



Solar Radiation Decline in India

For Prelims: [Climate Change](#), [India Meteorological Department \(IMD\)](#), [Aerosol](#), [Renewable Energy](#), [PM-KUSUM](#), [Rooftop Solar Programme](#).

For Mains: Solar Energy and Development in India, Challenges Related to Solar Energy, Government Schemes to Enhance Solar Energy Production in India

[Source: TH](#)

Why in News?

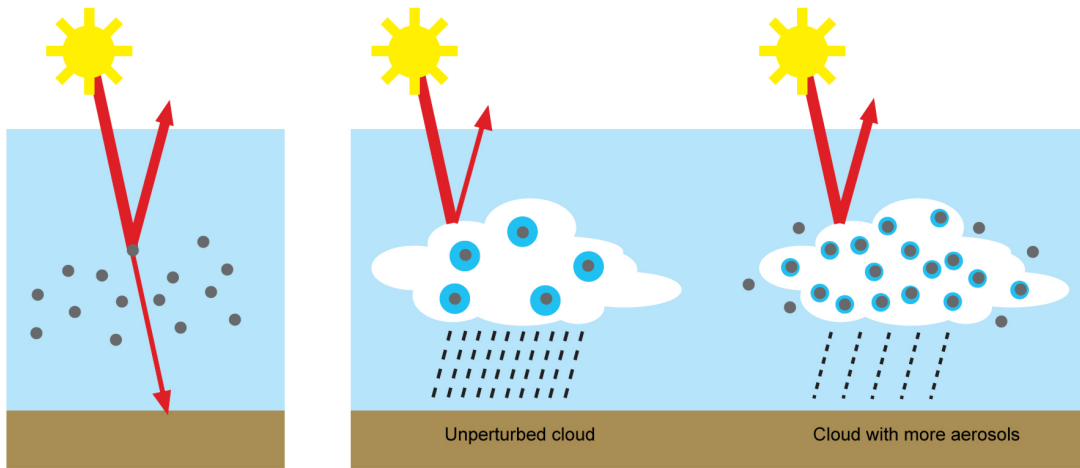
As concerns about [climate change](#) continue to escalate, the importance of [renewable energy](#) sources like **solar power** becomes increasingly evident.

- However, a recent study by scientists at the [India Meteorological Department \(IMD\)](#) has revealed a concerning trend about the **quantity of solar radiation** available for **conversion into electricity by solar panels** is on the decline in several locations across India.

What are the Key Highlights of the Study?

- **Aerosol Load:**
 - Increased [aerosol](#) load from [carbon emissions](#), [fossil fuel burning](#), and **dust**, along with **clouding**, contribute to the decline in solar radiation.
 - Aerosols absorb the sunlight and **deflect it away from the ground** and they can also precipitate the formation of **dense clouds that again block sunlight**.
 - The efficiency of solar panels is significantly influenced by the amount of sunlight incident on them.

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Aerosol direct effect
Scattering and absorption of solar radiation

Aerosol indirect effect
Decrease of cloud droplet size, increase of droplet number, increased scattering of solar radiation, decrease of precipitation

▪ **Decline in Solar Photovoltaic (SPV) Potential:**

- Analysis reveals a widespread decline in SPV potential across all monitored stations.
 - SPV is the amount of radiation that may be practically available to be converted to electricity by panels.
- SPV potential showed a **general decline in all stations** which included Ahmedabad, Chennai, Goa, Jodhpur, Kolkata, Mumbai, Nagpur, New Delhi, Pune, Shillong, Thiruvananthapuram, and Vishakhapatnam.
- **India's largest solar parks are located in the northwest**, particularly Gujarat and Rajasthan, and cities in both these States are also showing a decrease in SPV potential.

▪ **Global Solar Radiation (GR) over India:**

- Global solar radiation (GR) is the **total amount of solar radiation that is being received per unit area** on the earth's surface.
 - GR is **maximum over northwest India and inland peninsular India**, minimum over extreme north and northeast India.
 - Reduction attributed to increased atmospheric turbidity and cloudiness. Monsoon clouds reduce the GR over most parts of India.
 - Maximum GR in pre-monsoon season for most stations, except Srinagar.
 - Minimum GR varies between monsoon, post-monsoon, or winter depending on the station.

▪ **Diffuse Radiation (DR):**

- Diffuse radiation refers to **solar radiation scattered by atmospheric particles**.
 - Clear skies transmit a large percentage of solar radiation, resulting in relatively small diffuse radiation.
 - In contrast, a partly cloudy or turbid atmosphere exhibits high diffuse radiation due to increased scattering of solar radiation by atmospheric particles.
- Significant increase in DR observed in more than 50% of stations, especially in northwest and some parts of peninsular India.
 - Increase attributed to increased atmospheric turbidity and cloudiness.

Key Terms

Solar Radiation

- Solar radiation is **electromagnetic radiation** emitted by the sun that can be converted into useful forms of energy, such as **heat and electricity**.
- The amount of solar radiation

Aerosol

- Aerosols are **tiny particles** that are suspended in a **gas or liquid environment**.
 - They can be **solid or liquid** and range in size from a few tens of

that reaches a location on Earth's surface varies depending on **Geographic location, Time of day, Season, Local landscape, and Local weather.**

- The Earth's round shape causes the sun to strike its surface at different angles, ranging from **0° (just above the horizon) to 90° (directly overhead).** **Vertical 90° sun rays provide maximum energy,** while slanted rays travelling at 0-89° through the atmosphere become more scattered.
 - The **frigid polar regions never get a high 90° sun due to the Earth's round shape and 23.5° tilted axis.**
- The rotation of the Earth also causes hourly variations in sunlight.

nanometers to several tens of micrometres about the diameter of human hair.

- Aerosols can be **natural or artificial.**
 - Natural aerosols include: fog, gas from **volcanic eruptions, sea salt** generated from breaking waves, and mineral dust blown from the surface by wind.
 - Artificial aerosols consist of smoke from burning fossil fuels and various particles such as sulphates, nitrates, black carbon, and others emitted from automobiles, incinerators, smelters, and power plants.
- Aerosols are **short-lived, unlike [greenhouse gases](#)** that persist and accumulate in the atmosphere for longer periods.

Note:

- In tropical countries like India, solar energy has immense potential. The energy of about **5,000 trillion kWh per year is incidental over India's land area.**
- IMD confirms the findings of the [IPCC AR6 \(Intergovernmental Panel on Climate Change Assessment Report 6\)](#), multidecadal dimming and brightening trends in incoming solar radiation at Earth's surface occurred at various locations all over the world.

What are the Implications for India's Solar Power Goals?

- **Current Scenario:**
 - India's current installed solar power capacity is about **81 GW (1 GW is 1,000 megawatts)**, or roughly 17% of the total installed electricity.
 - **India stands 4th globally in Renewable Energy Installed Capacity**, 4th in Wind Power capacity and **5th in Solar Power capacity** (as per [International Renewable Energy Agency - Renewable capacity statistics 2023](#)).
- **Ambitious Targets:**
 - India has ambitious plans of sourcing about **500 GW, nearly half its requirement of electricity, from non-fossil fuel sources by 2030.**
 - This would mean at least 280 GW of solar power by that year or **at least 40 GW of solar capacity being annually added until 2030.**
- **Challenges:**
 - Despite ambitious goals, the country has struggled to meet its targets, with annual additions barely crossing 13 GW in the last five years.
 - Factors like the [Covid-19 pandemic](#) have been cited as hindrances to progress and the country was on track to add between 25-40 GW annually in the coming years.
 - And other challenges for solar power development in India include **land acquisition complexities, grid integration issues**, slow growth of rooftop solar, **limited**

availability of storage technology, and a need for more innovation.

Potential of Solar Advancements

- Beyond the economic and technological advancements, the environmental benefits of solar power advancements include:
 - **Mitigating Climate Change:** Solar panels significantly contribute to reducing climate change through their low ecological impact and **minimised carbon footprint**.
 - **Reduced Pollution:** Transitioning to cleaner energy sources reduces air and water pollution, promoting a healthier and sustainable environment.
 - **Securing the Planet's Future:** Solar power's environmental benefits go beyond progress, which is crucial in ensuring a sustainable future.

What are the Government Initiatives Related to Solar Energy?

- [The Production Linked Incentive Scheme \(PLI\) for the National Programme on High-Efficiency Solar PV Modules.](#)
- [Solar Park Scheme.](#)
- [PM-KUSUM.](#)
- [Rooftop Solar Programme.](#)
- [International Solar Alliance \(ISA\).](#)

Way Forward

- Analyse the aerosol types contributing most to the decline (e.g., [black carbon](#) from vehicles, industrial dust).
 - **Enact targeted policies to address those sources.** Partner with local authorities to tackle regional pollution hotspots.
- Focus on promoting bifacial solar panels that capture sunlight from both sides, potentially increasing generation even with diffused light.
 - Incentivise domestic manufacturing of these panels to reduce reliance on imports and create green jobs.
- Partner with international research organisations like the [International Renewable Energy Agency \(IRENA\)](#) to share data and best practices on mitigating the impact of air pollution on solar radiation.
- **Develop and deploy [Artificial Intelligence](#)-powered robotic systems** for automated cleaning of solar panels in arid regions.
 - **Dust accumulation on panels significantly reduces efficiency.** These AI cleaners can optimise cleaning schedules based on weather data and dust forecasts, maximising solar power generation.
- Enact [building codes](#) **mandating pre-installation of rooftop solar panels** on all new commercial and government buildings.
 - This can significantly increase rooftop solar adoption and reduce reliance on traditional grid power.

Drishti Mains Question:

Q. Analyse the impact of declining solar radiation availability on India's energy security and its implications for achieving renewable energy targets.

UPSC Civil Services Examination Previous Year Question (PYQ)

Prelims

Q. In the context of which of the following do some scientists suggest the use of cirrus cloud thinning technique and the injection of sulphate aerosol into stratosphere? (2019)

- (a) Creating the artificial rains in some regions
- (b) Reducing the frequency and intensity of tropical cyclones
- (c) Reducing the adverse effects of solar wind on the Earth
- (d) Reducing the global warming

Ans: (d)

Q. Consider the following statements: (2016)

1. The International Solar Alliance was launched at the United Nations Climate Change Conference in 2015.
2. The Alliance includes all the member countries of the United Nations.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Ans: (a)

Mains

Q. India has immense potential of solar energy though there are regional variations in its developments. Elaborate. (2020)