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Contribution of Solar Photovoltaic technology in making India leader in renewable energy

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Abstract:
The energy generated from the sources of nature which are replenish naturally , their resources are virtually inexhaustible in duration but limited in amount of energy that is available per unit of time is renewable energy. India being the world's third largest producer of electricity and third largest consumer of electricity, the national grid of India has an installed capacity of 374.199 GW as of 31st November 2020. But there is a demand and supply gap with gradually increasing demand in India. In 10 next ten years the demand will increase by 2.5 times the existing demand.
The primary objective of increasing the renewable energy installations in India is to improve the energy security of the nation, economical development, and improved access to energy and to mitigate climate change. Sustainable development is possible only by the means of sustainable energy which is reliable and affordable. Strong government policies, incentives and increasing opportunities have pushed India to be one of the top leaders in the world's renewable energy markets. There is a lot of scope for domestic jobs and entrepreneurship in renewable energy sector with the steep increase in the foreign investments and congenial policies. This paper aims to present significant achievements, prospects, projections, generation of electricity, as well as challenges and investment and employment opportunities due to the development of renewable energy in India.
Key words: *electricity, grid, renewable, energy security, photo voltaic technology, entrepreneurship*

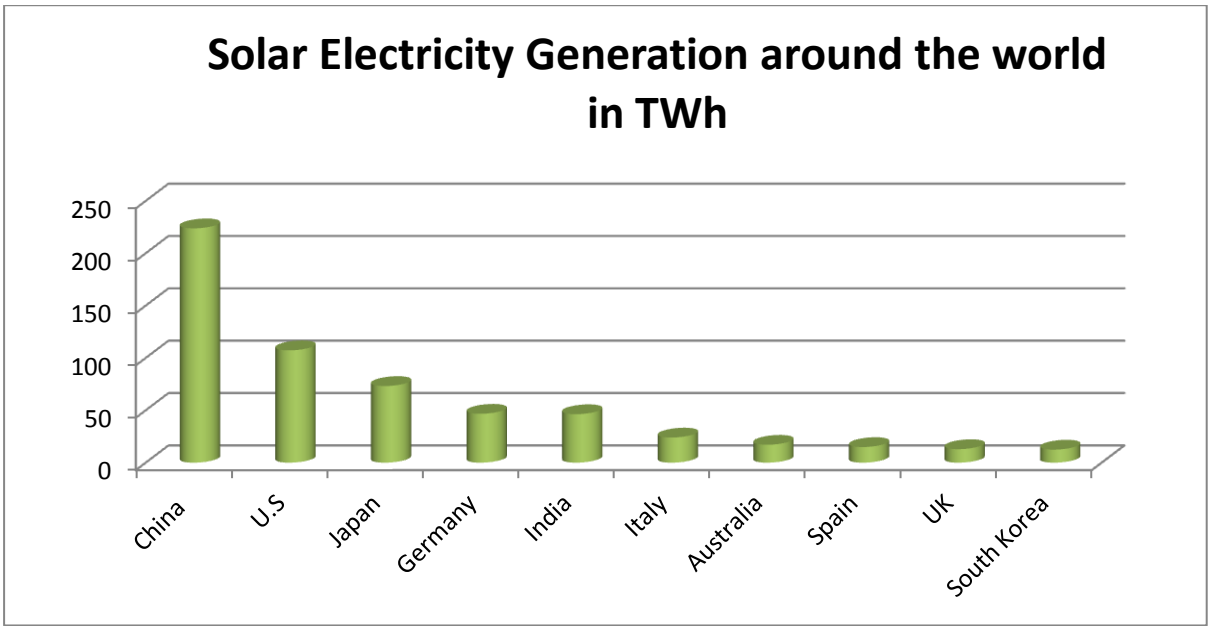
I. Introduction:

This is the era of energy transition from fossil fuel to renewable sources, also the critical time to take suitable actions which affect the impact of climate change. The Paris Agreement sets a goal to limit the increase in global average temperature to well below 2°C above pre-industrial levels and to attempt to limit the increase to 1.5°C. Renewable energy coupled with energy efficiency gains will provide reduction in CO2 emissions by 90% by 2050 [1]. The world countries are using the information technology, smart technology, policy frameworks and market instruments for decarbonising atmosphere and install the renewable energy stations. Solar energy which is available domestically and universally can be harnessed to reduce the carbon emission as well as to cater to the power needs of the country.

Solar Electricity Generation around the world:

The energy generated from the sun which can replenish naturally, virtually inexhaustible in duration but limited in amount of energy that is available per unit of time is Solar Energy. Both heat and light from the sun can be harnessed for various proposes. Solar thermal energy is used for cooking, industrial heating and electricity generation. Solar light energy can be trapped by using a solar photovoltaic cell which converts the light to electricity. The Solar photovoltaic cell which was first invented in 1954 at Bell Telephone laboratories and is now playing a major role in the global electricity generation. Solar photovoltaic energy can be combined to provide electricity on a utility scale or in smaller configurations for mini-grids or decentralised rooftops.

China is the leader in the manufacture and installation capacity of solar photovoltaic modules in the world due to congenial policies of the country which paves way for upgradation of manufacturing units in China. Countries with abundant sun shine which makes solar modules more productive like Australia, which has installed more than 13 GW is also trying to accomplish the entire electricity need of the country by solar photovoltaic installations. Countries like Germany where the electricity cost as high as 0.38 USD are also fast in the race of renewable energy particularly solar photovoltaic energy [3].

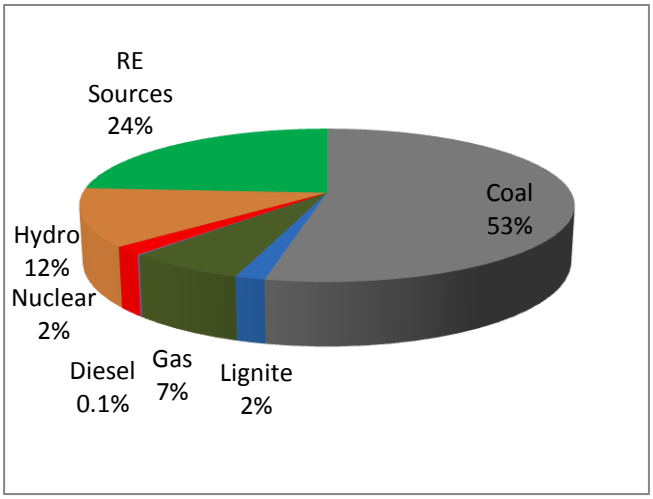


In nations like Australia and India the government policies and incentives for the consumer to install solar photovoltaic systems are very conducive and supportive. With an ambition of becoming the global leader in Solar Energy Generation, the Jawaharlal Nehru National Solar Mission was announced under the National Action Plan for Climate Change (NAPCC) in 2010 in our country, with target of 20 GW which was later increased to 100GW by 2022.

Projected primary energy consumption in India:

India being the world's third largest producer of electricity and third largest consumer of electricity, the national grid of India has an installed capacity of 374.199 GW as of 31st November 2020. India's power generation from renewable energy sources stood at 10.325 billion units (BU) in January 2020, a 9.46 % increase from 9.433 BU generated in the same month last year, according to provisional data released by the Central Electricity Authority (CEA). [2]

Installed capacity of various energy sources in India [4]

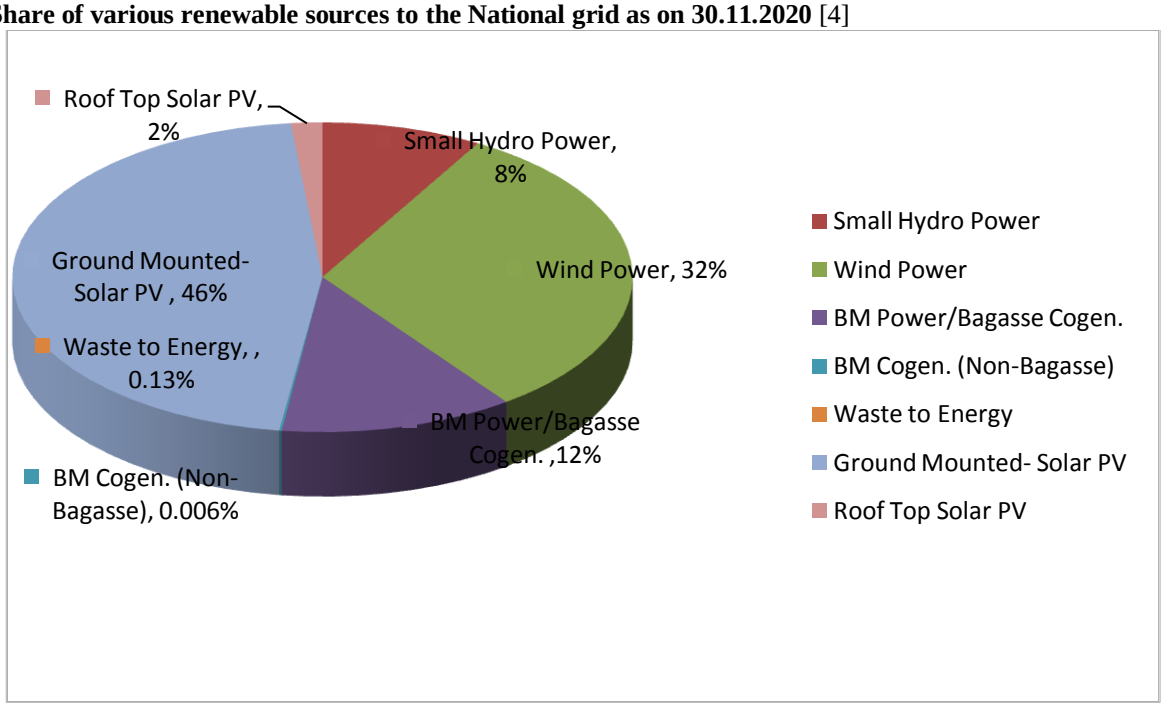


Source	Installed capacity in GW
Coal	199.594
Lignite	6.26
Gas	24.956
Diesel	0.509
Nuclear	6.78
Hydro	45.699
RE Sources	89.635

Geographical Suitability for solar installations:

India is a vast land, lying entirely in the Northern Hemisphere, the main land lies between 8˚ 4' North and 37˚6' North latitude and 68˚7' East to 97˚25' East longitude. India is a country with nearly 300 sunny days annually and has a favourable geographic location for generating solar power. Average annual peak sun shine hours are quite high for India due to the Tropical and Torrid Zone location of India.

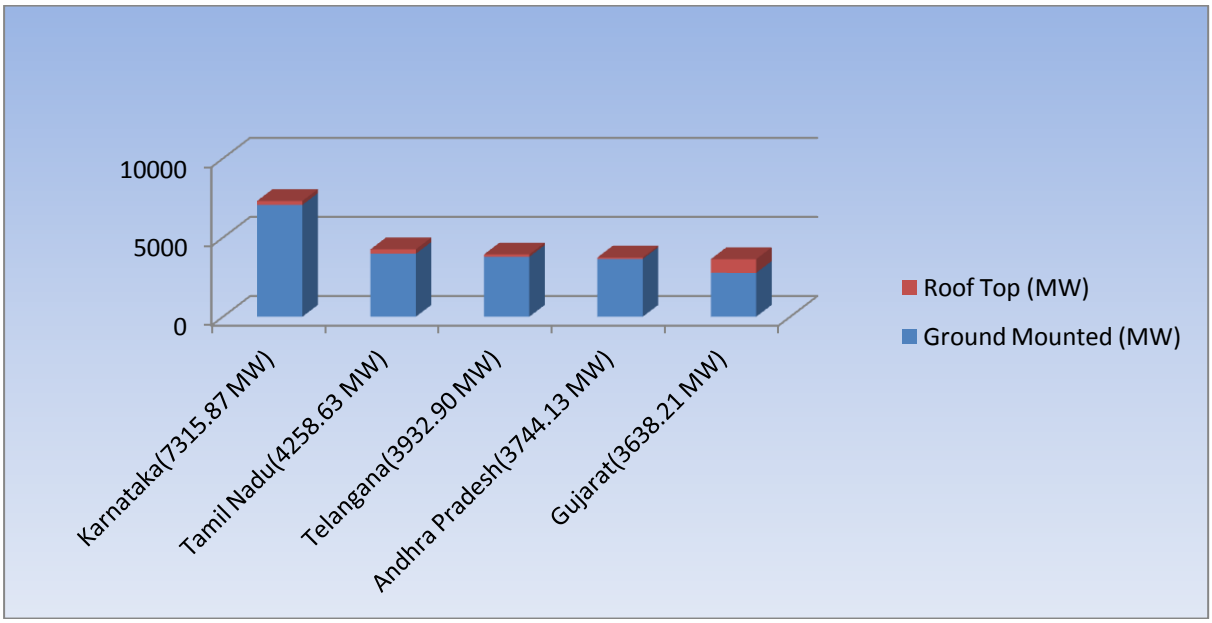
Share of various renewable sources to the National grid as on 30.11.2020 [4]



Solar Electricity Generation across India:

Five states of India i.e. Karnataka, Telangana, Rajasthan , Andra Pradesh and Gujarat which top in solar rooftop installations together account for more than 50% of the installations in India. Karnataka, the leader in solar installations, gets 63% of its installed power capacity from renewable and 25% of this comes from solar. Karnataka's 13,000-acre Pavagada Solar Park (or Shakti Sthala) in Tumakuru district is one of the biggest solar plants in India, with a production capacity 2,050MW.The state is likely to see three more mega solar parks with a capacity of 2,500MW each, in the districts of Bidar, Koppal and Gadag.

Solar Power installations as on 30.11.2020 [4]



The sunlit state of Rajasthan aims at installing 30 GW of solar power by 2024-25, while 20% of the installations of the state comprise of solar. The conductive solar policy of Gujarat state makes it the best states for largely due to good credit ratings of power distribution companies and their ability to pay on time. 50% of Tamilnadu's installed power comes from solar; the state is aiming at 9 GW solar installations by 2023.

In India, many state and central government public sector undertaking such as Cochin International and Domestic Airport, Delhi Metro, Educational institutions and government offices are consuming electricity through solar photovoltaic systems. Solar ground mounted systems have to contribute to the 60 GW target of the National Solar Mission and 40 GW has to come from the rooftop installations, which includes domestic, institutional, industrial and commercial rooftops.

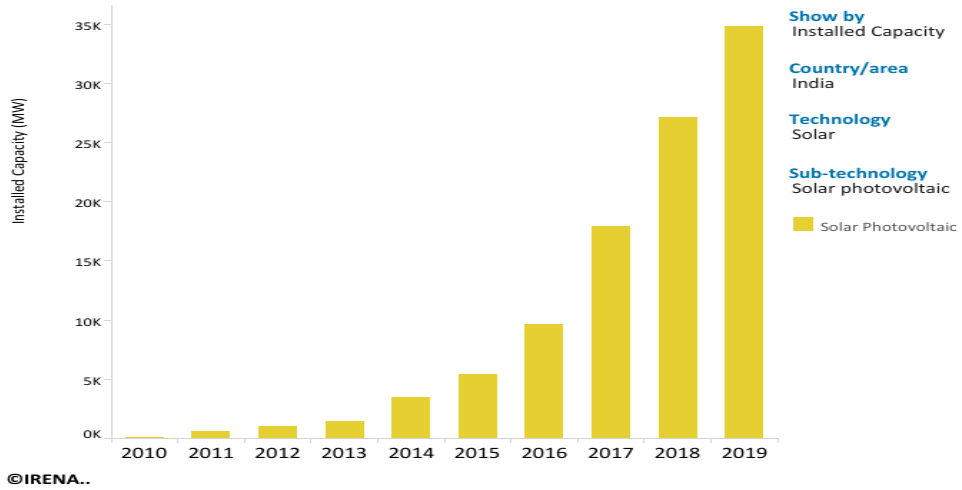
The "Made in India" initiative promoted the domestic manufacturing and supported the installation in a great way. India presently has the fifth largest solar installed capacity in the world. India has 1.5 GW manufacturing capacity of solar modules.

Solar Installed Capacity Trends in India

The rates of solar power plant installations have been constantly decreasing due to various reasons such has the decrease in the cost of solar cells/silicon wafers imported from other countries, incentives provided to the customers viz Industrial, Institutional, Commercial and domestic. This led to more installation after 2014 in India. The rate for solar module per watt was about 6 USD between 1990 and 1995, which is about 0.5 USD per watt now.

The cell technology has made this remarkable drop in the rates of silicon solar modules. Different types of solar modules which are free of toxic materials such as organic solar modules and the multi-junction heterogeneous solar modules are gaining popularity. Perovskite Solar Cell (PSC) is gaining popularity has a heterogeneous multi-junction non hazardous solar cell with more than 35% conversion efficiency.

Increasing trend in solar installations in India



Note: derived from IRENA statistics [5]

Employment in Solar Photovoltaic sector:

The solar PV industry retains 33% of the total renewable energy workforce in the world. In 2019, 87% of global PV employment was concentrated in the ten countries that lead in worldwide deployment and in the production of equipment [5]. India is the country which has employed major workforce in solar installation, operation and maintenance. The countries *Suryamitra Skill Development Programme*, a flagship programme of Ministry of New and Renewable Energy has created skilled workforce who are deployed in the solar installation sites.

Stand alone solar installations create direct job opportunities and a wide scope for entrepreneurship among the nation's youth. The increase in solar sector jobs also includes jobs in solar water heater production and maintenance. The Ministry for New and Renewable Energy also encourages farmers to shift to solar from their conventional power connection, in this was every year in Karnataka about 5000 solar water pumps are distributed to farmers in highly subsidised rates through the state nodal agency.

II. Solar Energy Sector Challenges in India:

- Solar cell manufacturing is the important aspect which may decide the easy availability of solar modules for local installations. Indian solar module manufacturers mostly depend on their solar cell imports; there are only 16 solar cell manufacturers in India in which half of them are below 100MW capacity.
- The challenge with manufacturing cells domestically is the huge infrastructure costs associated with it. Manufacturing cells is a complicated, multi-stage process, and requires extensive capital investment.

Upgradation of Solar cell technology every 8-9 months makes the whole process even more capital intensive.

- An optimum capacity of 500 MW is what would be profitable, for which we need an investment of about 4 billion USD. Even if manufacturers do decide to invest, there is no guarantee of demand as government policies change too often without much notice.[6]
- Thus, Indian solar cells are, on average, 20-30% more expensive than cells manufactured in China. India does not have any program like China's Technology Top Runner Program incentivizes the introduction of next-generation technology for higher efficiency solar cells. As a result, Chinese manufacturers bring in the latest technology at a competitive price.
- Then policies of each state and distribution company vary with respect to the solar grid connected systems which makes the process difficult for the domestic users to pursue.

III. Suggestions:

- If banks allow an interest rebate on housing loans if the customer installs renewable applications, this may encourage public to use renewable energy.
- Income tax rebates may be given to the individuals who implement renewable energy applications.
- There is need for regular monitoring of R&D and the budget allocation.
- The Goods and Service Tax (GST) that was introduced in 2017 worsened the industry performance and has led to an increase in costs and poses a threat to the viability of the ongoing projects, ultimately hampering the target achievement. These GST issues need to be addressed.
- Promotion of renewable sources should also accompany the promotion of energy efficiency practices. Government initiatives like *UJALA* scheme where LED lights were distributed could bring about energy saving of more than 35000 Mega Units in the country.
- We also need to address some challenges faced by power producers which include high fuel supply risk, time overruns at plants, and the limited paying capacity of the financially weak distribution utilities due to pre-defined *Renewable Purchase Obligations* in their Power *Purchase agreements.*
- China's Technology Top Runner Program incentivizes the introduction of next-generation technology for higher efficiency solar cells. As a result, Chinese manufacturers bring in the latest technology at a competitive price. Such programs do not exist in India, which is the reason for very less manufacturing units in India, this have to be addressed by suitable incentives and policies for the upgradation of solar cell manufacturing plants in India
- Popularising the urban and rural successful solar installations will bring about a positive drive among the public. Awareness programmes both in urban and rural areas towards the green energy and with thrust in solar photovoltaic systems in a proper way can do miracles.

IV. Conclusion:

Future researches and studies should come up with an optimal generation mix from the perspectives of technical economics, grid stability with great deal of renewable energy contribution. There is immediate need to share the best practices among the various Regional Load dispatch centres, coordinate for planned maintenance and upgradation for meeting the environmental norms. Further in the world which is looking forward for a new era of electric vehicles, solar charging booths which will replace the conventional petrol pumps are a boon to the society. Researches to obtain fast charging and slow discharging batteries with low maintenance must be encouraged in India in order to reduce the use of fossil fuel in a great way.

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