# THE SOLAR POWER SITUATION, ISSUES AND PROSPECTS IN INDIA

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## ABSTRACT

*The article takes a bird's eye-view of the economic and political context that led to the heavy fossil-fuel dependence of India and explores how a well-worked out innovative and strategic shift to the renewable sources of energy in general and the solar option in particular can lead to the environmentally sustainable industrialisation, urbanisation and development. While taking a long-run view, it assiduously delves into the finer aspects of the various issues that need to be dealt on the basis of scientific and social evidence, insight and innovation. The study weaves in the diverse aspects of the world economic situation to argue for building of the capability for strategic thought and action on a vast and diverse variety of matters to connect dots for emergence of India as a leader in sustainable, equitable and harmonious development through achievement of its developmental goals on the back of utilisation of its enormous solar power potential. By addressing a variety of concerns together, it attempts to boldly put forth considerations that touch the spinal cord of the complex problems that beset not only India but the world at large.*

## KEYWORDS

Energy economics, Electricity, Renewable sources of power, Solar power, Sustainable development, India

## INTRODUCTION

The editorial in a foremost science journal said it over forty years back "*The release of carbon dioxide to the atmosphere by the burning of fossil fuels is, conceivably, the most important environmental issue in the world today*" (Nature, 1979). If it has been a problem that was so well-recognised long back, the issue of how to tackle the problem of greenhouse gases and climate change is undoubtably one of the biggest challenges facing the world today. The Pollution is everywhere-from the highest reaches of our atmosphere to the darkest depths of our oceans. (UNEA, 2017)

A team of European scientists concluded that the changes in the climatic conditions are mainly due to anthropogenic factors (Scientists link Europe heat wave to manmade global warming, 2019). The continuous environmental degradation is creating serious threats not merely to the safety, health and congeniality of atmosphere but to the very existence of the diverse forms of life on the planet. One of the main reasons for this existential crisis is the enormous, rapidly rising and excessive use of fossil fuels (GGSDI, 2015). This fossil-fuel dependence has grown on the back of rising energy demand arising out of the hedonistic individualism, at the micro level, and an almost complete dependence on gross product as a measure of welfare at the macro level. What is strikingly common for both the levels of the economy and much of their analyses are the unbearable lightness of the concern for any credible and proper accounting of the true social costs of economic growth. However, it is not surprising because even while the overall awareness and support for action on global warming appears to be growing, one of the greatest obstacles is the yet unrevealed possibility for swift social change to significantly reduce global greenhouse gas emissions fast enough to stop large-scale climate disruptions.

It is a matter of great concern that the rural areas of the developing countries, and particularly in India, remain unmindful of this issue (Leiserowitz, 2007).

However, the dramatic events associated with climate change are triggering a dramatic questioning of the very notion of 'development' that ignores the true social cost of production. The most recent of such drama is the uncovering of the head-scratching inability of most governments to account for and prevent growingly menacing outbreaks of pandemics like the covid-19. Now, there is a call to "protect the environment, prevent pandemics, 'nature is sending us a clear message'" (U.N., 2020b). There is a prediction of growing discontent with the quality of growth amid a global slowdown during the current pandemic (U.N., 2020a). This situation where improvement in the environment-friendliness, efficiency and performance of the power sector has a huge importance both for environment and economic growth. Under these circumstances, it is a litmus test not only of the efficiency and sustainability of industrialisation and urbanisation but also that of commitment to environment. This is a rationale for the study from the macro point of view.

This likely awareness may incline and drive the enlightened public opinion for a sharp turn away from the fossil fuels. While the logic of industrialisation and the world turning urban is well-understood, the climate crisis may be forcing the 'invisible hand' away from the fossil fuels and towards the sources of renewable energy. The solar energy is one of the most climate-friendly forms of renewable energy and its share needs to be increased significantly among other sources of energy.

While the problems of slackening domestic demand, falling exports and economic slowdown in India make the government relegate the climate and environmental issues on the back burner, the enormity of the climate crisis threatens to overtake everything else. In such a scenario, the need for technological disruption in the energy sector is speaking for itself.

Under the very same world economic scenario, many countries are using the crisis of underutilisation of manufacturing capacity and slackening demand for investment goods to enact a sharp move away from the fossil fuels. The ambitious electrification of transport in China seems no less dramatic than its economic reforms four decades back.

In this context, an overview of the current solar energy situation in relation to other sources of energy is imperative in order to recognise the challenges and opportunities in realising its potential for climate-smart industrialisation and urbanisation through simultaneous improvements both in the efficiency of production and the environmental standards. There are reviews that extensively weave in literature. The work by Irfan, Zhao, Ikra, Gilal, Li & Rehman (2020) is one of the examples of such exemplary work. However, the scope of the paper has been restricted to an overview of the situation and discussion of issues that are coming up the context of the ongoing Covid-19 pandemic.

The rest of the paper is organised as follows. In Section 2, we describe the economic and environmental burden associated with the rising levels of the use of fossil fuels in India and bring up the resultant need to move to the renewable sources of energy. Section 3 brings out the relative situation, suitability and prospects of the different sources of renewal energy in India. In Section 4, we discuss the magnitude of the gap between the available potential for solar power and the actual installed capacity at the level of the country, individual states and also for union territories as a whole. The section also delves into the possible reasons for this stupendous gap between the possibility and the reality with regard to this vital green energy resource that the country has in abundance. Section 5 has a discussion of the problems and issues concerning land-use, licensing, technology, storage and timing that constrain the production, adoption and spread of solar power in India. This section also argues for an assiduous work to meet the need to find ways and means to deal with these issues so that the potential of solar power could be realised to the maximum extent. Last Section, Section 6 draws the conclusions.

## THE PROBLEM WITH FOSSIL FUELS IN INDIA

After independence, one of the big challenges before India was to ensure an adequate supply of energy, especially in the form of electricity, for the ease and speed of its reach into a vast and diverse geographic, social and economic terrain, and for boosting up of growth of the economy. Therefore, different levels of government in the country made huge investments in the power sector to ensure an adequate supply of the electric power. However, the focus was mainly on the development of thermal power stations that were seen as the easiest and fastest plants to set up and get huge volumes of electricity. This has to be seen in the context of the then prevailing economic and political situation. India had come out of the colonial rule. It decided to take up its own strategic route to an economically self-reliance development through the policy import-substitution. India was also pursuing its political independence from the colonial order through its leadership role in the non-aligned movement. The fossil fuels, and the coal in particular, were the easiest options in this strategy of fast forward in industrialisation and urbanisation (Sharma and Kumar, 2012).

Consequently, the share of coal as well as gas-based plants increased significantly. Until enforcement of the Electricity Act of 2003, about 70 percent of the electricity was generated using thermal power sources (Kumar, 2001). About one fourth of the electricity at that time was being contributed by hydro power. The remaining share- a less than five percent- came from all the other sources that included all the renewable sources of energy and the nuclear power. However, the share of renewable energy has been increasing slowly and steadily and it now looks like a respectable and significant share. The details can be gauged from Table 1 that contains the relative contribution of the different fuel sources in the total installed capacity of electricity as of 31st March 2020.

The heavy dependence of India on fossil fuels could be understandable when, soon after its independence, it took the route of strategic planning for a rapid domestic heavy industrialisation. However, eventually the same path that generated economic growth also created various types of challenges before the Indian economy. This model of economic growth riding on the back of fossil fuels became increasingly unsustainable. It brought out a few big and difficult challenges.

**Table 1**
**STATUS OF THE VARIOUS MODES OF ELECTRICITY GENERATION**
**(INSTALLED CAPACITY AT THE END OF MARCH 2020)**

| Fuel Source | MW | % of Total |
|---|---|---|
| Total Thermal | 2,30,600 | 62.8% |
| Hydro (Renewable) | 45,699 | 12.4% |
| Nuclear | 6,780 | 1.9% |
| RES* (MNRE) | 87,028 | 23.5% |
| Grand Total | 370,106 | 100.0% |

Source: Ministry of Power, Government of India.
Retrieved from https://powermin.nic.in/en/content/powersector-glance-all-india

The first of these challenges has been the environmental impact of heavy dependence on fossil-fuels. This largely went unaccounted in the almost a single-minded rush for increase in output and employment in the economy in general and the industry in particular. Since the thermal power is responsible for huge carbon emissions, the sustainability of the thermal power stations started being increasingly and vehemently questioned nationally as well as internationally. As a result of the political economy of international economic system, the developed countries criticised India for its total carbon emissions, even while the per capita carbon emissions in India were far lower in comparison to those for most of the developed countries (Levin & Lebling, 2019; IEA, 2020).

However, this quarrel over the total *versus* the per capita measures of carbon emission justified neither the damage being wrecked by the carbon emissions and nor the distraction from the need to keep such dangerous environmental consequences at the minimum possible levels.

The second big challenge is the fixed stock of fossil fuels due to the non-renewable nature of these resources. Whatsoever may be the type of fossil fuels but one common fact that remains true about each one of these is that the stock of each of these different types of fossil fuels is fixed. There is a limitation to using these sources for a longer period. Moreover, these are not endless and infinite by any definition or stretch of imagination. India's import dependency has significantly increased not only for the petrochemicals but also for the coal it imports. It is not only raising India's import bill but also creating a threat for the national energy security ("Thermal coal imports for 2019 rise 12.6%.", 2020, March 11).

The third great challenge faced by India in the matter of its energy situation and policy is the uneven distribution of fossil fuel sources across the country. Some of its states are very rich in terms of the potential and the actual extraction of coal and petrochemicals. Other states and union territories have almost none or miniscule stock of such fossil resources and, thus, are highly dependent on the states that command high share of fossil fuels. It was also observed that there was a huge difference in the availability of electricity across various states.

The fourth big challenge, which has turned out to be one of the most difficult and costly ones, pertains to the environmental consequences of the increasing size of India's thermal power plants. It is very usual to build thermal power plants of larger sizes following the common-sensical notion of the economies of scale. When the thermal power plants started getting built soon after the Independence of India from the colonial rule, the average size of its thermal units was less than 1000 MW. Then emerged the concept of super thermal power stations. Relatively recently, the Ultra Mega Power Plants (UMPP) have been established with each of these with capacity of generating 4000 MW or above. These power plants are not only creating greater threat to the environment but there are also questions on the reliability of power from these ultra-sized thermal power plants compared to that from the smaller size plants.When the ultra-sized ones fail, they cause much greater chaos and disruption of the power supply.

India will shift to the renewable sources of energy if it is prudent enough to realise these shortcomings. However, it will eventually have to perforce shift to renewables due to the very nature and scope of the fossil fuels that are becoming increasingly limited and unsustainable over time.

## The Renewable Sources of Energy

The considerations on the fossil fuel situation that came up in the preceding section clearly point to the limitations and negative sides of the fossil fuels and more so of it being the major source of energy in India. Therefore, keeping in view the significance of renewable energy sources for a sustainable development of the country we discuss, in this section, the relative situation with regard to the different sources of renewable energy in India. We also consider the advantages associated with solar energy vis-à-vis the fossil fuels as well as other renewables, i.e. non-solar, sources of renewal energy.

From time to time, a variety of incentives have been given by the government to boost up the share of renewable sources of energy in the total discovered potential as well as the actual installed capacity of energy production. The supply side incentives such as simplification of the licensing and approval processes have been provided for the promotion of the renewable energy sources. In addition to these, there are some other important

incentives such as mandatory and guaranteed procurement of the renewable energy. An example of the other ways of promoting the renewable sources of energy is the order by the Central Electricity Regulatory Commission (CERC) by which it was notified that each distribution company will source at least the ten per cent of its total procurement from the renewable energy sources (CERC, 2010). Consequently, the share of renewable energy in general and the share of its solar and wind power segments have increased significantly. Table 2 has the breakup of the total installed capacity by the various sources of renewal energy.

**Table 2**
**STATUS OF GENERATING CAPACITY BY SOURCES OF RENEWABLE ENERGY (AS REPORTED AT THE END OF MARCH 2019)**

| Fuel Source | MW | % of Total |
|---|---|---|
| Wind Power | 35625.97 | 45 |
| Solar Power (Ground Mounted) | 26384 | 33 |
| Solar Power (Roof Top) | 4593. | 2% |
| Small Hydro | 4593. | 5% |
| Biomass (Biomass & Gasification and Bagasse Cogeneration) | 9778 | 12% |
| Waste to Power | 138 | 0.01 |
| Grand Total | 78316 | 100.0% |

Source: Government of India (2019). Annual Report 2018-19, the Ministry of New and Renewable Energy.

It is clear from Table 2 that the share of wind energy is the highest amongst all the renewable sources of Energy. Initially after the introduction of Electricity Act 2003, the focus was on developing wind power. Therefore, the relative share of wind power in the installed capacity of the renewable sources is the highest. However, the limitation of wind energy is that its potential is not available in all the regions. It is not the case with solar energy. The solar energy has more potential in India and, therefore, it is more reliable compared to the other sources of renewable energy. Therefore, currently the focus of the government policy is on the solar power.

The Government of India has fixed the target of 100,000 MW of installed capacity of solar power production that it wants to actualise by 2022 at the national level (Nathan, 2015). Another important feature of solar energy is its easy operation and installation at smaller scales. For example, a solar roof top cell can easily be installed and operated on the roof. This is not possible with most of the other sources of renewable energy. In fact, such an ease and flexibility of scale is not possible even in the case of the wind energy that could otherwise be a good candidate for suitability for small-scale production.

## The Solar Power Situation in India

India has a huge potential of development of the solar power. However, its enormous potential has thus far remained mostly unutilised. If we look from the purely short-term market viewpoint, it is because of the high installation costs of solar energy plants and equipment. However, if one were to take a long-run overall view, it could well be a lack of strategic thought because, on balance and in the entirety, when all the environmental, health, economic, social and psychological factors come in play, the overall benefits of green energy far surpass its costs.

Even though the use of solar power has been increasing over time, so far it has been possible to utilise but only a tiny fraction of its potential. Table 3 has the figures for the potential for the production of solar energy in India, its various states and union territories and also the actual installed capacity at the end of March 2019.

**Table 3**
**SOLAR POWER POTENTIAL AND ITS UTILISATION IN INDIA**
**(AS REPORTED AT THE END OF MARCH 2019)**

| State | Soar Potential (in MWp) | Installed Capacity (MWp) | Percentage Utilisation |
|---|---|---|---|
| 1. Andhra Pradesh | 38440 | 3086 | 8.03 |
| 2. Arunachal Pradesh | 8650 | 6 | 0.07 |
| 3. Assam | 13760 | 23 | 0.17 |
| 4. Bihar | 11200 | 143 | 1.28 |
| 5. Chhattisgarh | 18270 | 231 | 1.26 |
| 6. Delhi | 2050 | 127 | 6.20 |
| 7. Goa | 880 | 4 | 0.45 |
| 8. Gujarat | 35770 | 2440 | 6.82 |
| 9. Haryana | 4560 | 225 | 4.93 |
| 10. Himachal Pradesh | 33840 | 23 | 0.07 |
| 11. Jammu & Kashmir | 111050 | 15 | 0.01 |
| 12. Jharkhand | 18180 | 35 | 0.19 |
| 13. Karnataka | 24700 | 6096 | 24.68 |
| 14. Kerala | 6110 | 139 | 2.27 |
| 15. Madhya Pradesh | 61660 | 1840 | 2.98 |
| 16. Maharashtra | 64320 | 1634 | 2.54 |
| 17. Manipur | 10630 | 4 | 0.04 |
| 18. Meghalaya | 5860 | 0.12 | 0.00 |
| 19. Mizoram | 9090 | 0.5 | 0.01 |
| 20. Nagaland | 7290 | 1 | 0.01 |
| 21. Odisha | 25780 | 395 | 1.53 |
| 22. Punjab | 2810 | 906 | 32.24 |
| 23. Rajasthan | 142310 | 3227 | 2.27 |
| 24. Sikkim | 4940 | 0.01 | 0.00 |
| 25. Tamil Nadu | 17670 | 2575 | 14.57 |
| 26. Telangana | 20410 | 3592 | 17.60 |
| 27. Tripura | 2080 | 5.09 | 0.24 |
| 28. Uttar Pradesh | 22830 | 960 | 4.20 |
| 29. Uttarakhand | 16800 | 307 | 1.83 |
| 30. West Bengal | 6260 | 76 | 1.21 |
| 31. UTs | 790 | 70 | 8.86 |
| Total | 748990 | 28185.72 | 3.76 |

Source: Government of India (2019). *Annual Report 2018-19, the Ministry of New and Renewable Energy*.

It is clear from Table 3 that India as a whole is able to make use of only 3.76 percent of its vast solar potential. If we look at the state-level, we find that the solar potential is the highest in Rajasthan. It is followed by Jammu and Kashmir. Maharashtra and Madhya Pradesh are the other two states that have very high potential for the production of solar energy. Interestingly, these four states comprise about one half of the total solar potential that is available in the country. So far as the utilisation of the solar power is concerned, only four states- Punjab, Karnataka, Telangana, Tamil Nadu- have utilised ten per cent or above of their respective potential for production of solar power.

Therefore, there is an urgent need for state-level specifically focused programmes and initiative to make a better utilisation of the resources that are available to the respective states and territories.

One of the main reasons for the poor utilisation of the potential for production of solar energy in India is the low Plant Load Factor (PLF) in respect of the solar power in comparison to the fossil fuel sources of energy, such as coal and gas-based power plants. Normally the fossil-fuel-based power plants can generate electricity continuously, i. e., during the daytime as well as during the night-time. However, the solar power plants can generate electricity only during the daytime when solar radiations are available. Therefore, apart from the factor of higher installation costs, this limitation of dependence only on the times of sunshine is also a major reason for poor utilisation of potential of the solar power in India and across its various states and union territories (Armin and Puri, 2017)

## ISSUES AND PROBLEMS IN SOLAR POWER IN INDIA

The various state governments have taken some steps to promote the solar power in the country. These steps include promotion of private investment in the sector as well as the subsidisation of solar power to make solar power affordable compared to the other sources of energy. However, there are still a lot of challenges that need to be addressed in order to speed up the process of solar power installation. The major challenges that have been highlighted in this Section include the implications of solar power on land use; the licensing issues and the technological issues.

### The Issue of Change of Land Use

First of all, the issue of change of land use is very important issue in the context of India. The roof top solar power has its limitations. After all, there is a limit to roofs themselves and there is also a limit of the extent to which the roofs can reasonably be used to install roof-top solar power capacity.

If we need more and big size power plants, then obviously we need massive chunks of land for the purpose of installation of solar panel and other related activities. It is estimated that, on an average, about four acres of land is required to generate one megawatt of solar power. If wasteland is available in abundance, then there is not much of problem on this score. The problem, however, is that no land is a completely wasteland. Even if there were a land which could be called an absolute wasteland, it may not be available for installing solar energy for other reasons (TERI School of Advanced Studies, 2017).

Since the roof-top plants can have only a limited role compared to both the need and the potential of solar energy, the only other alternative left for the solar power option to succeed is the conversion of the agricultural land into the land for power-production through the solar power option. The problem that further complicates the situation is the fact that the agricultural land is already under an increasing stress due to the increasing levels of industrialisation and urbanisation in the country. It is so particularly after the implementation of New Economic Policy of 1991. A lot of agricultural land has been occupied by private players with an intention of land-hoarding. It is often done in the name of ‘developmental’ projects. The chunks of land thus acquired are often disproportionately large compared to the purported use. In fact, in many cases, ‘development’ is a sheer alibi as nothing productive comes on these hoarded pieces of land that are often quite large in size.

Therefore, any attempt to occupy the agricultural land for the purpose of solar power with any sort of coercion may result in an emergence of a greater number, intensity and complexity of challenges.

If not handled properly, these challenges can, in turn, pose serious threats not only for output, income and employment but also for price stability, food security as well as for the quality of environment, social cohesion and peace and for political stability.

The state governments have issued policy guidelines for the use of land for the purpose of installing solar power. For example, the Government of Haryana issued the State Solar Power Policy in March 2016. The policy document specifies various provisions for setting up of the solar power plants in the state. The Policy targets on productive use of wasteland by installing the solar power. However, at the same time, it specifies that there is no requirement of the permission of change of land use from the Town and Country Planning Department (Government of Haryana, 2016). Moreover, such plants are exempted from the environmental clearance. However, as the policy framework does not provide any details or classification, there is an urgent need to remove the ambiguity.

There are huge geographical dissimilarities across various states of India as well as across districts within the states. Each of the state ought to clearly specify the sites at the district as well as the block levels where the solar power plants can be installed.We can justify the green nature of the solar energy for promotion of sustainable development only if there is mindfulness while promoting solar energy.

## The Issues in Licensing for Solar Power Generation

The licensing issues throw another important challenge for development of solar power. Firstly, the power is a subject under the concurrent list of the Constitution of India. Therefore, the centre as well state governments are empowered to make the laws and frame the rules and regulations regard any activity connected with power and, thus obviously anything related to solar power as well Nehra, et al. (2006). Secondly, the power industry is divided into various types of businesses or activities connected to it, namely generation, transmission, distribution and trading activities. As per various provisions of the Electricity Act 2003, licenses are issued by the state as well as central agencies depending upon the scope of any activity connected to power. If the functions are to be discharged at the state level, then the respective State Electricity Regulatory Commission (SERC) is the licensing authority. However, in case of national level or interstate business, the licensing authority is the Central Electricity Regulatory Commission (CERC). Therefore, the companies engaged in the solar business have to apply and act accordingly (Kumar, 2014).

In this context, it is pertinent to realise that the regulatory risks cannot be controlled at zero level. These create uncertainty in the businesses and may adversely affect the growth of solar power. However, most of the state governments have issued guidelines to reduce the uncertainty in the solar business. The state of Haryana has taken various initiatives to reduce the licensing complexities. These include exemption from the environment clearance; reducing the cost of transmission; and wheeling for a period of ten year so that the solar power plants can compete with the other sources of energy. In a similar vein, other concessions, such as 100 per cent exemption from the stamp duty, have been provided for the solar plants.

## The Technological Issues in Solar Power

The technology related to the solar power is the third important challenging area that needs to be addressed. There are some important technological issues. These include the manufacturing of the plants and components, the disposal of used solar cells, and the storage of power issues. In an earlier era, the solar power was very costly in comparison to other sources of energy.

Hence, most of the countries used solar power plants merely as 'demonstration' plants.

These were just about a mere symbolic commitment to green power. However, in the recent times, the focus on renewable energy has increased because of the raging debate about global warming and climate change issues. The governments are providing subsidy to promote the solar power. Consequently, the solar power has become cheaper (Kapoor & Dwivedi, 2017). Secondly, over the due course of time, a sharp increase has taken place in the cost of other sources of energy, such as coal, gas, petrochemical etc. In case of the solar power, there has not been any increase in the fuel cost as it uses the solar radiation that is freely available. Therefore, it has helped the solar power in competing with other sources of energy. Despite reduction in the absolute and relative cost of the solar power, the manufacturing of the solar cells is an important area of interest. Most of the manufactures of solar cells claim 20-25 years as lifetime of these solar cells. A huge quantity of these cells is imported from other countries including China ("*China accounts for 89% of India's total solar cells imports in 2017-18*", 2018, August 01; "*Government steps up efforts to cut solar panel imports from China, proposes 20-25% customs duty*"**,** 2020, June 26). In FY 2017-18, the share of import of solar cell from china was about 90 per cent (Gambhir A., 2018). Presently, we do not have any policy that can deal with the scraps of these solar cells when their useful lifetime is over. Therefore, there is a need to make a policy that can properly and comprehensively deal with these issues. The focus could well be on the domestic production of these solar cells as that could also work as an opportunity to boost income, output and employment in the economy.

Another technological challenge is the storage issues related to solar power. The storage issues arise because of two reasons of the timing of use of power and the conversion of voltage. Since the solar radiations are available only during the daytime, hence we need some storage capacity for the purpose of use during the night-times. Secondly, solar cells generate power in the form of Direct Current (DC) power while normally the domestic as well as industrial equipment run on Alternating Current (AC) power. Hence, the conversion of voltage from DC to AC is required, unless the DC voltage-based equipment is used. Therefore, the storage requirement imposes additional monetary as well as environmental cost in the use of solar power. After the popularisation of solar technology in India, the use of batteries for the storage of power has increased considerably. The ways and means need to be worked out to minimise the storage of power as its storage is not a completely environmental-friendly process. One of the possible options could be that during the daytime the solar power stations are operated as base load plants so that not much power is left for the storage. For the sake of environment and economy, efforts can be made to so plan the work that more and more industrial and commercial demand for electricity can be supplied during the daytime. However, the existing policy guidelines do not carefully deal with such detailed but important issues. In fact, the devil lies in the details. The details of the issues of green energy have potential to make or mar the performance, growth and prospects of the optimal utilisation of the vast solar potential of India (NITI Aayog, 2015). Hence, the policymakers, innovators, researchers, businesses and public at large need to be sensitised on details of the issues related to solar power. After all a nation has not only to put its money where its mouth is, but it needs to put all its heads and hearts too.

## CONCLUDING CONSIDERATIONS

The electricity is the most crucial source of energy in the world today. It is for this reason that various economies routinely focus on increasing the production as well as consumption of electric energy.

In fact, it is so important that the per capita consumption of electricity is often taken as an important indicator for measuring the economic prosperity and level of economic development. Consequently, increasingly the focus has shifted to enhancement of the installed power generation capacity.

However, in the earlier era of Indian economic development, due attention was not paid to the promotion of the renewable sources of energy. The installed generating capacity mainly comprised the thermal power capacity that uses fossil fuels like coal, oil, gas etc. The excessive use of fossil fuel created environmental and other problems. It not only resulted in the high levels of carbon emissions but also led to an increased fuel dependency of the developing countries and India was no exception to it. The share of thermal power in India was estimated to be about 70 percent about a decade ago.

Therefore, more and more use of renewable energy sources, and particularly that of the solar energy is emerging as a viable solution to address both the economic and environmental problems. Of course, there are other alternative sources of energy such as hydro, wind, tidal, biomass etc. However, their availability and suitability has more constraining factors. Apart from that, solar power also helps in deriving a solution to the problem of affordability and access to energy. It is so because many people in India live in remote areas, such as hilly sites. Due to low population density, the grid supply of power could not be accessed by these households. However, solar power became a viable option and helped in providing access to the households and businesses in these remote areas to electricity (Timilsina, et al. 2011).

In order to promote solar energy, the governments have taken some steps at their level. The Jawaharlal Nehru National Solar Mission (JNNSM) was launched in 2010 with the support of state governments. Under this programme, various solutions such as financial incentives and subsidy are being provided to promote the solar energy at the end-user levels. Consequently, the generating capacity of solar power has been increased significantly. Some of the states such as Karnataka, Rajasthan, Telangana, Andhra Pradesh, Tamil Nadu, Gujarat Madhya Pradesh, and Maharashtra etc. have made notable progress in promotion of solar energy. However, the vast potential still remains untapped and it needs to be utilised. So, India has been able to utilise a little less than 4 percent of its potential for solar power.

It is concluded that use of solar energy is environment-friendly and hence suitable to promote sustainable development. Its share in total installed capacity needs to be increased significantly so that this can be used as a complementary source in order to fulfil the increasing demand for electricity in India. However, there are some issues that need to be addressed to make the solar power as an engine of economic growth to increase the income, output and employment and reduce dependence on other countries. Some of the important issues relating to the existing level of technology, use of agricultural land etc., need to be addressed carefully and innovatively. It is high time for India to review the contribution of solar energy in its long-term sustainable development. Solar is a real green and safe option not only for the current generation but also for the coming generations.

If looked from the overall international context, while the populist and ethnic nationalistic framework of governance seems to be opportunistically using the unprecedented conjecture of world recession and pandemic to throw back the world into protectionist brigandage, free-floating anti-globalisation and the most audacious reneging on the national commitments that were assiduously built and recognised through international agreements and treaties on environment and climate. However, the very same conjecture has also brought out the falsehood of the dichotomy of ‘environment versus development’ as never before. There is potential for stricter international environmental auditing as a lesson from the pandemic.

However, even if the world as a whole is not able to rise to the occasion due to the leadership issues of all sorts at that level, the future developmental trajectory of a country will depend on if and how it turns this crisis into opportunity.

This is possible only by honestly recognising the interconnected and complementary, rather than independent and adversarial, nature of relation between environment and development. One of the tests of such a long-run vision of a country for achieving higher levels of welfare and prosperity could be if and how it takes to the policy of embracing the on-going technological disruption of the move away from fossil fuels and towards the more sustainable sources of energy. This is a way of strategic thought that would intrinsically involve promotion of solar energy as part of an answer to both the economic as well as the environmental issues. This is an imperative for all countries like India that are blessed with the heavenly blessings of the sun in more abundance and diversity than the others.

In this context, this paper has taken an original note of the reviews of the current situation and issues in solar power in their entirety. More follow-up of it can be thought by way of advocating micro changes in government schemes and macro policy changes for promotion of investment, output, incomes and employment through harnessing the vast solar potential of India. The article ventures to open scope for future studies to ask if and how India can become a net energy-exporter through a policy for promotion and adoption of solar energy.

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