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Accessibility of Solar Energy- Paving the Way towards Sustainable Development

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ABSTRACT: *Energy is linked to every other critical sustainable development challenge such as health, education, food security, gender equality, poverty reduction and climate change. India's focus on fighting climate change is a step towards the achievement of Sustainable Development Goal 7, which emphasizes universal access to affordable, reliable, sustainable and modern energy and increasing the share of renewable in the global energy mix. Renewable, clean energy and gender equality are preconditions for sustainable development and for tackling climate change, as envisioned by the Sustainable Development Agenda 2030. India's major strategy for mitigating carbon emissions can be conceived through decarbonising its electricity sector with ambitious target for solar in the renewable energy mix. India's position has gone up to 26th rank in WB's " Ease of getting Electricity" in 2017 from 99th spot in 2014 on account of its focus on energy efficiency measures and rapidly decreasing costs for renewable energy technologies. Of all renewable resources the abundance of solar energy offers a solution to fulfil the energy security. There is a greater focus on ensuring that the benefits of solar energy capacity should reach the farmers through appropriate interventions such as solar pumps and user friendly solar cooking solutions. The government has implemented policy framework to harness green and clean energy from natural resources for the benefit of the environment and to ensure energy security for the people. The paper aims at providing a long term sustainable solution for meeting the ever increasing energy needs by reducing dependence on fossil fuel based power.The analysis of increase in the contribution of solar energy projects in the total installed capacity creates an environment conducive to private participation and investment in solar energy needs.The paper highlights on the solar energy development potential , the govt. supportive policies and the increase in the installed capacity of the solar energy which paves the way for sustainable development.*

KEY WORDS *–solar energy, sustainable development, energy security, installed capacity,participation and investment.*

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I. INTRODUCTION

Energy and the optimal and proper usage of energy is inextricably linked to other critical sustainable development challenges like education, health, food security, gender equality, poverty eradication and climate change. Sustainable Development Goal 7 of the United Nations focusses on universal access to affordable, reliable, sustainable and modern energy and increasing the share of renewable in the global energy mix. India's part in fighting climate change as per the Paris Agreement of Conference of Parties 2015 is to enable the accomplishment of this goal by reducing the dependence on Carbon based emissions, mitigating Greenhouse Gases emissions and incrementing building of adaptive capacities that are sustainable in the long term along with accomplishing other SDGs by 2030. India's major strategy for mitigating carbon emissions can be conceived through decarbonising its electricity sector with ambitious target for solar in the renewable energy mix. Coal combustion was responsible for 72% of India's total fossil fuel combustion based CO2 emissions predominantly from the electricity sector.Coal accounted for 70% of electricity generation(CEA, 2016).

Solar energy can be an alternative, competitive energy resource to coal.India needs to produce solar energy to mitigate its carbon emissions significantly.Green Peace recommends that India's strive towards developing solar power as a dominant component of its renewable energy mix is based on certain indicators ie its high density of population,a large potential consumer base and high insolation.India can make use of renewable energy resources that can curtail carbon emissions without compromising its economic growth potential (MNRE).India needs to change its incumbent energy structure from fossil dependent coal and oil to clean and affordable one.Among all renewable resources solar energy's abundance offers a solution to fulfil the demand for energy.The paper aims at providing a long term sustainable solution for meeting the ever increasing energy needs by reducing dependence on fossil fuel based power and mitigating climate change.

Objectives

- To harness green and clean energy from natural resources for the benefit of the environment and to ensure energy security for the people.
- To augment the contribution of solar energy in the total installed capacity.
- To highlight on the solar energy development through government supportive polices.
- To increase the generation of solar energy for the long term energy security of the country as well as ecological security by reducing carbon emissions.
- To create an environment conducive to public, private, community participation and investment in solar energy needs in India.

Sustainable Development

Access to clean energy is vital for sustainable development. Economic welfare is endangered by increased use of traditional energy resources such as oil, coal, natural gas and its harmful green house gas emissions to atmosphere through burning of fossil fuels.Such increased energy use speeds up environmental degradation resulting in climate change.Renewable energy resources act as substitutes for not allowing detrimental impact on environment.

A sustainable economy through the flow of renewable resource usage acts as the fulcrum to solving ecological disasters, weather modifications, social and economic crises. A measure like the index of sustainable economic welfare was developed to address such concerns.In order to be sustainable a renewable resource should be unbounded having no harmful impact on environment.Where as sustainable energy should be affordable while percolating benefits to the common people over an extended period . This clean energy is associated with low carbon use,less pollution, enhanced employment opportunities, decreased reliance on import sources, no safety concerns. The availability of clean energy provides for socio-economic progress through the robust green growth, energy access ,energy security.

Environmental Kuznets Curve (EKC) says that a country's environmental degradation occurs as there is higher economic growth .Uncontrolled expansion of economic activities has caused global warming and climate change. A large amount of ambient air pollution is the direct outcome of economic growth based on fossil fuel based energy.Sustainable development leads to mitigation of environmental degradation through the use of clean energy.The EKC shows an increasing pollution with initial development. Further sustainable economic growth brings down pollution.At low level of income,people tend to value development over environmental quality. With use of renewable energy they are willing to care more about environmental quality and its improvement.Sustainable development encompasses interdependent and mutually reinforcing three pillars namely economy, ecology, and society.

EKC DIAGRAM

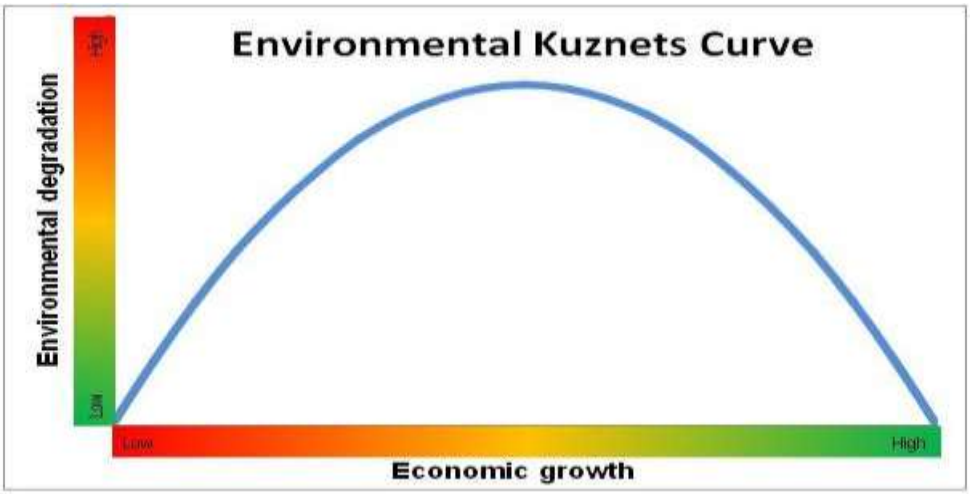

Fig.1

For equitable development and improved quality of life the people depend on reliable and affordable energy services.Access to universal sustainable energy acts as a potential to transform lives and economies through provision of income earning opportunities. Affordable and reliable energy is the essential requirement to achieve sustainable development by alleviating poverty and enhancing real income growth. India has been successful in adding capacity to solar energy to 9009 megawatts and wind to 1766 megawatts.

Fig 2. Source www.statista.com

Solar Energy In India

India, being in the tropical region, has optimum potential for abundant solar energy production as the subcontinent of India's landmass is located in peak solar radiation receiving area.The International Energy Agency (IEA) has numerated Photovoltaic applications into four categories, namely, off-grid domestic, offgrid non domestic, grid connected distributed and grid connected centralized. The use of renewable resources of energy is rapidly increasing worldwide. Solar power, one of the potential energy sources, is a fast developing industry in India. The country's solar installed capacity has reached 12.28 GW in year 2016-17 as compared to 6.76 GW during the year 2015-16. India has expanded its solar generation capacity by 5.52 GW during last one year which has led to downward trend in the cost and has increased usage. It clearly signifies that proper integration of policy interventions holds the key to achieve the sustainable development goals (CSO Energy statistics report, 2018).

Most parts of India get 300 days of sunshine a year. About 5000 trillion kWh per year energy is incident over Indian land area with most area receiving 4-7kWh per sq. meter per day. The solar energy available in a single year exceeds the possible energy output of all of the fossil fuel energy reserve in India. The daily average solar-power-plant generation capacity in India is 0.20kWh per m2 of used land area, equivalent to 1400-1800 peak (rated) Capacity operating hours in a year with available, commercially proven technology. Hence both technology solar thermal and solar photovoltaic can effectively provide huge capability for solar energy in India. Solar also provide the ability to generate power on a distributed basis.

India's utility solar capacity grew by a whopping 72% in 2017-18 over the previous year, says solar consultancy bridge to India in its latest annual report on the sector. It installed 9.1GW of utility solar against 5GW in 2016-17. Total solar installation was 10.4GW, the rest comprising rooftop solar plants and off-grid solutions, taking the country's cumulative solar capacity to 24.4GW.

The country's solar installed capacity reached 25.21GW as of 31st December. The International Solar Alliance (ISA), proposed by India as a founder member, is Headquartered in India. In 2015 the Indian government raised its solar target to 100GW of solar capacity(including 40GW from rooftop solar)by 2022 with the target investment of US$100 billion, which though an ambitious target since the world's installed solar power capacity is expected to be 303GW in 2017, is achievable due to the improvements in concentrated solar power technology with thermal storage in recent years as the cheaper solar power need not depend on costly and polluting coal/gas nuclear based power generation for ensuring stable grid operation.

Solar capacity addition in 2017-18 was higher than that of all other energy sources, both conventional and renewable, combined, the report notes. In comparison coal and wind only added 4.6GW and 1.7GW respectively.

The solar energy capacity in India from 2008 to 2017 in megawatts:

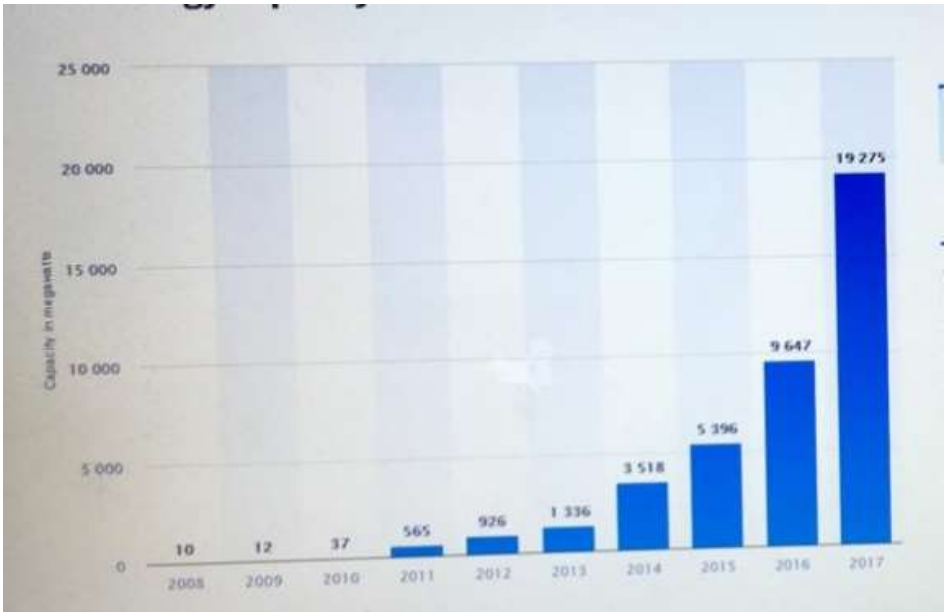

Fig. 3. Source: www.statista.com

The solar energy capacity in India was approximately 19275 megawatts in 2017 up from 9647 megawatts in 2016.

energy production statistics in India in Megawatts:

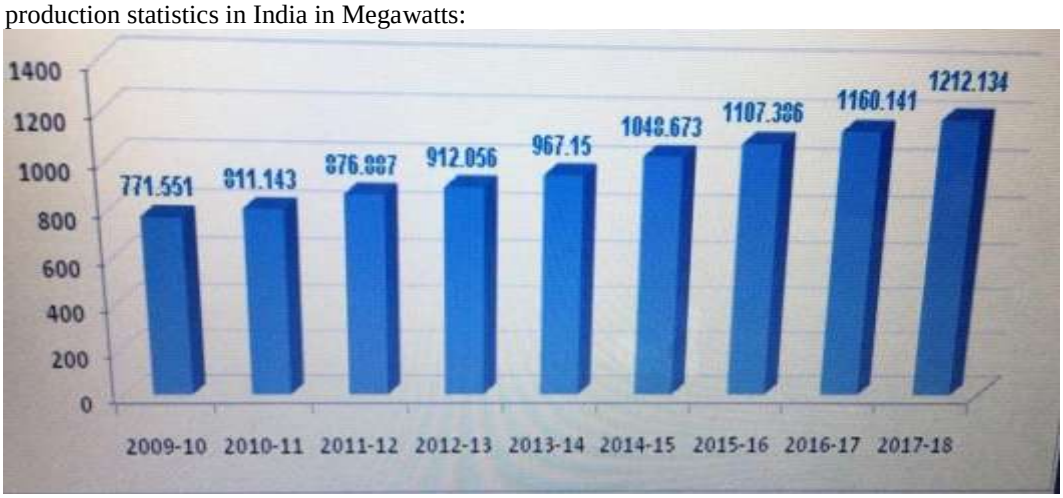

Fig.4.Source: www.statista.com

Solar energy production has been steadily increasing over the period from 2009-2010 to 2017-2018.

Solar Rooftop Project

"Solar Rooftop Project" means a roof top photovoltaic system connected on the consumer side of the meter. Rooftop solar power plants are defined as solar PV based electric generators either in stand alone or grid connected mode. The stand alone plants can work on complete DC mode or convert the DC power generated from SPV panel to AC power using power conditioning unit and feed the power to various captive loads. In grid connected mode, they can feed the power to grid either at **33** KV/11 KV three phase or at 440/220 volt three/single phase depending on the capacity of the system installed and the regulatory framework specified. They generate power during the day time which is utilized fully by powering the captive loads and feed excess power to the grid as long as grid is available. In case, where solar power is not sufficient due to cloud cover etc., the captive loads are served by drawing power from the grid.

There are two types of solar cells used in rooftop panels. High watt solar cells reduce the number of cells required in a panel and also reduce initial cost. On grid system cells are used more in urban areas, and are cheaper too, which also helps the consumer to become producer of energy. The application of rooftop solar projects is very high. Every appliance which requires electricity is supported by electricity is supported by the power generated through solar rooftops. Air conditioner, coolers, TV, heaters and many more.

Solar thermal energy is a form of energy and a technology for harnessing solar energy to generate thermal energy or electrical energy for use in industry and in the residential and commercial sector. The installed capacity of commercial solar thermal power plants (non storage type) in India is 227.5 MW with 50 MW in Andhra Pradesh and 177.5 MW in Rajasthan. Solar thermal plants with thermal storage are emerging as cheaper and clean load following power plants to supply electricity round the clock, working as dispatchable generation. Proper mix of solar thermal (thermal storage type) and solar PV can fully match the load fluctuations without the need of costly battery storage. The existing solar thermal power plants (non-storage type) in India, which are generating costly intermittent power on daily basis, can be converted into storage type solar thermal plants to generate 3 to 4 times more baseload 2WEpower at cheaper cost and not depend on government subsidies.

Projection of solar rooftop capacity additions in India from 2016 to 2020 in Megawatts

Fig. 5. Source: www.statista.com

The estimated solar rooftop capacity additions in India in 2018 is 1.3 GW.

Solar PV system in India:

Solar power can be generated by direct photovoltaic's (PV) or indirect by solar thermal power. In photovoltaic power plant a solar cell or photovoltaic cell (PV) is used which is a device that converts light into electric power using the photovoltaic effect. The PV cell is a solid state device consists of thin layers of semiconductor materials that produce electricity when exposed to light. Photovoltaic power generation consist of solar panels having a number of solar cells containing some photovoltaic materials. Materials presently used for photovoltaic are mono-crystalline silicon, poly-crystalline silicon, cadmium telluride and copper indium sulfide. The international energy agency has classified the photovoltaic applications into four categories namely off-grid nondomestic, off-grid domestic, grid connected distributed and grid connected centralized. In a concentrating solar power (CSP) plant the heat is collected by lenses mirrors and transformed to mechanical energy through a steam turbine and then into electricity. Wide ranges of technologies CSP plant are reflector and sterling dish. The various techniques are used to crack the sun and focus light.

Photovoltaics were initially solely used as a source of electricity for small and medium size applications, from the calculator powered by a single solar cell to remote homes powered by off-grid rooftop PV system. Commercial concentrated solar power plants were first developed in the 1980s. Grid connected solar electricity generation has reached nearly 2% of total utility electricity generation. Solar generation meets the daytime peak load in non-monsoon months when electricity spot prices exceed the daily average price.

The figure below, figure 6, shows the solar PV growth in India. India is the global leader in solar energy and the mission envisages an installed capacity of 21651 MW.

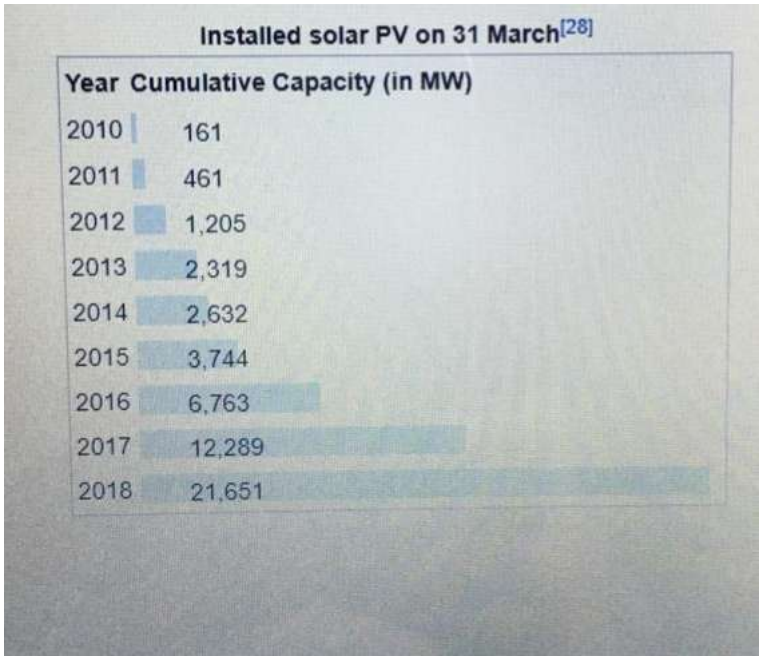

Fig. 6 Installed solar PV capacity in megawatts source: www.statista.com

China has the highest cumulative solar PV capacity of 131.1 GW followed by US' capacity of 51GW.

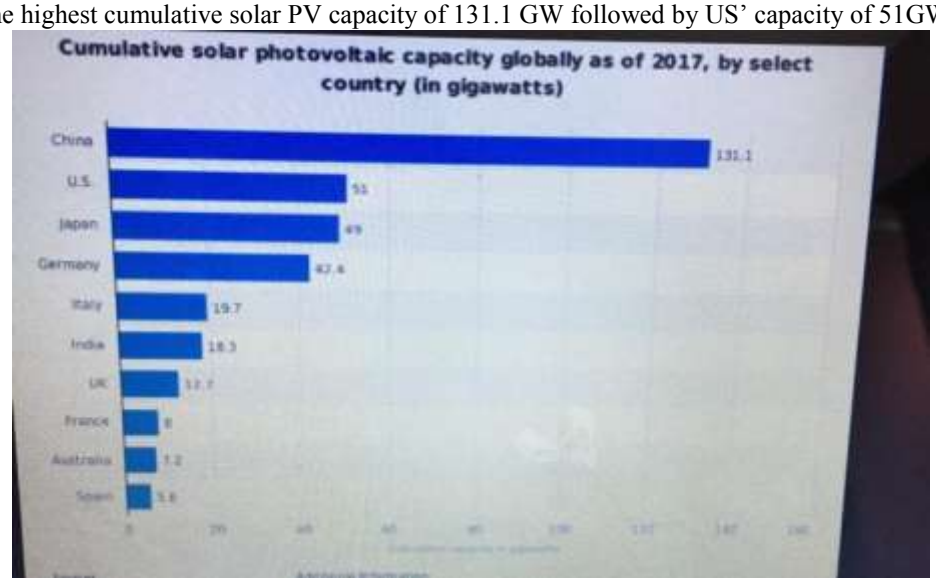

Fig. 7 the cumulative solar photovoltaic capacity globally as of 2017, by select countries in gigawatts Source: www.statista.com

By comparing globally, India can achieve its optimum potential of solar energy generation by adopting best practices from across the globe and increasing international cooperation through ISA.

Solar photovoltaic cells application

The analysis focusses on how application of PV light for rural electrification helps in increasing rural income as well as the living standards of the rural poor. The basic applied forms of solar PV in rural Bangladesh are solar home-lighting systems installed in households and local market/bazaar (haat). Seven solar modules of 50 WP each, divided into two groups, were installed in two suitable locations of the market. The battery banks and controllers accompanying each group were placed close to two respective solar panels. Similar systems were subsequently installed, serving business such as grocery shops, restaurants, barber shops, tea houses and doctors' clinics.

The success of solar PV micro utilities is attributable to several factors. These include the acceptability of a daily tariff structure and the rate of five taka, as well as proper marketing that explains the solar-energy-based system's capabilities, benefits, and constraints in comparison to other available options to potential users.

Benefits of the system also accrue because of the use of local institutions. An agreement, which was signed with the Bazaar Management Committee, includes the terms and conditions of the service, maintenance procedure, payment, and financial details of the users. The training of a technician to take care of the system on behalf of the collective is viewed favorably by users.

SDG Goal 7 Targets

In order to contextualise the discussion on SDG Goal 7, it might be useful to understand the specific targets (to be achieved by 2030), which are identified below. This is essential to understand the broad framework of intervention within which efforts towards achieving the various targets is embedded.

• Ensure universal access of affordable, reliable and modern energy services;
• Increase substantially the share of renewable energy in the global energy mix;
• Double the global rate of improvement in energy efficiency;
• Enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossilfuel technology, and promote investment in energy infrastructure and clean energy technology;
• Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all.

Some government supportive policies towards solar energy

Indian initiative of International solar alliance

In January 2016, Prime Minister Narendra Modi and French President François Hollande laid the foundation stone for the headquarters of the International Solar Alliance (ISA) in Gwal Pahari, Gurgaon. The ISA will focus on promoting and developing solar energy and solar products for countries lying wholly or partially between the Tropic of Cancer and the Tropic of Capricorn. The alliance of over 120 countries was announced at the Paris COP21 climate summit. One hope of the ISA is that wider deployment will reduce production and development costs, facilitating the increased deployment of solar technologies to poor and remote regions.

A report published by the Institute for Energy Economics and Financial Analysis (IEEFA) found that India installed 10GW of solar in 2017, almost double its record in 2016. Crucially, India's "Scheme for Development of Solar Parks" has proven successful at attracting foreign capital toward construction of the world's largest ultra-mega solar parks in India.

The Union Ministry of New and Renewable Energy (MNRE) has announced a scheme to develop 25 solar parks across the country. The solar parks are installations of multiple solar photovoltaic modules by different firms at one set location which provides all infrastructural facilities.

The capacity of each solar park would range from 500 to 1000 MW. So far, 12 states have shown interest in setting up solar parks with total capacity of over 22 GW. The estimated cost for development of a solar park would be around Rs 0.95 crore per MW and the capital cost for developing a grid connected solar power project is Rs 6.91 crore per MW. The top five solar parks in India are- Pavagada Solar Park, Karnataka, Kurnool Ultra Mega Solar Park, Andhra Pradesh, Kamuthi Solar Power Project, Tamil Nadu, Bhadla Solar Park, Rajasthan and Charanka Solar Park, Gujarat.

Some other initiatives by the government of India are- Union Cabinet approved for raising bonds worth 2360 crores INR by the Indian Renewable Energy Development Agency, for renewable energy projects in 2017-18. Schemes for farmers for installation of solar power pumps and grid connected solar power plants, development of Solar Park and Ultra Mega Solar Park, implementation of a subset of existing 5000 MW Viability Gap Funding (VGF) Scheme for setting up of 1000 MW Grid-Connected Solar PV Power Projects in North Eastern States including Sikkim under Jawaharlal Nehru National Solar Mission, Scheme for setting-up of over 2000MV Grid-connected Solar PV Power Projects with Viability Gap Funding(VGF) of NSM,scheme for setting-up of over 5000MV Grid-connected Solar PV Power Projects with Viability Gap Funding(VGF) of NSM, SKY scheme by Gujarat- the Suryashakti Kisan Yojana generates electricity for captive consumption as well as sell surplus power to the grid.

Government of India had launched Jawaharlal Nehru national solar mission (JNNSM) in 2009. The target was to start grid connected solar projects of 20 GW by 2022. In May 2015 government increases the target to 100 GW by 2022. India is one of the countries with the largest production of energy from renewable sources. In the electricity sector, renewable energy (excluding large hydro) accounted for 20% of the total installed power capacity (71.325 GW) as of 30th June 2018.

Potential of Solar Energy

The estimated solar energy capacity projection in 2020 is 15.2 GW.

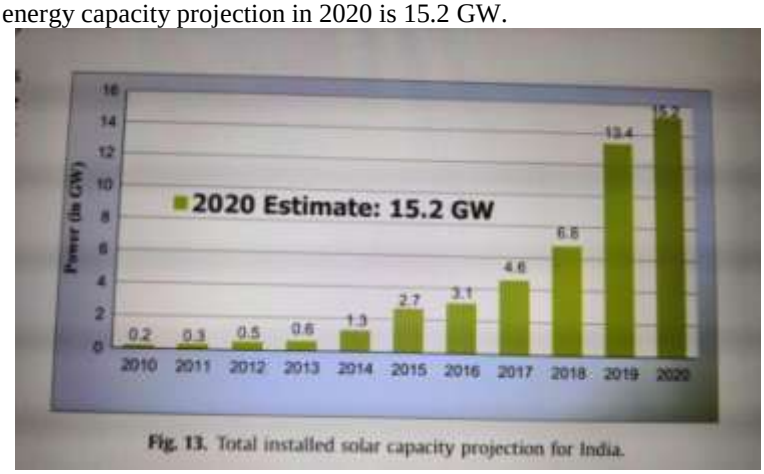

Fig. 13. Total installed solar capacity projection for India.

Some of the benefits of solar energy projects are-They can stimulate economic growth by flexible policy framework and long term strategy. Reliable and affordable energy can be available through solar panels to provide energy security, enable global climate change mitigation, enable new opportunities for employment generation which trigger sustainable economic development. The solar projects also help in capacity building and community empowerment through specialized and skill accumulation and up gradation of innovative ideas. The projects can generate extra income for landowners and land based activities. Farmers and forest owners can integrate solar energy production in their activities and diversify income sources. The projects will increase the tax base for improving service positions in the area. Additionally, solar energy provides benefits through a well designed policy framework that is place based and grounded in local conditions and opportunities. The energy strategies should reflect local potential and needs, and integrate solar energy within larger supply chain in rural economies like agriculture, forestry and traditional manufacturing and green tourism. It provides benefits to local communities thereby enabling inclusive growth.

II. CONCLUSION

This paper has analysed the solar energy status in India, its benefits, its schemes, etc. With increase in economic development, increasing per capita income, rapid urbanization and improving living standards have led to increase in demand and production of solar energy. India needs to realize the vast potential of renewable energy and needs to step up effort for attaining the goal of by 2020 i.e. 20% reduction in GHG, 11% reduction in consumption of energy by bringing about attitudinal changes, 20% share of renewable energy and 20% conservation of energy from the year 2011 till 2020. These targets are attainable and not only provide cleaner energy but also open a new field for providing employment opportunities to millions of people who are unemployed or disguised employment. This momentum then needs to be maintained so that India attains a target of having 70% renewable energy use by 2050 (Sahoo, 2016).

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