POWER GENERATION – RENEWABLE (Solar, Hydro, Bio, Wind) Sector in India

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Power Generation – Renewable (Solar, Hydro, Bio, Wind) Sector in India

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Overview of India’s Power Sector

- India's power sector is a rapidly evolving, diverse, and evolving global entity comprising three main segments: generation, transmission, and distribution
- India's installed power capacity stands at 446,190 MW as of 2024, reflecting a growing focus on reducing fossil fuel reliance

Current Capacity and Generation Mix

- **Total Installed Capacity:** As of June 2024, the total installed capacity stands at 446,190 MW
- **Thermal Power:** Thermal Power, accounting for 56.8% of total capacity, is primarily sourced from coal, accounting for 205,235 MW
- **Renewable Energy:** The installed capacity of renewable energy has increased significantly to 195,013 MW, aiming to achieve 500 GW of renewable energy by 2030

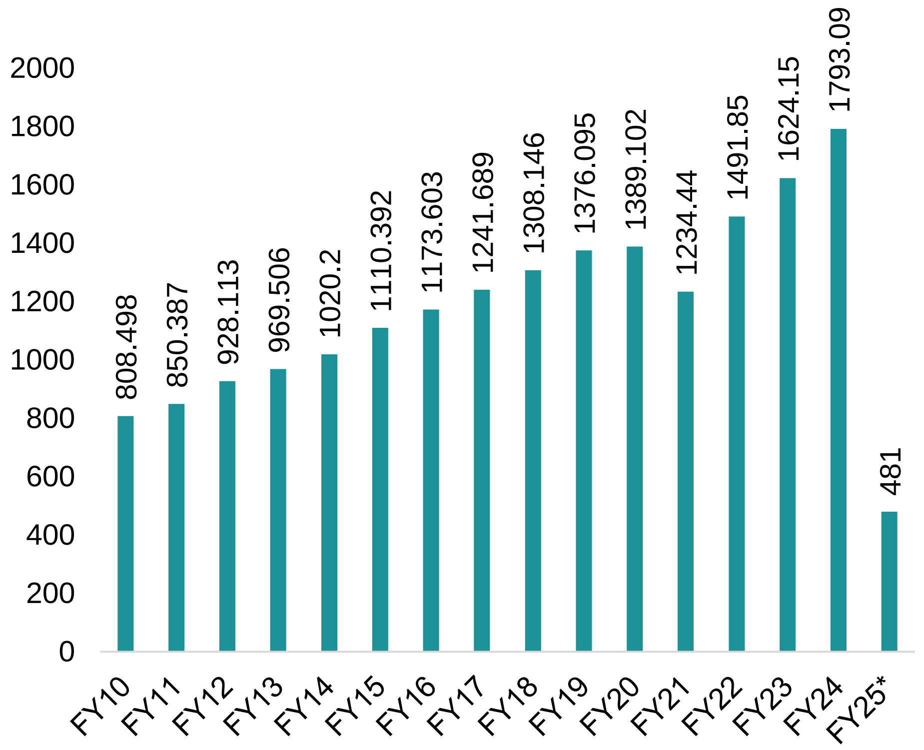
The current **nuclear power capacity** is 8,180 MW, with plans to increase to 22,800 MW by 2031-32

Power Generation: India's installed power generation capacity as of May 2023 is around 442.85 GW, with various sources of generation

- **Fossil Fuels:** Coal is the primary source of energy, accounting for 49.1% of the total capacity, followed by natural gas at 6%, lignite at 1.6%, and diesel at 0.1%
- **Renewable Energy:** The segment has significantly grown, accounting for 41.4% of the total capacity, with wind (10.3%), solar (16.1%), and hydroelectric power (11.2%) being key contributors
- **Nuclear Power:** Nuclear power accounts for around 2% of the total generation capacity

- **Transmission**: State-owned entities manage India's transmission segment, with Power Grid Corporation playing a key role. Infrastructure expansion, from 14 GW in 2007 to 95 GW in 2019, significantly increases inter-regional capacity
- **Distribution:** Power distribution is primarily handled by state-owned companies (Discoms), with private entities operating in major cities like Delhi and Mumbai.

Total Power Generation in India (including renewable sources) (Billion Units) (BU)



** (Until June 2024)*

Source: Ministry of Power

India's Renewable Energy Capacity Hits 200 GW Milestone

- India has achieved a total capacity of 201.45 GW in its renewable energy sector as of October 10, 2024

- India's electricity generation capacity has reached 452.69 GW, with renewable energy accounting for 46.3% of the total installed capacity, a significant shift in India's energy landscape

Key Highlights:

Solar Energy Leadership: Solar power generates the most power, accounting for 90.76 GW, followed by wind energy at 47.36 GW and hydroelectric power at 46.92 GW

- Small hydro contributes 5.07 GW, while biomass and biogas add around 11.32 GW

State Contributions:

India's renewable energy capacity leaders include Rajasthan, Gujarat, Tamil Nadu, and Karnataka. Rajasthan has 29.98 GW, Gujarat 29.52 GW, Tamil Nadu 23.70 GW, and Karnataka 22.37 GW. These states are contributing significantly to India's renewable energy goals and a sustainable future

The leading states in renewable energy capacity include:

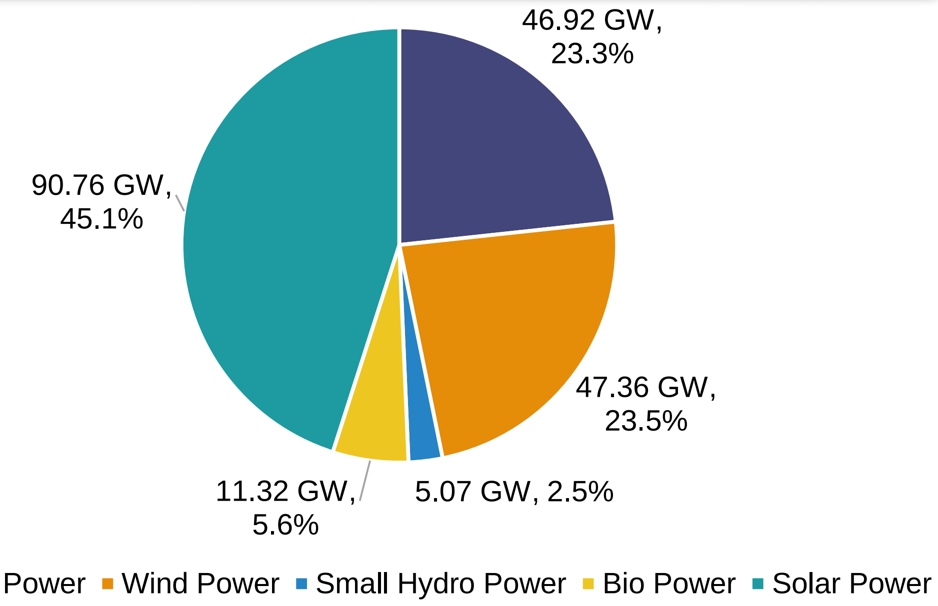
Rajasthan: 29.98 GW

Gujarat: 29.52 GW

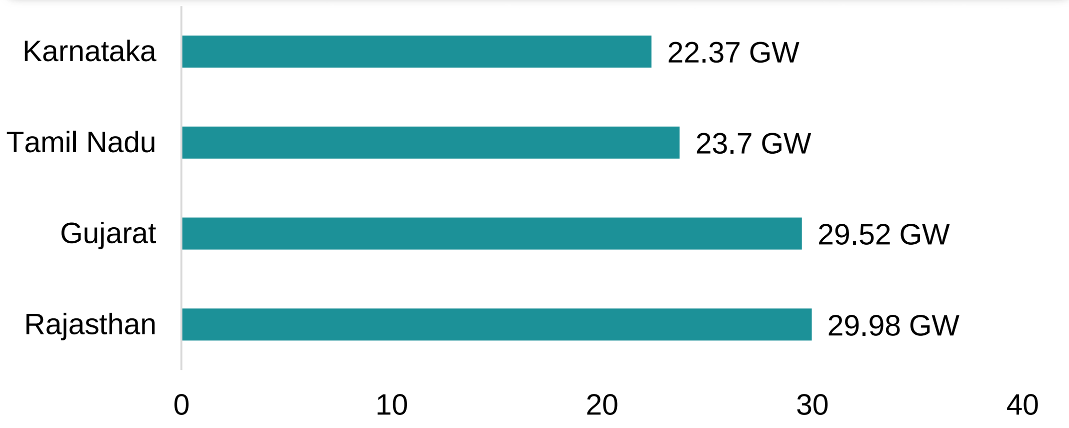
Tamil Nadu: 23.70 GW

Karnataka: 22.37 GW

Renewable Energy Capacity in India *



Leading States in Renewable Energy Capacity *



* As of October 10, 2024

Source: Ministry of New and Renewable Energy

Executive Summary

India's journey towards 500 GW presents a promising future for the country

- India's power sector is globally diverse, generating power from conventional sources like coal, natural gas, oil, hydro, nuclear power, and non-conventional sources like wind, solar, agricultural, and domestic waste
- India, with the fourth largest installed renewable energy capacity globally, received over $14,858 million (mn) in Foreign Direct Investments (FDI) between April 2000-June 2023
- The Union Budget 2023-24 allocated Rs 7,327 Crore for the solar power sector, a 48% increase from the previous year
- India is a leading player in the global solar revolution, ranking 4th globally in solar power capacity
- India aims to achieve 50% of its cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030
- **With a significant increase in installed capacity, India aims to achieve 500 GW of renewable energy capacity by 2030, focusing on sustainable energy and a greener future for the planet**
- As of September 2024, renewable energy sources in India, including large hydropower, have a combined installed capacity of 201.45 GW, including wind power, solar power, biomass/co-generation, small hydro power, and waste to energy.
- India's renewable energy capacity has grown significantly since 2014, with solar power installed capacity increasing from 2.6 GW to 90.76 GW and wind capacity rising from 21 GW to 47.36 GW as of September 2024
- India's clean energy sector saw a significant investment of Rs. 8.5 lakh crore between 2014 and 2023, with an expected investment of Rs. 30.5 lakh crore between 2024 and 2030
- The Central Electricity Authority's National Electricity Plan predicts a significant increase in non-fossil fuel-based capacity, from 203.4 GW in 2023-24 to 349 GW in 2026-27 and 500.6 GW in 2029-30, indicating a potential for significant growth in this sector
- The Indian government has increased its efforts to meet rising electricity demand, with peak demand increasing by 13% to 243 GW in FY24, with the highest increase in electricity generation recorded in renewable energy resources
- In 2023, the solar industry gained prominence due to its declining costs, improved energy storage solutions, and grid advancements, making it a global necessity
- India's government has introduced a Production Linked Incentive Scheme (PLI) for the National Programme on High-Efficiency Solar PV Modules with an outlay of Rs. 24,000 Crore, aiming to boost domestic manufacturing and solidify India's solar power position

Executive Summary

- The PLI (Tranche-I) has added 8737 MW of integrated capacity, while Tranche-II allocated 39,600 MW of domestic Solar PV module manufacturing capacity to 11 companies, generating Rs. 93,041 Crore
- India's Solar Park Scheme aims to establish 50 500 MW and above solar parks by 2025-26, attracting investments and promoting solar power development. 11 parks have completed, and 7 have partially completed, with projects totalling 10,237 MW. These parks contribute to economies of scale and affordability
- PM-KUSUM schemes aim to add 30.8 GW of solar power capacity by March 2026, transforming India's agricultural sector by establishing decentralized solar power plants, replacing diesel pumps with solar water pumps
- The fiscal allocations for solar power and green hydrogen initiatives have grown significantly, with the Interim Budget for 2024-25 increasing solar grid infrastructure development to Rs. 8,500 crore
- India's 2030 vision focuses on renewable energy dominance, green growth, and climate change mitigation, guided by the Panchamrit Policy and COP26 targets. The Panchamrit Policy aims for 500 GW of renewable capacity, 50% renewable energy requirement, reduced carbon emissions, and a net-zero carbon country by 2070
- India aims to achieve energy independence by 2047 through electric mobility, CNG/piped natural gas, 20% ethanol, and green hydrogen production, with 90% renewable energy sources
- India's renewable energy sector is thriving despite challenges, but policy reforms, infrastructure investment, and public awareness are crucial for achieving targets and a sustainable energy future
- India, with abundant renewable energy, is experiencing rapid growth in its renewable energy sector, despite facing obstacles in attracting foreign investments. The government is promoting foreign investments to develop new technologies for better generation and storage. Despite progress, India still needs to fully rely on renewable energy for its development
- India's wind energy capacity reached 45.9 GW in March 2024, a 56% year-over-year increase, with a significant 1.2 GW addition in the first quarter

Generation from Renewable Energy Sources

Year	2019-20	2020-21	2021-22	2022-23
Conventional Generation (MU)	10,89,220.3	10,75,542.6	11,61,826.5	12,52,071.8
RE Generation (excluding Large Hydro) (MU)	1,38,377.0	1,47,247.5	1,70,912.3	2,03,552.2
Large Hydro Generation (MU)	1,61,563.6	1,59,065.0	1,59,120.5	1,68,841.2
Total Renewable Energy Generation (including Large Hydro) (MU)	2,99,940.6	3,06,312.5	3,30,032.8	3,72,393.3
Total Generation (MU)	13,89,160.9	13,81,855.2	14,91,859.4	16,24,465.1
% of RE Generation (including Large Hydro) w.r.t. Total Generation (MU)	21.6	22.2	22.1	22.9

Source: Central Electricity Authority (*CEA)*

Market Overview - Introduction

- The Indian government aims to increase its wind energy capacity to 140 GW by 2030, as part of its overall goal of achieving 500 GW of renewable energy capacity
- India's wind power is primarily located in Gujarat and Tamil Nadu, which together account for a significant portion of the total installed capacity
- India, as the fourth-largest wind energy producer, is committed to expanding renewable energy sources and aiming to play a significant role in the global renewable energy landscape
- The Electricity Act 2003 permits up to 100% FDI in renewable energy generation and distribution projects
- India's renewable energy sector is expected to experience sustained growth, driven by substantial FDI inflows and government-driven initiatives to improve sustainable energy production
- India's renewable energy sector is rapidly evolving, offering numerous investment opportunities due to government targets and a favourable regulatory environment
- **Market Dynamics:** The growing population and rising electricity demand are driving the demand for sustainable energy solutions, with projected demand exceeding 400 GW by 2030
- India's renewable energy transition offers numerous investment opportunities due to supportive government policies, rising demand, and ambitious targets
- India's renewable energy capacity has increased by 165% from 2014 to 203.1 GW, demonstrating its commitment to clean energy and sustainability, making it a global leader in renewable energy installations

Installed Electricity Generation Capacity in India (GW)

Year	Installed Generation Capacity (GW)				
	Thermal	Hydro	Nuclear	Renewable Energy Sources (RES)**	Total
2008-09	93.7	36.9	4.1	13.2	148.0
2009-10	102.5	36.9	4.6	15.5	159.4
2010-11	112.8	37.6	4.8	18.5	173.6
2011-12	131.6	39.0	4.8	24.5	199.9
2012-13	151.5	39.5	4.8	27.5	223.3
2013-14	168.3	40.5	4.8	35.0	248.6
2014-15	188.9	41.3	5.8	39.0	274.9
2015-16	210.7	42.8	5.8	45.9	305.2
2016-17	218.3	44.5	6.8	57.2	326.8
2017-18	222.9	45.3	6.8	69.0	344.0
2018-19	226.3	45.4	6.8	77.6	356.1
2019-20	230.6	45.7	6.8	87.0	370.1
2020-21	234.7	46.2	6.8	94.4	382.2
2021-22	236.1	46.7	6.8	109.9	399.5
2022-23*	237.3	46.9	6.8	125.2	416.1

*Provisional
Source: CEA, Growth of Electricity Sector in India, various issues.
** RES includes Small Hydro Project (≤ 25 MW)

Renewable Energy's Growing Role in India's Power Generation

India's Renewable Revolution: Tradition to Transition

- India's growing energy demand necessitates a shift towards renewable energy sources for sustainability, energy security, and economic development, as industrialization and urbanization drive this shift
- India's transition towards renewable energy is vital for enhancing energy security, reducing greenhouse gas emissions, and achieving sustainability goals due to rapid economic growth and urbanization
- India's renewable energy capacity has grown significantly, reaching 179 GW as of May 2023, with solar and wind comprising 67 and 43 GW respectively, driven by ambitious government targets and increasing investments

Electricity Generation Targets

India has set an ambitious electricity generation target of 1,900 billion units (BU) for the fiscal year 2024-25.

Thermal Generation	1,444 BU
Hydro Generation	147.7 BU
Nuclear Generation	55.3 BU
Renewable Energy Sources (excluding large hydro)	244 BU

Growth Trends: FY 2023-24 saw a 7.04% growth in electricity generation, driven by population growth and increased electrification efforts, with demand expected to continue rising.

- The Indian power sector is aiming for a non-fossil fuel-based generation capacity of over 68% by 2031-32, focusing on sustainability and energy transition
- India is enhancing its energy security and reducing carbon emissions through innovative policies and investments in clean energy technologies, presenting a promising future

Rapid Growth of Renewable Energy in India

- India is experiencing rapid growth in its renewable energy sector, driven by ambitious targets, supportive policies, and increasing investments
- India aims to achieve 500 GW of non-fossil fuel-based electricity generation capacity by 2030
- The country's installed renewable energy capacity is projected to rise to 170 GW by March 2025, from 136.57 GW as of December 2023
- India issued a record 69+ GW of renewable energy tenders in fiscal year 2024, exceeding the central government's target of 50 GW
- The total installed capacity of grid interactive renewable power increased by 13.90% year-on-year to 1,25,160 MW in 2023 as against 1,09,885 MW in 2022
- Solar power, including roof tops, accounted for 53.4% of installed renewable power generation capacity in 2023, with a 23.68% year-on-year growth rate from FY 2021-22 to FY 2022-23
- India, the world's third-largest energy consumer, has reached a record high peak demand of 223 GW in June 2023, a 3.4% increase from 2022
- The country's total installed power capacity exceeds 400 GW, supported by industrial growth, urbanization, government policies, and geopolitics
- The power sector uses traditional and sustainable fuel sources, including coal, oil, and gas, and is growing rapidly due to its population of 1.4 billion and the world's fastest-growing economy
- India's power sector is dominated by fossil fuels, but the country aims to increase renewable and nuclear energy. Non-fossil fuels account for 25.44% and 22.45% of total electricity production, during the year 2022-23 and 2023-24 (till May 2023), respectively
- India aims to reduce greenhouse gas emissions and energy import dependence while enhancing energy security
- India’s rapid transition to net zero energy requires substantial investments in alternative energy sources and infrastructure, requiring a diverse energy mix and technology integration

Sector-wise Growth of Installed Electricity Generation Capacity

Year	Installed Generation Capacity (GW)			
	State	Central	Private	Total
2008-09	79.3	45.8	22.9	148.0
2009-10	82.9	47.5	29.0	159.4
2010-11	87.4	50.8	35.5	173.6
2011-12	85.9	59.7	54.3	199.9
2012-13	89.1	65.4	68.9	223.3
2013-14	92.3	68.1	84.9	245.3
2014-15	95.1	72.5	104.1	271.7
2015-16	101.8	76.3	124.0	302.1
2016-17	104.0	80.3	142.6	326.9
2017-18	104.0	84.5	155.5	344.0
2018-19	105.1	86.6	164.4	356.1
2019-20	103.3	93.5	173.3	370.1
2020-21	103.9	97.5	180.8	382.2
2021-22	104.9	99.0	195.6	399.5
2022-23	105.7	100.1	210.3	416.1

The total installed generation capacity experienced a 7.7% CAGR from 2008-09 to 2022-23, with the state sector declining from 54% to 25%, the central sector declining from 31% to 24%, and the private sector increasing significantly

*Provisional
Source: CEA, Growth of Electricity Sector in India, various issues

India’s Current Energy Landscape

- India is making significant progress in renewable energy, but the transition from coal requires careful planning and implementation to balance economic growth, energy security, and environmental sustainability
- Challenges persist due to India’s coal's reliance on energy, necessitating substantial investments in alternative energy sources and infrastructure for rapid transition to net zero

Current Energy Landscape

- India's energy sector relies heavily on coal, accounting for 55% of its energy needs and 75% of electricity generation. Despite renewable energy efforts, coal is expected to remain a significant component for at least two decades, necessitating active policies and the development of alternative energy sources.
- India aims to achieve net zero emissions by 2070 and 50% renewable electricity by 2030, as part of the “Panchamrit” initiative, which includes increasing renewable energy capacity and reducing emissions intensity
- The Ministry of Coal aims to increase renewable energy capacity to over 9 GW by 2030, primarily through solar energy solutions, including rooftop installations and reclaimed mining parks

Transition Strategies

The transition strategy involves several strategic initiatives.

- **Investment in Renewables:** The coal sector is promoting renewable energy projects, with 1,700 MW of solar installations and additional wind capacity currently in operation
- **Technological Innovation:** India aims to become a global leader in renewable batteries and green hydrogen production, focusing on technological innovation to create substantial economic opportunities
- **Just Transition Framework:** India is developing a “Just Transition” framework to support communities reliant on coal mining, addressing potential job losses and economic disruptions, recognizing the socio-economic impacts of reducing dependency

Installed Renewable Energy Sources (RES) Capacity in India (GW)

Year	Installed Generation Capacity (GW)				
	SHP	Wind	Bio-Power	Solar	Total Res
2008-09	2.2	9.3	1.7	0.0	13.2
2009-10	2.6	10.7	2.3	0.0	15.5
2010-11	2.9	12.8	2.7	0.0	18.5
2011-12	3.4	16.9	3.3	0.9	24.5
2012-13	3.6	18.5	3.7	1.7	27.5
2013-14	3.8	21.0	7.5	2.6	35.0
2014-15	4.1	23.4	7.8	3.7	39.0
2015-16	4.3	26.8	8.1	6.8	45.9
2016-17	4.4	32.3	8.3	12.3	57.2
2017-18	4.5	34.1	8.8	21.7	69.0
2018-19	4.6	35.6	9.2	28.2	77.6
2019-20	4.7	37.7	10.0	34.6	87.0
2020-21	4.8	39.3	10.3	40.1	94.4
2021-22	4.9	40.4	10.7	54.0	109.9
2022-23*	4.9	42.6	10.8	66.8	125.2

Source: Source: CEA, Growth of Electricity Sector in India

India's Global Standing and Future Targets in Renewable Energy

- India ranks third in global renewable energy consumption and production, with 40% of its 160 GW installed electricity capacity coming from renewable sources as of 2023.

Renewable Energy Hubs and Infrastructure

- India has established several key regions as hubs for renewable energy development:
    - Rajasthan
    - Gujarat
    - Andhra Pradesh
    - Karnataka
    - Telangana
    - Tamil Nadu
- These states are pivotal in expanding India's renewable capacity through various projects and partnerships aimed at achieving self-reliance in energy production
- The International Energy Agency (IEA) suggests that India's clean energy transition could serve as a model for other developing economies, demonstrating its potential to balance economic growth with sustainability
- India's development of renewable energy infrastructure and policies is poised to lead the global sector, promoting innovation and investment while tackling climate challenges.

Future Targets

- India's renewable energy capacity is expected to reach 170 GW by March 2025, indicating significant growth in the country's energy sector
- The government has set forth various milestones:
    - 175 GW target by 2022 (achieved)
    - 500 GW target by 2030
    - Commitment to generate 50% of total electricity from non-fossil sources by 2030

Commitments and Goals

- India's renewable energy sector, primarily solar, wind, biomass, and hydroelectric power, has experienced significant growth and diversification, making it a global leader in renewable energy capacity
- India's electricity generation is categorized into conventional and non-conventional sources, with conventional sources including thermal, hydro, and nuclear power, and non-conventional sources like solar, wind, and agricultural waste
- The Indian power sector, a globally diverse sector, has undergone significant transformation through reforms and policy initiatives, addressing key challenges and enhancing its overall efficiency and competitiveness

Current Status of Renewable Energy in India:

- India's installed renewable energy capacity, including large hydroelectric power, stands at around 205.38 GW as of 2024
- As of August 2024, the combined installed capacity of renewable energy sources, including large hydropower, stands at 199.52 GW
- India aims to reduce carbon intensity by 45% by the end of the decade, achieve 50% renewable electric power by 2030, and achieve net-zero emissions by 2070
- India aims to produce 5 million tons of green hydrogen by 2030, supported by 125 GW of renewable energy capacity
- India has approved 50 solar parks with a combined capacity of 37.49 GW, while Wind Energy aims to achieve an off-shore target of 30 GW by 2030
- Renewable energy activities will be considered for trading carbon credits under bilateral/cooperative approaches under Article 6.2 mechanism under NDAIAPA's Paris Agreement implementation

Breakdown of Installed Capacity (as of August 2024)

Energy Source	Installed Capacity (GW)
Solar Power	89.43
Wind Power	47.19
Small Hydro Power	5.07
Large Hydro	46.92
Biomass/Co-generation	10.35
Waste to Energy	0.60

Contribution by Source

- **Solar Energy:** India's solar energy, accounting for 53.4% of its total renewable energy capacity, holds a significant potential of 748 GW, making it a vital part of its energy strategy
- **Wind Energy:** India ranks 4th globally in wind power capacity, accounting for 34.1% of total renewable energy (RES) capacity, with potential for further expansion, especially offshore`
- **Biomass and Hydro:** Biomass and hydroelectric power contribute 8.6% and 5.03 GW respectively to the renewable mix, respectively, with their generation remaining stable and contributing to overall renewable energy output

Electricity Generation Overview

- India's electricity generation is primarily thermal, accounting for 57% of total capacity in 2022-23. However, thermal-based capacity has decreased from 63.3% in 2008-09 to 57% in 2022-23. Hydro-based capacity also decreased, while renewables-based capacity increased. The CAGR of total installed electricity generation capacity was 7.7%
- The solar sector in India accounts for 53.4% of total renewable energy (RES) capacity, followed by wind (34.1%), bio-power (8.6%), and small hydropower (4%). Solar's share has significantly increased from less than 1% in 2008-09
- The Electricity Act of 2003 liberalized electricity generation, promoting license-free regimes, boosting competition and private player participation. The segment comprises central public sector undertakings, state public sector boards, and private sector companies.

Installed Electricity Generation Capacity in India (GW): 2008-09 to 2022-23

Category	Thermal	Hydro	Nuclear	Renewable Energy Sources (RES)**	Total
2008-09	93.7	36.9	4.1	13.2	148.0
2009-10	102.5	36.9	4.6	15.5	159.4
2010-11	112.8	37.6	4.8	18.5	173.6
2011-12	131.6	39.0	4.8	24.5	199.9
2012-13	151.5	39.5	4.8	27.5	223.3
2013-14	168.3	40.5	4.8	35.0	248.6
2014-15	188.9	41.3	5.8	39.0	274.9
2015-16	210.7	42.8	5.8	45.9	305.2
2016-17	218.3	44.5	6.8	57.2	326.8
2017-18	222.9	45.3	6.8	69.0	344.0
2018-19	226.3	45.4	6.8	77.6	356.1
2019-20	230.6	45.7	6.8	87.0	370.1
2020-21	234.7	46.2	6.8	94.4	382.2
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2022-23*	237.3	46.9	6.8	125.2	416.1

Source: CEA, Growth of Electricity Sector in India, various issues.
** RES includes Small Hydro Project (≤ 25 MW)

Renewable Energy Growth and Energy Mix

- India's renewable electricity generation increased significantly from 65.78 BU in 2015-16 to 203.55 BU in 2022-23, with solar generation also showing a CAGR of 45.3%
- India's gross electricity generation increased from 747.07 BU in 2008-09 to 1624.47 BU in 2022-23 at a CAGR of 5.7%, compared to 7.7% growth in annual installed capacity due to low utilization factor
- Thermal electricity, primarily coal, accounted for 74% of the country's energy mix in 2022-23. However, its share has declined due to increased focus on renewable energy sources, increasing from 3.7% in 2008-09 to 12.5% in 2022-23
- India's Prime Minister announced a goal to increase non-fossil fuel energy capacity to 500 GW by 2030, primarily through solar and wind power installations, aiming to diversify India's energy mix
- The increase in installed electricity generation capacity positively impacted the power supply position, increasing energy requirement and peak demand from 2008-09 to 2022-23, and decreasing energy and peak deficit

Renewable Electricity Generation* in India (BU)

Category	SHP	Wind	Bio-Power	Solar	Others	Total RES
2015-16	8.4	33.0	16.7	7.5	0.3	65.8
2016-17	7.7	46.0	14.2	13.5	0.2	81.6
2017-18	7.7	52.7	15.3	25.9	0.4	101.8
2018-19	8.7	62.0	16.3	39.3	0.4	126.8
2019-20	9.5	64.7	13.7	50.1	0.4	138.3
2020-21	10.3	60.2	14.8	60.4	1.6	147.3
2021-22	10.5	68.6	16.1	73.5	2.3	170.9
2022-23	11.2	71.8	16.0	102.0	2.5	203.6

Source: CEA, Growth of Electricity Sector in India, various issues.* Excluding Large Hydro

Gross Electricity Generation in India (BU)

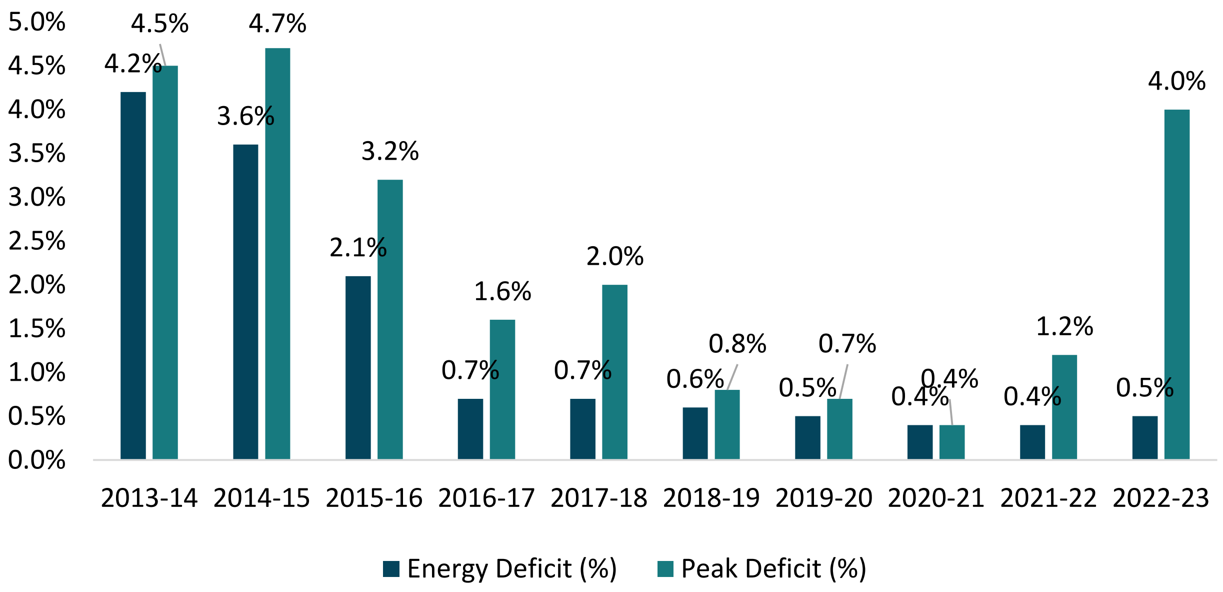
Category	Thermal	Hydro	Nuclear	Renewal Energy Sources (RES)	Bhutan Import	Total
2008-09	588.3	110.1	14.9	27.9	5.9	747.1
2009-10	640.2	104.1	18.6	37.0	5.4	805.3
2010-11	665.0	114.3	26.3	41.2	5.6	852.4
2011-12	708.4	130.5	32.3	51.2	5.3	927.8
2012-13	760.5	113.7	32.9	57.5	4.8	969.3
2013-14	792.1	134.9	34.2	59.6	5.6	1026.4
2014-15	877.9	129.2	36.1	61.8	5.0	1110.1
2015-16	943.0	121.4	37.4	65.8	5.2	1172.8
2016-17	994.2	122.3	37.7	81.9	5.6	1241.7
2017-18	1037.1	126.1	38.4	101.8	4.8	1308.2
2018-19	1072.0	135.0	37.7	126.8	4.4	1375.9
2019-20	1044.5	155.7	46.4	138.3	5.8	1390.6
2020-21	1032.5	150.3	43.0	147.3	8.8	1381.9
2021-22	1114.7	151.6	47.1	170.9	7.5	1491.9
2022-23*	1206.2	162.1	45.9	203.6	6.7	1624.5

Source: CEA, Growth of Electricity Sector in India, various issues.
** RES includes Small Hydro Project (≤ 25 MW)

Energy Deficit and Peak Deficit in India

- India experienced a 4.0% energy deficit, with a total energy requirement of 1,511,847 MU and a supply of 1,504,264 MU, resulting in an energy shortfall of 7,583 MU. The energy deficit has decreased from 9.0% in 2012-2013 to 4.0% in 2022-23, largely due to reforms like open access in transmission and distribution
- The peak electricity demand reached 215,888 MW, while the peak met was 207,231 MW, resulting in a peak deficit of 8,657 MW, resulting in a 4.0% shortfall
- Peak demand has significantly increased, reaching 243,271 MW by September 2023, marking a 79% growth over the past decade. India's fiscal year 2023-24 saw a 0.3% reduction in energy shortage, with peak demand increasing by 12.7% compared to the previous year. The government plans to increase electricity generation capacity by 1,750 billion units (BU) for 2023-24, up from 1,624 BU in 2022-23

Energy Deficit and Peak Deficit in India



Power Supply Position in India

Year	Energy (BU)			Peak (GW)		
	Requirement	Availability	Deficit (%)	Requirement	Availability	Deficit (%)
2008-09	777.0	691.0	0.1	109.8	96.8	11.9%
2009-10	830.6	746.6	0.1	119.2	104.0	12.7%
2010-11	861.6	788.4	0.1	122.3	110.3	9.8%
2011-12	937.2	857.9	0.1	130.0	116.2	10.6%
2012-13	995.6	908.7	0.1	135.5	123.3	9.0%
2013-14	1002.3	959.8	0.0	135.9	129.8	4.5%
2014-15	1068.9	1030.8	0.0	148.2	141.2	4.7%
2015-16	1114.4	1090.9	0.0	153.4	148.5	3.2%
2016-17	1142.9	1135.3	0.0	159.5	156.9	1.6%
2017-18	1213.3	1204.7	0.0	164.1	160.8	2.0%
2018-19	1274.6	1267.5	0.0	177.0	175.5	0.8%
2019-20	1291.0	1284.4	0.0	183.8	182.5	0.7%
2020-21	1275.5	1270.7	0.0	190.2	189.4	0.4%
2021-22	1379.8	1374.0	0.0	203.0	200.5	1.2%
2022-23	1511.9	1504.3	0.0	215.9	207.2	4.0%

India has made progress in reducing its energy deficit and meeting increasing power demands, but challenges persist due to rising demand, necessitating ongoing government investments and reforms.

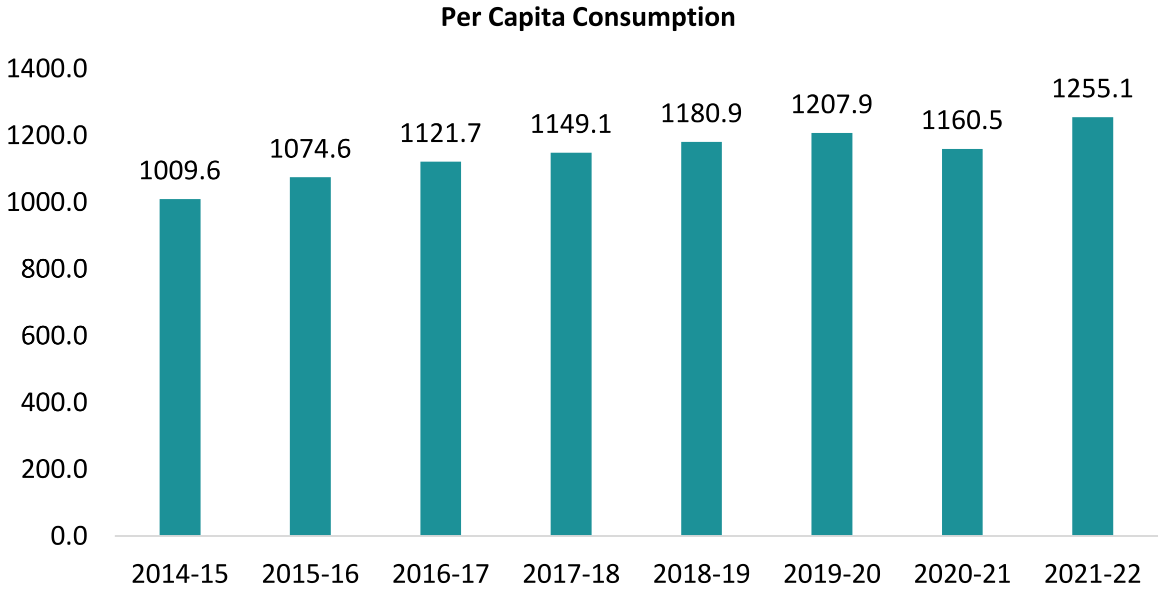
Source: Central Electricity Authority

India's Electricity Consumption Growth

- The government is prioritizing the well-performing distribution sector in the electricity supply chain, focusing on improving the financial health of DISCOMs and SEBs. This is to ensure reliable, quality power and universal access to electricity, by increasing rural electrification, reducing technical and commercial losses, ensuring DISCOMs' financial viability, and encouraging private sector participation

- The total electricity consumption in India increased from 611.29 BU in 2008-09 to 1403.40 BU in 2022-23 at a CAGR of 6.1%, with per capita consumption rising from 734 kWh to 1327 kWh, compared to the international average

Per Capita Consumption of Electrical Energy (kWh)



Source: Central Electricity Authority (CEA)

Growth of Electricity Consumption in India (Consumer category-wise) (BU)

Year	Domestic	Commercial	Industrial	Agriculture	Traction	Miscellaneous	Total
2008-09	130.1	53.5	279.7	107.8	11.8	28.5	611.3
2009-10	144.3	59.3	290.3	119.3	12.4	27.7	653.2
2010-11	156.0	68.7	301.3	123.4	13.1	29.9	692.4
2011-12	171.1	65.4	352.3	141.0	14.2	41.3	785.2
2012-13	183.7	72.8	366.0	147.5	14.1	40.3	824.3
2013-14	199.8	74.3	384.4	152.7	15.5	47.4	874.2
2014-15	217.4	78.4	418.4	168.9	16.2	49.3	948.5
2015-16	238.9	86.0	423.5	173.2	16.6	63.0	1001.2
2016-17	255.8	89.8	440.2	191.2	15.7	68.5	1061.2
2017-18	273.6	93.8	468.6	199.3	17.4	70.8	1123.4
2018-19	288.2	98.2	519.2	213.4	18.8	72.1	1210.0
2019-20	308.8	106.1	532.8	211.3	19.2	70.0	1248.1
2020-21	330.8	87.0	508.8	221.3	14.7	67.7	1230.2
2021-22	339.8	97.1	556.5	228.5	21.9	73.0	1316.8
2022-23*	362.0	105.1	595.0	240.8	25.0	75.5	1403.4

* Estimated
Source: CEA, Growth of Electricity Sector in India, various issues.

India's Average AT&C Losses and Policy Initiatives

- Power Finance Corporation's report shows India's average Aggregate Technical and Commercial (AT&C) losses reached 16.42% in 2021-22, with over 90% attributed to Transmission and Distribution Losses
- The average cost of supply and revenue in India increased from Rs. 3.40/kWh in 2008-09 to Rs. 6.29/kWh in 2021-22. The gap between supply and revenue increased from Rs. 0.77/kWh to Rs. 1.31/kWh, with revenue varying between 76% and 81% over the past five years
- The Union Government has implemented several policy initiatives to improve the financial health of DISCOMs, including the Ujwal DISCOM Assurance Yojana (UDAY), Integrated Power Development Scheme (IPDS), and National Smart Grid Mission (NSGM). These initiatives aim to improve operational efficiencies, reduce power purchase costs, interest costs, and enforce financial discipline
- The Saubhagya Scheme, launched in 2017, provides free electricity connections to households above poverty line in rural and urban areas. Eligible DISCOMs, including Private Sector DISCOMs, State Power Departments, and Renewable Energy Cooperative Societies, enhance sub-transmission and distribution networks, and improve power supply availability

Average Cost of Supply and Average Revenue of State Power Utilities

Year	Average Cost of Supply (₹/kWh)	Average Revenue (without subsidy) (₹/kWh)	Revenue Gap (₹/kWh)	Revenue as % of Cost
2008-09	3.4	2.63	0.77	77%
2009-10	3.55	2.68	0.87	75%
2010-11	3.98	3.03	0.95	76%
2011-12	4.55	3.3	1.25	73%
2012-13	5.03	3.76	1.27	75%
2013-14	5.19	4	1.19	77%
2014-15	5.21	4.15	1.06	80%
2015-16	5.43	4.23	1.2	78%
2016-17	5.48	4.36	1.12	80%
2017-18	5.6	4.51	1.09	81%
2018-19	6	4.65	1.35	78%
2019-20	6.15	4.93	1.22	80%
2020-21	6.19	4.71	1.48	76%
2021-22	6.29	4.98	1.31	79%

Source: PFC, Report on The Performance of State Power Utilities, Central Electricity Authority (CEA)

Role of REC and PFC in India's Power Distribution Sector

- The Rural Electrification Corporation (REC) and Power Finance Corporation (PFC) play a crucial role in India's power distribution sector, financing and implementing reforms to improve efficiency and sustainability

- REC and PFC are crucial in reducing AT&C losses through stringent financing, reform initiatives, and liquidity support, enhancing operational efficiency of DISCOMs and providing reliable electricity services. REC and PFC provide financial support and enforce disciplined approaches to reduce AT&C losses, enhancing India's power distribution sector's overall viability

Financing and Reform Initiatives

- **Prudential Norms for Financing:** The Ministry of Power revised prudential norms for REC and PFC in September 2021, requiring loss-making DISCOMs to create an action plan to reduce AT&C losses before financing access, promoting accountability and strategic planning

- **Revamped Distribution Sector Scheme (RDSS):** The RDSS, launched in June 2021, aims to reduce AT&C losses to 12-15% by 2024-25 and bridge the gap between Average Cost of Supply and Average Realizable Revenue, with an outlay of ₹3,03,758 crores. The scheme promotes financial discipline and operational efficiency by linking fund disbursement to performance metrics related to AT&C losses

- **Liquidity Support During Crises:** REC and PFC provided long-term concessional financing to DISCOMs during the COVID-19 pandemic, ensuring operational continuity amidst financial distress

- **Project Management Support:** DISCOMs are urged to engage independent Project Management Agencies (PMAs) to oversee their action plans, ensuring effective and timely execution of AT&C loss reduction projects

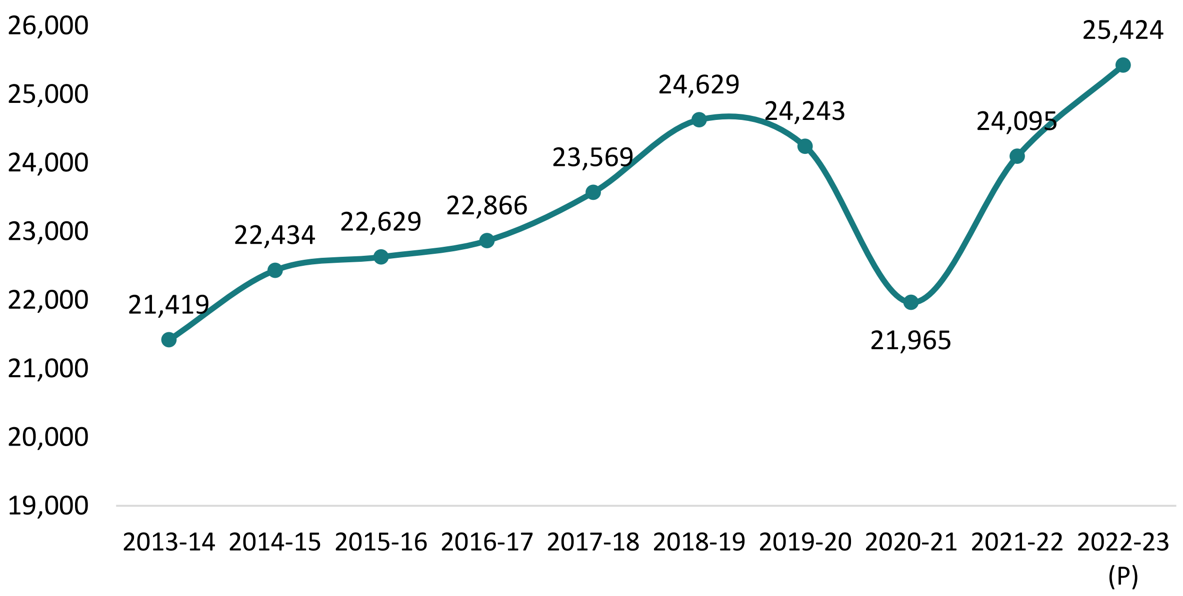
- **Collaborative Approach:** DISCOMs create action plans in consultation with the Ministry of Power and stakeholders, addressing operational challenges and fostering a sense of ownership in performance improvement strategies

These initiatives led by REC and PFC have significantly reduced AT&C losses across the country, from 22% in FY 2021 to 16% in FY 2022. The reduction not only enhances the financial health of DISCOMs but also improves their infrastructure maintenance and reliable power supply to consumers

Per-capita Energy Consumption

- The per-capita energy consumption has significantly increased from 21,419 Mega joules in 2013-14 to 25,424 Mega joules in 2022-23
- The rise in per-capita energy consumption is primarily due to industrial growth, urbanization, increased electric appliance adoption, and expanding infrastructure and services requiring more energy
- Despite this growth, India's per-capita energy consumption remains lower than many developed nations, indicating potential for further expansion

Per Capita Energy Consumption in India (Megajoule/Person)



Source: Central Electricity Authority (CEA)

Per-Capita Energy Consumption and Energy Intensity

Year	Energy Consumption in petajoules	Mid year population (in Thousands) *	GDP at 2011-12 prices (Rs. crore) **	Per Capita Energy Consumption (in Megajoules)
2013-14	26,822	12,52,267	98,01,370	21,419
2014-15	28,453	12,68,310	1,05,27,674	22,434
2015-16	29,063	12,84,350	1,13,69,493	22,629
2016-17	29,713	12,99,434	1,23,08,193	22,866
2017-18	30,966	13,13,815	1,31,44,582	23,569
2018-19	32,712	13,28,206	1,39,92,914	24,629
2019-20	32,548	13,42,586	1,45,34,64	24,243
2020-21	29,807	13,56,980	1,36,94,869	21,965
2021-22	33,018	13,70,311	1,50,21,846	24,095
2022-23 (P)	35,159	13,82,894	1,60,71,429	25,424

* Mid-Year (as on 1st October) population has been taken from Population Projections for India and states 2011 – 2036; Report of the Technical Group

On Population Projections, July, 2020

** GDP estimates are at base 2011-12 price as per the National Accounts Division's, NSO, MoSPI

Source: Ministry of Statistics and Programme Implementation, National Statistical Office

P: Provisional

Transmission Sector Overview; Significant increase in bulk transmission

- The transmission sector was opened for private investments in 1998. The Central Transmission Utility (CTU) provides medium-term and long-term access to the interstate transmission system for generating stations or traders
- The PGCIL manages inter-state transmission and national grid development. RLDCs grant short-term open access, while the National Load Despatch Centre provides transmission access to power exchanges
- Open Access allows generators and bulk consumers to sell their generated electricity at a certain surcharge and access their transmission and distribution networks without discrimination from distribution line owners. This principle aims to provide consumers with a choice in electricity consumption
- A significant increase was seen in bulk transmission which increased from 2.21 lakh ckm in 2008-09 to 4.71 lakh ckm in 2022-23, with a CAGR of 5.6% in transmission lines and 10.6% in sub-stations
- Annual transmission charges surged at a 16.48% CAGR from 2011-12 to 2022-23, driven by growth in transmission lines, waiver of charges for inter-state renewable energy generators, and relinquishing long-term access

Annual Transmission Charges

Year	Transmission Charges as on 31st March (₹ Crore)
2011-12	8743
2012-13	12797
2013-14	15118
2014-15	17680
2015-16	22476
2016-17	27383
2017-18	31405
2018-19	35599
2019-20	39285
2020-21	41051
2021-22	41696
2022-23	46800

Growth of Transmission System in India

Year	Transmission Lines (AC+HVDC) (ckm)	Transformation Capacity of Substations (220KV and above) (MVA)
2008-09	2,20,794	2,88,615
2009-10	2,36,467	3,10,052
2010-11	2,54,536	3,45,513
2011-12	2,57,481	4,09,551
2012-13	2,74,588	4,73,216
2013-14	2,91,336	5,30,546
2014-15	3,13,437	5,96,100
2015-16	3,41,551	6,58,949
2016-17	3,67,851	7,40,765
2017-18	3,90,970	8,26,958
2018-19	4,13,407	8,99,663
2019-20	4,25,071	9,67,893
2020-21	4,41,821	10,25,468
2021-22	4,56,716	11,04,450
2022-23	4,71,341	11,80,352

- The transmission sector has a natural monopoly due to high costs, limiting entry for non-public entities. Private investments require CERC approval, with 85 Inter-state transmission licensees granted as of 31.3.2023
- The Ministry of Power released a detailed plan in March 2023 for integrating over 500 GW renewable energy capacity by 2030, aiming to provide transparency for developers

Source: CEA, Monthly Reports, GRID-INDIA

Generating Capacity Addition

- India's total installed electricity generating capacity, including thermal, hydro, nuclear, and renewable energy sources, stands at 4,16,058.89 MW as of 31st March 2023
- In 2022-23, conventional sources added 1580.00 MW of generation capacity, the largest increase in the last decade
- India's installed capacity reached 428,299.27 MW in December 2023, reflecting a growing trend in electricity generation across sectors. The government aims to increase non-fossil fuel-based capacity to over 500,000 MW by 2030

All India Installed Electricity Generating Capacity- Sector wise

Type	Central Sector (MW)	State Sector (MW)	Private Sector (MW)	Total (MW)
Thermal	75,977.9	75,979.9	85,311.1	2,37,268.9
Hydro	15,664.7	27,254.5	3,931.0	46,850.2
Nuclear	6,780.0	-	-	6,780.0
Renewable Energy Sources*	1,632.3	2,492.1	1,21,035.4	1,25,159.8
Total	**1,00,054.9**	**1,05,726.4**	**2,10,277.5**	**4,16,058.9**

Capacity addition during the last 10 years – Mode-wise

Year	Thermal	Hydro	Nuclear	Total
2013-14	16767.00	1058.01	0.00	17825.01
2014-15	20830.30	736.00	1000.00	22566.31
2015-16	22460.60	1516.00	0.00	23976.60
2016-17	11550.80	1659.00	1000.00	14209.80
2017-18	8710.00	795.00	0.00	9505.00
2018-19	5781.755	140.00	0.00	5921.755
2019-20	6765.00	300.00	0.00	7065.00
2020-21	4926.15	510.00	0.00	5436.15
2021-22	4485.00	393.00	0.00	4878.00
2022-23	1460.00	120.00	0.00	1580.00

* Provisional
Source: Central Electricity Authority

Capacity addition during the last 10 years – Sector-wise

Year	Central Sector	State Sector	Private Sector	Total
2013-14	2574.0	3367.0	11884.0	17825.0
2014-15	4395.2	4886.1	13285.0	22566.3
2015-16	3775.6	7070.0	13131.0	23976.6
2016-17	4310.5	5177.3	4722.0	14209.8
2017-18	3560.0	1960.0	3985.0	9505.0
2018-19	2070.0	2879.8	972.0	5921.8
2019-20	4240.0	2780.0	45.0	7065.0
2020-21	4380.0	957.2	99.0	5436.2
2021-22	2370.0	1590.0	918.0	4878.0
2022-23	660.0	920.0	0.0	1580.0

Source: Central Electricity Authority

State Wise Renewable Energy Generation (MU)

Name of State/UT	RE Generation July'2024	RE Generation July'2023	RE Generation Apr'24-Jul 24	RE Generation Apr'23-Jul'23
Northern Region				
Chandigarh	0.7	0.6	3.6	5.5
Delhi #	60.2	59.8	258.8	229.2
Haryana *	175.9	116.3	703.4	469.7
Himachal Pradesh	6,703.4	6,102.0	20,004.4	16,637.9
Jammu & Kashmir	2,265.4	2,279.9	8,075.6	8,219.9
Ladakh	64.8	65.7	179.6	150.8
Punjab	836.8	1,085.8	2,835.7	3,447.0
Rajasthan	4,974.7	3,984.6	20,076.3	16,955.5
Uttar Pradesh	463.3	478.6	2,243.3	2,412.5
Uttarakhand *	2,183.8	1,979.3	5,632.3	5,327.7
Sub Total	**17,728.7**	**16,152.6**	**60,013.0**	**53,855.7**
Western Region				
Chhattisgarh	256.2	211.3	1,056.9	820.7
Gujarat	4,386.2	3,347.4	17,866.4	14,964.1
Madhya Pradesh	1,364.7	1,502.8	5,971.0	5,079.8
Maharashtra	2,476.4	2,456.8	8,640.3	8,759.6
Dadra & Nagar Haveli and Daman & Diu	1.4	1.8	9.1	9.1
Goa*	5.4	7.0	21.7	22.9
Sub Total	**8,490.3**	**7,527.1**	**33,565.5**	**29,656.1**
Southern Region				
Andhra Pradesh	1,910.0	2,550.4	6,610.4	7,433.0
Telangana	739.0	616.8	2,774.2	2,817.0
Karnataka	5,356.7	4,013.7	14,527.8	14,015.2
Kerala	1,040.3	639.4	3,418.1	2,790.3
Tamil Nadu	5,633.1	5,061.7	14,012.3	13,461.9
Lakshadweep *	0.0	0.0	0.0	0.0
Puducherry *	1.0	1.0	4.1	4.1
Sub Total	**14,680.2**	**12,883.1**	**41,346.8**	**40,521.6**

Name of State/UT	RE Generation July'2024	RE Generation July'2023	RE Generation Apr'24-Jul'24	RE Generation Apr'23-Jul'23
Eastern Region				
Andaman & Nicobar	3.6	2.9	12.5	11.1
Bihar	32.1	19.0	111.8	103.8
Jharkhand *	11.7	7.2	45.4	28.9
Odisha	608.0	805.1	2,098.1	2,278.5
Sikkim *	350.6	1,784.0	744.1	4,662.9
West Bengal	451.2	523.6	1,500.2	1,725.5
Sub Total	1,457.4	3,141.8	4,512.2	8,810.6
North-Eastern Region				
Arunachal Pradesh *	603.6	697.0	1,693.8	1,643.6
Assam	188.1	67.5	582.5	231.2
Manipur *	78.9	13.8	200.0	33.0
Meghalaya *	190.5	133.4	477.2	310.4
Mizoram *	48.8	14.8	104.0	56.2
Nagaland	63.9	41.4	101.3	65.7
Tripura	0.5	0.5	2.0	2.0
Sub Total	1,174.3	968.4	3,160.8	2,342.0
All India Total	**43,530.9**	**40,673.0**	**1,42,598.3**	**1,35,186.0**

Source: Central Electricity Authority

FDI inflows in renewable energy sector

- India's renewable energy sector has attracted significant Foreign Direct Investment (FDI) due to its commitment to enhancing its green energy capabilities

- **Total FDI Inflows:** India has received a total FDI Equity investment amounting to $ 6.14 billion in the renewable energy sector, during the last three financial years and the current financial year (till 30.09.2023)

- India's renewable energy sector saw a 50% year-on-year increase in Foreign Direct Investment (FDI) in 2023-24, reaching $3.76 billion, up from $2.5 billion in the previous fiscal year, according to the Ministry of Commerce and Industry

- Since FY 2010-11, India's renewable energy sector has seen a total of $17.07 billion in foreign direct investment (FDI), with the government allowing 100% FDI without prior approval

- The solar energy sector has seen a significant increase in foreign direct investment (FDI) over the past three financial years, indicating investor confidence in this sector

- India's renewable energy sector has seen a surge in FDI, indicating the confidence of foreign investors and the effectiveness of government policies in promoting sustainable energy development. The Indian government aims to generate 500 GW of non-fossil fuel-based electricity by 2030, attracting further investments in the renewable energy sector due to global trends towards sustainable solutions

Key Drivers of Investment

FDI Liberalization and Government Initiatives

The Indian government permits up to 100% foreign direct investment (FDI) in renewable energy projects through the automatic route

Incentives and Waivers

The government has waived Inter-State Transmission System (ISTS) charges for solar and wind power sales until June 2025, promoting inter-state renewable energy trade and enhancing domestic manufacturing capabilities.

Ambitious Targets

India's ambitious goal of achieving 500 GW of renewable energy capacity by 2030 has garnered significant global investor interest

Market Demand and Economic Growth

India's growing energy demand and commitment to clean energy make investment favorable, with solar capacity growing rapidly from 2.6 GW to 89.4 GW in nine years

Strategic Investments by Corporates

Indian corporations like Reliance Industries and Tata Group are significantly investing in renewable energy, aiming for carbon neutrality by 2035, enhancing the sector's appeal to foreign investors

Technological Advancements and Infrastructure Development

India's modernization of its power grid and advancements in renewable technologies make foreign investment easier, supported by the government's focus on renewable energy infrastructure

Global Trends Toward Sustainability

Global sustainability and net-zero emissions are driving investment decisions, prompting diversification into renewable sectors and long-term viability of clean energy solutions.

Sectoral Shift

Since FY 2014, coal production investments have declined significantly, with no FDI recorded, indicating a shift towards renewable sources

Foreign Currency Financing

The Indian Renewable Energy Development Agency plans to finance projects in foreign currency, thereby enhancing investment opportunities.

Favorable policies and strong market demand

India's renewable energy sector is expected to experience sustained growth in FDI due to favorable policies and strong market demand for clean energy solutions

Steps Taken by Indian Government to Attract Investments in Renewable Energy

The government has taken various steps to attract investments, including foreign direct investment (FDI), in the renewable energy sector, including:

FDI Policy Enhancements

The Indian government allows FDI up to 100% under the automatic route for renewable energy projects, significantly easing the entry for foreign investors. This policy resulted in substantial equity investments totalling around $6.1 billion from April 2020 to September 2023

Financial Incentives

The Union Budget for 2024-25 allocated $1.2 billion to solar power grid projects and introduced viability gap funding for offshore wind energy projects, boosting their financial viability

Waivers and Regulatory Support

The government has waived inter-state transmission system charges for solar and wind power projects commissioned by June 30, 2025, to encourage developers to invest in renewable energy.

Infrastructure Development

Establishment of Ultra Mega Renewable Energy Parks offer developers access to essential infrastructure, including land and transmission facilities, on a plug-and-play basis while the Green Energy Corridor scheme aims to improve grid connectivity for renewable power evacuation

Standardization and Clarity

Standard bidding guidelines for tariff-based competitive bidding processes have provided policy clarity and consistency, thereby de-risking investments in renewable energy projects

Project Development Cell Setup

Setting up of Project Development Cell for attracting and facilitating investments

Renewable Purchase Obligation Trajectory

Declaration of trajectory for Renewable Purchase Obligation (RPO) up to the year 2029-30

Green Energy Corridor Scheme:

Laying of new transmission lines and creating new sub-station capacity under the Green Energy Corridor Scheme for evacuation of renewable power,

Launch of Schemes

Launch of schemes such as Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM), Solar Rooftop Phase-II, 1200 MW CPSU Scheme Phase II, etc.

National Green Hydrogen Mission Launch

Launch of National Green Hydrogen Mission with an aim to make India a global hub for production, utilization and export of Green Hydrogen and its derivatives

India's Renewable Energy Promotion Rules, 2022

The Ministry of Power notified the Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022, on June 6, 2022, to expedite India's renewable energy programs for Promoting Renewable Energy

Launch of Green Term Ahead Market (GTAM)

Launch of Green Term Ahead Market (GTAM) to facilitate sale of Renewable Energy Power through exchanges

Financing Mechanisms and Instruments in India's Power Sector

- India's power sector is undergoing significant transformation, focusing on renewable energy, necessitating a robust financing framework to mobilize capital for both traditional and renewable projects

Government Schemes and Initiatives

- **IREDA Financing Schemes:** The Indian Renewable Energy Development Agency (IREDA) offers various financing schemes, including:
  - **Loan against Securitization** of future cash flows from renewable projects
  - **Bridge Loans** for claims against solar water heating systems and generation-based incentives for wind and solar projects
  - **Credit Enhancement Guarantee Scheme,** which facilitates raising bonds for renewable energy projects
- **Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY):** This scheme providing financial support for rural electrification
- **Integrated Power Development Scheme (IPDS):** This scheme is a government-backed initiative aimed at enhancing the quality of power supply and ensuring financial sustainability

Private Sector Financing

- **Debt and Equity Financing**: The financing structure typically consists of 70% debt and 30% equity, with private equity investors increasingly providing equity funding, shifting away from traditional balance-sheet financing by project developers
- **Green Bonds:** Green bonds are being issued to raise funds for renewable energy projects, enabling investors to finance environmentally sustainable initiatives with potential for favourable returns
- **Non-banking financial companies (NBFCs)** have played a crucial role in early-stage financing of renewable energy projects, recognizing their potential and developing project financing frameworks

International Financing

- **Foreign Investments:** India has significantly attracted FDI in the power sector, allowing 100% in various segments, enabling access to international capital markets and investment from sovereign wealth funds and pension funds
- International **Development Finance Institutions (DFIs)** are vital in providing long-term loans at competitive rates, which are crucial for funding large-scale renewable energy projects

Innovative Financial Instruments

- **Generation-Based Incentives (GBI):** Incentives promote renewable energy generation by rewarding actual electricity production, ensuring financial returns are in line with performance
- **Viability Gap Funding (VGF):** VGF aids in making projects financially viable, especially in high-cost power generation sectors, by attracting private investments into risky sectors

Measures Taken to Promote Renewable Energy in the Country (1/3)

India has implemented several measures to promote renewable energy, particularly solar energy, as part of its commitment to sustainable growth and energy security. India's solar potential is largely untapped despite significant growth, but the government is implementing various schemes and programs to achieve its renewable energy targets.

Waiver of IST Charges for Solar/Wind Power Projects

The Indian government has waived inter-state transmission system (ISTS) charges for solar and wind power electricity for projects to be commissioned by June 30, 2025, aiming to boost renewable energy development and improve their economic viability

Declaration of Renewable Purchase Obligation Trajectory

The declaration of the trajectory for Renewable Purchase Obligation (RPO) up to 2029-30 has been released

India's Ministry of Power has announced the Renewable Purchase Obligation trajectory, aiming to increase renewable energy's share in power consumption by 2029-30

The trajectory is crucial for India's clean energy goals and ensuring a significant portion of electricity consumption is met through renewable sources by 2030.

Ultra Mega Renewable Energy Parks Setup

The establishment of Ultra Mega Renewable Energy Parks aims to offer land and transmission to RE developers for large-scale installation of renewable energy projects

These large-scale parks in India have significantly boosted economies of scale and attracted foreign capital to the renewable energy sector.

Indian Government's Renewable Energy Initiatives

The Indian government has launched several initiatives, including Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM), Solar Rooftop Phase II, and the 12,000 MW CPSU Scheme Phase II, to promote renewable energy, particularly solar power

The Ministry of New and Renewable Energy's Solar Rooftop Phase II program aims to install 40,000 MW of grid-connected rooftop solar projects by 2026

India's 12,000 MW CPSU Scheme Phase II aims to increase solar power capacity through CPSUs' solar power projects, enhancing India's overall solar power generation strategy

The schemes aim to boost solar energy adoption in India, assisting farmers, residential consumers, and public sector units in transitioning to renewable energy sources for energy security and sustainability

Permitting upto 100% FDI via Automatic Route

The government allows 100% FDI without government approval in India's solar energy sector, aiming to attract significant investments for energy security and sustainability.

This move is also aimed at boosting economic growth, achieve energy security, and strengthen its solar energy capabilities

Measures Taken to Promote Renewable Energy in the Country (2/3)

Green Energy Corridor Scheme

India is promoting renewable energy, particularly solar, through the Green Energy Corridor scheme, which involves the construction of new transmission lines and substations to transport renewable power from resource-rich areas

India's Green Energy Corridor project aims to boost renewable energy capacity, particularly solar and wind, to achieve ambitious targets and ensure stable power supply by establishing a robust transmission infrastructure

Solar Photovoltaic System Deployment Standards:

The Bureau of Indian Standards (BIS) has set standards for solar photovoltaic systems and components to guarantee their quality and safety

Project Development Cell Setup

India has established Project Development Cells (PDCs) to promote renewable energy, particularly solar energy, by facilitating investments in various sectors

PDCs in India aim to facilitate $121 billion investments across renewable energy sectors, collaborating with investors, state governments, and stakeholders to streamline the investment process

Establishment of Tariff-Based Competitive Bidding Guidelines

The Ministry of Power and CERC in India have established Standard Bidding Guidelines for Tariff-Based Competitive Bidding Process for grid-connected solar and wind projects, promoting private sector participation

The Standard Bidding Guidelines are crucial for transparent and efficient procurement of power from grid-connected solar PV and wind projects through tariff-based competitive bidding processes

Government Orders Power Dispatches to RE Generators

The government has ordered power dispatch to RE generators based on Letter of Credit (LC) or advance payment to ensure timely payment by distribution licensees

Measures Taken to Promote Renewable Energy in the Country (3/3)

Green Energy Open Access Rules 2022

The Indian government has announced the Green Energy Open Access Rules, 2022, aimed at promoting renewable energy generation, purchase, and consumption, in line with its 2030 emissions reduction goal

The Ministry of Power has partnered with Grid Controller of India Limited to manage the Green Open Access Registry portal, promoting transparency and efficiency in green energy applications

Notification of LPS Rules on Electricity

The Indian Ministry of Power has notified the Electricity (Late Payment Surcharge and Related Matters) Rules, 2022, to address late payments in the electricity sector

The rules aim to ensure timely payments and financial stability in the Indian electricity sector, enhancing service delivery and reliability for consumers

Green Term Ahead Market Launch

India launched the Green Term Ahead Market (GTAM) in September 2020, enhancing the renewable energy sector by facilitating short-term trading without long-term Power Purchase Agreements (PPAs), allowing more flexible and efficient output sales

GTAM expands renewable energy markets, promoting capacity development beyond Renewable Purchase Obligations (RPOs), while offering competitive pricing and transparent procurement processes for buyers and sellers in the renewable energy sector

National Green Hydrogen Mission Approved

The Indian government approved the National Green Hydrogen Mission in January 2023, investing Rs. 19,744 crore to establish India as a global hub for green hydrogen production and export, thereby enhancing renewable energy capacity, including solar

India Approves Green Energy Corridor Phase-II for Renewable Energy Project in Ladakh

- The Union Cabinet of India has approved the Green Energy Corridor Phase-II – Inter-State Transmission System for a 13 GW renewable energy project in Ladakh, with the central government providing financial assistance covering 40% of the estimated cost of ₹20,773.70 crore
    - **Implementation Agency**: The Power Grid Corporation of India Limited (POWERGRID) will manage the project in Ladakh, considering the region's challenging terrain and climatic conditions
    - **Infrastructure:** The project aims to construct 713 km of transmission lines, including a 480 km High Voltage Direct Current line, and establish two 5 GW terminals in Ladakh and Haryana
    - **Power Transmission:** Power generated will be transmitted through Himachal Pradesh and Punjab, integrating with the national grid at Kaithal, and interconnected to the Ladakh grid in Leh for reliable supply and connection to Jammu and Kashmir.
    - **Strategic Importance:** India aims to achieve 500 GW of non-fossil fuel electricity capacity by 2030, enhancing energy security, reducing carbon emissions, and creating employment opportunities for local communities

India's Clean Energy Investment Surge

India's clean energy investments have surged in the past three years, driven by ambitious goals to increase renewable energy capacity and decrease carbon emissions

- **Clean energy investment** reached a record $68 bn in 2023, a 40% increase from the 2016-2020 average
- The majority of the investment was allocated to low-emissions power generation, primarily solar PV
- India aims to double clean energy investment by 2030, but requires a 20% increase to achieve its energy and climate goals
- Renewable energy investments are projected to increase by 83% to approximately $16.5 bn in 2024
- India aims to achieve 500 GW of renewable energy capacity by 2030, which accounts for over 40% of its incremental electricity generation
- The **installed solar energy capacity** has grown by 300% in the past 9 years, reaching 89.4 GW as of August 2024
- **India's installed non-fossil fuel capacity** has grown by 396% over the past 8.5 years, now accounting for 46% of the country's total capacity
- India's ambitious targets to reduce carbon emissions and expand renewable energy are driving a surge in clean energy investment

Future Investment Projections

- India is projected to attract $370 billion in renewable energy sector investments by 2030, crucial for achieving 500 GW of capacity
- The Economic Survey emphasizes the need for significant financial mobilization and resolution of land acquisition issues to achieve these ambitious objectives
- The Indian government's proactive approach, including favourable policies, financial incentives, and infrastructure development, makes the country an attractive investment destination for renewable energy

Policy and Regulatory Framework

National targets for renewable energy capacity

India has set ambitious national targets for renewable energy capacity as part of its commitment to sustainable development and climate change mitigation.

Key Renewable Energy Targets

- **500 GW by 2030:** India aims to achieve 500 GW of renewable energy capacity by 2030, aiming for 50% of its total electricity generation from non-fossil fuel sources
- **Net-Zero Emissions by 2070:** India aims to achieve net-zero carbon emissions by 2070, demonstrating a long-term commitment to transitioning towards greener energy sources
- **Annual Capacity Additions:** India plans to increase renewable energy capacity by 44 GW annually, primarily solar and wind, to meet the 500 GW target, requiring up to $385 bn in investment
- **Green Hydrogen Production:** India aims to produce 5 mn tonnes of green hydrogen by 2030, supported by an additional 125 GW of renewable energy capacity

Specific Initiatives and Policies

- **Solar Parks and Projects:** The government has approved 50 solar parks with a combined capacity of 37.49 GW, along with significant projects like the Jawaharlal Nehru National Solar Mission for extensive solar capacity development
- **Offshore Wind Energy:** India aims to install 30 GW of offshore wind energy by 2030, promoting the use of marine resources for renewable energy
- **Carbon Credits and Trading:** The country is exploring the use of carbon credits for renewable energy projects, such as solar thermal power and offshore wind, as part of its international climate agreement commitments

Government Incentives for Investment in Renewable Technologies

The Indian government is promoting renewable energy through financial incentives, policy frameworks, and research, aiming to achieve clean energy targets, address environmental concerns, and promote economic growth

Financial Incentives

- **Central Financial Assistance (CFA):** The Central Financial Assistance (CFA) offers up to 40% for solar capacity installations up to 3 kWp, and up to 20% for capacities beyond 3 kWp and up to 10 kWp
- **Production Linked Incentive (PLI) Scheme:** The Production Linked Incentive Scheme, with an outlay of Rs. 24,000 crore, aims to boost domestic manufacturing of high-efficiency solar PV modules by rewarding manufacturers based on production and sales over five years
- **Subsidies for Solar Pumps:** The North East and Union Territories are receiving a 30% subsidy on stand-alone solar pumps, with an additional 50% support
- **Green Energy Corridor Scheme:** The scheme offers a 40% CFA for developing intra-state transmission systems for renewable energy projects, enhancing grid integration
- **Biomass and Waste-to-Energy Programs:** The maximum CFA for biomass initiatives is Rs. 5 crore per project, promoting sustainable energy from waste sources.

Policy Support and Regulatory Framework

- **National Solar Mission:** The initiative aims to boost solar energy development through financial incentives, subsidies, and policy support, with ambitious capacity addition targets
- **Renewable Purchase Obligations (RPO):** The Renewable Purchase Obligations (RPO) mandate that state electricity distribution companies must allocate a specific percentage of their power to renewable sources
- **Tax Incentives:** The government provides tax incentives like accelerated depreciation and income tax exemptions to encourage investments in renewable energy projects

Research and Development

- **Renewable Energy Research and Technology Development Programme:** The program offers financial support of up to 100% for government/non-profit research organizations and 50-70% for start-ups and private entities involved in renewable technology development
- **Collaboration with State-Owned Enterprises (SOEs):** The government is encouraging SOEs to prioritize investments in renewable energy projects, aiming to reduce carbon emissions and enhance sustainability

Challenges in India's Renewable Energy Sector…… (1/3)

High initial costs and lack of skilled workforce

Renewable energy projects face significant hurdles due to high initial costs, capital costs, and inadequate debt financing. This makes renewable energy appear riskier to investors compared to conventional fossil fuel plants. India needs to find ways to reduce these costs and make renewable energy more financially viable for investors

Lack of Skilled Workforce

The shortage of skilled workforce for renewable energy infrastructure is a significant challenge, hindering the rapid deployment of clean energy technologies. Inadequate training facilities and limited indigenous manufacturing capabilities exacerbate this issue. Bridging this skill gap through targeted education and vocational programs is crucial for the renewable energy sector's growth

Significant Financial Risk

The financial health of power distribution companies (DISCOMs) is significantly impacted by debt issues and potential delays, thereby increasing the overall risk for renewable energy projects. Energy dispersing organizations face financial uncertainty, debt, and infrastructure challenges, causing postponed instalments and increasing risks for renewable energy projects. However, with advancements and better coordination between public and private partners, India can overcome these obstacles

Insufficient Infrastructure

India's aging power transmission infrastructure is causing grid overload, congestion, inefficiencies, and blackout risks. Lack of modern smart technologies exacerbates these issues

The insufficient infrastructure in renewable energy projects hinders efficiency, leading to delays in obtaining permits and building infrastructure, extending project timelines and reducing profitability

Renewable Energy Integration

As the country transitions towards a sustainable energy model, integrating renewable energy sources and improving storage capabilities is crucial for reliability and efficiency

India's renewable energy investment aims for 500 GW by 2030, but intermittent sources like solar and wind pose grid integration challenges. Advanced forecasting techniques and improved grid infrastructure are needed to address these issues

Challenges in India's Renewable Energy Sector…… (2/3)

Energy Storage Solutions

India's increasing reliance on renewable energy necessitates energy storage solutions to manage fluctuations, but financial viability remains a concern due to high initial investments and perceived risks

Variability and Intermittency

Renewable energy sources like solar and wind face variability due to weather conditions, necessitating robust energy storage systems and grid infrastructure to effectively manage these fluctuations

Policy Uncertainty

Inconsistent policies and regulatory hurdles can create an uncertain investment environment, deterring private sector involvement and complicating long-term planning for renewable energy projects

Complex Permitting Processes

Bureaucratic red tape can hinder project implementation and make it challenging for developers to efficiently navigate the regulatory landscape

Limited Understanding Among Investors

Many investors lack a comprehensive understanding of renewable energy, viewing it as a non-traditional investment, which can result in hesitance in investing in renewable projects

Challenges in India's Renewable Energy Sector…… (3/3)

Public Awareness

The lack of education on renewable energy technologies, especially in rural areas, is a significant barrier to its widespread adoption

Access to Raw Materials

The renewable energy sector's reliance on rare earth metals, which may face supply shortages, could significantly impact the manufacturing of renewable energy technologies

Land Use Conflicts

Large-scale renewable energy projects, like solar parks, can cause land use conflicts, impact agricultural production, and raise food security concerns due to land conversion

Outlook

India's Renewable Energy Sector Growth	• India's renewable energy sector is expected to grow due to government initiatives, investment opportunities, and commitment to reducing carbon emissions, with a goal of 50% renewable electricity capacity by 2030
Rapid growth in solar and wind power	• India's renewable energy sector is rapidly evolving, with solar and wind power being key contributors to its ambitious energy goals
India's Solar Energy Growth	• India's solar energy capacity has surged from 100 MW in 2010 to over 87 GW by mid-2024, thanks to government policies, international investments, and technological advancements, positioning the country as a global leader
India's Solar Energy Enhancement Strategy	• India is well-positioned to enhance its solar energy capabilities and achieve its ambitious renewable energy targets through various supportive policies and initiatives
India's 2030 Non-Fossil Fuel Electricity Goals	• India aims to achieve 500 GW of non-fossil fuel electricity capacity by 2030, requiring significant transmission network enhancements and successful implementation of the Global Energy Convention
India's Role in Clean Technology Manufacturing	• India's policy ecosystem, manufacturing clusters, and unique skill set enable it to play a crucial role in clean technology manufacturing, aiming for secure, affordable, and sustainable energy by 2047

Outlook

India's Solar Power Sector Crucial for economic development	• India's solar power sector, with potential of 7,48,990 MW, is crucial for economic development and energy transition, fostering job creation and innovation
India's Rapid Economic Growth and Renewable Energy Transition	• India's rapid economic growth and projected electricity demand over 400 GW by 2030 make transitioning to renewable energy a strategic necessity and economic opportunity. With projected growth in installed capacity to 170 GW by March 2025, India's commitment to renewable energy generation, substantial investments, and supportive policies positions it as a leader in sustainable energy solutions
Global Nuclear Power Generation Predicted to reach record high by 2025	• The International Energy Agency predicts a 3% annual average growth in global nuclear power generation by 2026, reaching a new record high by 2025
Nuclear Output Predictions	• Nuclear output is predicted to surpass 2021's record due to increased France output, restarted plants in Japan, and the commencement of new reactors in China, India, South Korea, and Europe
Asia's Nuclear Potential	• Asia is expected to contribute 30% of global nuclear generation by 2026, with an additional 29 GW of new nuclear capacity expected to be operational between 2024 and 2026
COP28 Countries Pledged to Triple Nuclear Power Capacity	• Over 20 COP28 countries pledged to triple nuclear power capacity by 2050, adding 740 GW to the current 370 GW

Solar Energy Sector

Industry Scenario: Solar Energy

- India ranks 5th globally in solar PV deployment, with installed capacity reaching 70.10 GW as of 30th July 2023

India's Solar Energy Growth

- India's solar energy capacity has experienced significant growth since the 2010 launch of the National Solar Mission. From **2009-2010,** India's National Solar Mission (NSM) aimed to generate 20 GW of solar power capacity by 2022, despite India's current solar capacity being only a few hundred megawatts
- In **2020,** solar capacity increased significantly to 36 GW, with the Bhadla Solar Park becoming the world's largest, generating 2,245 MW. In **2021**, India ranked fourth globally in solar power capacity, with installed capacity exceeding 50 GW. India's solar capacity reached 70.10 GW by the end of **2022,** solidifying its position as a leading global player in the solar industry

Significant Milestones

- **2010-2019:** India invested $20.7 bn in solar projects between 2010-2019, resulting in significant growth in installed capacity due to government initiatives and reduced technology costs

Current Capacity and Growth

- **Installed Capacity:** India's solar energy capacity has increased by 30 times since 2014, reaching 89.43 GW as of August 2024
- **Future Targets:** The Indian government plans to build 280 GW of solar capacity by 2030, with tenders for 40 GW of solar and hybrid projects set for FY2023-2027
- **Potential:** India's favorable climate, with approximately 300 sunny days per year, is estimated to have a solar potential of around 748 GW, according to the National Institute of Solar Energy

Recent Growth and Future Targets

- In early 2023, the installed solar capacity reached 64,380 MW, a 197% increase from 21,651 MW five years ago, with the government aiming for 500 GW of non-fossil fuel capacity by 2030. In July 2024, the installed solar capacity reached 87.21 GW AC, with government schemes and initiatives promoting solar energy to further expand capacity
- The Indian government has installed 64,380 MW of solar projects, a 197% increase from 21,651 MW in the last five years
- The country aims to achieve 500 GW of installed capacity from non-fossil fuels by 2030, including around 270 GW of solar capacity. Maharashtra has 3772 MW of solar projects, providing electricity generation and local employment

Rooftop Solar Initiatives: The rooftop solar (RTS) segment experienced a 2.99 GW increase in 2023-2024, reaching 11.87 GW. The government aims to reach 100 GW by 2030 to meet the 500 GW renewable energy capacity target

Key Government Initiatives to Boost Solar Power Adoption in India

National Solar Mission (NSM)

- The National Solar Mission (NSM), launched in 2010, aims to establish India as a global leader in solar energy, promoting technology diffusion and enhancing energy security
- Initially set with a target of 20 GW of solar capacity by 2022, the government revised its solar capacity target to 100 GW in 2015, aiming to increase renewable energy capacity and decrease carbon emissions

PM-KUSUM Scheme

- PM-KUSUM scheme aims to increase solar energy use in agriculture by 2026, installing decentralized solar power plants and replacing diesel pumps with solar-powered ones

PM Surya Ghar Muft Bijli Yojana

- The initiative, launched in February 2024, aims to install rooftop solar panels in 1 crore households, providing up to 300 units of free electricity per month

Production-Linked Incentive (PLI) Scheme

- The PLI scheme aims to boost domestic manufacturing of high-efficiency solar PV modules, with a financial outlay of Rs 24,000 Crore, reducing import dependence

Solar Park Scheme

- The government plans to establish 50 large-scale solar parks across the country with a combined capacity of around 39.28 GW, providing infrastructure and support to facilitate solar project development

Financial Support and Subsidies

- The government offers financial incentives, such as subsidies for rooftop installations and tax incentives for manufacturers, to boost solar project investments and improve consumer affordability

Skill Development Programs

- The Suryamitra Skill Development Programme aims to train individuals in solar technology installation and maintenance, fostering a skilled workforce to support the growing demand

Net Metering Policies

- The government has implemented net metering policies to make solar energy more economically appealing by enabling residential and commercial users to sell surplus power back to the grid

Primary Factors Driving the Growth of Solar Energy Sector in India

India's solar energy sector is experiencing significant growth due to government policies, technological advancements, economic factors, and environmental awareness, contributing to its overall development, with a goal of 280 GW of solar installations by 2030, shaping its energy landscape

Government Policies and Initiatives

- **National Solar Mission:** The National Solar Mission, part of India's Climate Change Action Plan, aims to boost solar energy development and investment through ambitious capacity targets
- **Incentives and Subsidies:** The Indian government provides financial incentives, such as subsidies and tax benefits, to boost solar sector growth and make solar energy more affordable for consumers and businesses
- India has successfully implemented net metering policies across various states, enabling consumers with rooftop solar systems to receive credits on their electricity bills
- **Net-Metering Policies:** Net-Metering policies have revolutionized rooftop solar installations enabling consumers to use their rooftop solar system's electricity and export surplus to the grid, with the consumer being billed for the net electricity consumed, thereby promoting the adoption of solar technologies

Technological Advancements

- **Improved Solar Panel Efficiency**: Advancements in photovoltaic technology have improved solar panel efficiency, reducing the cost per watt of solar energy, making it more appealing to consumers
- **Cost Reduction:** Solar panels' decreasing prices, driven by manufacturing advancements and increased competition, have made solar energy more accessible, making it comparable to fossil fuels
- **Utility-Scale Projects:** Large-scale solar projects have led to economies of scale, reducing costs and increasing the country's solar energy generation capacity

Economic Factors

- **Rising Electricity Demand:** India's growing population and industrialization are driving an increase in electricity demand, making solar energy a crucial sustainable solution
- **Job Creation:** The solar sector is generating numerous job opportunities in manufacturing, installation, and maintenance, thereby boosting economic growth and promoting rural electrification
  - India's solar and wind energy sectors saw a 47% increase in employment in FY'22, with 164,000 workers employed, primarily in project development roles, with 99% of the new workforce absorbed by solar energy
  - The solar sector, accounting for 84% of the workforce, added 52,100 new jobs in FY'22, an eight-fold increase from FY'21
  - The report by Council on Energy, Environment and Water (CEEW), Natural Resources Defense Council India (NRDC India), and the Skill Council for Green Jobs (SCGJ) shows that 84% of India's workforce is engaged in solar energy, indicating potential for 3.4 million jobs in the expansion of solar and wind capacities by 2030

Environmental Awareness

- **Climate Change Mitigation:** The growing awareness of climate change and environmental issues is driving a strong push towards renewable energy sources like solar power, supported by both the government and the public
- **Health Benefits:** Solar energy offers significant health benefits by reducing pollution, improving air quality, and promoting public health, which drives its widespread adoption

Wind Energy Sector

Wind Energy: Overview

- India's wind energy sector, ranking fourth globally, contributes to 10% of the country's utility power generation capacity, with an installed wind power capacity of 47.07 GW as of March 2023
- India has a wind turbine manufacturing capacity of 15,000 MW, with major global players and Indian companies utilizing joint ventures, subsidiaries, and their own technology
- India is a significant wind turbine manufacturing hub, hosting 17 global companies and producing critical components like towers and gearboxes
- The Indian government aims for 500 GW of renewable energy by 2030, with 140 GW from wind power, indicating substantial growth potential in the sector
- Gujarat, Tamil Nadu, Karnataka, and Rajasthan are the primary states contributing to the identified potential, holding approximately 676.55 GW of the resources
- Wind power generated 71.814 TWh in fiscal year 2022-23, accounting for 4.43% of total electricity generation
- India had an installed wind power capacity of 45.887 GW as of March 31, 2024, making it the 4th largest global wind power market
- The government has installed over 900 wind monitoring stations through the National Institute of Wind Energy (NIWE) to evaluate the wind potential
- The Indian offshore wind market is anticipated to grow significantly, with annual installations expected to rise from 1.8 GW in 2022 to 5 GW in 2025
- India's wind power manufacturing sector has experienced significant growth, with 70-80% indigenization achieved

Key Players

The Indian wind power manufacturing ecosystem comprises a blend of domestic and international companies.

- Suzlon Energy Ltd
- Siemens Gamesa Renewable Power
- GE India Industrial Pvt. Ltd.
- Vestas India
- Regen Powertech

These companies are involved in various aspects of wind turbine production, including assembly and component manufacturing.

Key Wind Power States in India

Wind Power Potential Assessment

- The National Institute of Wind Energy (NIWE) has installed over 900 wind-monitoring stations across the country, indicating a gross wind power potential of 695.50 at 120 meters and 1163.9 GW at 150 meters, primarily in eight windy states
- Gujarat, India's top wind energy state, boasts a wind potential of 142.56 GW at 120 meters, significantly contributing to India's overall capacity
- Rajasthan, second in line, has achieved significant capacity additions, boasting potential of 127.75 GW at 120 meters
- Karnataka, with a wind energy potential of 124.15 GW at 120 meters, is a significant player in the sector. Maharashtra, India's wind energy hub, boasts a potential of 98.21 GW at 120 meters while Tamil Nadu, a wind energy leader, boasts a potential of 68.75 GW at 120 meters
- India's wind energy capacity is substantial but still lags behind top three nations, despite robust growth trajectory supported by government initiatives and investments in renewable energy infrastructure

State	Wind Potential at 120 m (GW)	Wind Potential at 150 m (GW)
Andhra Pradesh	74.9	123.3
Gujarat	142.56	180.8
Karnataka	124.15	169.3
Madhya Pradesh	15.4	55.4
Maharashtra	98.21	173.9
Rajasthan	127.75	284.2
Tamil Nadu	68.75	95.1
Telangana	24.83	54.7
Total 8 windy states	**676.55**	**1136.7**
Others	18.95	27.1
Total	**695.5**	**1163.9**

Major Wind Energy Producing Countries in 2023

Rank	Country	Installed Wind Turbine Capacity in 2023* (Megawatts)
1	China	4,41,895
2	United States	1,48,020
3	Germany	69,459
4	India	44,736
5	Spain	31,028
6	United Kingdom	30,215
7	Brazil	29,135
8	France	22,196
9	Canada	16,989
10	Sweden	16,252
11	Italy	12,308
12	Turkey	11,697
13	Australia	11,327
14	Netherlands	10,749
15	Poland	9,307

- China leads globally in wind energy, with approximately 442,000 MW installed capacity, boosted by government investments and carbon emission reduction policies
- The United States the second-largest wind energy producer with installed capacity of around 148,020 MW, has experienced significant growth in wind energy, particularly in offshore projects, thanks to government incentives and a diverse production landscape
- Germany, ranking third with 69,459 MW, is a dominant player in the wind energy sector, primarily focusing on onshore installations
- India ranks fourth in wind energy production with an installed capacity of 44,736 MW, bolstered by various initiatives and investments

Wind Energy Impact on India's Renewable Energy Goals

India's wind energy sector significantly influences its renewable energy targets, playing a crucial role in achieving its ambitious climate goals

Contribution to Renewable Energy Capacity

- India aims to install 140 GW of wind energy capacity by 2030, contributing 10% of its total installed utility power generation capacity, with 47 GW operational as of early 2024

Economic and Environmental Benefits

- Wind energy's sustainability and cost-effectiveness make it competitive with fossil fuels, attracting investments and creating millions of jobs by 2030
- India's Renewable Purchase Obligations (RPO) mandate a growing percentage of electricity generation from renewable sources, incentivizing wind energy development to achieve net-zero emissions by 2070

Potential and Growth Drivers; Major Drivers Behind India’s Renewable Energy Growth

- India has a gross wind power potential of 695.50 GW at 120 meters above ground level, primarily in Gujarat, Tamil Nadu, Andhra Pradesh, Karnataka, and Rajasthan
- The government is promoting wind power projects through various fiscal and financial incentives, such as accelerated depreciation, concessional custom duty exemptions, and generation-based incentives
- The wind industry's growth is primarily driven by energy security, self-sufficiency, and the need to combat climate change
- **Increasing Electricity Demand:** India's growing economy is driving a shift towards renewable energy sources, driven by a projected electricity demand exceeding 400 GW by 2030
- **Government Policies and Incentives:** The Indian government has implemented various measures to enhance domestic manufacturing and project development in the wind energy sector
  - **Financial Incentives:** The government is implementing custom duty exemptions on critical components and waivers for transmission charges for projects commissioned by mid-2025
  - **Renewable Purchase Obligations (RPO)** mandate state utilities to purchase a certain percentage of their power from renewable sources, thereby increasing market demand
  - The promotion of wind-solar **hybrid projects** aims to enhance resource efficiency and optimize resource use
- **Technological Advancements:** The wind industry is undergoing technological advancements, focusing on larger, more efficient turbines and offshore wind projects, particularly in Gujarat and Tamil Nadu, to enhance energy capture and reduce costs
- **Investment Trends:** India's renewable energy sector has attracted over $14 billion in FDI from 2000-23, with a projected 8% CAGR growth over the next decade. The sector is expected to experience a CAGR of over 8% over the next decade
- **Domestic Manufacturing Capacity:** India is enhancing its domestic manufacturing capacity for wind turbine components, with initiatives like ‘Make in India’ aiming to further enhance its global supply chain competitiveness
- **Focus on Energy Security:** India aims to reduce global energy price volatility and enhance domestic energy production by increasing non-fossil fuels' share in its energy mix from 32.30% in 2014 to 45.54% in 2024
- **Regional Renewable Energy Hubs:** Rajasthan, Gujarat, Karnataka, and Tamil Nadu are key renewable energy project hubs due to favourable geographic conditions and government support initiatives, facilitating project implementation and capacity growth

Government Policies and Initiatives – India's Wind Energy

India has implemented several key policies and initiatives to promote wind energy growth, demonstrating its commitment to renewable energy and environmental sustainability

The Indian government has introduced fiscal incentives like accelerated depreciation benefits and customs duty exemptions to boost wind energy

- Tariff-based competitive bidding guidelines have been established to streamline procurement processes and encourage private investment in wind projects
- The government has waived inter-state transmission system charges for projects commissioned by mid-2025 and established over 900 wind-monitoring stations nationwide to efficiently assess wind resources
- The government is encouraging wind power projects through private sector investment, offering incentives like Accelerated Depreciation benefit, concessional custom duty exemption, and Generation Based Incentive Scheme
- The government is addressing obstacles in wind energy growth by enhancing stakeholder coordination and creating consistent demand to ensure effective targets are met
- The **National Offshore Wind Energy Policy,** introduced in 2015, promotes offshore wind energy projects in India, establishing guidelines for resource assessment, project development, and regulatory frameworks
- The **Wind Renewable Purchase Obligation** mandates utilities to purchase a specific percentage of their energy from wind sources, ensuring a guaranteed market for wind energy producers
- The **Solar-Wind Hybrid Policy** promotes the integration of solar and wind power projects, aiming to optimize land use and enhance energy generation efficiency
- **Generation Based Incentive (GBI):** The GBI scheme offers financial support based on the electricity generated by wind projects, making investments in wind energy more appealing
- **Custom Duty Exemptions:** The government has granted concessional custom duty exemptions on wind turbine manufacturing components, thereby reducing project costs and promoting domestic manufacturing
- **Central Financial Assistance (CFA)** schemes provide funding for renewable energy projects, particularly for small wind and hybrid systems

India's Wind Energy Sector Challenges

India's wind energy sector faces numerous challenges that hinder its growth and potential, including:

- The wind sector faces challenges like fluctuating capacity utilization factors (CUF), which averaged around 18% in 2022-23, below the minimum requirement of 30% for wind potential assessment
- The shift from feed-in tariffs to competitive bidding has resulted in project installation volatility due to aggressive bidding practices, potentially compromising project viability
- India's wind energy sector faces complex land acquisition challenges, including inflated prices, farmer resistance, and site access obstacles, making the process time-consuming and challenging
- Right-of-way (ROW) issues are common in large wind projects, causing delays in completion due to construction challenges, logistics, and transmission lines
- **Technological and Manufacturing Challenges:** The wind turbine industry faces technological and manufacturing challenges due to a lack of local manufacturing, outdated technology, and the need for skilled labour for installation and maintenance
- **Financial Viability:** The financial viability of wind energy projects is a concern, despite government support, due to market fluctuations, rising commodity prices, and delayed payments from power distribution companies
- India's wind energy sector faces significant challenges due to insufficient grid connectivity and transmission infrastructure
    - Wind energy's intermittent nature hinders grid integration, causing economic viability issues. Inadequate transmission infrastructure and improved power evacuation infrastructure are needed for new developments
    - Wind power curtailment in windy states due to limited transmission capacity, inadequate infrastructure, grid connectivity issues, and weak financial conditions of distribution companies causing delayed payments
    - To address these challenges, the government should improve agency coordination, expand transmission network for wind capacity additions, and establish regional cooperation mechanisms to effectively manage power exchange challenges
- Technological challenges include the absence of suitable wind turbines and components, the need for specialized skills, and the insufficient financing for innovative technologies
- **Policy Uncertainty:** Inconsistent government policies and regulatory frameworks, causing uncertainty and deterring long-term investments in wind energy projects from investors and developers
- Rising interest rates and commodity prices have exacerbated the cost of capital for renewable projects, potentially deterring investment compared to more cost-competitive solar projects
- The decreasing cost of solar power is widening the gap with wind energy. Solar costs have significantly decreased between 2010 and 2019, compared to wind energy, making solar more attractive due to advancements in technology and economies of scale, thus causing delays in signing power purchase agreements for auctioned wind projects
    - Though India's wind energy sector has made significant strides in reducing costs, it faces challenges such as declining solar prices, rising investment costs, integration issues, and competition from fossil fuels

Outlook

- The wind energy sector is crucial for India's renewable energy targets, contributing to economic growth, job creation, and environmental sustainability through proactive policies and ambitious targets

- The Indian wind energy market is expected to grow significantly, with projections of 21.2 GW installed by 2027 and potential for 26.2 GW if market conditions improve

- India's wind energy sector holds significant growth potential and supportive frameworks, which can enhance its global leadership in renewable energy production and contribute to its sustainability goals

- India's wind power capacity is projected to increase from 45.887 GW in March 2024 to 70 GW by 2028. India plans to significantly boost its wind energy capacity, adding nearly 25 GW between 2025 and 2028, driven by the growing demand for renewable energy for grid stability

Hydro Energy Sector

Hydro Energy Sector: Overview

- The Ministry of Power primarily manages India's hydro energy sector, which is a crucial part of the country's renewable energy landscape
- India's installed hydropower capacity, as of early 2024, is around 46.92 GW, encompassing both large and smaller projects
- The government plans to increase renewable energy capacity by 50% by 2031-32, ensuring stability and integration into the grid

Strategic Importance

- India's climate strategy focuses on reducing emissions intensity by 45% from 2005 levels by 2030 and ensuring 50% of installed power capacity comes from non-fossil sources
- Pumped storage projects (PSPs), similar to water batteries, are gaining popularity, with capacity expected to rise significantly from 4.7 GW to 55 GW by 2031-42

Government Initiatives:

- The Indian government is enhancing hydropower infrastructure in north-eastern states, with 15 GW projects under construction and plans to support state investments in this sector
- The Ministry of Power emphasizes the significance of favourable climatic conditions, including good monsoons and snowmelt from the Himalayas, in enhancing water reservoir levels and supporting hydropower generation

Capacity Expansion

- Hydroelectric projects under construction with a combined capacity of 15 GW are expected to increase the total hydro capacity from 42 GW to 67 GW by 2031-42
- Pumped Storage Projects (PSPs), crucial for energy storage and grid stability, are expected to increase from 4.7 GW to approximately 55 GW within the same timeframe

Small hydro projects, with a capacity of 25 MW or less, are cost-effective and environmentally friendly, using natural water flows or reservoir storage methods

In contrast, Large hydro projects exceeding 25 MW generate substantial electricity but face criticism for their environmental and social impacts, including dams that can lead to significant environmental and social impacts

Hydro Energy Sector: Overview

Impact of Climate Events

- Hydro power generation faced challenges in 2023-24 due to natural disasters, particularly flash floods in Himachal Pradesh and Eastern India, disrupting operations at several power stations
- Rainfall patterns have impacted generation, but predictions for improved monsoon conditions could potentially help replenish reservoir capacities in the future

Hydropower's Role in Energy Transition

- Hydropower is recognized for its capacity to provide peak electricity grid support, especially as India shifts towards solar and wind energy reliance
- India's transition aligns with its international climate agreements commitments to reduce emissions and increase non-fossil fuel sources in its energy mix

Classification and Potential

- India's hydropower projects are categorized into large and small, with potential for small projects estimated at 21,133 MW across states, particularly in hilly regions

Challenges and Opportunities

- Hydropower projects face challenges like geological issues, natural disasters, and regulatory hurdles, slowed capacity additions despite their potential
- The government is actively promoting hydropower as part of its renewable energy strategy, acknowledging its crucial role in achieving energy security and sustainability objectives

India's hydro energy sector faces challenges due to environmental and operational issues, but remains a crucial part of its renewable energy strategy with ambitious growth targets

Key Data and Stats about India's Hydro Energy Sector in 2024

Installed Capacity

- India's installed electricity generation capacity reached 495,199 MW as of March 31, 2023, with utilities accounting for 84.02% of the total
- Renewable energy sources, excluding large hydro, accounted for 27.6% of the total installed capacity, totalling 136,507 MW
- Large hydro projects, exceeding 25 MW, contributed 46,920 MW to the total renewable energy capacity, accounting for 37% of the total

Generation

- In 2022-23, utilities generated 1,415,000 GWh of electricity, a 10.5% rise from the previous year
- The generation from renewable sources, excluding large hydro, saw a 12.2% increase over 2021-22, reaching 173,000 GWh
- Large hydro projects saw a 2.5% increase in generation of 122,000 GWh compared to the previous year.

Growth Plans

- India aims to achieve 500 GW of non-fossil fuel-based electricity capacity by 2030, with a significant hydro contribution
- The government has set a 50% increase in hydro capacity target to 67 GW by 2031-32, up from the current 46.9 GW
- Pumped Storage Projects (PSPs) are gaining prominence, with 2.7 GW under construction and 50 GW in various stages of development.

Investment

- India's clean energy investments reached $68 bn in 2023, with nearly half devoted to low-emissions power generation, including hydro
- The spending on fossil fuels increased by 6% from 2016-2020 to reach $33 bn in 2023 due to increasing demand

Hydro generation has declined due to lower rainfall and natural disasters, but remains crucial for grid reliability. Government's focus on renewable energy and ambitious growth plans for hydro are promising

Biomass and Bioenergy Sector

Overview of the Biomass and Bioenergy Sector

- India's biomass and bioenergy sector is a crucial part of its renewable energy strategy, aiming to achieve sustainability and decrease reliance on fossil fuels
- The country, a major global producer of biomass energy, has significant potential due to its vast agricultural resources and high population density
- India's biomass and bioenergy sector, utilizing abundant biomass resources and growing demand for sustainable energy solutions, is transforming the country's renewable energy landscape

Current Status and Potential

- **Installed Capacity:** India's biomass power has a cumulative installed capacity of 10,232 MW, with Maharashtra and Uttar Pradesh being key players in its energy production
- India's installed biomass power generation capacity, at 10,248 MW as of May 31, 2023, accounts for 2.5% of the country's total electricity generation capacity
- The capacity encompasses various methods of biomass utilization, including biomass co-generation and waste-to-energy projects
- The Indian government has introduced a revised Biomass Policy, aiming to increase biomass co-firing in thermal power plants from 5% to 7% by 2025-26
- As of May 2023, 47 thermal power plants have successfully integrated agro-residue-based biomass pellets into their operations, utilizing around 164,976 metric tonnes of biomass
- **Biomass Co-Firing:** The Ministry of Power has introduced a 5% biomass co-firing in thermal power plants from FY 2024-25, increasing to 7% from FY 2025-26 to combat stubble burning.
- **Biomass Utilization:** As of May 2023, 47 coal-based thermal power plants have co-fired around 164,976 metric tonnes of agro-residue-based biomass, indicating a growing trend towards utilizing agricultural waste for energy production.

The government aims to boost renewable energy usage by achieving 50% of installed electricity capacity from non-fossil sources by 2030 and achieving net zero emissions by 2070

The Indian government is enhancing its biomass energy infrastructure through ongoing projects and policy support, with a focus on reducing emissions and promoting sustainable practices for further investments

India's vast biomass resources, government initiatives, and employment opportunities make it a promising destination for growth in the biomass and bioenergy sector

Key Programs and Initiatives

The Indian government, through the Ministry of New and Renewable Energy (MNRE), has initiated several initiatives to effectively utilize biomass, aiming to decrease reliance on fossil fuels

- **National Bioenergy Programme (2021-2026):** The Ministry of New and Renewable Energy launched the National Bioenergy Programme in November 2022, aiming to use biomass, cattle dung, and urban waste for energy recovery, including biogas, bio-CNG, and biomass power generation

This program includes multiple sub-schemes aimed at promoting bioenergy applications:

  - **National Bioenergy Programme:** The initiative seeks to improve biomass utilization by providing financial support for projects involving biogas, biomass power, and waste-to-energy initiatives
  - The Indian government has initiated the National Bioenergy Programme, with a budget of Rs. 1715 Crore for two phases, from 1st April 2021 to 31st March 2026, to support the establishment of new and efficient biomass energy plants. The first phase, with a budget of Rs. 858 Crore, provides Central financial assistance
  - **Biomass Programme:** The Biomass-based Cogeneration Programme, launched in May 2018, aims to maximize biomass resources in sugar mills and industries. The scheme now supports pellet and briquette manufacturing for power generation, reducing stubble burning in northern states. Central Financial Assistance will be available for projects
    - The **Biogas Programme** promotes the installation of biogas plants for rural energy needs, enhancing clean fuel access for cooking and lighting

- **Waste to Energy Programme:** The initiative focuses on utilizing biogas and bio-CNG production to recover energy from waste from urban, industrial, and agricultural sectors
- **The Biomass Power and Cogeneration Program** aims to enhance biomass resources in industries like sugar mills through cogeneration technology
- The **SATAT Initiative** aims to promote cleaner transportation fuels by focusing on the production of compressed biogas (CBG) from agricultural waste

Financial Incentives

- **Central Financial Assistance (CFA):** The Ministry of New and Renewable Energy (MNRE) offers Central Financial Assistance (CFA) to biomass energy projects, ensuring their economic viability, particularly in rural areas
    - Up to Rs. 4 crore for bio-CNG generation from new biogas plants
    - Rs. 40 lakh per MW for biomass cogeneration projects.
- **Subsidies and Support Programs:** The government has launched the National Bioenergy Programme, a 2021-2026 initiative aimed at converting agricultural and urban waste into energy through biogas production and biomass-based cogeneration
- **GOBARDHAN Scheme:** The GOBARDHAN scheme, funded by the Department of Drinking Water and Sanitation, provides up to Rs. 50 lakh per district for community biogas plants in rural areas, promoting sustainable agricultural practices
- The **SAMARTH Mission** promotes the integration of biomass into coal-fired thermal power plants, aiming to increase energy diversity and decrease carbon emissions from traditional power sources
- **State-Level Initiatives:** Uttar Pradesh State has introduced the Uttar Pradesh Bio Energy Policy 2022, offering financial support of up to Rs. 20 crore for the establishment of compressed biogas, biodiesel, and bio-coal production plants, along with subsidies for equipment procurement
- **Additional Support Measures:** The government has allocated Rs. 50 crore for biomass pellet plant establishment and introduced tax relief measures for compressed biogas blending with natural gas, boosting bioenergy projects' economic viability

Economic and Environmental Benefits

The transition to bioenergy offers numerous advantages, including the potential to harness biomass for energy production

- **Reduction in Fossil Fuel Dependence:** India can reduce its dependence on imported fossil fuels by utilizing local biomass resources
- **Job Creation:** The bioenergy sector's growth has the potential to create job opportunities in rural areas
- **Environmental Impact:** Biomass is a sustainable alternative to traditional fossil fuels, as it helps reduce air pollution and greenhouse gas emissions

Challenges Facing the Sector

The biomass sector in India, despite its potential, is grappling with numerous challenges.

- **Supply Chain Issues:** The project's viability may be hindered by inconsistent availability and rising feedstock costs
- **Regulatory Framework:** The regulatory framework requires clearer policies and effective financing mechanisms to support biomass projects
- **Technical Capacity:** The efficiency of biomass energy production technologies can be significantly enhanced by enhancing technical expertise

India's biomass and bioenergy sector is expected to grow as part of its renewable energy strategy, with government support and environmental sustainability enhancing capacity

India's biomass and bioenergy sector offers sustainable energy development with government support and resources, but challenges must be overcome to fully realize its potential.

State-wise details of Bioenergy plants established in India between FY 2017-18 to FY 2021-22

State	Capacity of Bio-energy plants excluding small Bio-gas plants (MWeq)	No. of small Bio-gas plants
Andhra Pradesh	43.732	11581
Arunachal Pradesh	0	69
Assam	0	9641
Bihar	13.72	254
Chhattisgarh	30.23	6896
Delhi	24	0
Goa	0.34	8
Gujarat	41.31	2454
Haryana	72.91	1965
Himachal Pradesh	0	115
Jammu & Kashmir	0	17
Jharkhand		292
Karnataka	355.308	21279
Kerala	1.6	4208
Madhya Pradesh	10.392	13875
Maharashtra	513.034	33196
Manipur	0	0
Meghalaya	0	667
Mizoram	0	255
Nagaland	0	0
Odisha	0	954
Punjab	68.159	10557
Rajasthan	0	1312
Sikkim	0	0
Tamilnadu	120.29	1202
Telangana	38.74	309
Tripura	0	133
Uttar Pradesh	48.671	1201
Uttarakhand	0.59	3997
West Bengal	1.36	448
Total	**1384.386**	**126885**

State-wise details of Biomass Power and Bagasse/Non-bagasse cogeneration projects installed in India as on date

State	Total installed capacity of Biomass Power, Bagasse Cogeneration and Non-bagasse Cogeneration Plant as on date (MW)
Andhra Pradesh	483.67
Arunachal Pradesh	0
Assam	2
Bihar	124.7
Chhattisgarh	274.59
Delhi	0
Goa	0
Gujarat	77.3
Haryana	240.66
Himachal Pradesh	9.2
Jammu & Kashmir	0
Jharkhand	4.3
Karnataka	1887.3
Kerala	2.27
Madhya Pradesh	107.347
Maharashtra	2584.4
Manipur	0
Meghalaya	13.8
Mizoram	0
Nagaland	0
Odisha	59.22
Punjab	481.15
Rajasthan	121.25
Sikkim	0
Tamilnadu	1012.65
Telangana	160.1
Tripura	0
Uttar Pradesh	2117.26
Uttarakhand	130.22
West Bengal	338.62
Total	**10232.007**

Major Companies in India's Renewable Energy Sector

- India's power generation landscape has significantly transformed, with Central Public Sector Enterprises (CPSEs) playing a crucial role in achieving the country's ambitious renewable energy capacity targets
- India's CPSEs are driving renewable energy agenda with substantial investments, contributing to climate goals and sustainable development through cleaner energy sources

Key Players and Contributions:

Public sector companies in India significantly contribute to India's electricity generation capacity, focusing on renewable energy initiatives and expanding to meet growing energy demands

Key PSU Players	Contributions
NTPC	• NTPC, India's largest energy conglomerate, contributes 25% of the country's total power generation and 17% of the national capacity as of March 2023 • NTPC, India's largest integrated power generator, achieved a record 422 billion units in FY24, aiming for 50% renewable energy by 2032 and significant coal production growth • The company has diversified into renewable energy, including solar and wind projects, with a focus on generating a significant portion of its capacity from non-fossil fuel sources
NTPC Renewable Energy	• A subsidiary of NTPC is focusing on diversifying its energy portfolio by incorporating more renewable sources. NHPC has expanded its renewable energy portfolio beyond hydroelectric power by focusing on solar and wind energy development • NTPC's subsidiary plans to increase renewable energy capacity to 60 GW by 2032, investing heavily in solar park development and hybrid energy projects
National Hydroelectric Power Corporation (NHPC)	• NHPC, India's largest hydropower development organization, is actively pursuing solar and wind energy projects • As of August 31, 2024, NHPC has an installed capacity of 7,144.20 MW, including contributions from joint ventures and subsidiaries. It aims to enhance its capacity significantly through ongoing projects and diversifications
SJVN Limited	• SJVN's portfolio comprises hydro, wind, and solar power projects across various states and neighboring countries like Nepal. The company currently has a portfolio of projects totaling 44,378 MW, with operations extending beyond India into Nepal
North Eastern Electric Power Corporation (NEEPCO):	• NEEPCO is a leading company in hydroelectric power generation, having been involved in significant projects such as the Nathpa Jhakri Hydroelectric Plant. The company has a total installed capacity of 2,092 MW, with ongoing projects across various states
THDC India Limited	• THDCIL is engaged on hydro and thermal power generation, developing significant solar power parks, and enhancing its capacity in renewable energy sectors
Solar Energy Corporation of India (SECI):	• SECI is a key player in India's solar energy promotion, implementing large-scale projects and auctions for solar parks, significantly contributing to the country's solar capacity growth

Major Private Sector Players

The private sector plays a crucial role in India's energy landscape, accounting for 52.8% of the country's total electricity generation.

Private Sector Companies	Contributions
Adani Power	The company is a significant player in thermal power generation, significantly contributing to the overall capacity
Tata Power	Engaged in both thermal and renewable energy generation, with a focus on sustainable practices. Tata Power plans to allocate 45% of its capital expenditure from FY23 to FY27 towards renewable energy projects, aiming to significantly boost its core earnings
Adani Energy Solutions Ltd	The company is actively enhancing its renewable energy capacity in both generation and transmission to meet the increasing demand for cleaner energy sources
Vedanta Limited	Vedanta, a leading power generation company in India, is actively working to tackle the country's power shortages through various initiatives and power purchase agreements with state governments
Power Grid Corporation of India	Power Grid, a transmission utility, significantly contributes to the private sector's power generation through partnerships and infrastructure development
JSW Energy	JSW Energy primarily generates power through thermal and hydroelectric sources, prioritizing sustainability and integrating renewable energy into its operations. JSW is significantly increasing its renewable energy presence as part of its growth strategy
Sterlite Power Transmission Limited	Sterlite, a company involved in transmission and generation, is actively working to improve India's energy infrastructure

Major Private Sector Players

Private Sector Companies

The private sector plays a crucial role in India's energy landscape, accounting for 52.8% of the country's total electricity generation

Private Sector Companies	Contributions
ReNew Power	ReNew Power, established in 2011, is a leading independent power producer in India, focusing on wind and solar energy, operating over 110 utility-scale projects across eight states
Adani Green Energy Ltd (AGEL)	The company is actively enhancing its renewable energy capacity in both generation and transmission to meet the increasing demand for cleaner energy sources. AGEL, established in 2015, operates significant solar projects, including the Kamuthi Solar Power Project, with a market capitalization exceeding Rs 310,000 crore
Tata Power Renewable Energy	Tata Power Company Limited's subsidiary plans to significantly increase its renewable energy capacity, including 932 MW solar and 907 MW wind, as part of its broader strategy for cleaner energy sources. Tata Power plans to allocate 45% of its capital expenditure from FY23 to FY27 towards renewable energy projects, aiming to significantly boost its core earnings
Suzlon Energy	Suzlon, a leading wind energy company, has installed over 12,500 MW in India, aiming to significantly contribute to the country's renewable energy targets
Amplus Solar	Amplus Solar, a subsidiary of Malaysian state-owned PETRONAS1, specializes in distributed solar power generation, offering solutions for industrial and commercial clients with capacities exceeding 800+ MW.
Hindusthan Power	The company, with a capacity of 6,000 MW across various sources, focuses on maximizing stakeholder benefits through sustainable practices in the hydro, thermal, and renewable energy sectors
Orient Green Power Company Ltd	Established in 2006, this company primarily focuses on wind power generation and is expanding its portfolio to include more renewable projects across India
JSW Energy	JSW Energy primarily generates power through thermal and hydroelectric sources, prioritizing sustainability and integrating renewable energy into its operations. JSW is significantly increasing its renewable energy presence as part of its growth strategy

Market Share of Companies: Renewable Electricity (in %)

	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Tata Power Renewable Energy Ltd.	2.32	3.07	3.98	4.30	5.76	6.34
Kamuthi Solar Power Ltd. [Merged]	1.07	0.87	0.87	0.84	0.77	2.64
Apraava Renewable Energy Pvt. Ltd.	3.50	3.34	3.15	2.93	2.89	2.56
Sembcorp Green Infra Pvt. Ltd.	1.10	1.18	1.82	2.37	2.39	2.29
Renew Power Pvt. Ltd.	1.30	1.32	1.30	1.78	1.89	1.69
Powerica Ltd.	0.71	0.68	0.77	0.72	0.83	1.66
Walwhan Renewable Energy Ltd. [Merged]	2.16	1.96	1.77	1.74	1.94	1.65
Parampujya Solar Energy Pvt. Ltd.	0.24	1.96	1.87	1.99	1.76	1.61
Wardha Solar (Maharashtra) Pvt. Ltd.	0.00	1.53	1.53	1.61	1.41	1.38
Megasolis Renewables Pvt. Ltd.	0.00	0.06	0.47	0.69	1.08	1.26
Adani Green Energy (U P) Ltd.	0.00	0.78	1.07	1.21	1.10	1.23
G R Engineering Pvt. Ltd.	-	0.01	0.01	0.01	0.01	1.18
Gujarat Industries Power Co. Ltd.	-	-	-	-	-	1.08
Adani Green Energy (Tamilnadu) Ltd. [Merged]	1.33	1.19	1.18	1.12	1.06	1.02
P T C Energy Ltd.	1.26	1.35	1.23	1.11	1.03	0.99
Bannari Amman Sugars Ltd.	0.45	0.68	0.68	0.74	0.83	0.91
Bothe Windfarm Devp. Pvt. Ltd.	1.23	1.22	1.15	1.03	0.94	0.90
Renew Solar Power Pvt. Ltd.	0.02	0.47	0.77	0.99	0.89	0.88
B S E S Rajdhani Power Ltd.	0.47	0.96	0.27	0.42	0.76	0.82
Prayatna Developers Pvt. Ltd.	0.87	1.03	0.99	1.07	0.93	0.76

Source: B2K Analytics

Key Financial Ratios: Renewable Electricity Industry

Sl. No	Ratios	Unit	2018-19	2019-20	2020-21	2021-22	2022-23
1	Debt to equity ratio	Times	2.93	2.93	2.94	3.48	2.84
2	Interest Coverage ratio	Times	0.96	1.03	0.89	1.12	1.27
3	Debt service coverage ratio (DSCR)	Times	0.47	0.45	0.46	0.49	0.58
4	Net Working Capital	Rs. million	-136,857.90	-121,621.80	-97,161.10	-76,927.60	-18,095.40
5	Current Ratio	Times	0.54	0.59	0.70	0.78	0.94
6	PBDITA as % of total income	%	76.53	75.52	76.05	78.23	78.33
7	PAT as a % of total income	%	-5.46	-3.26	-6.78	2.45	7.63
8	Debtors turnover	Times	3.16	2.55	1.33	1.27	1.37
9	Creditors turnover	Times	0.99	1.28	0.64	0.67	0.66
10	PAT as a % of capital employed	%	-0.82	-0.47	-0.91	0.35	1.17
11	PAT as % of total assets	%	-0.72	-0.42	-0.78	0.30	0.99

Source: B2K Analytics
Data as on 7 October 2024

Outlook

India's Renewable Energy Sector Growth	India's renewable energy sector is expected to grow due to government initiatives, investment opportunities, and commitment to reducing carbon emissions, with a goal of 50% renewable electricity capacity by 2030
Rapid growth in solar and wind power.	India's renewable energy sector is rapidly evolving, with solar and wind power being key contributors to its ambitious energy goals
India's Solar Energy Growth	India's solar energy capacity has surged from 100 MW in 2010 to over 87 GW by mid-2024, thanks to government policies, international investments, and technological advancements, positioning the country as a global leader
Enhancing solar energy capabilities.	India is well-positioned to enhance its solar energy capabilities and achieve its ambitious renewable energy targets through various supportive policies and initiatives
India's 2030 Non-Fossil Fuel Electricity Goals	India aims to achieve 500 GW of non-fossil fuel electricity capacity by 2030, requiring significant transmission network enhancements and successful implementation of the Global Energy Convention
India's Role in Clean Technology Manufacturing"	India's policy ecosystem, manufacturing clusters, and unique skill set enable it to play a crucial role in clean technology manufacturing, aiming for secure, affordable, and sustainable energy by 2047

** Views are personal*

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