunities. At one side it is a clean energy helping in reducing the rising concerns of climate change, solar energy also addresses the issue of energy security. The secured and ample amount of energy is a major factor that plays important role in development of any country. Solar energy will help in getting secured energy which will support in the process of development in underdeveloped and developing countries.

Conclusion

India being a developing country needs to grow in a rapid pace and therefore the energy demand is also high but there is huge gap between demand and supply of energy. In non-conventional sources of energy the potential is enormous and solar power is very good option in India to increase power production due to conducive geographical and climatic conditions. India has lot of potential in solar power. The gap between installed and potential of solar power need to be lessened to meet the energy requirement efficiently. Government has many schemes running on solar power (grid connected and off- grid) which has set target to meet its energy requirement. Some scheme have even fulfilled their targets before time and further increased them. The suggestions given above can be considered to overcome the challenges in efficient power generation and usage. Also technological advancement are essential to meet the targets effectively and efficiently.

References

Dawn, S., Tiwari, P., Goswami, A. & Mishra, M.. (2016). Recent developments of solar energy in India: Perspectives, strategies and future goals. *Renewable and Sustainable Energy Reviews j.rser.*62. 215-235. Retrieved from https://www.researchgate.net/publication/301916941_Recent_developments_of_solar_energy_in_India_Perspectives_strategies_and_future_goals

EAI. Key challenges in the growth of solar PV technology in India. Retrieved from http://www.eai.in/ref/ae/sol/cs/spi/kc/key_challenges_in_the_growth_of_solar_pv_technology_in_india.html on 27/04/2020

Gupta, S. K. and Anand, R. S. (2013). Development of solar electricity supply in India: and overview. *Hindawi Publishing Corporation Journal of Solar Energy.* Retrieved from http://dx.doi.org/10.1155/2013/632364

Kumar, S., Setty, S., Tyagi, B., Sharma,S. & Mathew, S.(2020). Increasing energy access by using super-efficient appliances in rural homes and productive businesses: India Stakeholders Mapping Report *Alliance for an Energy Efficient Economy.*

Kumar, C.R. & Majid, M. A. (2020) Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society Review.* Retrieved from https://link.springer.com/article/10.1186/s13705-019-0232-1

Ministry of Statistics and Program Implementation, 2019. Energy statistics 2019. Retrieved from http://www.mospi.gov.in/sites/default/files/publication_reports/Energy%20Statistics%202019-finall.pdf

Ministry of New and Renewable Energy. Overview of Solar. Retrieved April 17, 2020 from https://mnre.gov.in/solar/current-status/

Ministry of Power. Overview. Retrieved April 18,2020 from https://powermin.nic.in/en/content/overview

Rathore,P.K.S, Rathore, S., Singh, R.P. & Agnihotri, S.(2018). Solar power utility sector in india: Challenges and opportunities. *Renewable and Sustainable Energy Reviews.81,.part2,*2703-2713. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S1364032117310171?via%3Dihub

Raina, G. & Sinha, S. (2019) Outlook on the Indian scenario of solar energy strategies: Policies and challenges. *Energy strategy reviews.24*, 331-341. Retrieved from https://www.sciencedirect.com/science/article/pii/S2211467X1930032X

Suman,S. K. & Ahamad, J. (2018). Solar Energy Potential and Future Energy of India: An Overview. *IJESC, 8*,5,17575-17579. Retrieved from http://ijesc.org/upload/154bf24473964709c5089756045c0ffa.Solar%20Energy%20Potential%20and%20Future%20Energy%20of%20India%20An%20Overview.pdf

Srivastava,S.P. & Srivastava,S.P(2013) Solar Energy and its future role in Indian Economy. *International Journal of Environmental Science: Development and Monitoring (IJESDM) 4*, 3. Retrived from https://www.coursehero.com/file/17611663/ijesdmv4n3-18/

S, Rachit, K.G., Vinod, (2016). Solar Power – Current Status, Challenges and Policies in India. *Research & Reviews: Journal of Engineering and Technology*, 5 (*2):* 18-22. ISSN:2319-9873

Venkatkrishnan, G. R., Rengaraj, R. (2014). Overview of Solar Energy in India. *International journal of development research*, 4(3):605-608.

Vikaspedia.in. Jawahar lal Nehru National Solar Mission. Retrieved from https://vikaspedia.in/energy/policy-support/renewable-energy-1/solar-energy/jawaharlal-nehru-national-solar-mission on 27/04/2020

Yadav, H., Kumar, V. & Yadav, V. (2015). Potential of Solar Energy in India: A Review. *National Conference on Renewable Energy and Environment* (NCREE-2015). Retrieved from https://www.researchgate.net/publication/306034848_Potential_of_Solar_Energy_in_India_A_Review