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RESEARCH ARTICLE

An empirical analysis of Climate Change mitigation by Solar Energy

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Abstract

The study is based on the data collected from the Ministry of New & Renewable Energy - Government of India to assess energy consumption across the country. This study also collected data from relevant agencies responsible for energy supply to various residential, commercial, industrial, and transportation sectors. The equivalent carbon emissions from the selected fuel and energy sources operations are calculated using Gen Less Tools, a unique and customised emissions calculation tool. India has surpassed Germany to become the world's fourth-largest solar power installation country. Solar power capacity has increased more than sevenfold in the last five years, from 6.7 GW in 2016 to 44 GW in August 2021. Solar tariffs in India are highly competitive and have reached grid parity. In nine states with a considerable percentage of solar power installed, emissions were reduced by 42227 thousand tonnes.

Keywords: Climate Change; solar energy; mitigation; fossil fuels; technology

Introduction

Climate change is a cause for concern in India. For survival, a large portion of the country's population relies on climate-sensitive industries, including agriculture, forestry, and fishing. Increased severity of drought and flooding may jeopardise food security and economic viability due to climate change's adverse effects, such as decreasing rainfall and rising temperatures. In addition, the country's adaptive capacity to climate change is harmed by poor infrastructure, weak institutional systems, a lack of financial resources, and significant sectoral and regional diversity. Climate change might put even more strain on ecological and socio-economic systems already under enormous strain due to increasing urbanisation and economic expansion (Wei & Ye, 2014). Climate change has been regarded as a scientific, economic, or ethical concern at various periods. Climate change is now considered a development concern in India to attain high levels of economic growth (Stern, 2013). It was securing improvements in the standard of living of the people in India that required increased economic growth. However, herein lies the paradox of the climate change-development nexus.

Energy demand and consumption are driven by economic growth. For both power generation and transportation, most of this energy comes from the combustion of fossil fuels. Sulphur dioxide (SO_2) and carbon dioxide (CO_2) are produced by fossil fuels (CO). These compounds contribute to acidification and climate change (Armaroli & Balzani, 2011). Electricity is a powerful infrastructural resource that contributes to climate change when generated by thermal power stations. As of August 2021, India's national electric grid had an installed capacity of 388.134 GW(Lee & Lee, 2019). Of this current installed generation capacity, as of August 2021, India has a total Thermal installed capacity of 234 GW, of which 53% of the thermal power is obtained from coal and the rest from Lignite, Diesel, and Gas, meeting the lion's share of the nation's power demand. This indicates a grave problem of air pollution due to power generation by fossil fuel.

Electricity generation through solar energy is an environmentally friendly option. It has been used as a substitute for thermal power stations. Though solar energy is considered a substitute for thermal power, India cannot withdraw the existing thermal power stations. As the size and rate of growth of the population in India is at a high rate, and as the nation has the responsibility of providing its subjects with an uninterrupted power supply, it is forced to allow the existing thermal power stations to operate. The nation ought to do that the further increase in power demand ought to be met by solar power energy has significantly impacted the Indian energy market in recent years. Solar energy-based localised and distributed applications have helped millions of people in Indian communities, allowing them to meet their cooking, lighting, and other energy needs in an ecologically benign manner. As a result, this study aims to investigate the potential of solar energy in India to mitigate climate change. Furthermore, because solar energy may replace coal-based thermal power plants, this research examines the potential of solar energy to reduce climate change.

In climate change, mitigation refers to human actions that reduce greenhouse gas sources or increase greenhouse gas sinks. Using fossil fuels more effectively for industrial operations or electricity generation, transitioning to solar or wind power, increasing building insulation, and growing trees and other sinks to take more CO_2 from the atmosphere are just a few examples (Fawzy et al., 2020)

Review of literature

Consumption of fossil fuels and CO emission In India

India is ranked third globally, with 2.46 billion metric tonnes of carbon emissions, or 6.8% worldwide. However, India's carbon emissions per capita are still low, at 1.84 tonnes, compared to the US's 16.21 tonnes. Though India is the third-largest CO emitter globally, it managed to control the CO emissions into the atmosphere thanks to the hectic efforts to develop renewable energy technologies (Pathak & Shah, 2019). It believes that higher economic development and a stress-free environment can achieve with renewable options like solar energy. Therefore, its economic development efforts have always been guided by the principles of sustainable development, with a commitment to a greener environment.

World Solar energy Scenario

Solar energy is the world's fastest-growing alternative energy source. Ten nations accounted for about 90 per cent of the solar power installed capacity in the world. India is one of the world's most important countries and has occupied fourth place in the top ten nations. The installed solar power capacity of the top ten nations is depicted in Table 1 (*Statista - The Statistics Portal for Market Data, Market Research)*

Table 1. Country-wise solar energy installed capacity

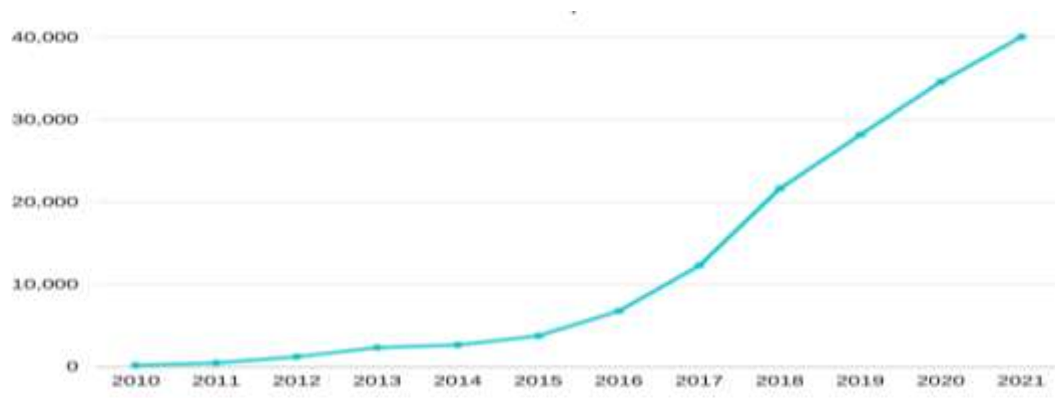
SNo	Country	Capacity in Gigawatts
1	China	895
2	USA	292
3	Brazil	150
4	India	134
5	Germany	132
6	Canada	101
7	Japan	101
8	Italy	55
9	France	55
10	UK	50

Source:Statistica

India's performance is well above Germany, Canada, and Japan. Though India ranks fourth, its installed capacity is nearly six times lower than the installed capacity of China, which stands first. Anyhow, the solar power development of India can not be undermined. It is a promising one. So, studying the climate change potential of solar energy in India will help the nation maintain an emission-free environment.

Solar energy Scenario in India

In the recent decade, solar power has received much interest and priority. Solar farms became operational in India in the last five years, and it took a few more years for this technology to be fully established. By the beginning of the twenty-oneth century, solar technology overcame most of the teething problems faced in the field and pronged its technical viability. Since then, it has received significant thrust and backup from industries, technocrats, policymakers, financial organisations, and other agencies. As of August 2021, the country's solar installed capacity was 44.3 GW, and further additions are expected to be faster in the coming years (*Solar Panel Making Company In India, Solar Companies In India | IBEF*, n.d.). The CO emission can be reduced to the extent of solar power projects installed in India. So, the solar power installed capacity is of grave concern here. Considering the importance of solar power installed capacity in mitigating the CO2 emission, India's year-wise installed capacity is examined in graph 1.



Source: renewable India, yearly solar energy power installation in India

Graph 1 shows a clear picture of India's year-wise solar power installed capacity. On the X-axis, the years 2010 through 2021 are represented, while on the Y-axis, the change in installation measured in megawatts (MW) is shown. Year after year, the installed capacity increased at a remarkable rate. The solar power installed capacity was 161 MW in 2010. It increased to 40,085 MW from 2020 to 21 (Suganthi & Williams, 2000). During the years between 2015 to 2018, the installed capacity had been raised by more than doubled. From 2010 to 2021, the annual solar power installed capacity exhibited a rising trend, as seen in the table above. The annual increase in the installed capacity is 411 MW. The annual Compound Growth Rate of the installed capacity from 2010-2021 is 154 per cent.

Methodology

CO Emission Reduction Potential of Solar energy in India

Solar energy is one of the most efficient forms of renewable energy. It is essential to the maintenance of a pollution-free environment. Estimating the environmental advantages of solar energy-generated electric power is based on coal displacement in power generation. One unit of electric power generated by solar energy can displace one unit from coal-based electricity generation. So, one unit of power generated by solar energy can mitigate environmental pollution emissions caused by coal combustion to generate one unit of power in coal-based thermal power stations. The CO emissions mitigated by solar energy depend upon the total annual useful energy and the amount and type of fossil fuel replaced. This analysis accentuated that increased use of solar power can reduce the need for new coal-fired power plants, thereby slowing down both coal depletion and atmospheric pollution. The CO emission reduction calculation has been based on the following formula (Marques et al., 2015).

$EC(t) = C(t) \times O_c \times N_c \times M$

Where EC(t) is the carbon dioxide emission from coal combustion.

C(t) is coal consumption in Tera joules.

Oc is the carbon emission factor of coal (25.8/TJ)

Nc is the fraction of carbon oxidised of coal (0.98) and M is the molecular ratio of carbon dioxide to carbon (44/12)

In table 3, the state-wise CO_2 emission abatement potentials of solar power in India is examined.

Table 3. Statewise CO2 emission mitigation potential of solar energy in India

State	*solar power Generation (MW)	Coal saving in Thousand Tonnes	Energy Content in (TJ)	*CO_2 emissions reduction (in thousand tonnes)
Rajasthan	8076.70	3052.99	91193.00	8182.00
Karnataka	7469.01	2823.28	84331.00	7566.00
Gujarat	5987.39	2263.23	67603.00	6065.00

Tamil Nadu	4675.23	1767.15	52785.00	4736.00
Andhra Pradesh	4380.28	1655.74	49457.00	4437.00
Telangana	3992.13	1509.10	45077.00	4044.00
Madhya Pradesh	2633.60	995.50	29736.00	2668.00
Maharashtra	2444.64	924.07	27602.00	2477.00
Uttar Pradesh	2025.48	765.63	22869.00	2052.00

Source: computed/ *mnre.gov.in/

Results and Discussion

India is a tropical country that gets a lot of sunlight year-round. About 5,000 trillion kilowatt-hours of electricity are delivered to India annually, with most areas receiving between 4 and 7 kilowatt-hours per square meter. During the past several years, solar energy has dramatically impacted India's energy landscape (Jin et al., 2022). According to the CEA 2021, India's solar energy generation increased to around 12%of the increasing renewable energy capacity, implying that India needs to raise this to fulfil the 50% electricity generation objective by 2030. Rajasthan, Karnataka, Gujarat, and Tamil Nadu have significantly reduced CO2 emissions through solar power. The emission reduction potential of solar energy in these states is 26,549 thousand tonnes. Andhra Pradesh and Telangana have a percentage share of the total CO_2 emission reduction capacity of 10.12 and 9.52, respectively. Madhya Pradesh, Maharashtra, and Uttar Pradesh have a minimal share of the total. High sulphur, volatile matter, vitrinite, and low ash content are just a few of the peculiar Physico-chemical features of northeast Indian coals (Arjunan et al., 2009). As a result of its rarity and widespread industrial use, mining it has a reputation for leaving a more significant ecological footprint. Large-scale landscape degradation, soil erosion, deforestation, declining wildlife populations, and air, water, and soil pollution are only a few environmental problems (CRK & VK, 2019). Therefore, a considerable shift in demand for the remaining power-producing units results from the widespread adoption of solar energy as an alternative to coal. Therefore, solar electricity is India's ideal alternative to coal, which is undergoing significant socio-economic development.

The state of Rajasthan has long enjoyed a climate ideal for producing renewable energy, and recent policy changes have helped to further encourage this trend. In addition to funding infrastructure improvements in the renewable energy industry, the state government offers numerous incentives for such initiatives (Dogan et al., 2022). There is now a more favourable climate for investors partly due to efforts like the Rajasthan Investment Promotion Scheme 2019 and others. The RIPS 2019 emphasises renewable energy as a critical industry, per the state's directive. The 26th United Nations climate change conference saw the adoption of policies that have since been shown to have far-reaching social and economic benefits (Clémençon, 2016). After COP26, India made a promise to increase its use of renewable energy to cover half of the country's energy needs by 2030, as well as to double its ability to generate power from sources other than fossil fuels to 500 GW by the end of the decade.

Conclusion

Solar power can help reduce CO_2 emissions into the atmosphere and save the environment from acute air pollution and global warming. As there is no possibility of replacing the existing thermal power stations, solar farms may replace new thermal power stations. As CO emission poses global warming, every country has to take strenuous steps to develop this new strategy faster. India has much scope for solar power installation. However, it has miles to go to tap it fully. So far, private investment has been responsible for the growth of India's solar industry. The government is also doing its part to promote the solar energy business in the country by providing a number of incentives and new programmes. That guarantees a sustained increase in solar power capacity to meet the nation's energy needs without negatively impacting society, the economy, or the environment. So, India is improving its Solar energy technology to accomplish the goal of fuller utilisation of the available Solar potential. If these positive trends persist, solar energy will be the only Source of electricity that doesn't contribute to global warming.

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