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Policies for Promotion of Solar Energy in India: A Review

Abstract: - Worldwide, nations are formulating strategies and promoting the adoption of sustainable energy sources in order to mitigate the adverse impacts of fossil fuels on the environment and the associated CO2 emissions. In 2023, global CO2 emissions resulting from energy use saw a 0.1% increase, reaching a record high of 35.8 gigatons of CO2 due to the escalating energy consumption. A significant portion of this increase in emissions can be attributed to the power sector, which indirectly contributes to global warming, rising temperatures, and sea level changes. Consequently, numerous governments have enacted policies aimed at bolstering the role of solar energy in their energy portfolios to reduce their reliance on fossil fuels and mitigate environmental harm. Therefore, this review paper delves into an examination of trends in electricity generation and consumption, the importance of solar energy, solar energy policies in India, and an evaluation of the effectiveness of these policies. Furthermore, it discusses the challenges faced, outlines policy implications, and provides recommendations for the implementation of large-scale solar photovoltaic power generation projects.

Keywords: solar energy, policy, sustainable, challenges, mitigation

I. INTRODUCTION

Solar energy entails capturing renewable energy from the sun, achieved through photovoltaic technology or concentrated solar power. The trend towards adopting solar energy is gaining momentum, propelled by governmental policies [1]. By the end of 2020, the global capacity for renewable energy generation had reached 2,799 megawatts, with solar energy generation experiencing steady growth worldwide. Many countries are integrating solar power plants into their electricity production [2], with Iceland and Norway prominently relying on solar sources, while China leads as the foremost solar energy producer. Solar power accounted for 8% of the global electricity supply [3]. Several leading nations are embracing solar energy capacity to curb pollution and reduce resource consumption. The feasibility of solar energy production hinges on environmental variables such as geographic location, sunlight exposure, wind speed, and humidity. Solar power serves as a sustainable and renewable energy alternative to fossil fuels, addressing environmental issues like air pollution and global warming. Technological advancements, cost reductions, and growing awareness of the need for eco-friendly energy options are driving the adoption of solar energy. China, the United States, India, and the European Union are among the countries spearheading solar energy initiatives and investing in research and development. Solar energy production does not emit greenhouse gases, making it a crucial player in climate change mitigation and air pollution reduction efforts, contributing significantly to the global transition away from fossil fuels. Moreover, the solar energy industry creates job opportunities across various sectors including manufacturing, installation, maintenance, research, and related fields. Figure 1 illustrates the factors driving solar energy adoption [4].

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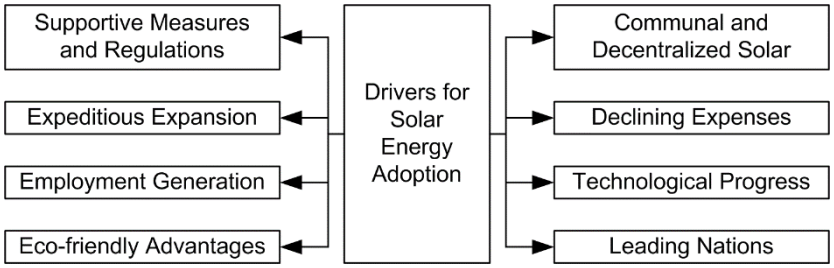

Fig. 1 Drivers for solar energy adoption

II. SOLAR ENERGY AND SDGS

By 2030, the aim is to attain the 17 Sustainable Development Goals (SDGs), which cover crucial domains like healthcare, gender equality, education, poverty reduction, and sustainable energy [5]. These goals set forth ambitious targets and receive differing levels of backing from governments. Within the framework of the SDGs, solar energy assumes a vital role in delivering sustainable and environmentally-friendly energy that is accessible to everyone. The worldwide energy demand is steadily escalating, with a projected 28% upswing by 2040, as indicated by the EIA. The surge in demand is primarily propelled by developing countries, and solar energy stands out as a solution to guarantee access to essential electricity [6]. Urgent concerns related to climate change, air quality, and overall public health highlight the imperative for transitioning to cleaner and more sustainable energy usage. As a result, there is a mounting worldwide call, supported by both policymakers and the public, to align with UN Sustainable Development Goal 7, which focuses on clean energy.

The alarming levels of air pollution in numerous Indian cities and around the globe underscore the worsening environmental conditions and the substantial health burdens these places on populations [3]. According to surveys conducted by the WHO, 13 Indian cities are ranked among the top 20 with the worst air quality. Consequently, there is an urgent need for substantial efforts to implement clean energy solutions. In this context, the Indian government launched the National Solar Mission (NSM) in 2010 with the goal of achieving a 20 GW solar power capacity by 2022 [7]. This initiative holds significant importance, considering that more than 60% of the country's energy is currently generated from coal, while renewable energy accounts for only 23.39% [6]. Furthermore, the cost of solar power has decreased in recent years, reaching levels in some countries that are competitive with traditional coal-based electricity generation [7].

III. P SOLAR POWER DEVELOPMENT WORLDWIDE

In response to the negative environmental impacts and various difficulties associated with fossil fuels, many nations have begun investigating and transitioning to environmentally sustainable alternatives, notably renewable energy sources, to fulfill the rising energy demand [8]. A number of countries have formulated policies focused on solar energy to decrease dependence on fossil fuels and enhance local energy generation through solar power [9]. This summary outlines the diverse solar energy strategies implemented by different countries internationally. As per the 2010 BP Statistical Energy Survey, the collective installed capacity of solar power globally surged to 22,928 MW in 2009, demonstrating a significant 46% rise from the previous year. Research indicates that Feed-in Tariffs (FITs), Renewable Portfolio Standards (RPS), and incentives stand out as highly effective energy policies adopted by numerous countries worldwide [10]. These policies play crucial roles as incentives and catalysts for the advancement and adoption of renewable energy technologies. Additionally, an analysis of Malaysia's solar energy policy status is conducted, drawing comparisons with successful nations globally [11]. Despite the acknowledged advantages of solar energy, its current global production remains a small fraction of its immense potential, constituting just 0.05% of the total primary energy supply [12]. To tackle this disparity, it is imperative for researchers to equip policymakers with tools to evaluate their countries' potential for solar energy generation relative to current production and consumption levels. This entails a thorough assessment of each country's capacity for electricity generation from both centralized and decentralized solar facilities [13]. Table 1 gives information about the various policies adopted worldwide for promoting solar power.

IV. SOLAR POLICEIS IN INDIA

India stands out by having sunlight throughout the year compared to other top-ranking countries, ranking fourth with an installed capacity of 48.556 megawatts [14]. The nation aims to achieve approximately 450 megawatts of solar power generation by 2030, with the objective of sourcing 60% of its energy from solar. The Indian government in 2014 revised the mission on solar project, known as RPSSGP, to promote the growth of rooftop and ground-mounted solar power systems [3]. India has implemented numerous policies to stimulate solar energy production. MNRE (Ministry of New and Renewable Energy) plans to offer incentives to distribution companies at a rate of 40 paise per kilowatt-hour for purchasing solar energy. Various countries have also developed policies to boost the adoption of solar energy [15]. Machine learning techniques, statistical methods, and other approaches can be used to estimate solar energy production [16].

Table 1: Policies fostering solar power development

Country	Policies
China	Feed-in Tariffs (FiTs), subsidies, Renewable Portfolio Standards (RPS), tax incentives, Green Finance Initiatives, demonstration projects, grid connection priority, funding for technology research and development, import tariffs, export rebates, and carbon emission reduction goals
USA	Federal Investment Tax Credit (ITC), Net Metering, State and Local Incentives, Solar Renewable Energy Certificates (SRECs), Property Assessed Clean Energy (PACE) Financing, USDA Rural Energy for America Program (REAP), Federal Grants and Incentives, Green Power Purchasing Programs, State-Specific Programs, Solar Leasing and Power Purchase Agreements (PPAs)
Japan	Feed-in Tariff (FiT) programs, Renewable Portfolio Standards (RPS), subsidies and incentives, net metering, tax credits, floating solar, environmental initiatives, smart grid development, and research and development efforts.
India	Jawaharlal Nehru National Solar Mission (JNNSM), Solar Park Scheme, Solar Rooftop Program, Renewable Purchase Obligation (RPO), Solar Water Pumping, Net Metering, International Solar Alliance (ISA), Customs and Duties, Incentives and Subsidies, Solar Research and Development, Off-Grid Solar Solutions, Bidding and Competitive Tenders.
Germany	Feed-in Tariffs (FiTs), Renewable Energy Act (EEG), Net Metering, Tendering System, Energy Storage Promotion, Direct Investment Incentives, Grid Expansion and Modernization, Research and Development Funding, Carbon Pricing, Energy Efficiency Measures, Energiewende, International Collaboration.
Australia	Small-scale Renewable Energy Scheme (SRES), Feed-in Tariffs (FiTs), Large-scale Renewable Energy Target (LRET), Renewable Energy Target (RET), Net Metering, Grid Connection, State-Specific Programs, Solar and Battery Storage, Solar Research and Development, Environmental and Emission Reduction Initiatives
Spain	Renewable Energy Auctions, Grid Access and Integration, Feed-in Premiums, Regulatory Stability, Energy Storage, Net Metering, Environmental Targets, Support for Research and Innovation, International Collaboration.
Italy	Feed-in Tariffs (FiTs), Renewable Energy Incentives, Grid Access and Integration, Net Metering, Renewable Energy Auctions, Environmental Targets, Energy Storage, Research and Innovation, European Union (EU) Collaboration, Environmental Certifications.

South Korea	Renewable Portfolio Standard (RPS), Feed-in Tariffs (FiTs), Renewable Energy Certificates (RECs), Energy Storage Development, Government Subsidies, Green New Deal, Floating Solar, Research and Development, Smart Grid Integration, International Collaboration, Environmental Targets, Net Metering.
Brazil	Net Metering, Renewable Energy Auctions, Tax Incentives, Financing Programs, Energy Efficiency Labeling, RenovaBio, Environmental Licensing, Local Content Requirements, Energy Research and Development, Climate and Sustainability Goals, Job Creation.

India has shown consistent growth in its solar energy capacity starting from 2008. The installed capacity was 3 MW in 2008-09 and had surged to 8 GW by July 2016. India has established an ambitious goal of reaching 100 GW by 2022, with a division of 60 GW onshore and 40 GW offshore [17]. The annual targets from FY 2015-16 to FY 2021-22 are outlined in Table 2.

The nation's solar energy potential, based on land availability and solar radiation, is estimated to be approximately 750 GWP. According to data from MNRE, these breaks down the GWP state by state [18], Uttarakhand accounts for 16.80% of the country's estimated solar energy potential. India is abundantly endowed with renewable resources and possesses significant potential. As of August 31, 2020, India boasts a total installed capacity of 372.69 GW, making it the world's third-largest generation sector. India's overall renewable energy capacity, including hydropower, stands at 35.94% [19]. The private sector's share of the total installed capacity is on the rise, currently representing 155 GW (45.2%), followed by state and federal governments with 84 GW (24.6%) and 103 GW (30.2%) respectively.

Table 2: Grid-connected targets for solar energy installations

Financial Year	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Roof Top Solar (MW)	200	4800	5000	6000	7000	8000	9000
Ground Mounted Solar (MW)	1800	7200	10000	10000	10000	9500	8500
Total Capacity (MW)	2000	12000	15000	16000	17000	17500	17500

India had also set up solar parks and large-scale solar initiatives to streamline the development of extensive solar projects. These parks furnished the essential infrastructure and land required by solar developers. Numerous Indian states had adopted net metering regulations, enabling owners of solar systems to inject surplus electricity back into the grid and gain credits on their electricity invoices. This stimulated the adoption of solar systems among residential and commercial properties. A heightened emphasis was placed on rooftop solar installations, both in residential and commercial settings. Financial incentives and subsidies were offered to incentivize rooftop solar initiatives. India had been deploying off-grid solar solutions to supply electricity to remote and rural regions with limited access to the conventional power grid. This encompassed systems like solar-based home lighting and small-scale electricity grids. India had been actively striving to bolster its domestic solar manufacturing sector to decrease reliance on imported solar panels and related components. India engaged in partnerships with international entities and nations to advocate for solar energy, notably through initiatives such as the International Solar Alliance (ISA), which sought to mobilize global solar resources. Solar power was considered a means to mitigate carbon emissions and tackle air pollution in urban areas across India. Additionally, it held the promise of enhancing energy availability in rural regions [20]. By 2002, significant solar power applications were being deployed in the telecommunication sector, street lighting systems, solar-powered pumps, and various other applications [21].

A. National Solar Mission

The "Jawaharlal Nehru National Solar Mission (JNNSM)", commonly referred to as the Solar Mission, is a pivotal element of "India's National Action Plan on Climate Change (NAPCC)", initiated in 2010. It unfolds in three distinct phases: Phase I spanning from 2010 to 2012, Phase II from 2013 to 2017, and Phase III from 2017 to 2022. Phase I incorporates the "Rooftop PV and Small Scale Generation Programme (RPSSGP)", which aims to promote the development of rooftop and ground-mounted solar installations. In 2014, the Indian government revised the Solar Mission with the ambitious target of achieving 100 GW of installed solar power capacity by 2022. To realize this ambitious goal, the government implemented various policies to encourage the adoption of solar energy [22].

B. Electricity Act, 2003

The law sets up a framework to encourage the comprehensive growth of India's energy industry, incorporating provisions for preferential tariffs and quotas designed to incentivize the uptake of renewable energy sources. It also mandates the procurement of renewable energy by distribution licensees and includes measures to streamline grid connectivity [23].

C. National Electricity Policy, 2005

The policy facilitates the application of preferential tariffs for electricity produced from renewable sources. Its aim is to guarantee widespread access to electricity and raise the minimum per capita availability to one thousand kWh per year by 2012 [24].

D. Tariff Policy, 2006

The "Renewable Purchase Obligation (RPO)" mechanism requires states to acquire a specified minimum percentage of their electricity consumption from renewable sources. Furthermore, it incorporates provisions for providing a distinct tariff for solar power, alongside other renewable energy sources [25].

E. Integrated Energy Policy, 2006

This comprehensive policy emphasized a dedicated emphasis on the growth of renewable energy and set forth precise targets for expanding capacity [26].

F. National Action Plan on Climate Change (NAPCC), 2008

Under the "National Action Plan on Climate Change (NAPCC)", the Indian government initiated mission-driven action plans for sustainable development to tackle climate change. Initially, the emphasis was on bolstering the development of solar energy. This initiative not only introduced the RPO set at 5% of the total grid purchase but also mandated an annual increase of 1% in RPO requirements over a decade [27].

G. Generation Based Incentives (GBIs) for Solar

The implementation of the "Generation-Based Incentive (GBI)" was intended to provide assistance to small grid solar projects with a capacity below 33 kW. GBIs function to reduce the disparity between a base tariff of INR 5.5 and the tariff established by the "Central Electricity Regulatory Commission (CERC)", serving as a financial incentive [28].

H. Jawaharlal Nehru National Solar Mission (JNNSM), 2010

Referred to as the "National Solar Mission, JNNSM" is one of the eight pivotal national missions outlined in India's NAPCC. The mission targets the attainment of 20,000 MW of grid-connected and off-grid solar power capacity by 2022, with an allocation of 2000 MW specifically designated for off-grid capacity [26].

I. Renewable Energy Certificates (RECs), 2011

"Renewable Energy Certificates (RECs)" introduce a market-oriented strategy to enhance renewable energy capacity. They tackle the disparities in renewable electricity generation across different regions and fulfill the obligation of entities to meet their RPOs by providing separate rates for solar and non-solar sources [29].

J. Energy Cess, 2010

The introduction of the "Clean Energy Cess" enforced a levy of INR 50 per ton of coal consumed domestically. This levy facilitated the creation of the "National Clean Energy Fund (NCEF)", designed to finance clean energy endeavors. Administered by the "Indian Renewable Energy Development Agency (IREDA)", the NCEF provides financial assistance of up to forty percent of the total expenses for renewable energy projects. Presently, the cess has increased to INR 400 for every ton of coal used [30].

K. Sustainable Rooftop Implementation for Solar Transfiguration of India (SRISTI) Scheme 2017

Through this driver, substantial monetary aid will be provided to domestic sectors, with an emphasis on augmented participation of DISCOMs. Subsidies of up to 40% will be available for the setup of rooftop solar systems ranging from 3.0 kW to 10.0 kW. DISCOMs will be eligible for performance-based incentives determined by the total installed capacity exceeding the base capacity achieved within the fiscal year [31].

L. Pradhan Mantri Sahaj Bijli har Ghar (PM-SAUBHAGVA) Yojna 2017

Under this program, authorities are advocating for the electrification of all appropriate homes in both countryside and metropolitan areas through the utilization of solar energy. This initiative was launched by the government of the state of Manipur [32].

M. KisanUrja Suraksha Evam Utthaan Mahabhiyan (KUSUM) Yojna 2018

The aim of this initiative is to offer financial aid and ensure water stability to agriculturalists. It comprises the installation of solar pumps, converting conventional electricity based pumps to solar power, and setting up grid-connected renewable energy plants. Government departments are overseeing the implementation of this program. Farmers can utilize the generated energy for irrigation purposes, with any excess energy being sellable to DISCOM [33].

N. One Sun One World One Grid' (OSOWOG) Plan 2020

Recently, the Indian government introduced the concept of "One Sun One World One Grid' (OSOWOG)" with the aim of supplying solar energy across international borders [34]. The fundamental visualization overdue this concept is that the sun remains consistently available across all geographical locations worldwide at any given time. Through this enterprise, the government aims to collaborate with more than 140 nations spanning from the Far East to the Far West nations to foster agreement, pledge energy strategy requirements, and lay the groundwork for such worldwide collaboration. This initiative seeks to drive the establishment of a sustainable system of combined clean energy services that can be flawlessly substituted for joint advantage and worldwide sustainability.

O. Integrated Solar Energy Policy 2023

Increased Targets for Renewable Energy: India has been ambitious in its renewable energy targets, aiming to reach 500 GW of renewable energy capacity by 2030. Solar energy, being a major component of this goal, has seen substantial support and expansion. Production-Linked Incentive (PLI) Scheme: The government has promoted the manufacturing of solar PV cells and modules within the country through the Production-Linked Incentive Scheme. This policy aims to not only boost domestic production but also reduce dependency on solar imports, particularly from countries like China. Basic Customs Duty (BCD): In April 2021, India announced the implementation of a Basic Customs Duty on imported solar cells and modules, which came into effect in April 2022. The duty aims to encourage local manufacturing and protect domestic enterprises from cheap imports. Solar Parks and Ultra Mega Solar Power Projects: The development of large-scale solar parks has been a cornerstone of India's strategy to increase solar capacity. These parks benefit from economies of scale and streamlined processes for installation and grid connection. Rooftop Solar Incentives: Policies and subsidies for rooftop solar installations in residential, commercial, and industrial sectors have been enhanced. This includes net metering policies which allow consumers to sell excess power back to the grid.

Focus on Solar in Agricultural Sector: Programs like the PM-KUSUM scheme aim to support the installation of solar pumps and other solar power-based agricultural tools, which help reduce the dependency of farmers on diesel and electric grids. Renewable Purchase Obligations (RPOs): Renewable Purchase Obligations have been enforced more rigorously to ensure that a certain percentage of electricity generated by utilities comes from renewable

sources, with specific carve-outs for solar energy. International Solar Alliance (ISA): Headquartered in India, the ISA continues to play a vital role in global solar policy advocacy and project implementation, promoting solar technology in over 120 countries [35].

V. CHALLENGES, POLICY IMPLICATIONS AND RECOMMENDATIONS

The solar industry faces several challenges, including financial barriers, a shortage of skilled personnel, and skepticism about the feasibility of these systems. Another drawback is the limited availability of electricity during daylight hours [36]. Therefore, it's crucial to implement corrective measures to incentivize the adoption of solar energy. This section provides a concise overview of the primary challenges that need to be tackled to achieve the objectives of capacity expansion. These obstacles can be categorized as technological, economic, environmental, social, policy and auxiliary barriers.

Solar power production fluctuates due to weather and daylight variations. Despite significant technological advancements in solar photovoltaic technology, it has not yet reached a level of performance deemed adequate [37]. Research indicates that, due to a multitude of variables [38], the outlay needed for PV connections is generally minimal in evolving nations. An examination of the cost-effectiveness of solar PV pricing in impoverished nations conclude that while low-cost PV installations are feasible, they necessitate meeting a variety of criteria, including high capacity factors, affordable auxiliary equipment, low-risk investments, and more [39]. Photovoltaic (PV) technology has a notable environmental footprint [40]. Ensuring that solar development is environmentally sustainable is crucial. Policies should encourage responsible land use, wildlife protection, and proper disposal of solar components at the end of their life cycle. The complete utilization of the benefits provided by solar PV equipment has yet to be achieved primarily because there is insufficient public awareness regarding the technology. This presents a hurdle to the progress of solar PV systems, particularly in developing countries. [41]. Insufficient understanding of the technology has proven to be a hindrance in local customers considering solar PV as a viable option. Moreover, there is also a concern about the limited availability of land, as significant amounts of land are required for building large-scale solar PV power plants.

Policies should encourage equitable market practices and eliminate obstacles for new entrants in the solar industry. Solar energy transcends borders, making it a global effort. Research identifies various additional challenges in the advancement of solar PV systems within the nation. While these challenges might appear insignificant, their repercussions can be far-reaching. Issues such as dust accumulation and insufficient cleaning of solar panels frequently lead to decreased panel efficiency by obstructing incoming sunlight (insolation) from the sun. Furthermore, uncertainties and the absence of accurate weather data can result in incorrect system designs tailored to specific loads. This could ultimately curtail the system's longevity, yielding diminished or non-existent returns on investment for the developer. Figure 2 below depicts the hurdles obstructing solar energy development.

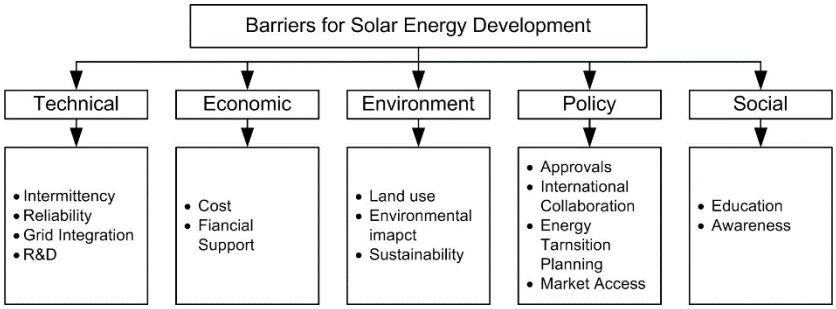

Fig. 2 Barriers for Solar Energy Development

VI. RECOMMENDATIONS FOR SOLAR POWER DEVELOPMENT

To overcome the challenges and promote the development of solar power, several recommendations ware proposed by many stakeholders of the solar energy. These recommendations encompass many sub areas for solar power development such as technical, economic, environmental, regulator and social. Some of the major recommendations based on the above literature review findings are

- Governments should dedicate funding to research and development initiatives aimed at enhancing the efficiency of solar panels, advancing energy storage technologies, and optimizing grid integration. They should also promote cooperation and partnerships between government agencies, research institutions, and private sector firms.

- Enhance and modernize the energy grid to adapt to the fluctuations in solar power generation. Invest in smart grid solutions, energy storage systems, and advanced prediction methods to enhance the dependability and stability of the grid.

- Encourage the adoption of energy storage solutions like batteries to store surplus solar energy for utilization during periods of limited sunlight. Promote research and development in energy storage technologies to lower expenses and enhance effectiveness.

- Offer economic incentives like tax incentives, refunds, financial aid, and low-interest loans to increase the affordability of solar installations for individuals, enterprises, and utility companies.

- Streamline and accelerate the authorization and approval procedures for solar initiatives to diminish administrative obstacles and speed up the process. Set up unambiguous directives and criteria to guarantee efficient project advancement.

- Sustain stable and unwavering policies to create a foreseeable environment for solar investors. Prevent sudden policy alterations that could disrupt the sector and diminish investor trust.

- Promote equitable market practices and competitiveness within the solar sector. Eliminate obstacles to entering the market and back small-scale and local solar enterprises. Advocate for inventive business approaches like community solar initiatives.

- Create all-encompassing energy transition strategies that include distinct objectives, schedules, and significant achievements for shifting from fossil fuels to renewable energy sources, encompassing solar energy.

- Engage in partnerships with other nations for research and development efforts in renewable energy, exchange of technology, and investments. Join international initiatives and accords to propel global progress in solar power.

- Support developing countries in constructing their solar energy infrastructure by offering technical know-how, financial assistance, and programs to enhance their capabilities. Promote the transfer of technology and the exchange of knowledge.

- Promote stronger cooperation between government entities and private enterprises to tackle technological and regulatory issues. Involve stakeholders in the creation and execution of policies.

- Create innovation centres or hubs dedicated to advancing solar technology, bringing together researchers, entrepreneurs, and industry professionals to collaborate and drive innovation.

- Introduce energy-saving measures alongside the expansion of solar power to lower the overall energy requirements, simplifying the fulfilment of energy demands with renewable sources.

- Enforce rules and ecological protections to handle land utilization and ecological consequences linked to extensive solar initiatives. Advocate for conscientious land planning and measures to safeguard wildlife.

- Initiate campaigns and educational programs for the public to raise awareness about the advantages of solar power. Disseminate information about accessible incentives, financial choices, and the environmental benefits associated with solar energy.

- Despite these proactive steps, India faces challenges such as land acquisition difficulties, financial constraints of state discoms, and the need for technological upgrades in grid infrastructure to handle large-scale integration of renewable energy. Overall, India's approach in 2023 reflected a comprehensive and supportive stance towards solar energy, emphasizing both the expansion of capacity and the establishment of a robust domestic industry, aligning with global trends towards sustainability and energy security.

VII. CONCLUSIONS

Solar photovoltaic energy systems have garnered worldwide interest due to their efficient performance and minimal environmental impact. They have demonstrated great potential in advancing Sustainable Development Goal 7 (SDG7). Consequently, nations have formulated strategies and incentives to bolster their solar energy capacity. Nevertheless, numerous countries must further bolster their energy production using environmentally friendly technologies. As a result, this paper extensively examines the current trends in global electricity consumption and generation. We thoroughly examined the significance of renewable energy, particularly solar photovoltaic power. The investigation determined that, in accordance with the continually expanding electricity demands that significantly affect the environment, solar photovoltaic energy emerges as a promising solution. It not only addresses the electricity requirements but also helps mitigate adverse environmental consequences. We also provided an in-depth analysis of the policies and incentives implemented by the top 10 solar photovoltaic producing countries. This analysis offers insights into the achievements of countries that are at the forefront of solar photovoltaic adoption and can serve as guiding examples for numerous developing nations. Additionally, this examination can serve as a foundation for devising innovative incentive approaches by assessing future policies and incentives for solar photovoltaic systems. If these same policies and incentives are proven effective, they can potentially be extended to other renewable energy sources and microgrid systems. The ongoing essential dilemma involving energy, the economy, and the environment remains prevalent. A trade-off becomes necessary among these factors to effectively advance and sustain solar photovoltaic initiatives while adhering to constraints. Within this context, we've outlined the challenges encountered by solar photovoltaic projects that impact their development, along with recommendations for enhancing their prospects.

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