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Solar Revolution: Paving the Path to a Clean Energy Future

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Abstract: ***This paper analyzes the evolution, cost trends, and policy developments of solar energy in India between 2015 and 2024. It highlights how technological innovation, government initiatives, and global investment trends have driven rapid capacity expansion by more than 90 GW between 2015-2024 positioning India as a global leader. Through literature review and data analysis, the study finds that solar panel prices have declined by nearly 47% between 2015 and 2024, driven by economies of scale, improved material efficiency, and financial incentives. Major government schemes like the Jawaharlal Nehru National Solar Mission, KUSUM, and the Solar Park Scheme have played pivotal roles in enabling adoption.***

Keywords: Solar energy, policy developments, technological innovation, government schemes, India

1. Introduction

Global warming, largely caused by the burning of fossil fuels, is one of the biggest challenges faced globally. As countries around the world look for solutions, renewable energy has become a key focus, with solar energy standing out as one of the most promising alternatives. Over the years, solar energy has grown significantly by more than 20% every year since 2010 (IEA, 2013).

India has also recognized the importance of solar energy and set ambitious goals to reduce its dependence on fossil fuels. The country aims to achieve 500 GW of non-fossil fuel-based energy by 2030, with a solar energy target of 290 GW. As of 2023, India has already installed over 116 GW of solar capacity, making it one of the leading countries in solar power generation.

This paper explores the growth of solar energy in India and the factors that have contributed to its rise. The paper notes a significant drop in solar energy costs, making it competitive with traditional energy sources. Several other factors, such as technology, innovation, economies of scale, government support and declining material cost have shaped it.

The paper is organized as follows: First, we will review the existing literature on solar energy, then analyze data on solar energy adoption in India. Finally, we will conclude by summarizing the findings and discussing future research possibilities.

2. Literature Review

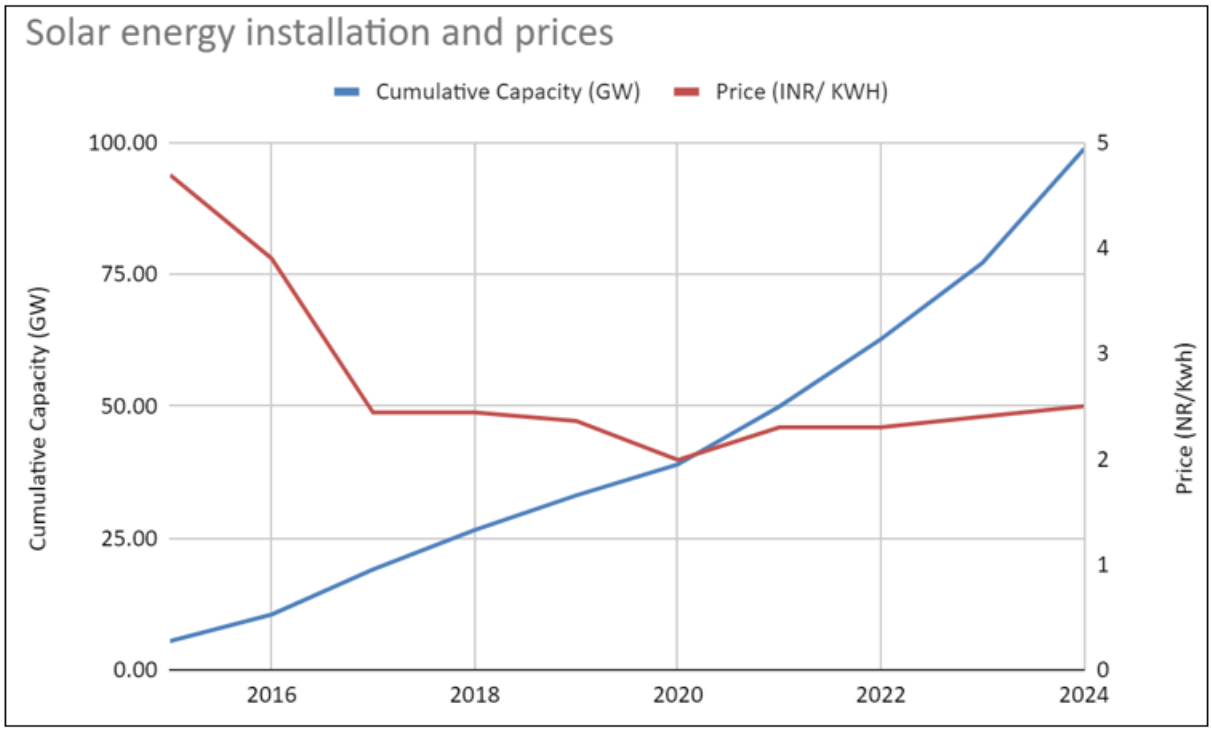
Title	Authors and Year	Summary
Solar Energy and its Future Role in Indian Economy	Srivastava (2013)	In 2012, India's grid-connected solar power capacity stood at 481.48 MW, growing from just 12 MW in 2009 to 190 MW in 2011. Falling solar costs, dropping by 50% in a year, and rising grid power tariffs make solar increasingly competitive, with projected capacity rising to 35 GW by 2020 and potentially over 50 GW by 2022.
Solar Energy Potential and Future Energy of India: An Overview	Suman And Ahmed (2018)	The paper examines India's vast solar energy potential and the role of policies such as the Jawaharlal Nehru National Solar Mission in promoting sustainable energy. The Government of India launched JNNSM, which aims to boost solar capacity installation in the country. It aims to support this by pushing large-scale installation through development of solar parks, innovation, and R&D to increase local production that helps to bring the cost down.
India's Renewable Energy Boom: The Power of Solar and Beyond	Government Institution (2025)	The paper discusses India's progress in renewable energy, emphasizing solar power as the main focus. It emphasizes technological innovation and India's goal to reach 500GW of renewable capacity by 2030 and net zero emissions by 2070.
India's Renewable Energy Capacity Achieves Historic Growth in FY 2024–25	Sreejith (2025)	Between 2014 and 2024, India experienced a significant surge in solar energy capacity, driven by declining photovoltaic (PV) costs, and policy incentives. The government has set ambitious goals of achieving 500 GW of renewable capacity by 2030 and net-zero emissions by 2070, with 280 GW of solar targeted by 2030 alone. Large-scale solar parks, such as the 2.2 GW Bhadla Solar Park in Rajasthan, exemplify India's leadership, while financial tools like competitive solar auctions have helped reduce tariffs to as low as Rs. 2.50 (US$ 0.030) per kWh.
Solar panel prices have fallen by around 20% every time global capacity	Ritchie (2024)	Costs of solar panels have declined substantially in the last few decades following Wright's law—it has fallen by 20% for every doubling of global cumulative capacity. The costs have declined from around $7.5/watt in 2000 to $0.2/watt in 2022—a 97.33% decline in the last two

doubled		decades.
Growth and Economic Impact of Solar Energy in India	Chand (2025)	India is the fourth-largest solar power producer globally. Solar accounts for around 15% of India's 175 GW renewable energy capacity, with ~73 GW from utility-scale projects, ~14 GW from rooftop systems, and ~5 GW off-grid. Key initiatives like the Jawaharlal Nehru National Solar Mission, the Solar Park Scheme (~38 GW target), and the PLI Scheme have driven growth. Solar energy has also spurred employment, rural electrification, and significant domestic and foreign investment while reducing fossil fuel dependence.
Scenario of solar energy and policies in India	Kumar et al. (2024)	In early 2024, solar power contributed about 55% of the total renewable mix in India. Large-scale solar parks such as Bhadla (7,738 MW) and Pavagada (7,469 MW) have played a key role in this growth. Solar PV systems have become economically viable with a payback period of ~4.26 years Government schemes, such as KUSUM and Surya Mitra, along with 60% subsidies for solar pumps, have promoted adoption, particularly in agriculture and rural electrification.
Solar Energy Harnessing in India: An Overview	Bharathi and Usha (2020)	By end of 2019, India's total installed solar capacity reached 31.7 GW, growing from just 161 MW in 2010, contributing 8.6% of the country's total installed electricity capacity. The solar energy sector has expanded rapidly, driven by supportive policies and falling costs—from ₹12.16/kWh in 2010 to ₹4.00/kWh in 2019.
Solar Energy Policy for India: An Overview	Saxena et al. (2024)	The solar sector In India saw rapid growth from just 2.82 MW in 2009 to 37,627 MW by 2020. The country targets 100 GW of solar capacity by 2022, supported by policies like the JNNSM, KUSUM, and SRISTI, and international initiatives like One Sun One World One Grid (OSOWOG).
Evolution of Solar Energy in India: A Review	Kapoor et.al (2024)	India has a solar energy potential of ~5000 trillion kWh/year, with 250–300 sunny days annually. Only 0.1% of India's land (3000 km²) is needed to meet its total electricity demand via solar. By 2014, India had installed 2.2 GW of grid-connected solar capacity and 140 MW off-grid. Solar thermal progress was slow, with only 55 MW installed against a 470 MW target. Solar PV costs dropped significantly—from ₹1700 lakh/MW in 2009 to ₹612 lakh/MW in 2014.

Data Analysis

In this paper we analyse the growth of solar energy in India and the factors shaping this development. Data for solar energy capacity was taken from the Government of India (MNRE) in the Financial Year Format and then we converted to calendar year by pro -rating the data. As price data was not available from a single source, we referred to data from three different sources and used their average.

The amount of solar energy installed has increased between 2015 and 2024 by eight times during which prices nearly declined by 50% from Rs 4.69 to Rs 2.5/kwh. There was a steady increase from 2015 to 2017, with some slowdown between 2017 and 2020. Post 2020, yearly capacity installation picked up from 5GW in 2020 to more than 10 GW in 2021 and about 12 GW in 2022. The graph below shows that as price declined over the years, solar installation increased simultaneously. Below, we discuss various factors that have contributed to this growth.



What has caused the decline in solar energy costs?

1) **Technology and Innovation**: Research and development has brought innovation and better technology that has reduced costs. For example, it has improved the efficiency of converting sunlight into electricity. Manufacturers are also able to use less silicon and cheaper materials. For instance, improved module efficiency was the biggest contributor behind falling costs from 1980 to 2012 (Compass Energy Consulting, 2019).
2) **Economies of Scale:** Production at large scale has allowed more panels to be produced with shared infrastructure and inputs and thus has reduced the cost per unit. Large solar plants have thus used equipment and labor effectively. In turn, bulk buying also reduced the expenses especially for large projects.
3) **Government support:** Government support across the world has boosted innovation and helped improve solar technology. Governments have provided policy support such as with tax credits and subsidies which made solar energy cheaper to buy (IRENA, 2020). They have also provided the investors with confidence by backing solar energy projects.
4) **Material cost**: Prices of silicon and other components dropped. Less waste and smarter designs reduced material waste. (SEIA 2020)

The analysis shows the critical role declining prices have played in development of solar energy, backed by government initiatives and industry- wide innovations. This indicates the importance of cost efficiency if renewable and green energy sources like solar have to compete with traditional and low-cost sources like coal and fossil fuels.

3. Conclusion

The study finds that India's solar energy capacity has grown significantly, from 5 GW in 2016 to 99 GW in 2024. This growth has been largely driven by the sharp decline in solar technology costs, making solar power increasingly competitive with traditional energy sources. Factors contributing to this price drop include technological innovation, economies of scale, reduced material costs, and strong government policy support.

Despite this impressive progress, India still needs to add over 193 GW of solar capacity by 2030 to meet its national renewable energy targets. To achieve this, more comprehensive measures are required. On the production side, scaling up domestic manufacturing, expanding solar parks, and strengthening grid infrastructure will be crucial. On the demand side, increasing rooftop adoption, improving financing access, and enhancing public awareness are essential. Future research can further explore region-specific adoption barriers, financing models, and the socio-economic impact of solar deployment in rural areas.

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