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The Role of Government Initiatives in Accelerating Solar energy deployment in India.

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ABSTRACT :

India possesses significant potential for solar energy generation due to its abundant solar insolation and favorable geographical conditions. The government's ambitious renewable energy targets and supportive policies have catalyzed rapid growth in the solar sector. This paper examines the expansion of solar energy in India, evaluates its current capacity, and addresses the challenges and limitations faced by the industry. It also highlights future opportunities, focusing on policy frameworks, technological innovations, economic viability, and the environmental advantages of solar energy. The study concludes with strategic recommendations aimed at fostering the sector's growth, ultimately contributing to India's energy independence and sustainable development.

INTRODUCTION :

India is well-positioned to capitalize on solar energy for the advancement of photovoltaic solar power systems, thanks to its high average daily radiation and a substantial number of sunny days across the country. Consequently, both the government and private enterprises are actively formulating policies and investing in photovoltaic solar power initiatives. One of the key advantages of rooftop solar PV systems is their ability to be authorized and installed more swiftly than other renewable energy power plants. These systems are environmentally friendly, silent, and aesthetically unobtrusive, often going unnoticed by the public. Given the impending shortages in traditional power generation and the increasing demand for energy, it is essential to pursue alternative energy sources.

The growing global focus on sustainable energy has established solar power as a crucial solution for meeting energy needs while minimizing carbon emissions. As a developing country with ambitious climate objectives, India's goal of reaching 500 GW of non-fossil fuel capacity by 2030 highlights the essential role of solar energy in its energy strategy.

Government initiatives such as the National Solar Mission, the establishment of solar parks, and financial incentives for both residential and commercial solar projects have been key in advancing the solar energy movement. These efforts not only encourage the use of clean energy but also drive economic development through job creation and investments in the renewable energy sector. Nevertheless, the execution of these initiatives encounters obstacles such as funding shortages, regulatory challenges, and a lack of public awareness. This research examines the influence of government policies and programs on the promotion of solar energy in India, assessing their effectiveness and pinpointing areas for enhancement to strengthen the country's renewable energy framework.

SOLAR ENERGY :

Solar energy is the radiation emitted by the Sun that can generate heat, initiate chemical reactions, or produce electricity. The total solar energy that reaches Earth far exceeds the current and projected global energy demands. If effectively captured, this abundant resource could meet all future energy requirements. In the 21st century, solar energy has gained significant appeal as a renewable energy source due to its limitless availability and environmentally friendly nature, especially when compared to the limited reserves of fossil fuels such as coal, oil, and natural gas.

Solar Cell (Photovoltaic Cell)

This device transforms sunlight (solar energy) into electrical energy. Essentially, it performs two primary functions: generating charge carriers (electrons and holes) within a light-absorbing material and separating these charge carriers to a conductive contact that facilitates the flow of electricity.

- **Mono-crystalline**

A monocrystalline solar cell is produced from single silicon crystals through a method known as the Czochralski process. The efficiency of these cells ranges from 15% to 20%. They are characterized by a cylindrical shape and are constructed from silicon ingots.

- **Poly-crystalline**

Polycrystalline solar panels, commonly referred to as poly panels, consist of numerous individual polycrystalline solar cells.

Similar to monocrystalline solar cells, polycrystalline cells are also composed of silicon crystals. However, the key distinction lies in their formation; instead of being created from a single, pure ingot, the silicon crystal cools and breaks apart naturally. These fragments are then melted in a furnace and shaped into cubes, which are subsequently sliced into thin wafers. As a result, this type of solar cell is made up of multiple crystals, unlike the single crystal structure found in monocrystalline cells. The manufacturing process for polycrystalline cells is less stringent than that of their monocrystalline counterparts, enabling a quicker and more cost-effective production of solar cells.

Typically, polycrystalline panels achieve an efficiency rating ranging from 13% to 16%. Although this is only a few percentage points lower than monocrystalline panels, the cumulative effect can be significant when considering a large number of solar panels.

- **Amorphous**

Amorphous solar panels utilize silicon-based photovoltaic technology similar to that found in traditional solar panels, but they do not incorporate solar cells. Rather than employing the layered crystalline silicon wafers characteristic of solar cells, these panels consist of a non-crystalline silicon layer applied to a thin substrate, which can be made of materials such as glass, plastic, or metal. This configuration results in a highly adaptable conductive material that is lightweight, malleable, and can be easily shaped to suit various applications.

- **Thin Film**

A thin-film solar cell is a device engineered to transform light energy into electrical energy through the photovoltaic effect. It comprises layers of photon-absorbing material that are only microns thick, deposited onto a flexible substrate.

Types Of Thin Film

1. **Cadmium telluride (CdTe)** thin-film solar cells represent the most prevalent option in the market. They are generally more affordable compared to traditional silicon thin-film cells. CdTe thin films have achieved a peak efficiency of over 22.1 percent, indicating the proportion of photons that convert into electric current upon striking the cell's surface. By 2014, CdTe thin-film technologies boasted the lowest carbon footprint and the fastest payback period among all thin-film solar cell technologies available.

2. **Copper indium gallium selenide (CIGS)** serves as another semiconductor utilized in the production of thin-film solar cells. In laboratory conditions, CIGS thin-film solar cells have achieved efficiencies of 21.7 percent, while field performance has reached 18.7 percent. This positions CIGS as a leading alternative material in the thin-film sector. However, CIGS cells tend to be more expensive than other available options, which limits their widespread adoption.

3. **Gallium arsenide (GaAs**) thin-film solar cells have demonstrated efficiencies nearing 30 percent in laboratory settings, yet their high manufacturing costs pose a significant barrier to market penetration. Consequently, GaAs solar cells are primarily utilized in specialized applications such as spacecraft and satellites.

4. **Amorphous silicon** thin-film cells are the most established and developed type of thin-film technology. Composed of noncrystalline silicon, they differ from conventional solar-cell wafers. The production of amorphous silicon is less costly than that of crystalline silicon and many other semiconductor materials. Its appeal also lies in its abundance, non-toxicity, and affordability. However, the average efficiency of these cells remains low, typically below 10 percent.

Solar PV System :

A photovoltaic system, commonly referred to as a PV system or solar power system, is engineered to harness solar energy for practical use through the application of photovoltaics. This system comprises various components, including solar panels that capture and convert sunlight into electrical energy, a solar inverter that transforms direct current (DC) into alternating current (AC), along with mounting structures, cabling, and other electrical accessories necessary for establishing a functional system. PV systems vary in scale, from small installations on rooftops or integrated into buildings with capacities ranging from a few kilowatts to several tens of kilowatts, to large utility-scale power plants that can generate hundreds of megawatts. Currently, the majority of PV systems are connected to the grid, while off-grid or standalone systems represent only a minor segment of the market.

On-Grid Solar System

Solar panels capture sunlight and transform it into electricity. This electricity is initially in the form of direct current (DC), which is subsequently converted into alternating current (AC) by a solar inverter. The AC power is then fed into the grid for everyday consumption. A net meter tracks both the electricity exported to the grid and the electricity consumed. At the end of each month, this net metering device produces a summary statement reflecting the overall energy usage.

Off-Grid Solar System

An off-grid solar system is defined as a solar setup equipped with battery storage and a backup, allowing it to generate electricity during power outages or at night. This system comprises four essential components: solar panels, an inverter, batteries, and system balancing. Its increasing popularity stems from its ability to provide power backup and operate independently from the electrical grid.

Government Initiatives

❖ **Solar Park Schemes**

- Solar power initiatives can be established throughout the country; however, the dispersed nature of these projects results in increased costs per megawatt and greater transmission losses. Smaller individual projects face substantial expenses related to site development, the installation of separate transmission lines to the nearest substations, water procurement, and the establishment of essential infrastructure. Additionally, project developers often experience delays in land acquisition and obtaining various clearances and permissions, which further postpones project timelines. To address these issues, the "Development of Solar Parks and Ultra-Mega Solar Power Projects" scheme was introduced in December 2014, aimed at enabling solar project developers to implement their projects more efficiently.

❖ **VGF (Viability Gap Funding) Schemes**

- The Union Cabinet, led by the Hon'ble Prime Minister, has approved a Scheme for Viability Gap Funding (VGF) aimed at the development of Battery Energy Storage Systems (BESS). This initiative plans for the establishment of 4,000 MWh of BESS projects by the fiscal year 2030-31, providing financial assistance of up to 40% of the capital costs through budgetary support in the form of VGF. This decision marks a significant step in the government's ongoing efforts to promote environmentally friendly initiatives, with expectations to reduce the costs associated with battery storage systems, thereby enhancing their feasibility.
- The VGF Scheme for BESS comes with an initial allocation of Rs. 9,400 crore, which includes a budgetary provision of Rs. 3,760 crore, underscoring the government's dedication to advancing sustainable energy solutions.

❖ **CPSU (Central Public Sector Undertaking) Scheme**

- The Government of India, via the Ministry of New & Renewable Energy (MNRE), has sanctioned the execution of Phase-II of the CPSU Scheme. This initiative aims to establish grid-connected Solar Photovoltaic (PV) Power Projects by Central and State Public Sector Undertakings (PSUs) and Government Organizations. The scheme includes a Viability Gap Funding (VGF) provision of Rs 8,580 crore, intended for self-consumption or utilization by Government entities, either directly or through Distribution Companies (DISCOMs).

❖ **Defence Scheme**

- The initiative to establish more than 300MW of grid-connected and off-grid solar photovoltaic power projects by Defence Establishments is designed to foster environmentally sustainable development and to make use of the available land and rooftops within the Defence sector to enhance energy security. Solar power facilities developed under this initiative will be required to be manufactured domestically to support the growth of local production of solar cells and modules.

❖ **Canal Bank & Canal Top Scheme**

- The aim of this initiative is to effectively utilize the unused spaces above canals and any available vacant government land along their banks for the establishment of Solar PV power generation facilities. This will facilitate the feeding of generated electricity into the grid, with a target of developing a total capacity of 100 MW in solar PV power projects, in alignment with the objectives outlined in the National Solar Mission (NSM) introduced by the Government of India.

❖ **Bundling Scheme**

- The RE Bundling Scheme allows any generating company operating a coal, lignite, or gas-based thermal generation station, as well as a hydro power station, to either establish or acquire renewable energy from a Renewable Energy (RE) power plant. This plant can be situated on the same premises or at a different location. The generating companies are required to use this renewable energy to fulfill their existing commitments or Power Purchase Agreements (PPAs) by replacing thermal or hydro power supplied to the procurers.

❖ **Solar Rooftop Scheme**

1. The Ministry of New and Renewable Energy is promoting the installation of solar panels on residential rooftops through the Grid-connected Rooftop Solar Scheme to harness solar power.
2. This initiative involves a grid-connected rooftop or small Solar Photovoltaic (SPV) system, where the direct current (DC) produced by the SPV panels is converted into alternating current (AC) by a power conditioning unit and subsequently supplied to the grid.
3. The scheme aims to encourage the adoption of grid-connected SPV rooftop systems and small SPV power generation facilities across residential, community, institutional, industrial, and commercial sectors.
4. It seeks to reduce reliance on fossil fuel-based electricity generation while promoting sustainable solar energy solutions.
5. As part of this initiative, the Ministry offers a subsidy of 40% for the initial 3 kW of solar panel capacity and a 20% subsidy for capacities exceeding 3 kW and up to 10 kW.

Environmental Impact and Benefits of Solar Energy

Solar energy, recognized for its cleanliness and renewability, offers numerous environmental advantages:

- Decrease in Carbon Emissions: Transitioning from coal and oil to solar energy significantly lowers carbon emissions, aiding India in meeting its climate objectives outlined in the Paris Agreement.
- Water Preservation: The maintenance of solar energy systems necessitates very little water, in contrast to thermal power plants that require substantial water for cooling processes.
- Protection of Biodiversity: Solar installations can be set up on previously degraded or unused lands, thereby reducing the adverse effects on forests and areas rich in biodiversity.

Conclusion :

Solar energy offers a significant opportunity for India to sustainably address its increasing energy needs while minimizing its carbon emissions. With ongoing technological innovations, favorable policies, and enhanced infrastructure investments, India is well-positioned to become a global frontrunner in solar energy. Nevertheless, it is crucial to tackle issues concerning grid infrastructure, financial sustainability, and policy consistency to fully realize this potential. India's dedication to solar energy is vital not only for its energy independence but also for its contribution to global climate change efforts.

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