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Outlook for solar Energy in India

Report

October 2022

Foreword

The renewable energy sector has evolved significantly in the last decade with solar energy capacity growing at ~43% CAGR from CY15 -21; largely owing to an increased focus on climate protection. This has been supplemented by policy support from the government and technological innovations from private players to ensure an increase in the usage of non-fossil fuels. India is the 2nd largest renewable energy producer in Asia-Pacific, constituting 10% of renewable energy produced in the region. Currently, only ~32% of total energy generation capacity is met through non-fossil energy in India, which is ~150GW, providing headroom to grow & contribute to 50% of total energy generation capacity in CY30 (expected to be ~500 GW). Solar power is expected to contribute over 60% of India's planned renewable energy capacity by CY30, making it an attractive sector for growth in the future.

In this report, we have discussed key tailwinds & headwinds for various renewable energy sectors, keeping a special focus on the solar sector in the latter half. We have discussed the upcoming technologies and key trends in manufacturing of solar cells and modules. Increased manufacturing & adoption of solar cells & modules will further lead to more opportunities in the development of solar infrastructure requiring software designers, system integrators, or EPCs & financial institutions. We have covered the business models existing in the mentioned spaces in detail. Further, we have also discussed the key action steps which can be taken to achieve the target of renewable energy contribution at 50% of installed capacity by CY30 & net zero carbon emissions by CY70.

The market is rapidly evolving, and some of the scenarios presented here may have slight variations. This report reflects our perspectives as of July 2022. At Praxis, we look forward to continuing the discussion with our friends across sectors and exchanging notes as the situation evolves.

Madhur Singhal
Managing Partner & CEO

Aryaman Tandon
Managing Partner & Co-Founder

Executive Summary

Topic	Summary of findings
Introduction	• Renewable energy has gained significant traction in the recent years due to better affordability and continuous support from policy makers • In the APAC region, China is dominating the renewable energy market followed by India; >90% of APAC market is dominated by 6 renewable energy producers with India contributing to just ~10% of APAC's total renewable energy capacity • Renewable energy capacity contributes ~32% to the total energy generation capacity in India (vis-à-vis the global average of ~38%) providing large headroom for expanding electricity generation from renewable energy sources by CY30
Shift to renewable energy	• India's dependence on thermal energy has been largely due to rapid urbanization. Share of renewable energy in meeting the energy demand is expected to increase rapidly going forward with India's energy demand likely to double by CY30 • Government of India has increased support for electricity generation from renewable energy sources through the Union Budget and various policies • Solar energy is growing rapidly driven by increased funding to meet expectations of covering 50% of India's renewable capacity by CY30 • Hydropower growth has slowed down over last 6 years; increased government focus to develop small capacity projects to ramp-up growth • Wind energy is growing steadily with support from the government through tax benefits, excise duty exemptions and viability gap funding • Biopower capacity has been growing at a steady pace, driven by Govt's push for optimal utilization of agricultural waste across sectors and policy step mandating all coal-fired power plants to use biomass pellets as at least 5% of the fuel mix

Topic	Summary of findings
Opportunity in solar energy	• Solar sector has seen maximum traction with most private players currently focussing on solar capacity addition • Solar energy is set to be one of the key contributors to India's energy mix in the future, with a 300GW capacity targeted by CY30 • Mono-PERC technology gives high cell efficiency of ~21-23% & has application in residential, commercial & utility. TOPCon, HJT & Perovskite are prominent upcoming technologies in solar cell and module manufacturing • Supply of solar modules and cells in India is dependent on imports. Safeguard duty imposed by the government has shown a positive impact by reducing imports • Domestic manufacturing of solar cells and modules at globally competitive costs has emerged as a key opportunity in the solar energy sector in India • Increased manufacturing and adoption of solar cells & modules in the country will further create more opportunities for solar products (mounting structures, inverters etc.), solar software solutions, system integrators (EPC players), financing institutions and developers
Future outlook on solar energy	• Advancement in technology, reduction in module prices, government incentives & availability of low-cost financing are expected to be the key growth drivers for solar energy in India going forward • Global solar module prices have declined by ~75%, triggered by a reduction in polysilicon prices during FY21-22. Improvement in technology will lead to further decline in solar PV module costs & improvement in efficiency • Established global players entering the Indian solar industry has led to the availability of efficient technologies at competitive costs • Solar energy has a must-run status, which makes it an attractive investment avenue for players in the private sector • Government policies are incentivizing upscaling and development of new technologies to capitalize on decreasing popularity of fossil fuels

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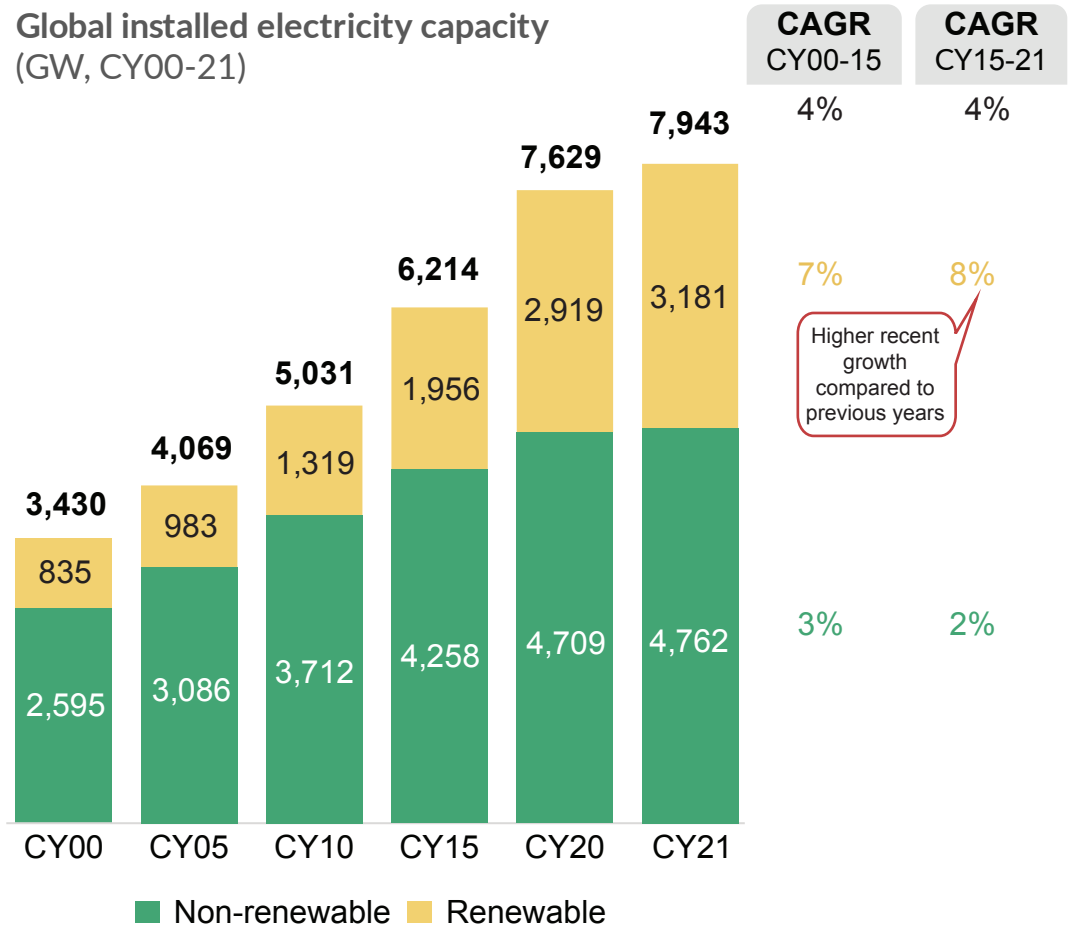
Introduction

Introduction

Renewable energy has gained traction in recent years due to better affordability and policy support

Over the last 6 years, renewable energy has grown ~4x faster than non-renewable energy



Lower running costs, policy support and climate change are key drivers of adoption of renewable energy sources

Decline in costs

- With increased use, a decline in cost has been seen due to economies of scale and competitive supply chains
- Cost of solar photovoltaic cells has fallen by ~85% and cost of wind electricity by ~50% since CY10

Policy support

- Renewable energy tax credits, subsidies, auctions, and feed-in tariffs have increased the affordability of renewable energy
- China, USA, and European nations became leaders in solar and wind energy through government investment in R&D

Climate Protection

- Due to increase in global warming, the IPCC** has called for scaling up renewables and increasing energy efficiency
- Under the Paris Agreement, 170 out of 190 countries mentioned renewable energy sources in their plan to counter climate change

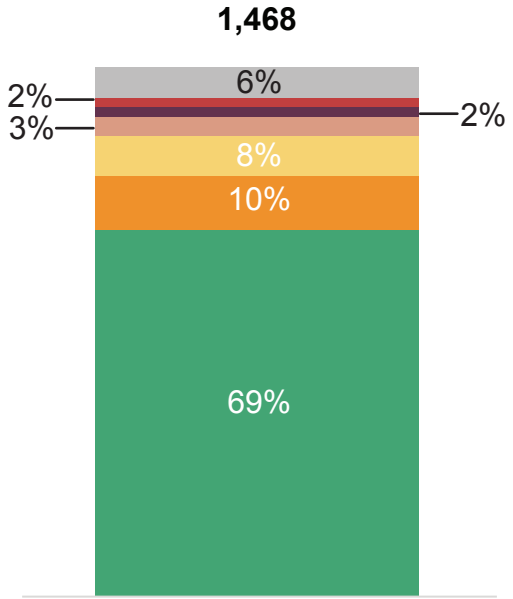
Note(s): *Renewable includes- solar, hydro, wind & biomass energy, **Inter-governmental Panel on Climate Change
Source(s): IRENA, Secondary research, Praxis analysis

Introduction

China is dominating the APAC renewable energy market, followed by India

In Asia-Pacific, China is the largest producer of renewable energy followed by India, and Japan close behind

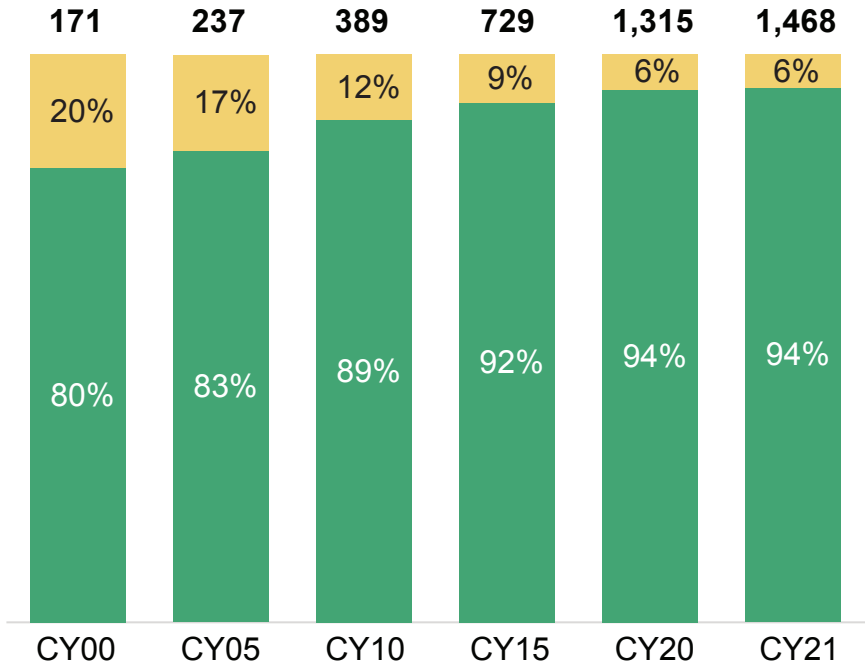
Distribution of total renewable energy - APAC
(%, CY21)



China India Japan Vietnam
Australia South Korea Others

Top 6 countries have been dominating the renewable energy market, increasing their market share steadily since CY00

Market share of renewable energy
(%, CY00-21)

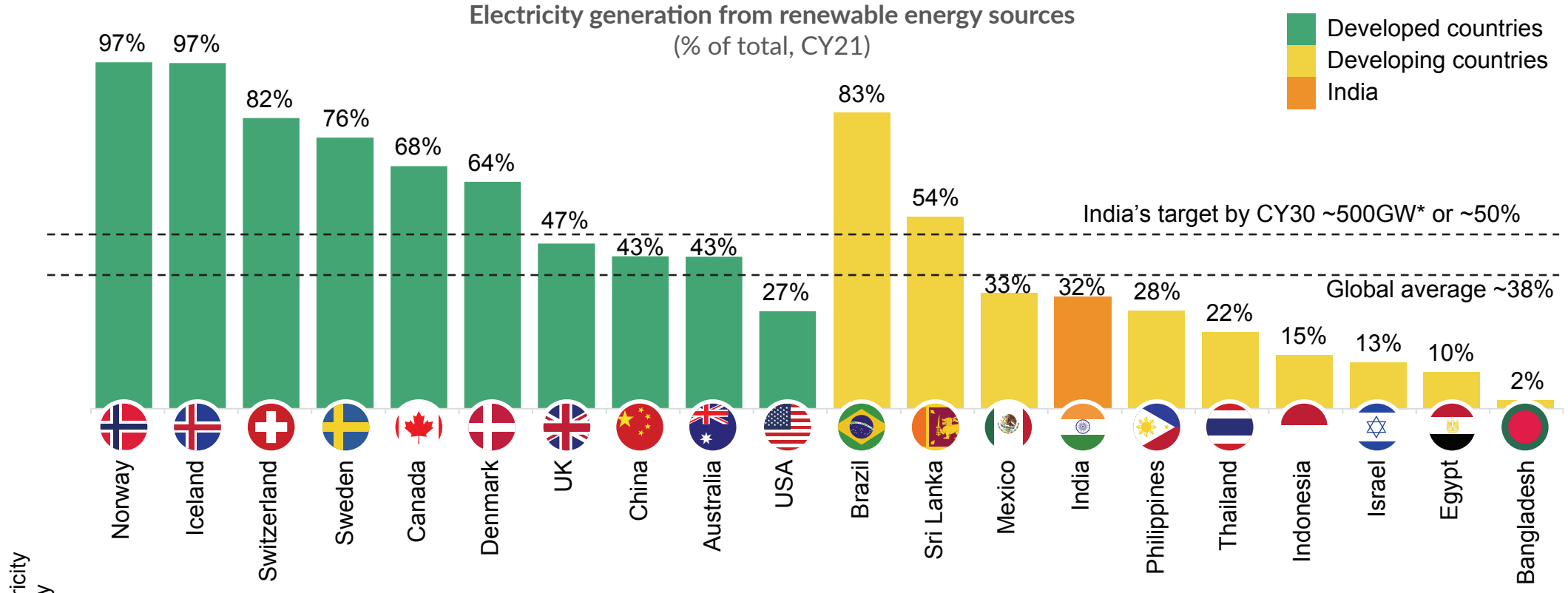


Top 6 countries Others

Note(s): Top 6 countries include China, India, Japan, Vietnam, Australia and South Korea
Source(s): IRENA, Praxis analysis

Introduction

India has large headroom for expanding electricity generation from renewable energy sources



	Norway	Iceland	Switzerland	Sweden	Canada	Denmark	UK	China	Australia	USA	Brazil	Sri Lanka	Mexico	India	Philippines	Thailand	Indonesia	Israel	Egypt	Bangladesh
Total electricity capacity (GW)	41	3.0	23	45	151	16	108	2,378	86	1,185	192	4.7	90	467	28	55	74	20	60	24
Renewable electricity capacity (GW)	40	2.9	19	35	103	10	50	1,020	37	325	160	2.5	29	147	7.6	12	11	2.6	6.2	0.6

Note(s): *Includes renewable energy and non-fossil energy such as nuclear energy
Source(s): IRENA, Secondary research, Praxis analysis

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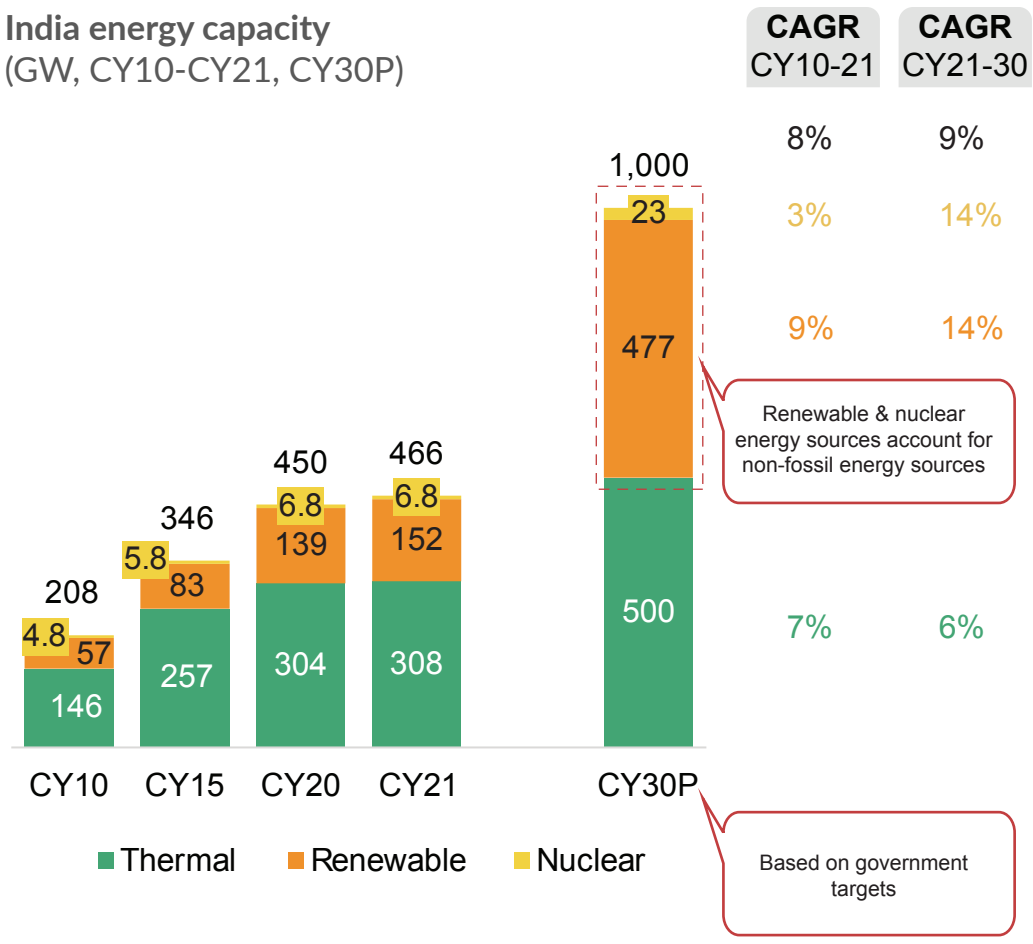
Shift to renewable energy

Shift to renewable energy

India's dependence on thermal energy is largely due to rapid urbanization

India's energy demand is expected to double by CY30 with the share of renewable energy increasing rapidly



Booming industry and transport pushing up carbon emissions has led to a stronger need for renewable energy

Thermal

- Rapid **population growth** and consequent **increase in energy demand,** with low per-capita emissions, result in reliance on thermal energy
- **High urbanization rate** leads to growth in infrastructure and energy demand, which renewable energy cannot address alone

Renewable

- Booming industry and transport **push up CO2** and harm air quality→**higher requirement** of energy from **renewable sources**
- In the STEPS*, India exceeds the goals set out in its Nationally Determined Contribution (NDC) under the Paris Agreement

Nuclear

- Expansion of nuclear energy sources complements rapid growth of renewable energy sources, and **decreases dependence on thermal energy**

Note(s): *Stated Policies Scenario
Source(s): IRENA, Secondary research, Praxis analysis

Shift to renewable energy

The government of India has increased support for electricity generation from renewable energy sources through increased policy support

Government policy support for renewable energy

Ensuring round-the-clock-power from projects

To overcome intermittency and low utilization of infra, and ensure uninterrupted power, renewable energy is bundled with power from other sources and combined storage

Renewable purchase obligations (RPO)

Uniform RPOs introduced - all electricity distributors must purchase or produce a specified minimum quantity of their total requirements from renewable energy sources

Renewable energy hybrid project

Solar and wind are complementary (wind is stronger during evening and night); Hybridization reduces variability and optimizes utilization of land and transmission systems

Waiver of inter-state transmission system charges

Costs and losses for inter-state sale of power from solar and wind power projects have been waived for all projects to be commissioned up to 30.06.2023

Solar cities

At least one city per state is being developed as a solar city – all electricity needs of the city will be fully met from renewable energy sources, primarily solar energy

SPECS**

Allocation of ~INR 3.3Cr to strengthen the component manufacturing ecosystem and position India as a global hub for electronics system design and manufacturing

Union Budget FY22-23 in support of renewable energy

Thermal

PLI scheme for solar modules

- GoI* allocated additional ~INR 19.5K Cr to existing ~INR 4.5K Cr for a PLI scheme to boost manufacturing of high-efficiency solar modules
- Prioritization of full integration of manufacturing units into solar photovoltaic (PV) modules

Net-Zero emissions target

- Allocation for the Solar Energy Corporation of India (SECI) stood at INR 1,000Cr
- GoI is planning development of Saksham Anganwadis with clean energy facilities

Push for green energy instead of coal-based

- Issuance of sovereign green bonds, conferring infrastructure status to energy storage systems
- Plans to provide financial support to allow coal-fired power plants to co-fire biomass pellets @ 5-7%

Budget for aligned ministries

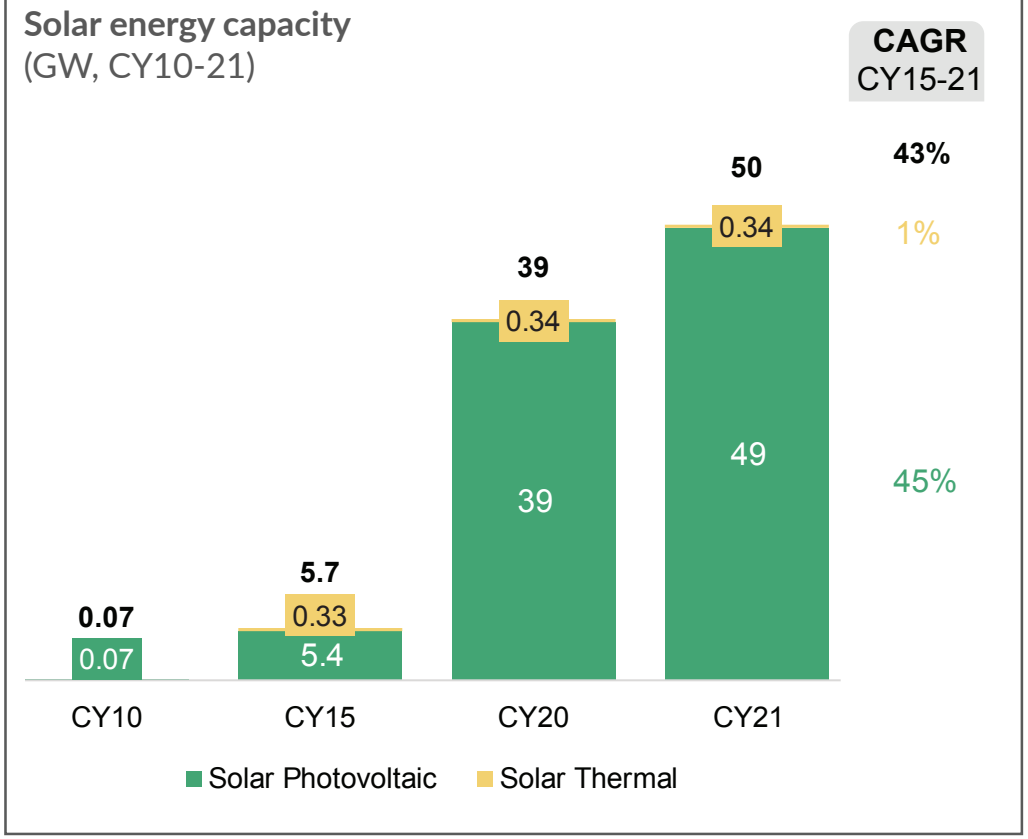
- Allocation for hazardous substance mgmt. stood at INR 4.5Cr
- Allocation for the Central Pollution Control Board (CPCB) remained at INR 100Cr (the same as the year before)

Note(s): *Government of India; **Scheme for promotion of manufacturing of electronic components & semi-conductors
Source(s): Ministry of New and Renewable Energy, GoI Union Budget 2022-23, Praxis analysis

Shift to renewable energy- Solar Energy

Solar energy is growing rapidly driven by increased funding to meet all expectations

Solar energy has gained traction in recent years with explosive growth from CY15 to CY21



Tailwinds and Opportunities

- Over **60%** of India's planned **renewable capacity** by CY30 is expected from solar power
- Rooftop solar program's second phase aims to install solar panels with capacity of **~4 GW in residential areas**
- Solar energy park projects of ~5 GW are planned by MNRE*, leading the way for m**ore large-scale solar energy projects**
- GoI** has **increased funding** for domestic solar cell and module manufacturing under the PLI scheme to **~INR 24K** Cr

Headwinds and Challenges

- **Land acquisition** is a challenge, and leads to delays and other similar problems with starting projects
- **Poor financial health** of power distribution companies combined with high import duty on solar modules slows the growth
- Poor awareness of rooftop solar and **high capital requirement** act as deterrents to widescale residential solar adoption

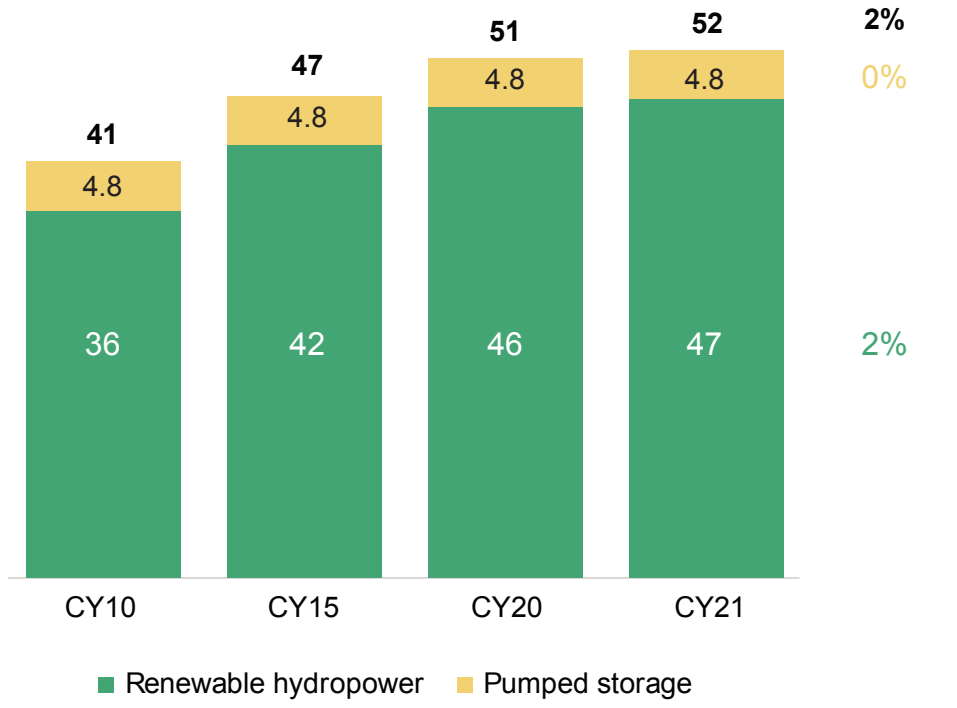
Note(s): *Solar photovoltaic converts sunlight directly into electricity; Solar thermal collects and concentrates sunlight to produce the high temperature heat needed to generate electricity; *Ministry of New and Renewable Energy, **Government of India
Source(s): Ministry of New and Renewable Energy, GoI Union Budget 2022-23, Praxis analysis

Shift to renewable energy- Hydro Energy

Hydropower growth has slowed down over the last six years, leading to increased focus on small capacity projects to ramp up growth

Hydropower has grown at a steady pace from CY15 to CY21 at a CAGR of 1.5%

Hydro energy capacity
(GW, CY10-CY21)



Note(s): Renewable hydropower comes from potential energy of dammed water driving a turbine and generator; Pumped storage generates electricity by moving water between reservoirs at different elevations;*Joint Venture
Source(s): IRENA, Secondary research, Praxis analysis

Tailwinds and Opportunities

- GoI is focusing on attracting **private capital** to fund future growth, especially in the **small capacity segment**, i.e., <25 MW
- Policies are being implemented to attract private sector participation in setting up **~100** plants of capacities >25 MW
- GoI has set a target of achieving **~175 GW** of cumulative renewable energy with **~5 GW** allocated to small hydro plants
- Jindal Power & GoI's JV* (~INR 25K Cr Etalin project) in Arunachal Pradesh will **open opportunities in the North-East**

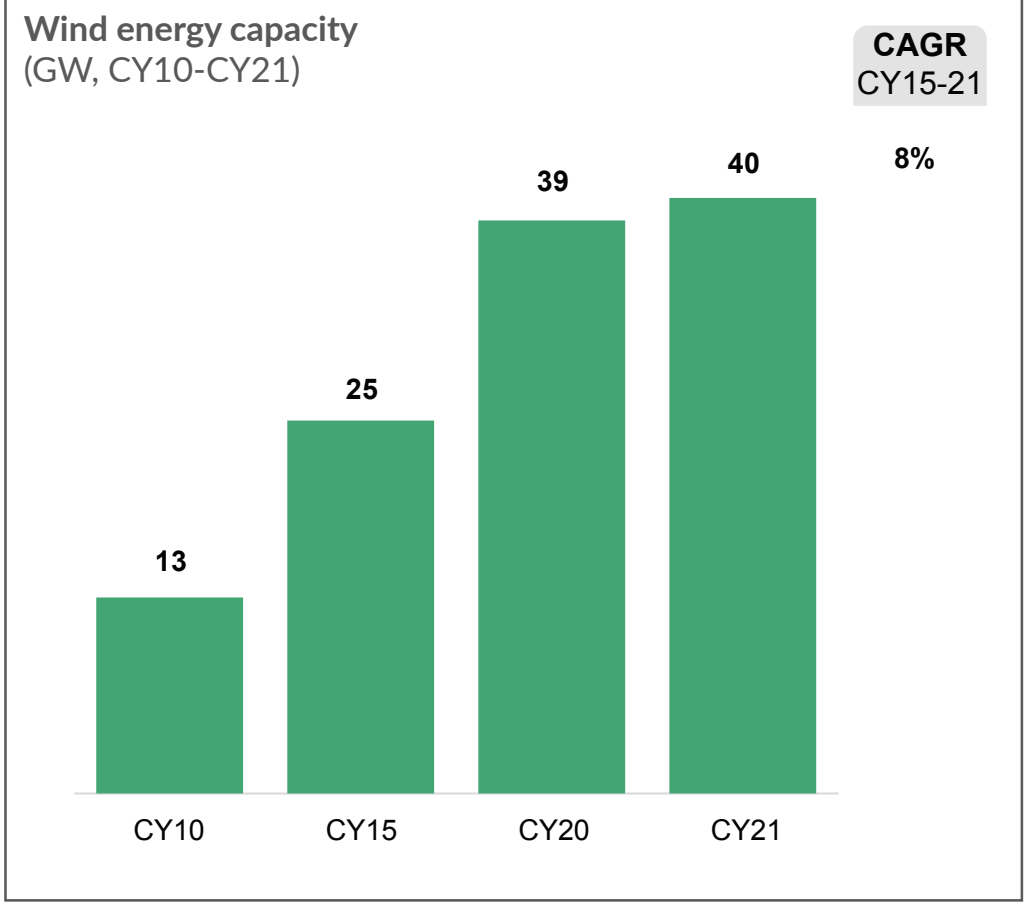
Headwinds and Challenges

- Development of roads and bridges for project implementation is demanding, often located in **difficult and inaccessible sites**
- Projects are languishing due to **contractual conflicts,** environmental litigations, and **protests from local citizens**
- Requirement of large **upfront investment**, government **focus on solar and wind** energy results in a lower market scope

Shift to renewable energy- Wind Energy

Wind energy is growing steadily with support from the government

Wind energy capacity has been growing at a CAGR of ~8% from CY15 to CY21



Tailwinds and Opportunities

- GoI has set a national target **140 GW** of onshore and offshore wind energy capacity **by CY30**
- **Tax benefits** such as the **accelerated depreciation** bill (40-80% project cost paid back) and **other incentives** implemented
- GoI has planned to **provide viability gap funding (VGF)** for offshore wind and storage projects for **adding 30GW** of capacity by CY30

Headwinds and Challenges

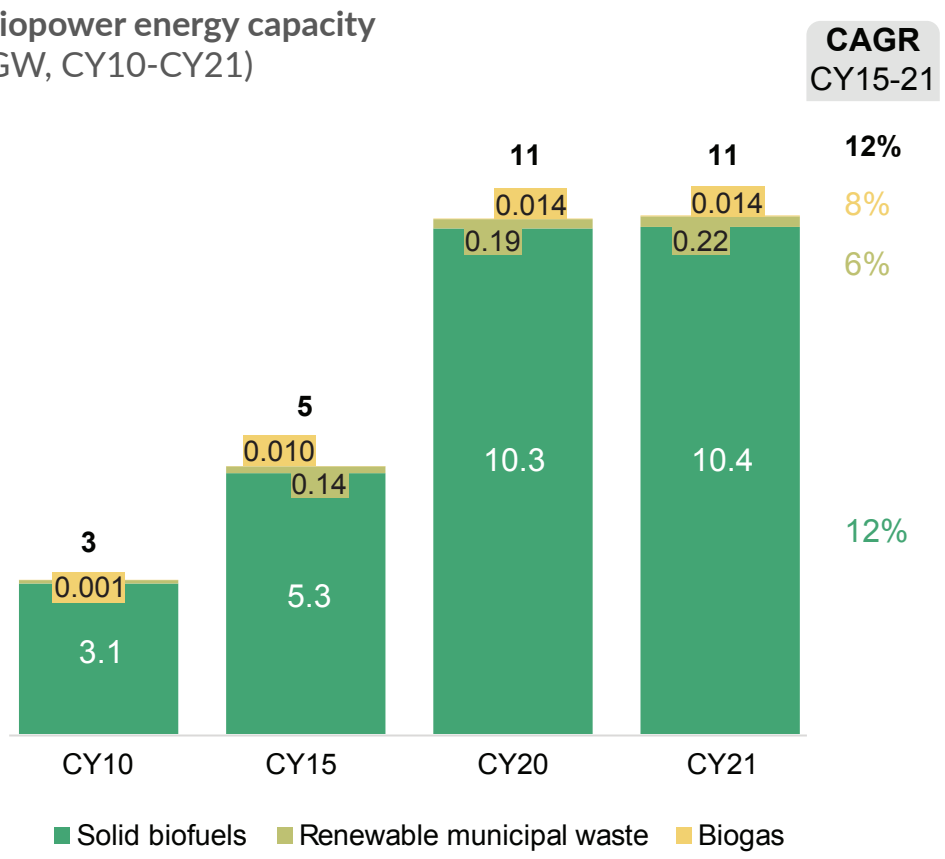
- **Land availability and acquisition issues** have slowed down the pace of wind capacity addition
- **Outdated technology** in wind turbines has resulted in **reduced efficiency and higher maintenance costs**
- **Competitive bidding** has slowed down industry growth due to a significant fall in tariffs, triggering a decline in bid responses

Source(s): IRENA, Secondary research, Praxis analysis

Shift to renewable energy- Biopower

Biopower capacity is growing driven by government policies and mandates for utilization across sectors

Biopower has gained attention recently, with capacity doubling between CY2015 and CY2020



Tailwinds and Opportunities

- GoI has approved a policy for o**ptimal utilization** of agricultural waste for **increasing efficiency** in production of biopower
- MNRE has estimated **surplus biomass** availability, corresponding to a potential of **18 GW** energy capacity
- GoI has **mandated** all coal-fired power plants to use **biomass pellets** as **at least 5%** of the fuel mix

Headwinds and Challenges

- Biomass from agriculture is **only available for 2-3 months** after harvesting period, making it expensive to procure and store
- Defragmented agricultural lands prevent high mechanization, resulting in **reduced efficiency & increased procurement cost**
- Growing operational costs and stagnant tariffs have made biomass power development **financially unviable** for developers

Note(s): Solid biofuels are derived from non-fossil, organic materials; Renewable municipal waste is garbage or trash that can be burned in a boiler; Biogas is a naturally occurring fuel, resulting from the breakdown of organic matter
Source(s): IRENA, Secondary research, Praxis analysis

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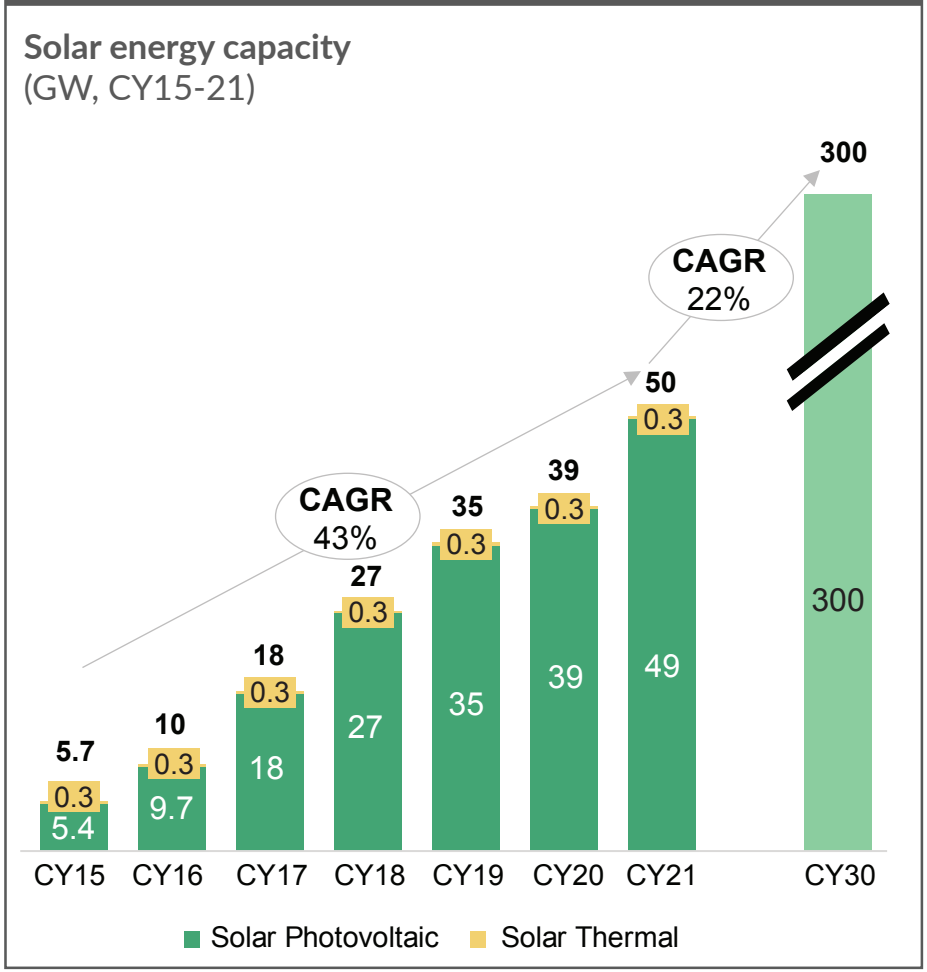
Opportunity in solar energy

Sector overview

Sector overview

Solar energy is set to be one of the key contributors to India's energy mix in the future, with a 300GW capacity targeted by CY30

Solar energy has gained traction in recent years with explosive growth from CY15 to CY21



Solar energy is the cornerstone of renewable energy in India

Solar power is set for explosive growth in India

- Matching coal's share in the power generation mix within 20 years in the STEPS* and even sooner in the SDS**

Global leader in solar energy

- India is already a leader in solar power, which will play a massive part in India's clean energy future

Resilience against COVID-19

- Solar energy was one of the least affected energy sources during the pandemic

Cheaper alternative

- Cost reductions in technology and ease of availability have made solar the cheapest option for new power generation

Government support

- Investment in infrastructure, support for solar parks, etc. reduce project development and land acquisition risks

Note(s): *Stated Policies Scenario; **Sustainable Development Scenario
Source(s): IRENA, Secondary research, Praxis analysis

Sector overview

The central government has undertaken various initiatives to promote domestic manufacturing of solar cells and modules [1/2]

Basic Customs Duty (BCD) on Imports

- Imposition of BCD on imports of solar cells and modules from April 2022:
  - 25% on cells and 40% on modules
- Expected to improve price competitiveness of domestically manufactured modules, thus prompting investments
- Lower duties on cells are expected to reduce current cost differential between domestically manufactured & imported modules

M–SIPS* scheme of Ministry of Electronics & IT

- 20-25% subsidy for investments in capital expenditure for setting up of electronic manufacturing facility
- 20% for investments in SEZ & 25% in non-SEZs

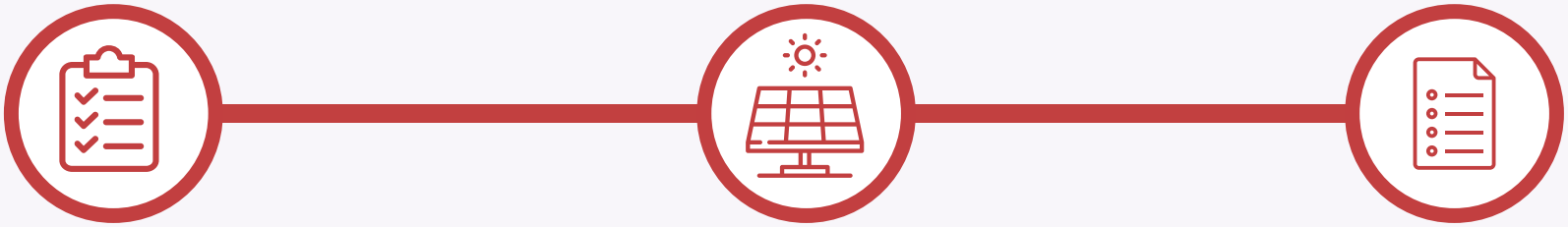
Manufacture & other operation in Warehouse Regulation

- Enables conduct of manufacture and other operations in a custom bonded warehouse
- Improved liquidity with deferment of import duty and no interest liability

Note(s): *Modified Special Incentive Package Scheme; **Power distribution companies; ***Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
Source(s): Ministry of New & Renewable Energy, Press Information Bureau, Praxis analysis

Sector overview

The central government has undertaken various initiatives to promote domestic manufacturing of solar cells and modules [2/2]



Manufacturing Linked Tenders

- Competitive bidding of solar power generation capacity along with mandated module manufacturing capacity
- Expected to partially offset the risk in setting up the module manufacturing capacity

Domestics content requirement (DCR) in projects

- 12 GW grid-connected solar capacity (for self-use or sell through DISCOMs**) would be set up by government agencies under the Central Public Sector Undertaking (CPSU) Scheme by using only domestically manufactured solar cells and modules
- Similarly, the PM-KUSUM*** Scheme aims to install 10 GW grid connected distributed solar capacity using domestically manufactured solar module

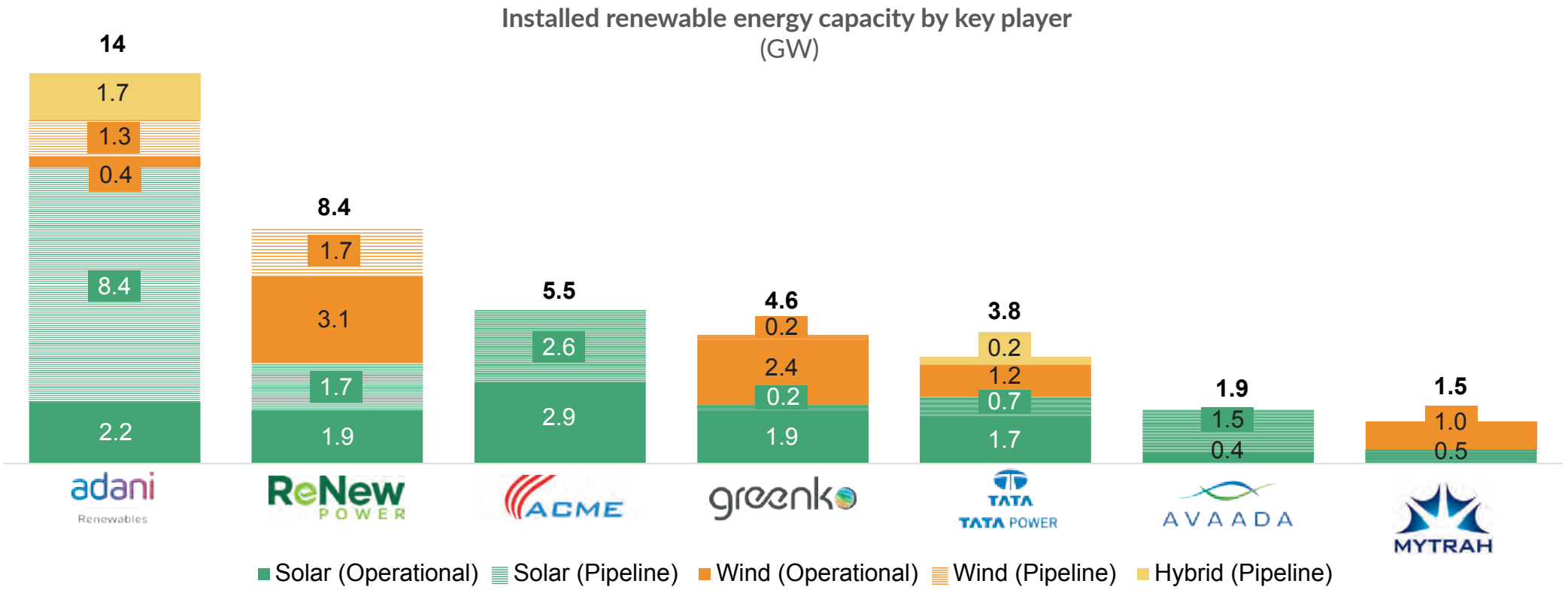
CPSU scheme

- Approval for setting up of solar PV manufacturing plant by government procedures using domestically manufactured solar PV cells and modules to encourage “Make In India”

Note(s): *Modified Special Incentive Package Scheme; **Power distribution companies; ***Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
Source(s): Ministry of New & Renewable Energy, Press Information Bureau, Praxis analysis

Sector overview

Most private players are focusing on solar capacity addition, and will account for most of the capacity in the coming years

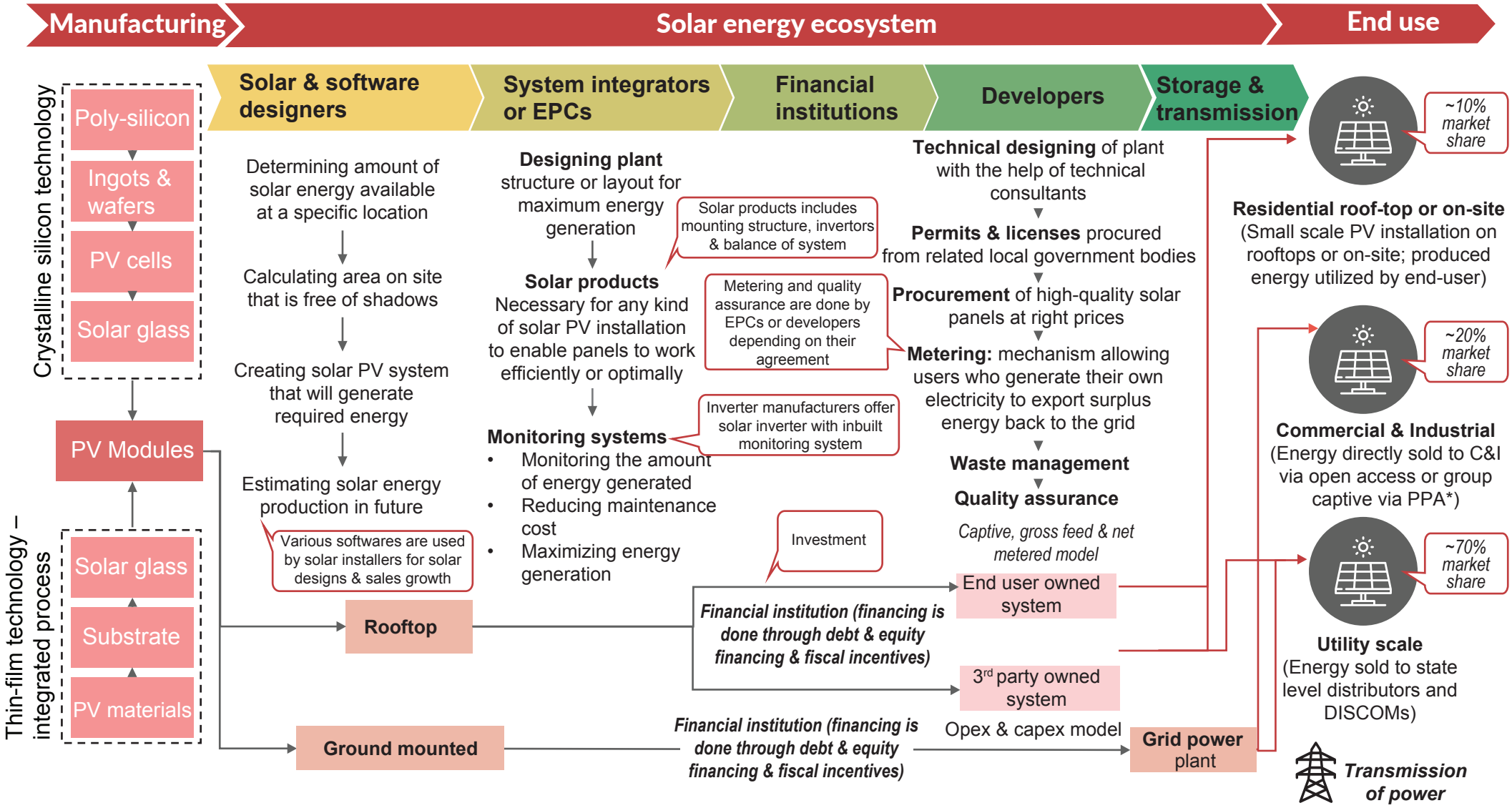


- There is a great demand for solar energy projects, which contribute most to the projects in pipeline for the largest private renewable energy players
- Hybrid solar and wind projects are gaining traction to address the issue of grid stability associated with renewable energy projects

Source(s): Secondary research, Praxis analysis

Sector overview

Value chain of solar energy sector in India spans three key phases from manufacturing of modules to end use of energy



Source(s): Expert conversations, Secondary research, Praxis analysis

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Opportunity in solar energy

Solar manufacturing

Solar manufacturing

Mono-PERC technology gives high cell efficiency of ~21-23% & has application in residential, commercial & utility



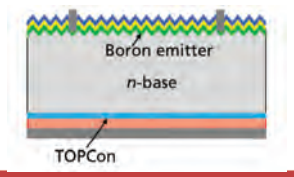


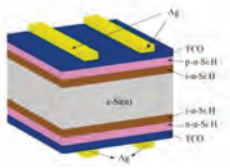
	Polycrystalline	Monocrystalline	Thin film	Mono-PERC	Bifacial
Description	• Comprises several crystals of silicon • Considered more eco-friendly • Lower heat tolerance compared to monocrystalline cells	• Pyramid pattern that facilitates a relatively larger surface area to collect energy from the sun	• Made by depositing a thin layer of semicon-ductor on a supporting material (substrates) such as glass, stainless steel or polymide • Made of CdTE***, CIGS****, or CIS*****	• Distinguished by an extra layer of material on the backside of the solar panel • Reflects light that passes through the panel giving it a second chance to be absorbed by the solar cell	• Treated with conductive material on both sides • Produces power from light that hits both sides of the panel • Installed on a tilt to produce more energy
Cell efficiency	~14-16%	~17-21%	~5-14%	~21-23%	~27%
Module MSP* benchmark (US$ or Wp) (Global, CY20)	0.25-0.27	0.25-0.27	0.28 (CdTE thin film)	0.25	0.32–0.37
PID resistance**	Low	Low	Lower than crystalline cells	High	-
Application	Residential or Commercial	Residential or Commercial	Commercial or Utility	Residential or Commercial or Utility	Residential or Commercial or Utility
Disadvantages	• Lower space efficiency • Not as aesthetically pleasing as monocrystalline	• Expensive • Durable • Complicated manufacturing process	• Lowest space efficiency • Tends to degrade faster compared to monocrystalline & polycrystalline	• Light induced degradation which occurs in all silicon solar cells, but can be pronounced in Mono-PERC cells	• Higher cost of production • Heavy weight • Degradation induced by light & elevated temperature

Note(s): *Minimum Sustainable Price; **Potential Induced Degradation; ***Cadmium Telluride; ****Copper Indium Gallium (di)selenide; *****Copper Indium Selenium (semiconducting material generally used in PV)
Source(s): NREL, VDMA, TERI, PV Insights, Secondary research, Praxis analysis

Solar manufacturing

Prominent upcoming technologies in solar cell and module manufacturing are TOPCon, HJT & Perovskite

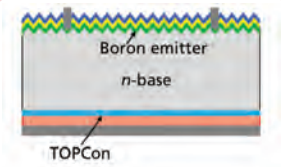


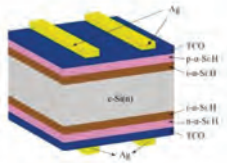


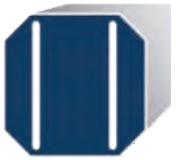
	TOPCon	HJT	Perovskite
Description	• **Tunnel Oxide Passivated Contact:** Involves depositing a nanometer scale layer of silicon oxide, followed by a thicker polycrystalline silicon layer, between the silicon wafer and metal contacts	• **Heterojunction:** special pn* junction, which combines two different technologies into one cell • Crystalline silicon cell sandwiched between two layers of amorphous "thin-film" silicon	• Includes perovskite which is a structured compound like a hybrid organic-inorganic lead or tin halide-based material (a specific crystal structure) • Can be used as light-harvesting active layer
Cell efficiency	• Currently ~23.5-24% (n-type silicon) • Expected to reach up to ~25% in 10 years	• Currently ~24% (n-type silicon) • Expected to reach ~25.5-26% in 10 years	• ~27% efficiency can be achieved by 2026
Companies using tech globally	中来股份 JOLYWOOD, MOTECH, SUNTECH, Trinasolar	Maxwell Technologies, HORAY SOLAR 禾润电力, SUNDRIVE, Hanergy Thin Film Power	MICROQUANTA SEMICONDUCTOR, JinKO Solar

Note(s); *A PN junction separates the electron & hole carriers in a solar cell to create voltage, **Lower levelized cost of electricity, ***Light Induced Degradation, ****Potential Induced Degradation
Source(s): PV-tech, VDMA, NREL, Secondary research, Praxis analysis

Solar manufacturing







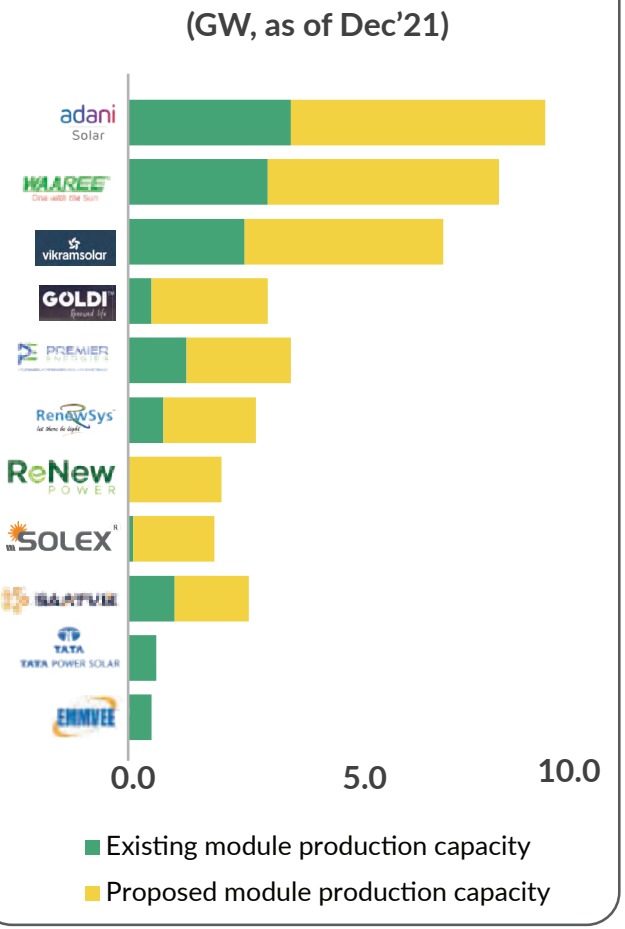
	TOPCon	HJT	Perovskite
Advantages	• **Higher carrier lifetime** because of reduced charge recombination between wafer and contacts, owing to silicon oxide layers • **Conversion efficiency boosted** by ~0.5% owing to higher carrier lifetime • **Lower LCOE** values** compared to bifacial PERC technology • **Lower investment** costs compared to HJT technology	• **Less than 3% degradation in 10 years** • Smaller temperature coefficient, resulting in **reduction of heat loss caused by sunlight** • Can be **prepared under lower temperatures compared to other technologies** (less than 250 degrees Celsius) • No **LID*** phenomenon** due to use of N-type solar cells • No **PID**** due** to unavailability of insulation layer • **Better bifaciality** • **Lower levelized cost of electricity** (LCOE) • **Good surface passivation** enabling cells to show efficiencies close to intrinsic limit for silicon solar cells	• **Hike in cell efficiencies of ~22%** compared to present technology • **Inexpensive and simple to manufacture** material used (methylammonium lead halides) • **Lower-level material consumption** resulting in same amount of light absorption compared to silicon, hence **cheaper than silicon** • Excellent light absorption, charge-carrier mobilities & lifetimes due to materials used resulting in **high-device efficiencies**
Disadvantages	• **Cost disadvantage** compared to PERC due to increase in silver paste consumption • **Higher degradation rate** compared to HJT technology	• Expensive equipment leading to **higher CAPEX (~3x)** compared to TOPCon • **~2.5x higher OPEX** compared to TOPCon	• **Degradation issue** of methyl ammonium lead iodide Perovskite • Issues in **film quality and thickness** • Material **breaks down quickly due to exposure to heat and moisture** • Material is **toxic** in nature

Note(s); *A PN junction separates the electron & hole carriers in a solar cell to create voltage, **Lower levelized cost of electricity, ***Light Induced Degradation, ****Potential Induced Degradation
Source(s): PV-tech, VDMA, NREL, Secondary research, Praxis analysis

Solar manufacturing

Adani Solar has the highest existing and proposed capacity for both cell & module production in India

Key PV module manufacturers – Current production capacities & proposed capacity additions



Key PV cell manufacturers – Current production capacities & proposed capacity additions

- Current capacity:
  - Cell: 4 GW
  - Module: 16 GW
- Imposition of BCD of 40% on module and 25% on cell from April 2022 for import substitution
- PLI scheme of INR 4.5K Cr, additional 19.5K Cr allocation made in CY22 – Creation of 10 GW integrated cell plus module manufacturing capacity with a total direct investment of INR 24K Cr
- Addition of 13.75 GW of module and 6.5 GW of cell manufacturing capacity in the next 18 months

Technological changes in solar cell & module production in India

- Indian market is expected to completely shift from monocrystalline to mono-PERC technology by CY22
- Shift to N-type technology (TOPCon & HJT) is unlikely in the near future due to high cost of investment involved. However, Adani Solar is planning to add ~4GW of cell capacity with upcoming TOPCon & HJT technologies as these technologies will be replacing Mono-PERC in future
- Higher wafer sizes from M2 to M6, M10, and M12
- Shift from mono-facial to bi-facial modules expected; ~2x jump in solar module production capacity in the coming 2 years
- These technological changes would lead to higher efficiency of cells & modules

Source(s): Secondary research, Praxis analysis

Solar manufacturing

PV tech landscape in India: Module manufacturing space across technologies has several players, whereas only a handful of players manufacture cells

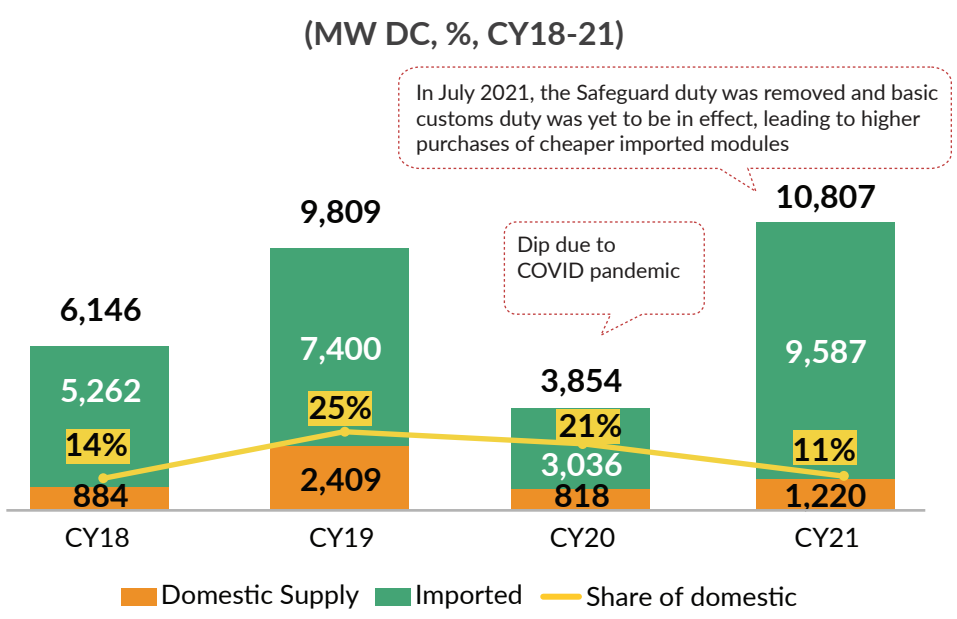
	Cell	Module
Mono-Crystalline	INDOSOLAR, TATA POWER SOLAR, MAHARISHI SOLAR, TERSUS, PREMIER ENERGIES, SUNMICRO, POWENCY, ASHA, MOSE SOLAR, CEL, WEBEL SOLAR	INDOSOLAR, GOLDI, RenewSys, WEBEL SOLAR, alpex, WAAREE, vikramsolar, MOSE SOLAR, SAATVIK, VEDANSH GROUP
Poly-Crystalline	adani Solar, JUPITER, MOSE SOLAR, WEBEL SOLAR, SUNMICRO, XL ENERGY LTD, USLsolar ENERGY, PREMIER ENERGIES, TATA POWER SOLAR, ASHA, CEL, MAHARISHI SOLAR, POWENCY, INDOSOLAR, RenewSys	INDOSOLAR, RenewSys, vikramsolar, GOLDI, alpex, PREMIER ENERGIES, SAATVIK, EMMVEE, VEDANSH GROUP, WAAREE, navitassolar, WEBEL SOLAR, adani Solar, MOSE SOLAR, JUPITER
Mono - PERC	adani Solar, TATA POWER SOLAR, TERSUS	adani Solar, TATA POWER SOLAR, MOSE SOLAR, EMMVEE, WAAREE, PREMIER ENERGIES, RenewSys
Bifacial	adani Solar	adani Solar, WAAREE, vikramsolar, EMMVEE, RenewSys, SAATVIK, TATA POWER SOLAR

Source(s): Company websites, Praxis analysis

Solar manufacturing

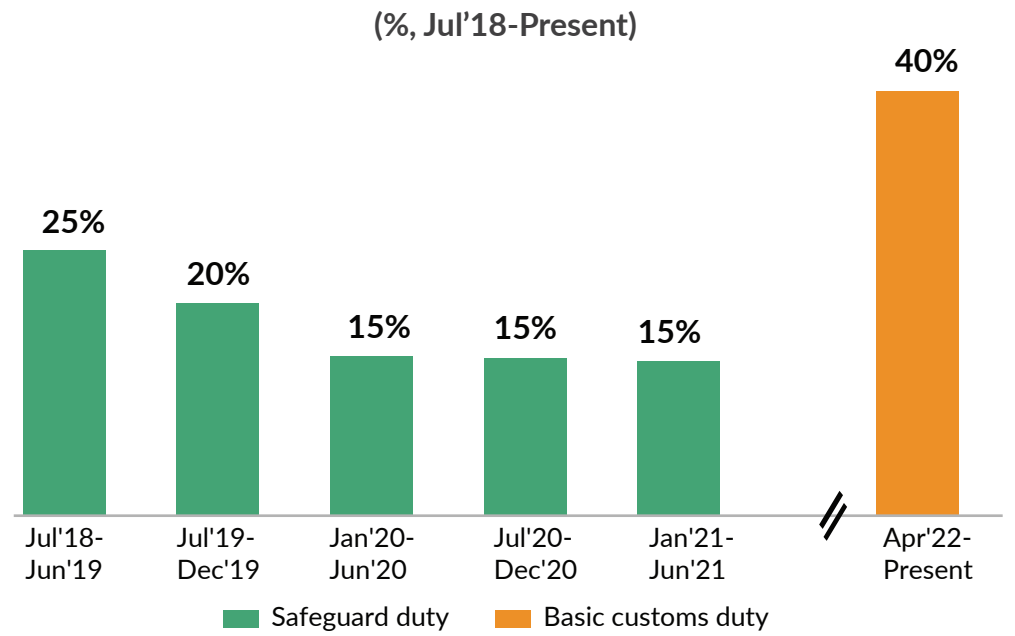
Supply of solar modules and cells is dependent on imports; Safeguard duty imposed by the government has shown positive impact by reducing imports

Domestic vs imported supply of solar modules



- China has the **highest share (80%)** share in total imports
- Adoption of imported modules is due to:
  - The **Chinese modules are about 20-25% cheaper** (before duties) than Indian modules
  - India has a vastly **lower production capacity** of solar modules than the demand levels
  - Chinese modules are more **premium quality** than Indian modules
- Adoption of the low-cost imported modules has helped in **bringing down the solar tariffs** in the country and aided **rapid capacity addition**

Duties on solar cells and modules



- The government implemented a **safeguard duty (SGD)** in July 2018 (extended up to June 2021) on **imports from China and Malaysia**
  - The SGD has helped in **increasing share of domestically manufactured modules** in the total supply
- After the safeguard duty was removed in July '21, high tariffs were announced through the **basic customs duty (BCD)**, 40% on solar modules, w.e.f. April '22
  - No additional tariff was applied on solar modules before the BCD, leading to **high purchase volume of imports** after Jun '21

Source(s): Bridge to India "India Solar Map", Secondary research, Praxis analysis

Solar manufacturing

Domestic manufacturing of solar cells and modules can be competitive if government takes actions to reduce cost of manufacturing

Cost	Reasons for higher cost	Recommendations

Raw material costs	• Indian manufacturers' BOM ~9% higher than Chinese for Non-DCR modules*, ~20% higher for DCR modules
	• Import dependence for key raw materials; Chinese players have end-to-end domestic value chain
	• Lack of scale and low 40-45% utilization; leads to:
	  • Economics of scale is not maintained in subcomponent manufacturing (4.3% for China vs. < 3% for India)
	  • Low bargaining power with suppliers (higher costs)
		• Lower import duties on cells and other raw material components in the short to medium term
		• Government support in scientific research and innovation in the field of cell and wafer manufacturing

Finance costs	• Free land parcels allotted by state provinces in China • Financing is available at negligible interest rates (vs. 11-14% in India) and cheaper electricity is provided to PV manufacturing facilities at very subsidized rates in China • Higher equity return expectations • Chinese manufacturers have assured global offtake - hence lower business risk and equity risk premiums	• Creation of demand visibility for domestic modules • Offering low-cost debt through a green manufacturing fund (GMF)
Labor costs	• Lower levels of automation • Dependence on imported plant equipment leads to higher capital costs	• Reduction of import duties on plant equipment and machinery
Overhead costs	• Low volumes leading to higher per unit apportionment of fixed costs	• Expansion of solar programs with domestic content requirement

Note(s): *modules that use imported cells
Source(s): Secondary research, Praxis analysis

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Opportunity in solar energy

Solar energy ecosystem

Overview of solar software solutions in solar energy sector

Key categories & features of solar software systems

Solar designing software

- AI assisted design creation
- Accurate simulation & shading analysis
- Efficient method of modeling in complex terrains
- Google map integration
- Multiple design configurations

Solar monitoring software

- Monitors real time parameters
- Forecast performance
- Real time malfunction alerts
- Optimize performance
- Real time performance updates

Solar Software Solutions

New-age players

Growatt, ESolar CRM, Longman Suntech Energy, Arnowa, Ranergy solutions, OctaBees, Ujjwal Systems, Megamic Electronics, Playsolar, ZTRIC, teqo by Mahindra, The Solar Labs, Aerem, aha solar, apollo, AGT, Quenext, deCon, Kirloskar Solar, Solar Ladder., Sky Solar, eSenz Innovations Pvt Ltd, Prescinto

Incumbent players

Trinity Touch, Eco Energies, NeoSilica, Homer, Statcon Energiaa, SMA, Moschip, Ellume Solar, Powercon, solaredge, Akshyapower Monitoring, A Four Technologies, solis, consyst, sunmoksha, Rogress, Greenwave

Note(s): New-age players are those incorporated post 2010
Source(s): Company website, Praxis analysis

Market landscape of solar products in solar energy sector

	Inverters	Mounting structures	Balance of system	Off-grid products
New-age players	Adhyan Solar, SOFAR SOLAR, CITIZEN SOLAR, avion power, CHAITANYA SOLAR, Growatt, Livguard, GOODWE, Kirloskar Solar, VRM STRUCTURES, LOOM SOLAR, UJJAWAL SOLAR, KENBROOK	Adhyan Solar, ASG, CHAITANYA SOLAR, CITIZEN SOLAR, ALOM, SuevOsol, RAYDEAN, Amcon Industries, SKY SOLAR'S, STROLAR, VRM STRUCTURES, SOLAR KIT, LOOM SOLAR, UJJAWAL SOLAR, KENBROOK	AEC SOLAR, CITIZEN SOLAR, DENO, KRYFS, Dhash, TRANS POWER INDUSTRIES, eteily, SIKCO, LOOP SOLAR, Spark Solar, SKY SOLAR'S, LOOM SOLAR, RPPL, MACMA PHOTOVOLTAICS, KENBROOK	CHAITANYA SOLAR, Deshmukh, avion power, CONNECTOR DEVICES, SunLink, APNA, EDT, ARNOWA, Livguard, ESSO FAB TECH PVT. LTD., OGC, Logics, CITIZEN SOLAR, Power, Northgreen, BM sunpower, Lubi SOLAR, SINFIN, SKY SOLAR'S, ROSOL, KENBROOK
Incumbent players	ABB, KACO new energy, DELTA, JAKSON, MICROTEK, KSTAR, Deye, LUMINOUS, novergy, EMMVEE, SMA, EXIDE, Enertech, Fronius, POLYCAB, ENPHASE, ESDEC, solaredge	Karamtara Engineering Pvt. Ltd, TATA, TATA INTERNATIONAL, SNS, Ganges Internationale, JAKSON, PINAX STEEL, METALKRAFT, JSW Steel, PENNAR INDUSTRIES	ABB, ABC TRANSFORMERS PVT LTD, KEI Wires & Cables, JOHNSON, K-flex, K M Cables & Conductors, elmex, ELCOM, POLYCAB, KRIPSON, Enertech, Finolex Cables Limited, RR KABEL WIRES & CABLES, PRIMECAB, Renufo, NORDIC (INDIA) SOLUTIONS PVT. LTD., PADMAVAHINI TRANSFORMERS PRIVATE LIMITED, ELECTRIC	ABB, Crompton, AQUATEX, JAKSON, Deye, kondaas, CRI, HIPE, Hi Powerr Electronics, EMMVEE, novergy, solaredge, NESSA, Omega Solar, FALCON, MATRIX, OSWAL PUMPS & MOTORS

Note(s): New-age players are those incorporated post 2010; Indicative list of players (not exhaustive)
Source(s): Company website, Press releases, Praxis analysis

Overview of role of EPC in solar energy sector

Engineering

- Includes consulting, sales & designing of project
- Analyzing client's requirements & preparation of model
- Weather surveillance & building plant design accordingly
- Designing of best structure with maximum power generation
- Selection of equipment & 3D model preparation

Procurement

- Includes procurement equipment at best available price
- High quality of material (panels) required as low-quality panels can lead to poor energy generation
- Building sourcing strategy for domestic & imported procurement for best quality & price

Construction

- Mounting of solar panels
- Installation of grid connectivity with high efficiency in energy storage & transfer
- After sales services like maintenance & monitoring of equipment

Basic function of an EPC Company

- **Feasibility check** of location by visiting site
- **Equipment selection** to ensure efficient & maximum power generation capacity
- **Designing,** 3D model preparation & installation, once approved
- **Connectivity with grid** for energy storage & transfer at maximum efficiency
- **Assistance with solar financing** like government rebates or grants & tax incentives
- **Equipment assessment & quality** checks to ensure no damages to panels; **Post sale maintenance work**

Representative list of players

Source(s): Expert conversations, Secondary research, Praxis analysis

Overview on developers in solar energy sector

Basic functions of developers

- **Procure land area** to start developing project; Land could be owned, leased, or client's land (in case of rooftop)
- Conduct technical & geological **research** regarding land, **availability of resources** & transfer of electricity through grids
- Apply for **permits & licences** that need to be collected from state & local government bodies
- **Secure financing** for construction of solar plant
- **Source high-quality equipment** such as panels, and frames at best available prices
- Select **EPC company** to construct solar plant if in-house EPC capabilities are not present

Key considerations

Energy distribution strategy (end use) due to complex bidding process for utility projects

Securing finance for projects considering high capital investment (upfront expenditure)

Sourcing of high quality solar panels; mostly being imported. Govt. has imposed 40% basic customs duty on modules

Representative list of players

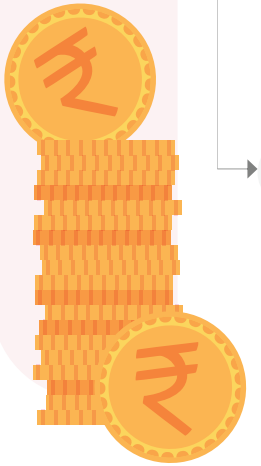
	Rooftop	Commercial & Industrial	Utility
New-age players	Voltcon, Hinduja Renewables, Cleantech Solar, Mahindra Solarize, Sunsure, ReNew Power, Kamati, Atria Power, Kalpa Power, RenSol Ecotech	G2 Power, Vector, Sprng, Kalpa Power, Kamati, IBC Solar, amp, Mahindra Solarize, Sunsure	Aditya Birla Group, JBM, Star, Hero Future Energies, Juniper Green Energy, Vena Energy, amp, Voltcon, Vector
Incumbent players	Jakson, Nova Energie, JSW Energy, BHEL, Waaree, adani Solar, Solex, Malpani	Photon Energy, Avaada, Rising Sun, Jakson, Azure Power, Star Energy, Tata Power Solar	NHPC, Greenko, Fortum, SCCL, APGENCO, ACME, JSW Energy, Waaree, Premier Solar, NTPC, Engie

Source(s): Expert conversations, Secondary research, Praxis analysis

Overview on financers in solar energy sector

Types of financing

Total financing required



Equity financing

Typically ~20-30%

Debt financing

Typically ~70-80%

Sources of financing

- **Promoters**
- **PE and VCs** — actis, GEF Capital Partners, Eversource Capital
- **International equity funds** — Goldman Sachs, I Squared Capital

~8-9% interest rate; Typically, full recourse debt

- **Public sector banks** — SBI, PNB
- **Private sector banks** — ICICI Bank, HDFC Bank
- **NBFCs** — IREDA, REC, PFC

~9-10% interest rate; Typically, partial / non-recourse debt

- **Financial companies** — Solar Square, CKers Finance, AEREM

~7-8% interest rate after factoring all the related cost including hedging cost for exchange risk

- **International banks** — European Investment Bank, ADB, The World Bank
- **Overseas lending agencies** — DFC U.S. International Development Finance Corporation, EDC

Process of funding

Approach
Borrower reaches out to financer

Project details
Financial models with current & future project costs & project revenue shared with financer

Project assessment
Financer evaluates technical & financial project plans & looks into borrower's balance sheet (DSCR, etc.)

Sanction amount
Financer informs sanction amount along with pre- disbursement conditions (if any)

Appointment of LLC & LIE*
Financer appoints LLC for documentation & LIE for independent project evaluation

Approval & disbursement
Investment is released once pre-disbursement conditions are met

Note(s): Sources of finance (logos) mentioned are just indicative players –not exhaustive, *LLC –Lender's Legal Counsel & LIE –Lender's Independent Engineer
Source(s): Expert conversations, Secondary research, Praxis analysis

Typically two financing models exist for solar rooftop projects: Capex & Opex or RESCO models

	Capex Model	Opex or ResCo Model
About Model	• Consumer pays 100% cost upfront for setting up project including equipment, materials, labor, and upgrades	• Consumer pays only for the energy consumed **Rooftop leasing:** Developer pays fixed lease to building owner over the time for installing solar panel **Power purchase agreement:** Project developer can sell power back to the building owner at lower solar power tariff for providing area at lease & sell excess power to the utility
Advantages	• Consumer is entitled to GST & depreciation benefits (~40%) • Consumer has complete ownership of type of technology & quality of components • Benefited from lower LCOE (levelized cost of energy) • Good Return on Investment ~25-30% • Long payback period ~4 years	• Payment can be done in mutually agreed monthly installments with no upfront payment • Enjoys central & state government support in the form of subsidiaries • Energy price offered in PPA* is significantly lower than grid-based energy • Option to sell excess power generated by grid at attractive feed-in tariff rates
Disadvantages	• Risks involved in owning & operating rooftop system borne by owner (operations, management & maintenance)	• Customers are not eligible to claim accelerated depreciation under Indian tax laws • Model not approved by net metering regulations of some states, such as Gujarat
Suitability	• GST & depreciation benefits make it beneficial for residential consumers, when coupled with state subsidies	• Typically meant for customers who are larger corporate houses with high credit ratings, & not smaller enterprises

Note(s): *Power Purchase Agreement
Source(s): Expert conversations, Secondary research, Praxis analysis

Barriers to solar energy ecosystem

Manufacturing, infrastructure, financing & operational barriers are the most significant barriers to solar energy development in India [1/2]

	Barriers	Comments
Manufacturing barriers	Poor raw material quality	• In the process of manufacturing, poor quality can lead to inefficiency, faulty solar modules, degraded quality of output
	Poor construction of structures & modules	• Improper construction of structures & modules leads to supply interruption & intermittent power generation
	Transmission infrastructure	• Inadequate transmission infrastructure leads to lower grid availability
Infrastructure barriers	Solar radiation data related barriers	• Less number of solar radiation data collection stations to facilitate accelerated development of solar power projects is also one of the major barrier for developers
	Limited clarity on regulations & processes	• Low awareness of regulations & policies in place leads to restricted addition of rooftop solar plants
	Land acquisition barrier	• Process of land acquisition differs from state to state • Lead time to acquire land in states ranges anywhere between 6-12 months & sometimes more than a year
	Unavailability of skilled labor	• Unskilled labor pose significant challenges to meeting India's ambitious target of 175 GW of installed renewable energy by CY22
	Issues with relation to water	• Lead time required for disbursement of annual estimated amount of water to developers by the local authorities ranges from 3-6 months

Source(s): World Bank, National Portal of Solar Rooftop, CRISIL, Secondary research, Praxis analysis

Barriers to solar energy ecosystem

Manufacturing, infrastructure, financing & operational barriers are the most significant barriers to solar energy development in India [2/2]

	Barriers	Comments
Financing barriers	Insufficient financing options	• Very few financing schemes targeting energy efficiency programs in MSMEs do not specifically cater to the installation of rooftop solar systems
	Credit worthiness	• Financial transactions are mostly conducted in cash which makes it very difficult for banks & other financial institutions to assess the credit-worthiness of people
	RESCO issues	• Reluctance of RESCOs due to concerns regarding the ability of MSMEs to honor power purchase agreements (PPAs) pose a big problem in implementing rooftop systems
	Collateral requirement	• MSMEs face difficulty in providing adequate property as collateral, especially if they plan to take up larger amounts of financing
Operational barriers	DISCOM apathy	• DISCOM not taking initiatives in executing net metering regulations, streamlining processes & becoming a part of payment security mechanisms is a barrier in the uptake of solar power systems
	Maintenance issues	• Firms not having the capacity & knowledge to maintain the installed equipment on their premises is also one of the major barrier

Source(s): World Bank, National Portal of Solar Rooftop, CRISIL, Secondary research, Praxis analysis

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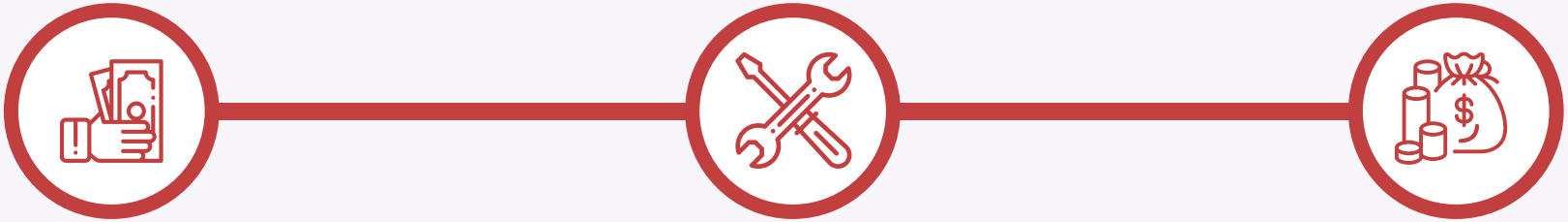
Future outlook of solar energy

Future outlook

Advancement in technology, reduction in module prices, government incentives & availability of low rate financing are the key growth drivers for the sector

[1/2]



Fiscal & regulatory incentives

- GoI has provided 40% **Accelerated Depreciation** (AD) for projects commissioned after April 2017
- Solar energy developers have been provided with a **generation-based incentive** (GBI) of ~INR 2.4B in FY22
- Solar energy has a **must-run status**, i.e., renewable energy generator is paid for even if electricity is not purchased on account of grid issues

Infrastructure support from the government

- GoI has prepared **land banks** for ~40 GW of solar projects
- GoI has provided **budgetary support** of ~INR 20L per MW for undertaking **solar park projects** with all necessary infrastructure
- **Grid capacity additions** have been undertaken via two schemes - green energy corridor & renewable energy zones scheme

Availability of financing

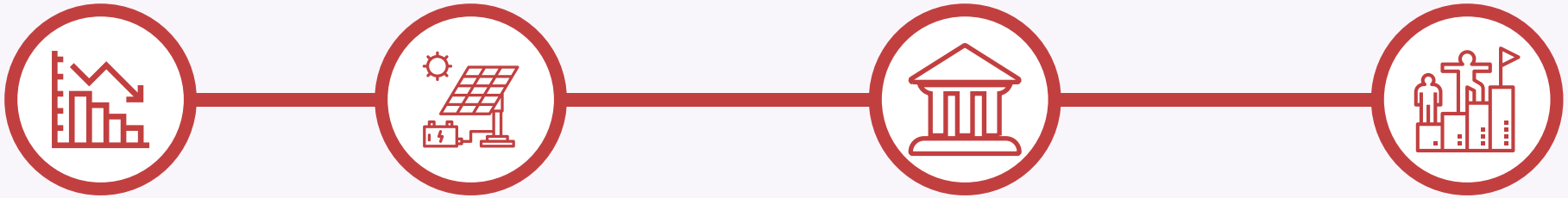
- Funding from institutions such as **IREDA & PFS, green bonds, pension, or endowment funds** can be availed
- Developers are exploring **options other than traditional funding channels** to ensure the availability of low-cost finance
- Asian Infrastructure Investment Bank (AIIB) has plans to lend **~INR 4K Cr for renewable projects** in India for a tenure of 15 years

Note(s): *National Solar Mission
Source(s): MNRE, Solar reports, Praxis analysis

Future outlook

Advancement in technology, reduction in module prices, government incentives & availability of low rate financing are the key growth drivers for the sector

[2/2]



Decline in module prices

- Global solar module prices have **declined by ~75%,** triggered by a reduction in polysilicon prices during FY21-22

Favorable technology

- **Improvement and introduction of new technology** such as longer-lasting cells, solar panels that track the sun from east to west throughout the day, and solar power plants that work at night, etc. will lead to a decline in overall module costs & improvement in efficiency
- **Capacity utilization factor** of solar plants has improved with **increased cell efficiency of sophisticated PV modules**

Large capacity allocations

- GoI is targeting the installation of **100 GW by December 2022** (large-scale central allocations planned under the NSM*)
- Under state schemes, **~9 GW projects** are under construction & expected to commission over FY'22-26
- GoI has **expanded** the 1 GW CPSU program to **12 GW** to encourage cash-rich central PSUs to set up projects

Rise of competition

- Established **global players entering the Indian solar industry** has led to the availability of efficient technology at competitive costs

Note(s): *National Solar Mission
Source(s): MNRE, Solar reports, Praxis analysis

Future outlook

India can learn from policy measures taken by other countries to achieve renewable energy targets and provide clean electricity at lower costs [1/2]

Country	Policy measure	Description	Status and challenges in India
 Norway	**Polluter-pays principle**	• Requires the **polluter to compensate** for harmful effects of their activities; **a cornerstone of Norwegian policy** on climate change • As of CY22, **> 80% of Norwegian greenhouse emissions are covered** by taxes and / or the EU – ETS*	• **Defined** in **1996;** comes under Section 20 of the National Green Tribunal Act • Unlike Norway, **no tax is imposed on individuals or companies for vehicular emissions in India**
 Canada	**Carbon pricing**	• **Fixed price on carbon pollution** in every jurisdiction; large industrial polluters pay per ton of carbon emitted • Canada's carbon price is set to rise from C$ 50 to C$ 170 (per ton) as part of Ottawa's commitment to **cut emissions 40-45% below CY05 levels** by CY30, reach net-zero by CY50	• **No explicit carbon price** levied by GoI • **Fuel excise taxes,** (an implicit form of carbon pricing) are imposed; only 58% of carbon emissions priced to date
 China	**Green Energy Certificate (GEC)**	• GEC allows companies to **claim the environmental benefits** associated with renewable electricity generation • Helps **reduce feed-in-tariff subsidies** from the government by driving a market-based mechanism	• **Renewable energy certificates (REC)** were introduced in CY10 to encourage renewable energy usage • Companies have **not been able to extract many advantages from such certificates** leading to target underachievement and non-compliance with state obligations

Note(s): *EU – Emissions Trading System
Sources(s): Secondary research, Praxis analysis

Future outlook

India can learn from policy measures taken by other countries to achieve renewable energy targets and provide clean electricity at lower costs [2/2]

Country	Policy measure	Description	Status and challenges in India
 Brazil	**Energy and Capacity auctions**	• Auctions **instrumental in promoting renewable energy** and overcoming the electricity crisis in Brazil; long-term contracts awarded to generators • Benefits such as **transparency, healthy domestic competition, and consequently, lower electricity prices** observed	• **First competitive auction** for renewable power recently held **in CY20;** • Continues to **attract large developers** & has helped in increasing transparency and maintaining healthy competition
 Australia	**State-based feed-in tariff (FiT) schemes**	• Some form of FiT for renewable energy **offered by every state or territory;** aimed at household systems • Each household **guaranteed a connection** at a set rate of US$ 0.25 for electricity fed into the grid • **>1 million rooftop solar systems** have been installed in Australia to date	• Feed-in-tariffs have the **potential to accelerate investment** in renewable energy technology • As of CY22, tariff for solar PV projects is ~INR 30 per kWh and for solar thermal projects is ~INR 26 per kWh

Note(s): *National Solar Mission
Source(s): MNRE, Solar reports, Praxis analysis

Future outlook

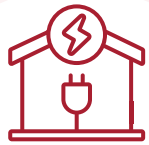
Multiple initiatives can be taken by stakeholders across the value chain to help increase the penetration of solar energy

Electricity generation companies

- Focus on R&D to **reduce running costs** of solar energy to make it **cheaper** than non-renewable and other renewable sources (cost currently ~INR 2.3K/MWh for solar, ~INR 2K/MWh for wind, ~INR 2.1K/MWh for natural gas
- Incorporate **"smart grid" technologies** into the **electrical grid to increase flexibility and efficiency** by recognizing irregularities within the grid and adjusting automatically
- Increase **solar-plus-storage infrastructure projects**, explore floating solar PV modules and expand **community solar projects** into new markets
- Emphasizing **plant storage value** is key to attracting investment for low, medium as well as extra high voltage applications

Government and regulatory bodies

- Encourage **rooftop solar** throughout the country, notably in **rural regions,** through **Rooftop Solar Program Phase II**
- Rooftop solar systems need to be **monitored and managed,** and connection codes need to stipulate **registration of individual systems**, with state- and national-level registrations
- Utilize **net-metering, accelerated depreciation mechanism, feed-in tariff, generation-based incentives,** and other incentives in rooftop solar PV facilities
- The government can take inspiration from other countries to introduce policies such as Green Energy Certificates, Polluter-pays, etc.
- There is a need for increased awareness in the general public as well as commercially



End users of electricity

Commercial

- Shifting to clean energy sources helps in price hedging and future-proofing energy plans
- The costs of solar energy have fallen 74% over 2016-21, helps in reducing overhead costs
- GoI has introduced incentives to decrease initial capital requirement (20-40% subsidy for up to 10kW)

Residential

- Homeowners can save ~600 units of electricity monthly reducing bills by ~INR 5,500 using rooftop solar, making them highly cost-effective
- GoI provides incentives through Grid Connected Solar Rooftop Programme for utilizing rooftop solar panels

Source(s): Secondary research, Praxis analysis

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How we help our clients

Strategy & Transformation
Growth strategy, Go-to-Market strategy, International strategy

Growth & Scale up
New market entry, Micro-market assessment, Offering design and validation

Cost & Performance Excellence
Operational and Process excellence, Unit economics improvement

Customer & Loyalty Experience
NPS improvement, Customer experience, Retention management

Organization Productivity
Organization role span design, KPI cascading

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Perception analysis and diagnostics, New channels & sources identification

Investment Advisory
Commercial due diligence, Target scan, Post-deal value creation

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Connect with us

We will be happy to share perspectives

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