



## 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?

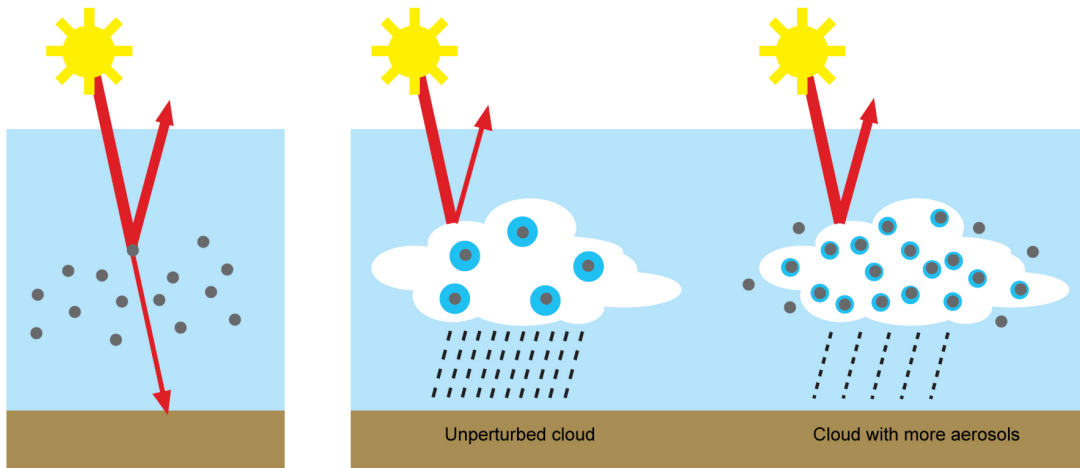
As concerns about [climate change](#) continue to escalate, the importance of [renewable energy](#) sources like **solar power** becomes increasingly evident.

- 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 4<sup>th</sup> globally in Renewable Energy Installed Capacity,** 4<sup>th</sup> in Wind Power capacity and **5<sup>th</sup> 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)**

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### **Mains**

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