



Solar Energy: An Approach to Sustainable Development

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Introduction

Climate change is the most burning issue affecting all the countries on the earth. In 2015, India found to stand on fourth position among the list of countries most affected by climate change. Though the 17% of world population is contained by India, the nation emits 7% of global emissions. The concern of India becomes more alarming with its about 3 gigatonnes (Gt) CO₂ of greenhouse gases emission each year; that counts about two and a half tons per person worsening the situation every year. The rise in temperature has increased the frequency of various disasters like flood, drought, landslide and water flow due to melting of Himalayan glaciers. It has been observed that in between 1901 and 2018, the temperature has reached to 51 °C risen by 0.7 °C (1.3 °F) increasing the likeliness of heat wave for 100 times. It is also assumed that if global temperatures were to rise by 2 °C (3.6 °F), parts of Mumbai and Chennai would be submerged and along with other reasons, it could be a reason of displacement for around seven million people.

To overcome the worsening impact of climate change, the need of hour is to take initiatives that can reduce the emission of green house gases. Contributing for around 60 per cent of total global greenhouse gases emissions, energy has become the leading contributor to climate change. Green Energy is one of the effective solution to overcome the issue of climate change. It has been seen that 75 percent of global greenhouse gas emissions and nearly 90 percent of all carbon dioxide emissions are generated by fossil fuels like coal, oil and gas. The blackout faced by India in 2012, affected almost 700 million people, paralyzed communication and transportation structure and was disastrous for unknown number of victims. This incident made everyone realized that steady, efficient and stable distribution of energy system is the basic requirement for efficient governance and economic activity.

India being the most populous and developing country faces more challenges. Increasing population and requirements of people has increased the per capita economic consumption and greater demands for the services and consequently for access to modern energy. It is clear that the major challenge for twenty-first century would be to meet the growing wave of energy demand.

Considering the emerging need, renewable sources of energy that can reduce the greenhouse effect is an important solution catching the central place. In this context, 2015 is considered to be the landmark year across the world for multilateral and international policy shaping, with the adoption of several major agreements.

Effects of traditional energy sources and challenges ahead

According to a report of UNEP, 3 billion people rely on wood, coal, charcoal or animal waste for cooking and heating. Kerosene lamp is one among the list causing major source of pollution, harming people's health and the environment. Coal is another important fuel that is crucial for the operation of industries and has been essential to industrialization and the overall growth of human well-being. It has been assessed that in rural India over 70% household continue to cook food on bio-mass based fuels that does not pollute the environment only but also has harmful effects on health on women. Even for decades, the fossil fuel like coal, oil, gas are main sources of electricity production in India and other countries without realizing that use of fossil fuels without managing greenhouse gases will have global climate implications causing climate change and have harmful impact on people's well-being and the environment.

India is the second-largest coal producing and consuming country on earth. According to the paper published in National Geographic Magazine in 2014 by Michelle Nijhuis, coal provides about 40 per cent of the world's electricity and nearly the same fraction of global carbon emissions. With a low mass-to-energy ratio, coal is also inefficient and creates massive pollution. Thus, coal is neither sustainable at the global level because of its contribution to anthropogenic climate change, nor at the local scale because it is a threat to public health and environmental conditions (it does not produce only polluting by-products of combustion, the process of coal mining creates innumerable ecological problems).

A large chunk of the greenhouse gases that has trapped the heat of sun are generated, by burning fossil fuels to generate electricity and heat used for energy production. The impact is worldwide affecting everyone without any discrimination. In a report of UNICEF, it has been mentioned that indoor air pollution, largely caused by the burning of solid fuels, contributes to over half a million deaths of children under 5. Besides death, many children suffer with long lasting damage to their developing brains and lungs. It's not only children who suffer from the gases released with the burning of fossil fuels, everyone including men and woman faces health challenges. In absence of electricity, women and girls have to spend hours fetching water, clinics are incapable to store vaccines for children and other emergency situations, students are unable to study at night, and people cannot run competitive businesses. In absence of serious implementation of policy decisions and efforts for green energy with the involvement of community, it is believed that nearly one third of the world's population – mostly women and children – will continue to be exposed to harmful household air pollution.

Indoor air pollution and other related health issues can be improved with sustainable energy measures. Lack of access to energy supplies and transformation systems is a serious constraint to human and economic development. It has been seen that global emissions of Carbon dioxide have increased by more than 46 per cent since 1990. Strategies need to be identified to shift to the use of renewable and related clean energy technologies to mitigate the fossil fuel usage.

Initiative of Sustainable Development Goals

The situational need has forced the people from different region to come together on same platform and find the solutions to overcome the alarming situation. The open working group of the General Assembly of the United Nations proposed the Sustainable Development Goals (SDGs) and recognized the significance of the natural environment and its resources for the survival of human well-being. In January 2015, the General Assembly began the negotiation process on the post-2015 development agenda and the process culminated in the subsequent adoption of "Transforming our World: the 2030 Agenda for Sustainable Development", by 193 United Nations Member States in September 2015. The 2030 Agenda for Sustainable Development provided a blueprint as a universal call to action for the areas affecting people at large in the planet. Global goals include 17 cross cutting issues, out of which access to affordable and reliable energy and focus on improving energy efficiency, international cooperation and investment in clean energy infrastructure was goal 7 to be achieved by 2030. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while protecting earth through tackling climate change and working to preserve our oceans and forests. It is also committed for innovations, clean water & sanitation, affordable & clean energy, sustainable cities &

communities, justice & strong institutions. The 17 SDGs are amalgamated — and are identified as interdependent. The action in one area not only affect outcomes in others but also complement in development and balancing other areas for social, economic and environmental sustainability.

Meeting the goals of SDG will support in controlling the damage caused to planet and the environment and encouraging use of green energy. Energy efficiency involves efficient utilization of energy resources that is necessary for sustainable development. It would not only increase the productivity, and reduce Green House Gas (GHG) emissions, solid waste production and thermal pollution but would also support in meeting other parameters of sustainable goals. Government for India has taken various policy decisions in overcoming the climate change performance index of India that ranks eighth among 63 countries which account for 92% of all GHG emissions in the year 2021.

Under Sustainable Development Goals by 2030, the targets linked to the energy involve;

- Ensure universal access to affordable, reliable and modern energy services;
- to 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 fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology; and
- expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support.

Why we need green energy sources?

The global electricity use is rising rapidly and without a stable electricity supply, the economy of countries may tumble down. Energy should generate a persistent stream of power to meet basic human needs, maintain & improve social functioning, to move ahead the living standards of people with overall environmental and economic growth. These functions should be sustainable enough to meet the demands of the community for personal and professional use. It can fulfill the requirement only if the power generated for energy use is greater than the resulting waste and pollution. In 2022, India claimed 100% electrification but as per new definition of electrified households, any village having at least 10 percent of the households connected with grid would be called as “electrified”. Reaching the millions of people in dark and uninterrupted electricity supply without affecting green house gases to those who have access around the world is a challenging task.

Renewable energy sources are all around us and available in abundance with earth in the form of the sun, wind, water, waste, and heat; emitting little or no greenhouse gases or pollutants into the air and are replenished by nature. The main sources for renewable electricity generation includes hydroelectric power, wind power, solar power, biofuels, geothermal energy and less common sources such as tidal power or wave power. Besides, if used with the support of proper technology, it's cheaper, healthier, creates jobs and supports in economic growth.

In the past few years it has been realized that the environment provides a series of renewable and non-renewable energy sources i.e. solar, wind, hydropower, geothermal, biofuels, natural gas, coal, petroleum, uranium. And a well-established energy system can support and promote all sectors: from businesses, medicine and education to agriculture, infrastructure, communications and high-technology.

Solar Energy is the lowest cost source of new energy in India and is the only solution of many issues of immediate concern. Solar energy also ensure to reduce the air pollution and water pollution since India is also suffering from the massive air pollution problem and it would also support in minimizing taxing on their water supply. Besides, it does not emit carbon dioxide or methane, so there is an additional benefit of solving the world's climate change emergency. Sustainable energy measures provide considerable benefits in reducing indoor air pollution and related health risks.

Solar Energy Initiatives of Government of India and different agencies

It is a known fact that energy is critical for economic and livelihood growth. India's National Action Plan on Climate Change has taken Solar Mission at a central place with National Solar Mission as one of the key missions. National Solar Mission (NSM) was launched on 11th January, 2010 and is a major initiative of the Government of India with active participation of states to promote ecological sustainable growth while addressing India's energy security challenges.

In 2014, Government of India initiated the scheme of solar parks. The solar projects having capacity of over 500 MW are considered as solar parks and also referred as Ultra-Mega Solar Parks (UMSP). Under this scheme, the parks were managed by Solar Power Project Developers and they also feed all generated power to the grid. For this purpose, non-agricultural waste-land was used.

In 2020, while considering the demand of locally manufactured power; to boost the domestic solar manufacturing base and reduce dependency on China for solar cells and modules, Indian power Minister announced incentives for Indian made solar modules to promote domestic units and suppliers. It has promoted the Indian manufacturers and India was benefitted with the combination of low-cost financing and expected lower cost of solar module resulting in driving down solar prices in India.

The largest coal-producing company in the world, Coal India also initiated in establishing an integrated solar wafer manufacturing facility to enter the solar value-chain business and launch a new renewable energy vertical.

The World Bank Group (WBG) is investing in energy access, energy efficiency and renewable energy through launch of its Scaling Solar, a "one-stop shop" for governments that want to attract private investors to build large-scale solar plants, but lack the purchasing power of bigger emerging markets where strong competition has driven down solar prices to virtual parity with oil, gas, and coal-fired electricity. Scaling Solar includes a package of technical assistance, templates for documents, pre-approved financing, insurance products, and guarantees that take the guesswork out of whether a solar project is viable and bankable for both governments and investors.

Organisations like UNICEF are also supporting and promoting sustainable energy by providing solar lights for schools, solar pumps in communities vulnerable to droughts and floods, and other off-grid energy solutions that helps in improving children's overall learning and health system.

To overcome the challenges of space, the rooftop solar system got the attention of government that is scalable, can be done quickly & provide electricity to end users directly. India aimed to install 40 GW of grid connected rooftop solar by 2022. According to Ministry of New & Renewable Energy, till 31 March 2021, India has installed 4.4 GW of rooftop solar.

To accelerate the roof-top solar energy installations, two models were introduced. Under first model named as CAPEX model, the user bears the cost of installation and is free to use generated electricity or can sell it to distribution company through net-metering. In the OPEX or RESCO model, the investors install the system at customer's premise and customer pays a pre-determined price per unit as mentioned in power purchase agreement.

To promote roof-top solar systems for residential/commercial/institutional set ups, government has created various policies. It also provide subsidy for small-scale residential projects (below 10 KW). Central government provides 30 to 40 percent subsidy for grid connected solar systems in residential areas linked to size of the system & benchmark costs. It works through DISCOM. As per the new amended Electricity (Rights of Consumers) 2020 Rules, net metering is allowed for loads of 500 KW or sanctioned load whichever is lower. Gross metering having loads above 500 KW under rooftop solar generator can sell energy to DISCOMS.

In August 2021, the concept of floating solar PV was introduced by NTPC Simhadri in Andhra Pradesh that got attention in different parts of country but that need to address many challenges including technical guidelines and specific standards.

At the end of 2021, India was on 4th position in solar PV deployment across the globe. On 30 November 2022, solar power installed capacity had reached around 61.97 GW. Solar tariff in India is very competitive and has achieved grid parity. Globally, India has achieved the 4th position in overall renewable energy. Solar power installed capacity has increased 25 times from 2.6 GW to 66.8 GW.

It is known fact that energy is critical for economic and livelihood growth. In 2021, United Nations Climate Conference more commonly referred to as COP 26, India committed to low carbon to combat climate change and set following 5 targets:

- a. Increase non-fossil energy capacity to 500 GW by 2030.
- b. To meet 50 percent of energy requirements from renewable energy by 2030.
- c. To reduce total projected carbon emissions by one billion tonnes till 2030.
- d. Carbon intensity reduction of its economy to less than 45 percent by 2030.
- e. Net zero emissions by 2070.

To meet the targets of COP 26, India needs to work on installation of following;

1. Solar energy rise to 280 GW along with wind energy to 140 GW and reduction in contribution of coal and gas for electricity generation from 78 percent in 2019 to 55 percent in 2030. The share of renewable energy will increase to 32 percent.
2. It is projected that in 2030, the power requirement would be 2518 BU and to meet the 50 percent of energy requirements from renewables, it needs to increase the installed capacity to 700 GW.
3. According to Intergovernmental Panel on Climate Change (IPCC), to stay below 1.5°C rise in temperature, global CO₂ emission must be 18.22 Gt in 2030. With the announcement of new NDC on November 2, 2021, India has targeted to occupy 9.5 percent of remaining IPCC 400 Gt carbon budget.
4. To meet the goal of carbon intensity reduction by 45 percent, India needs to enhance measures in reducing emissions from industrial and transport sector.
5. The IPCC set the target of net zero by 2050 for all the countries and India's net zero target of 2070 is an extension and can't exceed further.

Renewable energy sources would play critical role in achieving the deadlines and that too at affordable cost so that the citizens below poverty line can replace their energy needs from cow dung, firewood and coal to renewables. To meet the target of renewable energy by 2030, India needs to scale-up renewable power every year. A mechanism needs to be placed through which rampant retrenchment of renewable energy could be stopped.

Challenges for meeting the targets of renewable power

Contribution of solar energy in generation of renewable energy is very important and fortunately, government along with the support of DISCOM and C&I is able to stay near to its target in installation of utility scale solar which are at various stages of development. But meeting the targets is not an easy task and is full of challenges.

Generation of renewable energy in itself is not sufficient if it is not reliable and affordable to the needs of end users including poor people. With the generation of higher renewable energy, India also needs to find ways/systems for storage of electricity to improve the operations of the grid and grid stability management to handle high voltage and frequency fluctuations.

The financial instability of DISCOM has increased the risk of investment. The electricity distribution companies are facing the outstanding debt of over Rs. One lac crore in early 2022 that affects their paying capacity. This in turn creates pressure on renewable power developers and also the hydrogen policy of government empowered them to sell power directly to green hydrogen manufacturer. The rooftop power generation for domestic & institutional use also affects the electricity distribution companies to loose custom though they are supposed to supply electricity at all times even when there is no sun. Renewable power developers face the constant problem of curtailment of power.

Increase in import duty on solar components and hike in GST on critical components like photovoltaic cells and modules has increased the overall cost of large-scale solar projects. This changes the tariff rate per unit

of renewable energy from time to time but most of the electricity distribution companies have signed contract for 25 years and finds it difficult to change/ negotiate the same.

There is need of large land for utility scale solar projects. For rooftop solar energy plants, electricity distribution companies do not find incentives for institutional and commercial sectors. Besides, subsidy in electricity bill in residential sector and complete waive-off upto 200 units also resist households to install rooftop solar panels. Price cap for solar installations also leads to problems since solar module prices keep changing according to international market conditions.

Decentralized clean energy mini-grids also need attention to meet the needs of local. The leakages need to be repaired so that clean power can lighten up the lives of citizens.

Manufacturing of solar units in India is one challenge. Besides, recycling waste is another issue. It is expected that India might create 34,600 metric tonnes of PV trash by 2030 but there is no clear policy on how to deal with waste. Presently it is treated as part of electronic waste. Country also lacks any commercial raw material recovery plant for solar e-waste.

Suggestions and Conclusion

Sustainable Development Goals have helped to set the tone for cooperation and contributed to an emerging consensus on priorities. In the twenty-first century, integration of affordable, sustainable and modern energy is needed to be attached with global development. The transfer of clean energy technologies to developing countries is an important aspect for policy development. And the task is achievable if all the national and international organizations have sufficient vision, the governments can work together, and if correct vision is communicated to communities and individuals are offered the right incentives and the necessary means.

Out of all the green energy resources, solar energy intervention is the one that is very feasible in country like India. India is endowed with vast solar energy potential since it is abundantly available. It is the most secure perspective from the energy security perspective. The geography of India and solar cells are very supportive for solar energy system in the nation. About 5,000 trillion kWh per year energy is incident over India's land area with most parts receiving 4-7 kWh per sq. m per day. Solar photovoltaic power can efficiently be harnessed providing huge scalability in India. It also provides the ability to produce power on a scattered basis and enables fast capacity addition with little lead times. Other benefit of off-grid decentralized and low-temperature applications is valuable from a rural application perspective and meeting the energy needs for rural and urban areas. Its biggest advantage is that solar farms can be set up even in small sizes which increases availability and reduces transmission costs. Despite of these advantages, the uptake of solar energy has been slow. This is because the old silicon-based technology used in solar cells had to be imported and had efficiency below 15%, making it too expensive to have small solar farms. But this landscape is revolutionized with the recent technological and policy developments and hand holding of all the countries. The new perovskite-based technology has an improved efficiency of nearly 30% and its cost is only one-tenth of the old technology, which makes the system economically viable at smaller scales. The installation of home based solar panels has also enabled access to clean energy and reduced dependence on unreliable conventional energy and has overcome the difficulty of extending conventional electricity grids to remote areas.

The solar energy can bring the social and economic change we all want to see in India through reduction in labour among rural women and girls who need to collect fuel wood from long distances and do cooking in grey kitchens in presence of all the poisonous gases, minimization of the risks of contracting lung and eye ailments along with other skin issues, and eventually, the improvement in the standard of living and employment generation through creation of opportunities for economic activities at village level.

It can be clearly seen that solar energy sector could be emerged as a significant player in the grid connected power generation capacity over the years. For villages and far off places, installation of mini-grids is an attractive option. It would not only generate and supply energy to households but would also save the expenses. Mini-grids are more efficient during frequent interruptions and voltage fluctuations along with last-mile connectivity. It is affordable tailored solution for places where power supply has reached but is not reliable. The cost of energy generation through mini-grids range from 6 to 28 depending on the size of the

system and its configuration. We need to finalize the policy to support mini-grids not only to supply the uninterrupted energy but also to reduce poverty and meet the climate goals of world.

Besides supporting the government agenda of sustainable growth, it would also be emerged as an integral part of the solution to meet the energy needs of country and as an essential player for energy security. Solar energy based decentralized and scattered applications have the benefit to reach millions of people in villages and meet their cooking, lighting and other energy requirements in an environment friendly manner. Cooking through electricity is a viable option that is not only healthy but also cheaper and high in efficiency. The financial and structural reforms of DISCOM also needs to be improved.

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