International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Comparative Assessment of Solar Power Capacity and Policy Framework in India and China

Laxmi Saini[1], R.N. Sharma[2]

[1]Research Scholar, Department of Geography, University of Rajasthan, Jaipur
[2]Professor, Department of Geography, University of Rajasthan, Jaipur

Abstract
Solar photovoltaic technology represents the fastest-growing contributor to global renewable energy transitions, with dramatic cost reductions transforming solar electricity into a competitive alternative to fossil fuels, compelling emerging economies to accelerate deployment. This paper presents a comprehensive comparative analysis of solar energy development trajectories in India and China during 2015-2024, examining capacity growth patterns, policy frameworks, and their effectiveness in driving renewable energy transitions. China has established unprecedented global dominance in solar energy deployment, with installed capacity reaching approximately 887 GW by 2024—a remarkable 1940% increase from 2015 levels. Meanwhile, India has emerged as the world's leading renewable energy producer, expanding its solar capacity from 3.99 GW in 2015 to 81.81GW by 2024. The study employs time-series analysis, compound annual growth rate (CAGR) calculations, and thematic policy analysis to compare the divergent development models of both nations.

China's state-led manufacturing and deployment strategy emphasizes comprehensive government intervention, vertical integration of the solar supply chain, and control over 80% of global solar manufacturing capacity. In contrast, India's market-based approach leverages competitive bidding, private investment, and targeted incentives such as the Production Linked Incentive (PLI) scheme to drive development while managing fiscal constraints. Both nations demonstrate adaptive policy evolution, transitioning from initial mechanisms toward sophisticated market-based approaches. The fundamental drivers of rapid growth include dramatic cost reductions in solar photovoltaic technology, advances in manufacturing capacity, improved grid infrastructure, institutional capacity development, and abundant capital availability.

The paper concludes that while China's absolute capacity far exceeds India's, both nations have achieved remarkable growth through complementary policy approaches suited to their respective institutional contexts. These experiences provide critical policy lessons for other emerging economies pursuing large-scale renewable energy transitions to achieve climate targets and sustainable development objectives.

Keywords- Solar Energy, Installed Capacity, Policy, Compound Annual Growth Rate.

1. Introduction

Solar energy represents the radiant energy emitted by the Sun, which can be directly converted into electrical energy or heat through various technological means. Solar photovoltaic (PV) technology specifically deals with the conversion of incident sunlight energy into electrical energy through semiconductor devices known as solar cells (Shaikh et al., 2025) [1].

Solar energy can be classified into two primary categories: solar thermal energy, which captures heat directly from the Sun for heating purposes, and solar photovoltaic energy, which converts sunlight directly into electricity (Steinfeld, 2011) [2]. Photovoltaic systems can be further differentiated into different generations of technology, ranging from first-generation crystalline silicon cells to advanced third-generation technologies including perovskite and organic solar cells (De et al., 2023) [3]. The development of renewable energy sources, including solar technology, has been driven by increasing energy demands and the necessity to find alternatives to declining fossil fuel reserves (Hepbasli & Zgener, 2004) [4]. Throughout the latter half of the twentieth century, various renewable energy technologies underwent systematic investigation, with solar energy emerging as one of the most promising options due to its abundance and accessibility (Turduev et al., 2025) [5].

The global energy landscape has undergone significant transformation in recent years, with renewable energy sources, particularly solar energy, playing an increasingly prominent role. As of recent reports, solar energy represents the largest contributor to global renewable energy capacity, accounting for 36.67% of the world's total installed renewable energy capacity (Saeed & Siraj, 2024) [6].The paradigm for global energy systems has fundamentally shifted from non-renewable sources to renewable energy sources (RES) over the past several years, driven by the necessity to reduce carbon emissions and achieve environmental sustainability (Shaikh et al., 2025) [7].The acceleration in solar energy adoption has been facilitated by technological innovations, declining costs, improved grid integration mechanisms, and supportive policy frameworks implemented by various governments worldwide (Fell et al., 2015) [8].

Two of the world's most populous nations and leading emerging economies, China and India, have positioned themselves at the forefront of this solar energy revolution. Together, these nations account for a substantial portion of global solar capacity additions and manufacturing, making a comparative analysis of their solar energy development trajectories crucial for understanding global renewable energy trends and policy effectiveness (Jamro,2025) [9]. (Singh, 2022) [10].

China has established itself as the global leader in solar energy deployment, commanding over 80% of global solar manufacturing capacity and demonstrating unprecedented capacity additions in recent years (Chourasiya & Sharma, 2025) [11] (Han et al., 2023) [12]. As of 2024, China's installed solar capacity reached approximately 887 GW, representing a remarkable 1940% increase from 2015 levels. Conversely, India, despite starting from a much smaller base, has emerged as the world's fourth-largest renewable energy producer and is actively pursuing ambitious solar energy targets aligned with its climate commitments (Mishra et al., 2026) [13]. By September 2025, India's total installed electricity generation capacity crossed 500 GW, reaching 500.89 GW, reflecting sustained policy support and investment in the power sector. Non-fossil fuel sources, including renewable energy, hydro, and nuclear power, accounted for 256.09 GW (over 51%) of total capacity, surpassing fossil-fuel-based sources at 244.80 GW (about 49%). [14].

The divergent trajectories of India and China in solar energy development reflect not only differences in resource availability and economic capacity but also fundamental variations in policy frameworks, governance structures, technological strategies, and investment mechanisms. Understanding these differences is essential for policymakers, investors, and researchers seeking to optimize renewable energy transitions in developing economies. This paper provides a comprehensive comparative assessment of solar power capacity and policy frameworks in India and China during 2015-2024, examining how different policy approaches have shaped their respective renewable energy landscapes.

2. Objectives of the Study

- To examine the growth and development of solar energy in India and China during 2015-2024, analysing capacity expansion patterns and regional variations
- To analyse the policies implemented for solar energy development in India and China and conduct a comparative evaluation of their effectiveness.
- To identify the key factors responsible for technological advancement and rapid growth of solar energy in both nations
- To provide policy recommendations for optimizing solar energy deployment in emerging economies

3. Methodology

This study utilizes a comparative and descriptive research design based on secondary data analysis. The methodology focuses on evaluating the solar energy trajectories of India and China through the following framework:

Data Sources:

- IRENA Renewable Capacity Statistics 2025: For global capacity rankings and year-over-year growth data (2015-2024)
- India Renewable Energy Statistics 2024-25: From the Ministry of New and Renewable Energy (MNRE) for domestic targets and installation trends
- Academic literature and policy papers from peer-reviewed journals

Data Analysis Methods:

- Graphical represent to compare growth trajectories between the two nations
- Compound Annual Growth Rate (CAGR) calculations for different phases of development
- Thematic Analysis was used to compare policy drivers, such as China's manufacturing subsidies versus India's Production Linked Incentive (PLI) schemes
- Comparative policy framework analysis examining regulatory mechanisms, financing instruments, and technological strategies

4. Solar Energy Development in India (2015-2024)

India's solar energy sector has experienced remarkable growth over the past decade, transforming from a nascent industry to a cornerstone of the nation's renewable energy strategy (Sahdev et al., 2025) [15]. The annual growth of installed solar power capacity in India from 2015 to 2024 demonstrates the solar energy sector's rapid and continued expansion. Between 2015 and 2024, installed capacity rose dramatically from 3.99 GW to 81.81GW, indicating a significant shift toward renewable energy sources and a remarkable transformation in India's power generation structure [16].

4.1 Phase 1: Initial Implementation (2015-2017)

During the initial phase (2015-2017), solar capacity rose from 3.99 GW to 12.78 GW, reflecting the early implementation stage of national solar policies. This period was characterized by policy consolidation under the Jawaharlal Nehru National Solar Mission (JNNSM), improvement in regulatory mechanisms, and the gradual adoption of grid-connected solar projects, which laid the foundation for large-scale development. The Government of India, through MNRE and NITI AAYOG, established a systematic framework to promote solar energy deployment across the nation, leveraging both centralized solar parks and decentralized rooftop installations.

This foundational period witnessed critical institutional developments that would prove essential for subsequent growth. The establishment of state-level renewable energy agencies, development of transmission infrastructure, and formulation of renewable purchase obligations (RPOs) created a conducive environment for private sector participation. Solar tariffs declined significantly during this phase, with competitive bidding mechanisms emerging as the primary procurement tool (Kumar & Verma, 2025) [14].

4.2 Phase 2: Consolidation and Acceleration (2018-2020)

The intermediate phase (2018-2020) witnessed accelerated growth, with capacity increasing from 22.35 GW in 2018 to 35.6 GW in 2020. This growth was driven by declining photovoltaic module costs, competitive tariff-based bidding, and the establishment of large solar parks in high-potential states such as Rajasthan, Gujarat, and Karnataka [16].

During this phase, India witnessed significant technological advancement in solar PV systems, with capacity factors exceeding 20% in favourable regions. The standardization of solar equipment, improvements in inverter technology, and integration of battery storage systems enhanced the reliability and efficiency of solar installations.

4.3 Phase 3: Rapid Expansion and Maturity (2021-2024)

A significant surge is observed in the post-2020 period, particularly between 2021 and 2024, when installed capacity expanded from 41.24 GW to 81.81 GW. Between 2024 and 2025, India's solar installed capacity increased from 81.81 GW to 105.65 GW with an annual growth rate of approximately 29%. The strong 29% growth in solar installed capacity during 2024-2025 significantly strengthens India's pathway toward achieving its ambitious target of 500 GW of non-fossil fuel-based renewable energy capacity by 2030, as solar power continues to remain the largest and fastest-growing contributor to the renewable energy mix [16].

This phase reflects the maturity of India's solar sector, supported by enhanced transmission infrastructure, domestic manufacturing initiatives under the Production Linked Incentive (PLI) scheme, and increased private and foreign investment. The PLI scheme, launched in 2021, has been instrumental in attracting manufacturers and reducing India's import dependence for solar components. The rapid rise after 2022 also corresponds with India's strengthened climate commitments and targets for achieving net-zero emissions by 2070 (Singh, 2022) [10].

Policy innovations during this phase include the PM-KUSUM scheme, which targets solar deployment in agricultural sectors, rooftop solar subsidies, and enhanced renewable purchase obligations. These multi-faceted approaches have ensured that solar energy penetrates diverse market segments, from utility-scale projects to distributed generation systems (Sahdev et al., 2025) [15] (Mishra et al., 2026) [13].

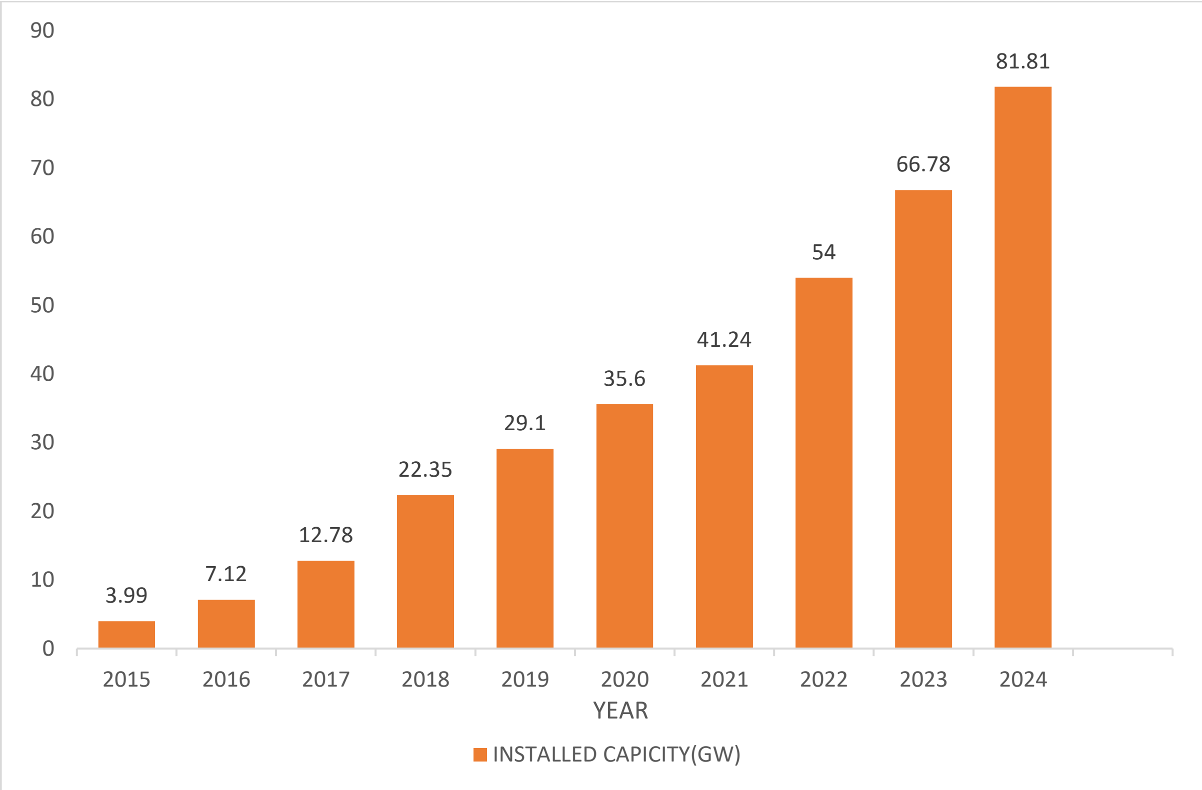

Figure 1 - Solar Energy Cumulative Installed Capacity in India

Source- Renewable Energy Statistics 2024-25

5. Solar Energy Development in China (2015-2024)

China has established unprecedented global dominance in solar energy deployment and manufacturing, reflecting decades of strategic investments and systematic policy support. The remarkable growth of solar energy installed capacity in China from 2015 to 2024 highlights China's dominant position in the global solar energy landscape [17].

5.1 Phase 1: Rapid Scaling and Manufacturing Leadership (2015-2017)

During the initial phase (2015-2017), China's solar capacity increased from 43 GW to 130 GW, reflecting strong government support through feed-in tariffs, large-scale utility projects, and rapid expansion of domestic photovoltaic manufacturing. According to the International Renewable Energy Agency (IRENA), this period laid the foundation for China's leadership in both solar power generation and solar technology production. The Chinese government implemented comprehensive support mechanisms including capital subsidies, tax incentives, and strategic investments in manufacturing infrastructure, enabling rapid capacity additions [18].

China's approach during this phase emphasized vertical integration in the solar supply chain, from polysilicon production to module manufacturing and project development. State-owned enterprises played a leading role in deploying large-scale solar farms, while private companies were incentivized to develop manufacturing capabilities. This coordinated approach between government and industry created economies of scale that reduced production costs dramatically (Chen et al., 2024) [19].

5.2 Phase 2: Policy Adjustment and Efficiency Focus (2018-2020)

The intermediate phase (2018-2020) shows continued but relatively moderate growth, with installed capacity rising from 175 GW in 2018 to 253 GW in 2020. This phase corresponds with policy adjustments aimed at improving grid parity, reducing subsidy dependence, and enhancing system efficiency, while maintaining steady expansion. The Chinese government shifted from fixed feed-in tariffs to market-based auction mechanisms, aligning renewable energy policy with broader economic efficiency objectives. This transition, while temporarily moderating growth rates, improved the long-term sustainability of the sector (Auffhammer et al., 2021) [20].

During this consolidation phase, China invested heavily in grid infrastructure modernization, smart grid technologies, and energy storage solutions to address the intermittent nature of solar power. Research and development investments in perovskite solar cells, tandem solar cells, and next-generation photovoltaic technologies positioned China as a leader in innovation (Sun, 2024) [21].

5.3 Phase 3: Unprecedented Acceleration and Dominance (2021-2024)

A dramatic acceleration is evident after 2020, particularly between 2021 and 2024, when installed capacity surged from 306 GW to approximately 887 GW. Between 2022 and 2023, China's solar installed capacity recorded an exceptional annual addition of 216 GW, reflecting unprecedented large-scale solar deployment. This momentum further intensified during 2023-2024, when capacity expanded by 278 GW in a single year, corresponding to a robust annual growth rate of approximately 45%, highlighting China's accelerated progress toward renewable energy expansion and carbon neutrality goals [17].

This rapid increase reflects China's intensified efforts to meet its carbon neutrality goals, large-scale deployment of desert-based solar mega-projects and integration of solar energy into national energy planning (Liao et al., 2025) [22]. The scale and pace of growth underscore China's global leadership in solar energy and provide an important comparative benchmark for other emerging economies pursuing large-scale renewable energy transitions (Peter et al., 2024) [23].

The acceleration during 2021-2024 was facilitated by continued government policy support, rapid cost reductions in manufacturing, and integration of solar with complementary technologies. China's capacity utilization rates for solar plants exceeded 15-17% in many regions, demonstrating effective grid integration despite the intermittent nature of solar generation (Xu & Wang, 2025) [24].

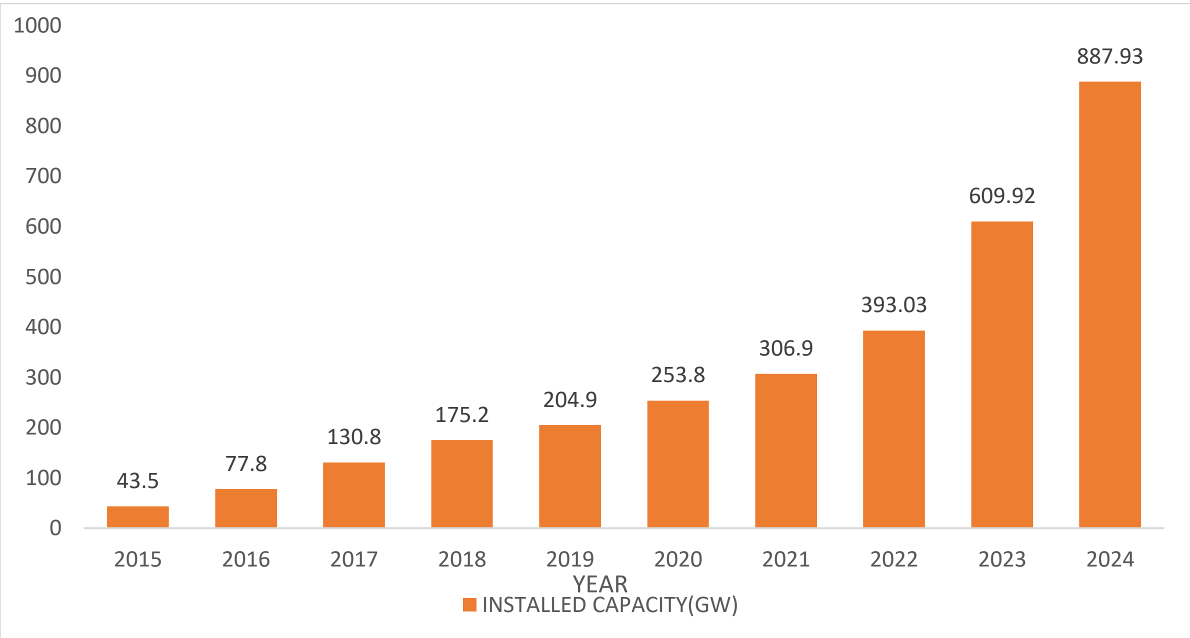

Figure 2 - Solar Energy Installed Capacity in China

Source- IRENA Renewable Energy Statistics 2025

6. Comparative Analysis of Solar Development Trajectories

6.1 Capacity Growth Comparison (2015-2017)

The comparative assessment of solar energy development in India and China over the period 2015-2024 reveals significant differences in scale, pace, and strategic approaches, despite both nations experiencing rapid growth. During the initial phase (2015-17), both countries witnessed rapid percentage growth, although from very different base levels. China's solar installed capacity increased from 43.5 GW to 130.8 GW in 2015-2017, marking China's emergence as a global leader in solar energy deployment. In contrast, India's capacity rose from 5.6 GW to 18.2 GW during the same period[17].

While the absolute scale remained modest compared to China, India's growth rate was significant, representing a compound annual growth rate (CAGR) of approximately 73% during the initial phase. This phase represents a foundation-building stage for India and a rapid scaling stage for China, with China's CAGR reaching approximately 80% during the same period.

6.2 Consolidation and Structural Maturation (2018-2020)

The intermediate phase (2018-2020) is characterized by consolidation and relatively stable expansion in both countries. China's solar capacity grew from 175.2 GW to 253.8 GW in 2018-2020, indicating a moderated growth pace as China maintained steady capacity additions. Similarly, India's solar capacity increased from 27.4 GW to 39.7 GW between 2018 to 2020. This phase reflects a transition from rapid expansion to system consolidation in both countries, with both nations focusing on improving grid integration, enhancing transmission infrastructure, and addressing intermittency challenges [17].

The moderation in growth rates, particularly evident in China, was driven by transitional policy changes from fixed feed-in tariffs to competitive auction mechanisms. India, conversely, strengthened its competitive bidding framework while introducing complementary support mechanisms like rooftop solar subsidies and renewable purchase obligations (Author, 2025) [25].

6.3 Post-2020 Acceleration and Diverging Trajectories

The post-2020 phase marks a decisive acceleration, particularly in China. China's installed solar capacity surged from 306.9 GW in 2021 to 887.9 GW by 2024. The exceptionally high annual additions during 2022-2023 and 2023-2024 underscore China's aggressive push toward carbon neutrality and renewable dominance. India also experienced accelerated growth after 2020, with capacity expanding from 49.9 GW to 97.3 GW in 2021-2024[17].

This phase reflects improved policy coherence, enhanced transmission infrastructure, and growing emphasis on achieving the national target of 500 GW of non-fossil fuel capacity by 2030. Although the absolute scale remains much smaller than China's, India's post-2020 growth highlights increasing momentum and structural maturity of its solar sector.

The divergence in growth rates during this phase is particularly striking: China achieved a CAGR of approximately 42% during 2021-2024, while India achieved approximately 25% during the same period. By 2024, China's installed solar capacity was approximately 9.15 times larger than India's, up from a ratio of 8.09 in 2015, demonstrating both absolute growth in both nations and relative acceleration of China's dominance [17].

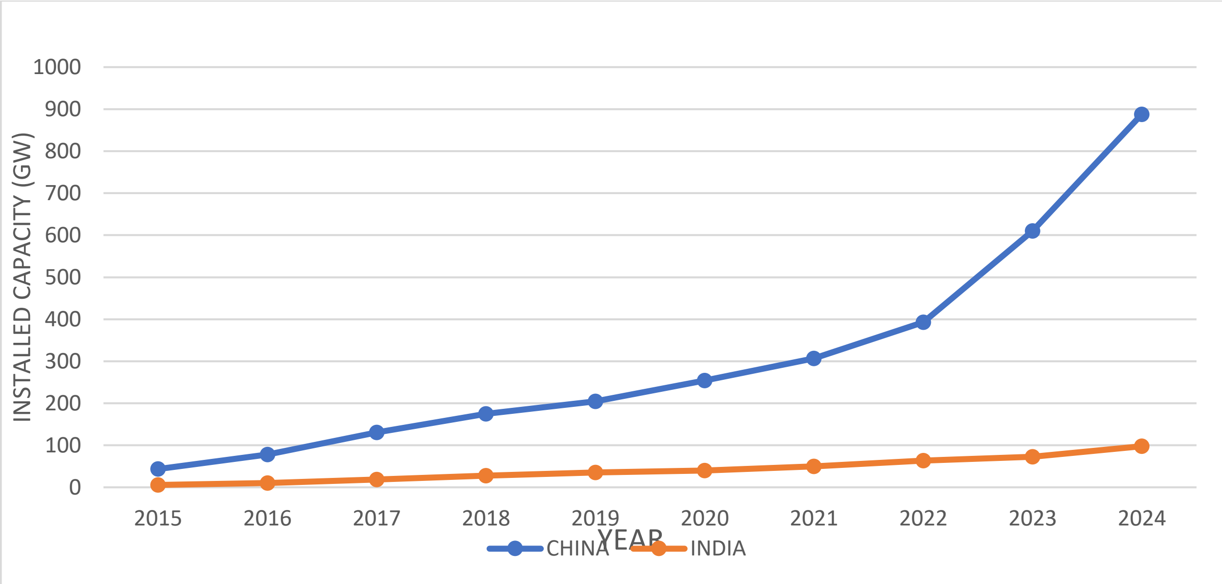

Figure 3 - Solar Energy Development in India and China
Source- IRENA Renewable Energy Statistics 2025

Table 1 Compound Annual Growth Rate % (CAGR) China vs India

Phase	Period	China (GW)	India (GW)	CAGR Growth China	CAGR Growth India
Initial	2015-2017	43.5→130.8	5.6→18.2	73.4%	80.3%
Consolidation	2018-2020	175.2→253.8	27.4→39.7	20.4%	20.4%
acceleration	2021-2024	306.9→887.9	49.9→97.3	42.5%	24.9%
Overall	2015-2024	43.5→887.9	5.6→97.3	39.9%	37.3%

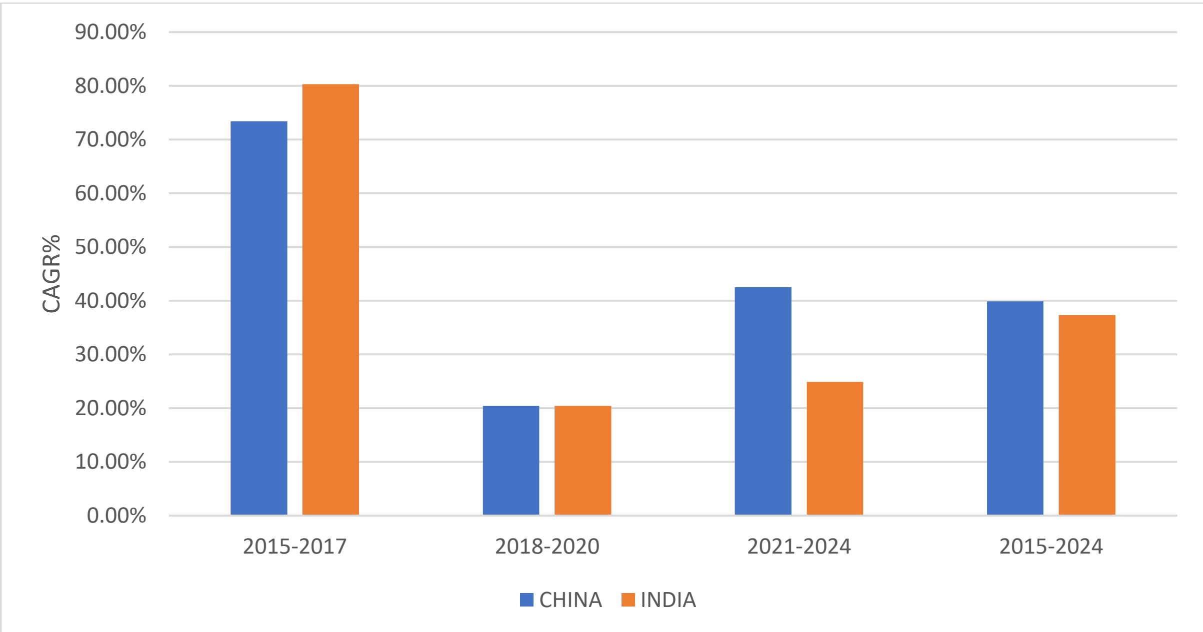

Figure 4 Compound Annual Growth Rate (CAGR)% China Vs India

7. Policy Framework Comparison

7.1 China's Policy Framework: State-Led Manufacturing and Deployment Strategy

China's approach to solar energy development is characterized by comprehensive state intervention, emphasis on domestic manufacturing, and integration of solar energy into broader economic and geopolitical strategies. The Renewable Energy Law (2006, revised 2009) established the foundational legal framework, mandating renewable energy targets and establishing renewable energy zones (Wu, 2024) [26].

Feed-in Tariff System (2011-2020): China implemented a structured feed-in tariff system that provided fixed payments for solar electricity generation, varying by region based on solar resource quality. This mechanism successfully incentivized rapid deployment and enabled developers to achieve financial viability (Xu & Wang, 2025) [27]. However, the system accumulated substantial government subsidy debt, with estimated liabilities exceeding 100 billion yuan by 2018, and resulted in high curtailment rates as grid infrastructure lagged behind capacity additions (Auffhammer et al., 2021) [20].

Five-Year Plans and Target Setting: Chinese solar development is embedded within Five-Year Plans established by the National Development and Reform Commission (NDRC), which set specific capacity targets, manufacturing goals, and policy adjustments. These plans provide long-term policy certainty and enable strategic coordination across provincial governments and state enterprises [18].

Manufacturing Strategy and Global Supply Chain Dominance: A distinctive feature of China's policy framework is the deliberate cultivation of domestic manufacturing capacity through capital subsidies, tariff protection, and strategic investment guidance. State support for polysilicon production, wafer manufacturing, cell production, and module assembly transformed China into the world's leading solar equipment manufacturer, controlling over 80% of global manufacturing capacity (Chourasiya & Sharma, 2025) [11].This vertical integration has provided China with competitive advantages in cost reduction and supply chain resilience.

Shift to Market-Based Mechanisms (Post-2020): Recognizing the fiscal burden of feed-in tariffs and the need for greater economic efficiency, China transitioned toward competitive auction mechanisms beginning in 2018. These auctions set renewable energy deployment targets and allow developers to compete on price, significantly reducing the cost of solar electricity and improving economic efficiency (Zhang et al., 2023) [28]. By 2020, auction-determined prices had fallen to 0.35-0.40 yuan/kWh, making solar competitive with coal-fired generation in many regions.

Climate Targets and Net-Zero Ambitions: China's pledge to reach peak carbon emissions by 2030 and attain carbon neutrality by 2060 acts as a strong long-term policy foundation supporting ongoing solar energy expansion. The incorporation of renewable energy within the country's wider low-carbon development strategy ensures continuous political support for solar power growth, even during periods of economic uncertainty.

Belt and Road Initiative Integration: China has leveraged solar energy development as a component of its Belt and Road Initiative (BRI), financing solar projects across Asia, Africa, and Latin America. This strategy simultaneously advances China's geopolitical interests while creating export markets for Chinese solar equipment (Jamro, 2025) [9].

7.2 India's Policy Framework: Market-Based Development with Strategic Incentives

India's approach to solar energy development emphasizes market mechanisms, competitive procurement, and targeted interventions to address market failures. Unlike China's comprehensive state control, India's framework relies on a mix of government directives and private sector participation (Author, 2025) [25].

Jawaharlal Nehru National Solar Mission (JNNSM): Launched in 2010, the JNNSM established India's foundational solar energy strategy with an initial target of 22 GW by 2022. The mission evolved through multiple phases, progressively increasing targets and refining implementation mechanisms. By providing policy certainty and institutional support, the JNNSM created confidence among developers and financiers (Sharma et al., 2015) [29].

Renewable Purchase Obligations (RPO): India mandates that electricity distribution companies procure specified percentages of electricity from renewable sources, creating a demand mechanism for renewable energy. This obligation-based approach contrasts with China's production-based system and transfers some demand risk to utilities. However, enforcement challenges and inadequate compliance have limited RPO effectiveness in some states (Pachauri et.al, 2022) [30].

Competitive Bidding and Auction Framework: India pioneered competitive auction mechanisms for renewable energy procurement, allowing developers to bid for projects based on price and technical specifications. Competitive auctions in India have driven down solar LCOE to levels among the lowest globally, improving the cost-effectiveness of solar deployment. This market-driven approach has attracted international investors and demonstrated the potential for competitive procurement in emerging markets.

Production Linked Incentive (PLI) Scheme (2021): Acknowledging India's reliance on imported solar equipment and the need to strengthen domestic manufacturing capacity, the government introduced the Production Linked Incentive (PLI) scheme in 2021. In contrast to China's broad and long-term subsidy framework, India's PLI scheme offers incentives for a fixed period based on production output and export achievements, thereby promoting manufacturing growth while controlling prolonged fiscal burden. The scheme has attracted significant private investment in solar cell and module manufacturing, leading several major firms to set up new production units. (Wandhe, 2024) [31].

Rooftop Solar Subsidies and Decentralized Schemes: India has implemented programs like the Pradhan Mantri Surya Ghar Muft Bijli Yojana to promote rooftop solar installations among residential and commercial consumers, complementing large-scale utility projects. These decentralized schemes have engaged diverse stakeholders and created opportunities for smaller entrepreneurs and contractors (Mishra et al., 2026) [13].

PM-KUSUM Scheme: Recognizing the energy needs of the agricultural sector, India launched the PM-KUSUM scheme targeting solar deployment on farmland and providing income opportunities to farmers. This multifaceted approach integrates rural development with renewable energy goals (Sahdev et al., 2025) [15].

Net-Zero Commitments and Climate Targets: India's pledge to achieve net-zero emissions by 2070 and its intermediate target of 500 GW non-fossil fuel capacity by 2030 provide strategic direction for solar energy development. However, India has been more cautious in its absolute emissions reduction targets compared to China, reflecting development imperatives and energy security concerns (Singh, 2022) [10].

International Cooperation and Technology Transfer: India has prioritized international cooperation through the International Solar Alliance and bilateral agreements facilitating technology transfer and capacity building. This approach recognizes India's need for technological advancement while promoting South-South cooperation (Jamro, 2025) [9].

7.3 Comparative Policy Effectiveness

China's policy framework has proven highly effective in achieving rapid capacity deployment through state-directed investment, manufacturing support, and long-term planning. The combination of feed-in tariffs, state enterprise involvement, and coordinated industrial policy created an enabling environment for both supply-side (manufacturing) and demand-side (deployment) growth. However, this approach has incurred substantial fiscal costs and created distortions such as curtailment in high-supply regions (Auffhammer et al., 2021) [20].

India's market-based approach has achieved competitive pricing and attracted private investment more efficiently than China's capital-intensive strategy. Competitive auctions have driven costs down and improved resource allocation. However, India's approach has been less successful in developing domestic manufacturing capacity and faces ongoing implementation challenges with renewable purchase obligations. The development of manufacturing capacity remains a critical gap for India's long-term energy security and economic competitiveness.

Both countries have demonstrated adaptability in their policy frameworks, transitioning from initial mechanisms that proved economically inefficient toward more sophisticated market-based and incentive-aligned mechanisms. The post-2020 period shows convergence in policy approaches, with both nations combining auction mechanisms with targeted support for specific segments (Narassimhan,2025) [32].

8. Key Drivers of Technological Advancement and Rapid Growth

8.1 Cost Reduction and Technology Improvement

The most fundamental driver of rapid solar energy growth in both nations has been the dramatic reduction in solar photovoltaic costs. The levelized cost of electricity (LCOE) for utility-scale solar PV has declined from approximately $370 - 420/MWhin2010tounder$30-50/MWh by 2024, making solar increasingly competitive with fossil fuels (Liao et al., 2025) [22]. These cost reductions have been enabled by technological improvements including increased module efficiency, manufacturing scale, supply chain optimization, and competition among manufacturers.

In India, solar LCOE has fallen below INR 2 per kWh, making it cheaper than coal-fired generation in many regions. In China, competitive auction results have demonstrated LCOE values approaching 0.25-0.35 yuan/kWh, driving continued deployment and financial viability (Xu & Wang, 2025) [24] (Zhang et al., 2023) [28].

8.2 Manufacturing Capacity Development

China's dominance in solar manufacturing has created self-reinforcing advantages in cost reduction. With over 80% of global solar cell and module manufacturing capacity, China controls the supply chain from polysilicon through module assembly. This manufacturing dominance enables continuous cost reduction through learning-by-doing, investment in automation, and economies of scale (Chen et al., 2024) [19].

India's manufacturing base remains limited, with domestic production serving only a fraction of demand. However, the PLI scheme is catalyzing domestic manufacturing capacity development in solar cells and modules. Companies like Adani Solar and Vikram Solar are building production capacity that will reduce import dependence and create employment (Nagaraj, 2025).

8.3 Supply Chain and Logistics Infrastructure

Both nations have invested in solar infrastructure including transmission networks, distribution systems, and energy storage solutions essential for integrating variable renewable energy. China's approach emphasizes integrated planning of solar farms with transmission infrastructure development, often using ultra-high-voltage transmission lines to transmit solar power from resource-rich regions to consumption centers.

India has focused on enhancing state transmission systems and establishing renewable energy zones with pre-built infrastructure, reducing project development timelines and risks. Grid modernization initiatives in both countries, including smart grid technologies and advanced control systems, have improved the integration of variable solar resources (Mahida, 2024) [33].

8.4 Institutional Capacity and Human Resources

Both nations have developed institutional capacity for solar project development, including specialized agencies, training programs, and research institutions. India's Ministry of New and Renewable Energy (MNRE), supported by NITI Aayog, provides policy guidance and implementation support. China's National Energy Administration (NEA) coordinates renewable energy development across provinces (Mishra et al., 2026) [13].

Universities and research institutions in both countries have contributed to technological advancement and workforce development. IIT Bombay, IIT Delhi, and Tsinghua University are among leading research centers advancing solar technologies and policy research (Cagorol & Sarsale, 2025) [34].

8.5 Financing Mechanisms and Capital Availability

Abundant capital availability has facilitated rapid solar deployment in both nations. India has attracted significant foreign direct investment from companies like Adani and ReNew Power, while international investors have recognized India's large market potential. Green bonds and development finance have mobilized capital for renewable energy infrastructure.

China's state banking system has provided subsidized capital for renewable energy projects through state development banks, enabling rapid deployment despite profitability challenges. This capital access, combined with equity investments by state enterprises, has accelerated capacity growth (Korneev & Tomberg, 2025) [35].

9. Conclusions and Policy Recommendations

9.1 Key Findings

The comparative analysis of solar energy development in India and China from 2015-2024 reveals several key findings:

1. **Scale and Pace Divergence:** While both nations achieved high growth rates, China's absolute capacity far exceeds India's, reflecting differences in capital availability, manufacturing infrastructure, and implementation scale.
2. **Policy Framework Effectiveness:** China's comprehensive state-led approach achieved rapid deployment but incurred substantial fiscal costs and grid integration challenges. India's market-based approach achieved cost efficiency and attracted private investment but faced manufacturing capacity constraints and renewable purchase obligation implementation challenges.
3. **Technological and Manufacturing Advantages:** China's dominance in solar manufacturing provides cost advantages and supply chain control. India's emerging manufacturing base, while limited, represents an important strategic development facilitated by the PLI scheme.
4. **Adaptive Policy Evolution:** Both nations have demonstrated flexibility in policy adjustment, transitioning from initial mechanisms toward more sophisticated market-based approaches combining competitive auctions with targeted support mechanisms.
5. **Convergence in Strategic Approach:** Despite different governance structures, both nations increasingly employ similar policy instruments while adapting them to their respective institutional contexts and development priorities.

6. **Climate and Development Balance:** India has prioritized balancing renewable energy expansion with development objectives and poverty reduction, while China emphasizes absolute emissions reduction and technological dominance. These differing priorities reflect respective national circumstances.

9.2 Policy Recommendations for India:

1. **Accelerate Domestic Manufacturing:** Strengthen implementation of the PLI scheme to reduce import dependence and create employment. Manufacturing capacity development should be synchronized with deployment targets to ensure supply chain resilience (Nagaraj, 2025).
2. **Enhance Grid Infrastructure:** Prioritize transmission network expansion and modernization to enable integration of higher renewable penetrations. Investment in smart grid technologies, demand-side management, and energy storage should accompany capacity additions (Sun, 2024) [21].
3. **Strengthen RPO Enforcement:** Improve institutional mechanisms for monitoring renewable purchase obligation compliance and consider market-based trading of renewable energy credits to enhance RPO effectiveness while reducing compliance costs (Giri & Sharma, 2025) [36].
4. **Develop Energy Storage Solutions:** Accelerate development of battery and pumped hydro storage capacity to address intermittency challenges. Storage deployment targets should align with solar capacity additions (Elavarasan et al., 2020) [37].
5. **Regional Capacity Building:** Establish specialized institutions and training programs in solar-rich states to develop local expertise and facilitate project development (Mahipal & Kamboj, 2025) [38].

10. Future Outlook and Conclusion

The solar energy revolution in India and China represents a fundamental transformation of the global energy system. By 2030, these two nations combined are projected to have over 1,000 GW of installed solar capacity, accounting for a substantial share of global additions. This deployment will prevent hundreds of millions of tonnes of annual carbon dioxide emissions and demonstrate the feasibility of large-scale renewable energy transitions within emerging economies.

The policy lessons from India and China have global relevance. China's experience demonstrates the potential for state-directed industrial policy to achieve rapid deployment and manufacturing dominance, albeit at substantial fiscal cost. India's experience demonstrates the effectiveness of market mechanisms and competitive procurement in driving cost reduction and attracting private investment while developing institutional capacity.

Future solar energy development in both nations will depend on addressing critical challenges including grid integration, energy storage, supply chain resilience, and environmental sustainability. Both nations are well-positioned to advance global renewable energy transitions, with continued policy innovation, technological progress, and investment mobilization essential for achieving climate targets and sustainable development objectives (Liao et al., 2025) [22].

The continued growth of solar energy in India and China will shape global energy markets, technology trajectories, and climate outcomes. Policymakers, investors, and researchers must continue learning from these experiences, adapting best practices to diverse contexts, and driving the clean energy transition forward with urgency and determination (Sahdev et al., 2025) [15].

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