1Lattice

PUMPS AND SOLAR ROOFTOP INDUSTRY REPORT

14th September 2024

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GLOSSARY OF ABBREVIATIONS USED

S.No.	Abbreviation used	Full form
1	AFI	Agriculture Infrastructure Fund
2	AI	Artificial Intelligence
3	ASEAN	Association of Southeast Asian Nations
4	Avg.	Average
5	B	Billion
6	BCD	Basic Customs Duty
7	BESS	Battery energy storage systems
8	BIS	Bureau of Indian Standards
9	BU	Billion Units
10	C	Celsius
11	C&I	Commercial and Industrial
12	CAGR	Compound Annual Growth Rate
14	CEA	Central Electricity Authority
15	CI	Cast Iron
16	CO2	Carbon Dioxide
17	CPI	Consumer Price Index
18	Cr	Crore
19	CY	Calendar Year
20	ETF	Enhanced Transparency Framework
21	EXIM	Export-Import Bank of India
22	FDI	Foreign Direct Investment
23	FY	Financial Year
24	G-20	Group of Twenty
25	GDP	Gross Domestic Product
26	GFCF	Gross Fixed Capital Formation
27	GHG	Greenhouse gas
28	GST	Goods and Services Tax
29	GVA	Gross Value Added
30	GW	Gigawatt
31	GW	Gigawatt
32	HVAC	Heating, Ventilation and Air Conditioning
33	IIP	Index of Industrial Production
34	IMF	International Monetary Fund
35	INR	Indian Rupee
36	IoT	Internet of Things
37	IRENA	International Renewable Energy Agency
38	K	Thousand
40	KSEB	Kerala State Electricity Board
41	KW	Kilowatt
42	LED	Light Emitting Diode
43	M	Million
44	MNRE	Ministry of New and Renewable Energy
45	MoSPI	Ministry of Statistics and Programme Implementation
46	MW	Megawatt
47	NDC	Nationally Determined Contributions
48	P2P	Peer-to-Peer
49	PE	Private Equity
50	PLFS	Periodic Labour Force Survey

51	PM	Pradhan Mantri
52	PMKSY	Pradhan Mantri Kisan Sampada Yojana
53	PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan,
54	PPA	Power Purchase Agreements
55	PV	Photovoltaic
56	R&D	Research and Development
57	RBI	Reserve Bank of India
58	RKVY	Rashtriya Krishi Vikas Yojana
59	RPO	Renewable Purchase Obligation
60	SMEs	Small and Medium-sized enterprises
61	SS	Stainless Steel
62	T	Trillion
63	UAE	United Arab Emirates
64	UK	United Kingdom
65	UNFCCC	United Nations Framework Convention on Climate Change
66	UPNEDA	Uttar Pradesh New and Renewable Energy Development Agency
67	US	United States
68	US$	United States Dollar
69	VC	Venture Capital
70	VNM	Virtual Net Metering

EXCHANGE RATE TABLE

Year (FY)	Rs. Equivalent of one US$	Euro equivalent of one US$	Year (CY)	Rs. Equivalent of one US$	Euro equivalent of one US$
2015-16	66.33	0.88	2016	67.95	0.95
2016-17	64.84	0.93	2017	63.93	0.83
2017-18	65.04	0.81	2018	68.36	0.88
2018-19	69.17	0.89	2019	69.89	0.89
2019-20	70.49	0.93	2020	74.18	0.83
2020-21	73.20	0.85	2021	74.50	0.83
2021-22	74.50	0.86	2022	76.10	0.91
2022-23	80.32	0.96	2023	82.31	0.93
2023-24	82.59	0.93	2024 (YTD)	82.98	0.92

Source: X-rate Monthly average

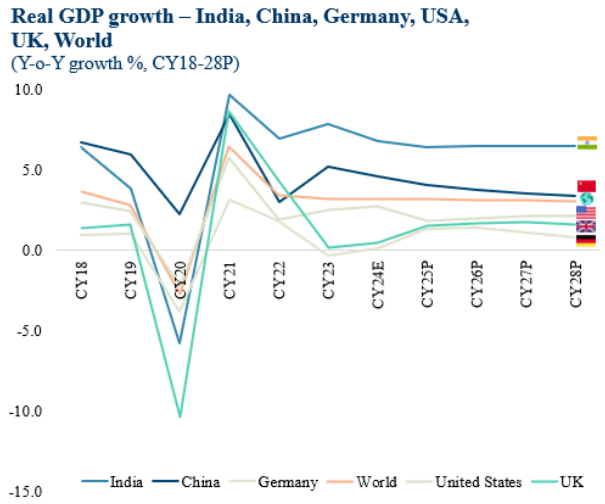
01

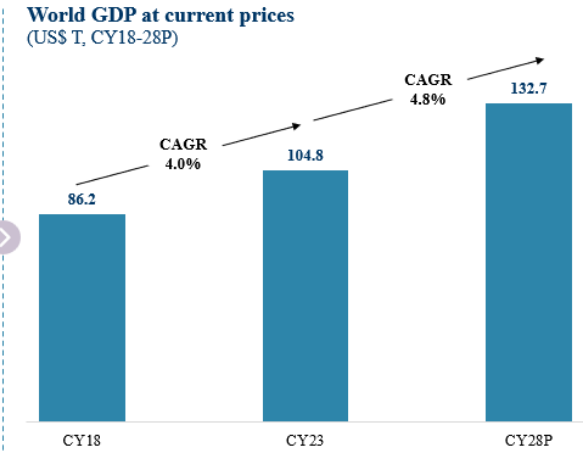
Macroeconomic outlook

1. Macroeconomic Outlook

1.1. Global Macroeconomic Overview

1.1.1. The real global GDP growth rate was 3.2% in CY23, and this growth rate is expected to be sustained until CY28



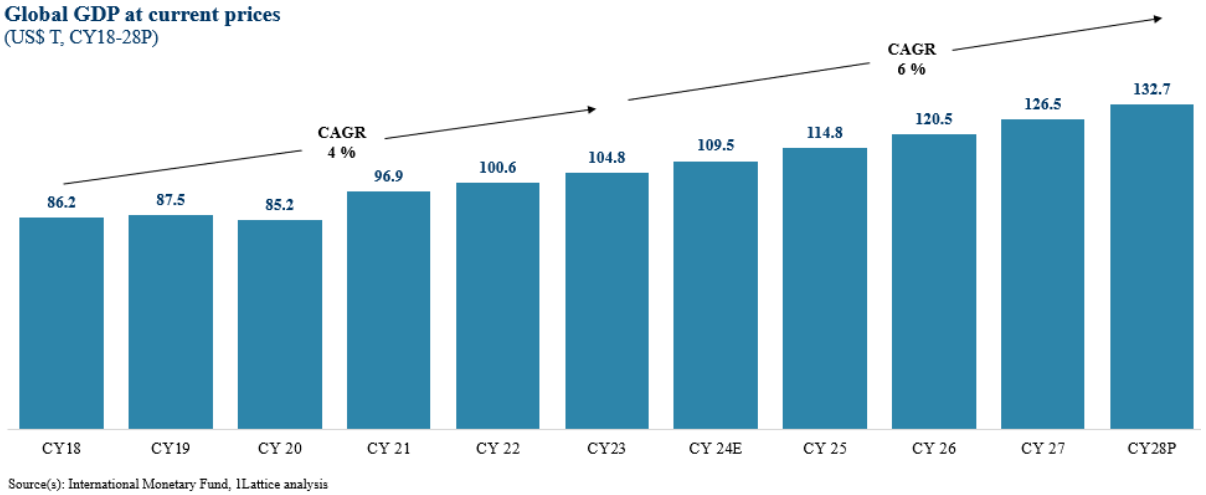


Source(s): International Monetary Fund

Global growth in CY23 remained above 3% despite higher interest rates, tighter financial conditions and geopolitical conflicts, including Russia's war in Ukraine, evolving conflict in the Middle East and turbulent US-china relations with a trend of sanctions ranging from solar cells to computer chips. GDP growth is projected to average 6.1% from CY23 to CY28. In comparison, India is expected to maintain the highest growth rate, with its current Y-o-Y growth rate at 8.2% in CY23 and expected to grow at 6.5% till CY28.

1.1.1.1. Global GDP per capita was at US$ 13.3K in CY23 and is expected to reach US$ 16.3K in CY28

Global GDP per capita stands at US$ 13.3K in CY23 and is expected to increase at a CAGR of 5.1% reaching US$ 16.3K in CY28. Global GDP per capita has increased by 3.1% CAGR over CY18 to CY23 driven by both public and private investments in infrastructure, education, healthcare, and technology. These factors will continue to shape the trajectory of global per capita GDP growth.

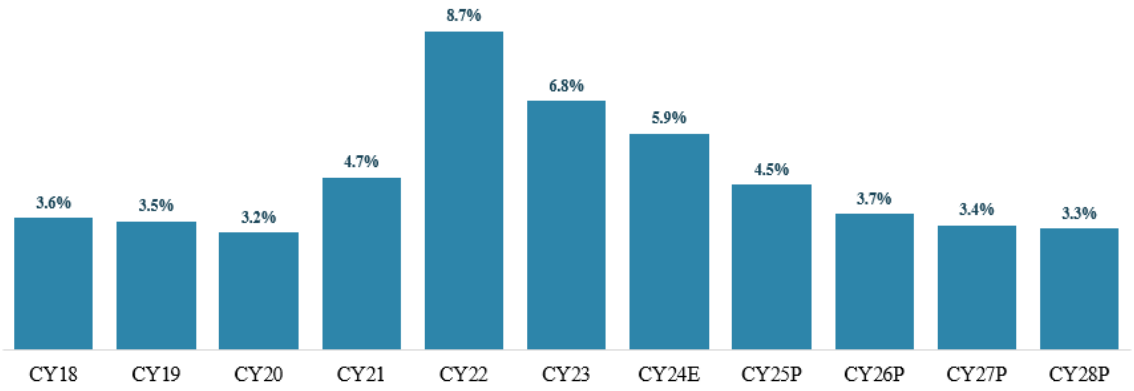


Source(s): International Monetary Fund, 1Lattice analysis

1.1.1.2. Global inflation is expected to decrease steadily from 6.8% in CY23 to 5.9% in CY24

Global inflation is predicted to decrease steadily, starting at 6.8% in CY23 and falling to 5.9% in CY24, driven by lower core inflation due to ongoing tight monetary policies, softened labor markets, and the continued impact of reduced energy prices. About 80% of global economies are anticipated to experience lower annual average inflation rates in CY24. High inflation erodes purchasing power, dampens consumer confidence, and can lead to economic instability. Conversely, deflation can also harm the economy by reducing consumer spending and investment.

World inflation at avg. consumer prices
(%, CY18-28P)



Source(s): International Monetary Fund

1.1.2. Emerging Asia region is expected to have the highest GDP growth rates when compared to other regions

According to the International Monetary Fund (IMF), global GDP growth is expected to be steady in CY24 and CY25. However, regional variations have resulted in stronger growth rates in certain areas compared to other regions. In comparison, Emerging Asia is expected to maintain the highest growth rate, with its current Y-o-Y growth rate at 5.2% in CY24E. This growth is driven by robust domestic consumption in most ASEAN countries and significant public investments in China and India.

Real GDP growth – Global economies
(Y-o-Y growth %, CY18-CY28P)

Global economies	CY18	CY19	CY20	CY21	CY22	CY23	CY24E	CY28P
Emerging Asia	6.4%	5.2%	-0.5%	7.7%	4.4%	5.6%	5.2%	4.5%
Emerging Europe	3.6%	2.5%	-1.6%	7.5%	1.2%	3.2%	3.1%	2.6%
Euro area*	1.8%	1.6%	-6.1%	5.9%	3.4%	0.4%	0.8%	1.3%
Major advanced economies (G7*)	2.1%	1.7%	-4.1%	5.5%	2.2%	1.7%	1.7%	1.6%
Latin America and the Caribbean	1.1%	0.2%	-7.0%	7.3%	4.2%	2.3%	2.0%	2.5%
Middle East and Central Asia	2.8%	1.7%	-2.4%	4.5%	5.3%	2.0%	2.8%	3.6%
Sub-Saharan Africa	3.3%	3.2%	-1.6%	4.7%	4.0%	3.4%	3.8%	4.3%

Source(s): International Monetary Fund

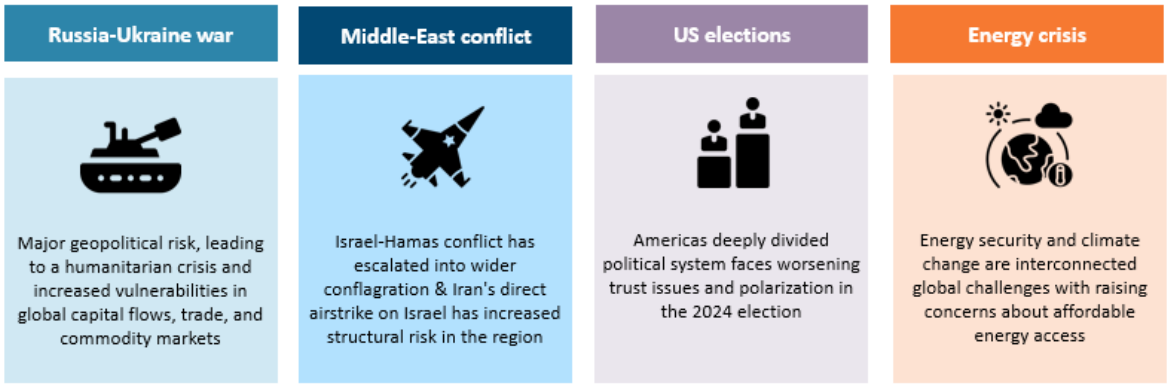
Note(s): *Euro area consists of advanced Economies like Germany, France, Italy, Spain, Netherlands, etc.
*G7 includes Canada, France, Germany, Italy, Japan, USA and UK

1.1.3. Key Factors Impacting the Global Business Environment

The global business environment is shaped by economic conditions, political and legal factors, technological advancements, social and cultural influences, environmental sustainability concerns, globalization and trade dynamics, and the competitive landscape. Understanding and navigating these key factors are essential for businesses to succeed and thrive in today's dynamic and interconnected marketplace.

1.1.3.1. Geopolitical situation & risks

Factors such as political instability, trade tensions, regional conflicts, and regulatory changes can create uncertainty and challenges for businesses operating internationally. These conditions can affect market access, supply chains, investment decisions, and overall business strategies. Currently, in CY24 geopolitical risks from elections, polarization, and conflicts within and between states have significant economic implications globally and for individual countries.



1.1.3.2. Economic performance:

Economic factors significantly impact purchasing power, supply and demand dynamics, thus impacting overall business performance. Exchange rates influence import costs and global competitiveness, while wage fluctuations affect consumer spending and inflation rates. Interest rates influence borrowing costs and investment decisions, while recessions can lead to reduced profits and increased unemployment. Changes in laws, government policies, and tax rates also shape business operations and economic stability. Monitoring and adapting to these economic factors are essential for businesses to navigate challenges and capitalize on opportunities effectively.

1.1.3.3. Government policies & regulations:

Government policies and regulations, including political and legal factors, significantly impact businesses globally. Political decisions, such as changes in tax policies and trade agreements, directly influence operations. The political environment also encompasses government actions in foreign markets, supporting or impeding business activities abroad. The legal environment governs trade agreements, contracts, organizational laws, and more, fostering international relations.

1.1.3.4. Technological factors:

Technological advancements like AI, automation, big data, and IoT are revolutionizing industries worldwide. However, the rise in cyberattacks, both in complexity and frequency, presents substantial challenges to businesses and national security.

Modern businesses heavily rely on technology for data management, communication, and tailored customer services. For example, the rise of e-commerce and online marketplace platforms have revolutionized global business operations. Understanding technology trends and consumer behavior is key to developing effective marketing strategies and ensuring business growth in today's dynamic landscape.

1.1.3.5. Environmental factors:

Switching to eco-friendly power sources benefits businesses and the environment. Businesses can save on energy costs, comply with regulations, access new markets, improve brand reputation, and attract green investments. Globally, this transition reduces carbon emissions, pollution, and resource depletion, while preserving biodiversity and enhancing energy security. Overall, it drives sustainable economic growth and environmental protection.

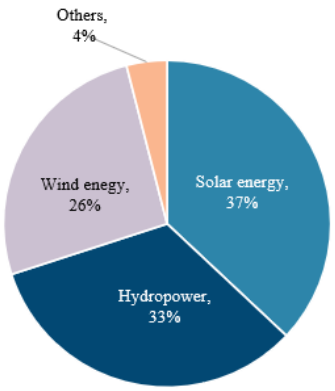
Fossil fuels like coal, oil, and gas, contribute over 75% of global greenhouse gas emissions and nearly 90% of carbon dioxide emissions driving climate change. Shifting to clean, accessible, and sustainable energy sources is crucial to reduce emissions and enhance energy security, fostering sustainable economic growth and environmental protection. This transition benefits businesses as well by cutting energy costs, complying with regulations, enhancing brand reputation, and attracting green investments.

The recent G-20 summit highlighted the need for increased investment, R&D, supportive policies, international cooperation, and public awareness to transform the global energy landscape and combat climate change. Companies are emerging actively with new design, manufacturing capabilities, in solar modules, wind turbines, and solar inverters to promote sustainable energy solutions and expand renewable energy capacity worldwide.

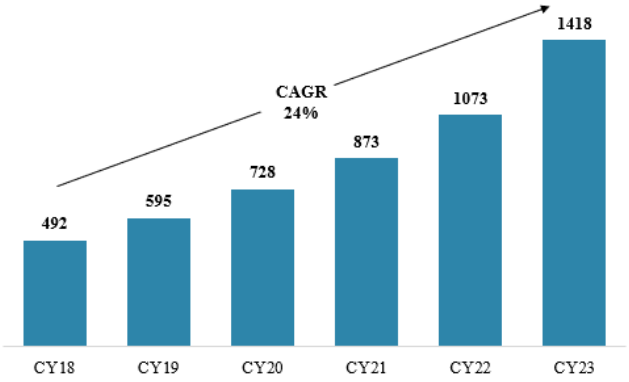
Globally, the top five solar power countries based on installed capacity are China, the USA, Japan, Germany, and India. India has ~192GW installed renewable energy as of April 2024 and aims for 500 GW of non-fossil fuel energy by CY30, and solar capacity is projected to quadruple to 392 GW. The government supports domestic

solar PV manufacturing with INR 14,007 Cr under the Production Linked Incentive Scheme. The National Green Hydrogen Mission targets producing 5 million metric tonnes annually by CY30, while the government plans to add 50 GW of renewable energy capacity annually until FY28. Additionally, India launched the Global Biofuels Alliance at the G20 Summit, partnering with countries like the US, Brazil, and the UAE to promote sustainable

Sectorial share of Renewable energy
(%, CY23)



Global solar energy production
(GW, CY18-23)



Note(s): Others include Bioenergy, Geothermal energy & Marine energy
Source(s):International Renewable Energy Agency(IRENA)

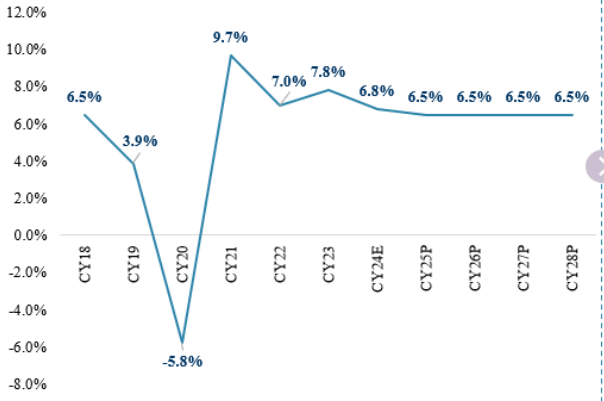
energy solutions.
According to the International Renewable Energy Agency (IRENA), renewables could supply 65% of the world's electricity by CY50 and create over 30M jobs in clean energy and related industries by CY30. At the end of CY23, the global renewable power capacity reached 3,870 GW. Solar energy held the largest portion of this total, with a capacity of 1,418 GW. Renewable hydropower and wind energy followed, with capacities of 1,268 GW and 1,017 GW, respectively. Global solar energy production has surged from 492 GW in CY18 to 1418 GW in CY23, marking a 24% growth due to growing demand for clean and sustainable energy sources. And in CY23, there was a net increase of 345 GW in global solar energy capacity, with Asia accounting for more than 60% of the new installations.

1.2. Indian Macroeconomic Overview

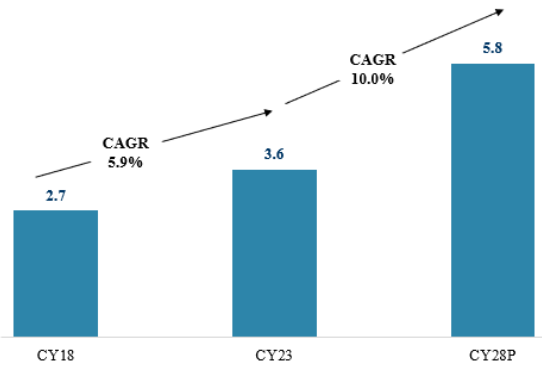
1.2.1 India's GDP was at US$ 3.6T in CY23 and is estimated to reach US$ 5.8T in CY28

India is the fifth largest economy in the world in CY23 and is expected to be the third largest by CY28, India is expected to reach US$ 7T by CY30 as per government targets. Over the next 10-15 years, India is expected to be

Real GDP growth – India
(Y-o-Y growth %, CY18-28P)



India's Nominal GDP (at current prices)
(US$ T, CY18-28P)



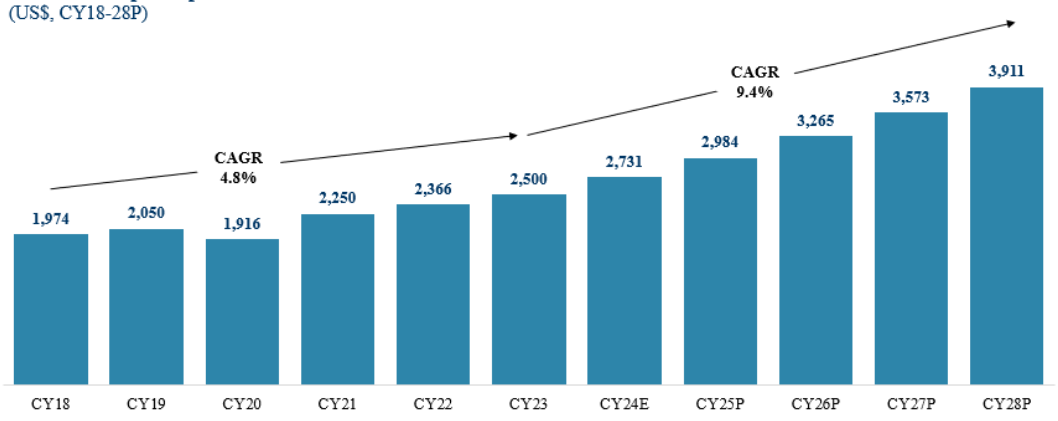
Source(s): International Monetary Fund

among the top economies on the back of rising demand, robust growth in various sectors. India's GDP (at current prices) grew from US$ 2.7T to US$ 3.6T between CY18 and CY23 on the back of robust reforms like GST, corporate tax revision, and revised FDI limits. As per IMF projections, India's real GDP is expected to grow at a rate of 6.5% from CY23 to CY28, making it one of the fastest-growing large economies globally.

1.2.1.1. India's per capita income stood at ~US$ 2.5K in CY23 and is expected to reach ~US$ 4.0K by CY28

India's per capita income is expected to rise from US$ 2.5K to ~US$ 4.0K by CY28 growing at a CAGR of 7.7%. With increased demand, substantial per capita income growth, and a demographic advantage, India is positioned as a market with vast growth opportunities.

India's GDP per capita
(US$, CY18-28P)



Source(s): International Monetary Fund

Over CY23-28, India's GDP per capita is projected to lead with a 9.4% growth rate, driven by strong manufacturing, higher agricultural output, and robust government spending, making it the fastest-growing major economy, followed by China (6.0%), the UK (5.2%), the USA (3.6%), and Germany (3.3%).

Global GDP per capita – Top economies
(US$, CY18-28P)

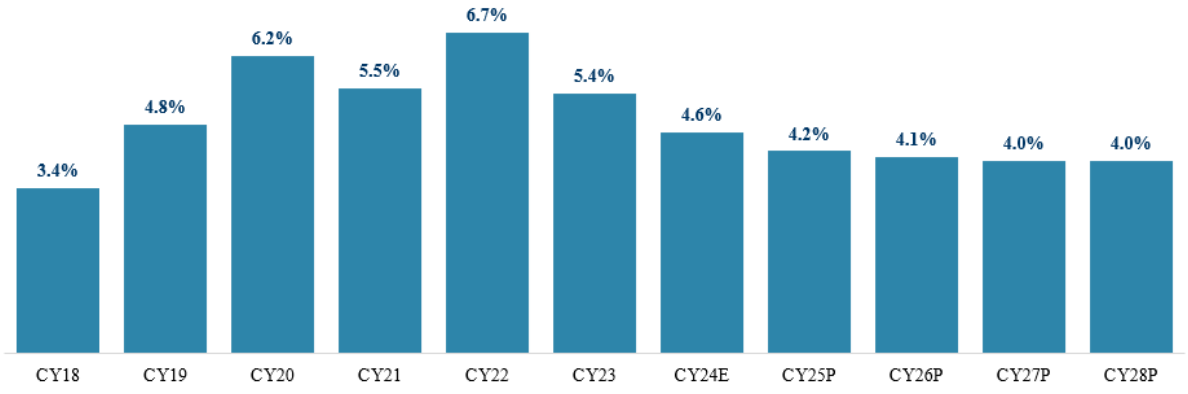
Top economies	CY18	CY23	CY24E	CY28P	CAGR CY18-23	CAGR CY23-28
India	1,974	2,500	2,731	3,911	4.8%	9.4%
USA	63,165	81,632	85,373	97,231	5.3%	3.6%
Germany	47,961	52,727	54,291	61,965	1.9%	3.3%
UK	43,275	49,099	51,075	63,279	2.6%	5.2%
China	9,849	12,514	13,136	16,782	4.9%	6.0%

Source(s): International Monetary Fund

1.2.2. India's CPI inflation rate was 5.4% in CY23, and RBI aims to bring it down to around 4% by the end of CY26

According to the IMF, India's CPI inflation rate was 5.4% in CY23 and is estimated to decline to 4.6% by CY24 due to a decrease in food inflation and favourable base effects from CY23 (Russia-Ukraine war). During CY20-23 period, CPI inflation rates have increased due to volatile components like vegetable prices, fuel costs, and commodities such as gold and edible oils. By CY26, the RBI aims to bring the CPI inflation rate to a target of 4%

India's inflation at avg. consumer prices
(%, CY18-28P)

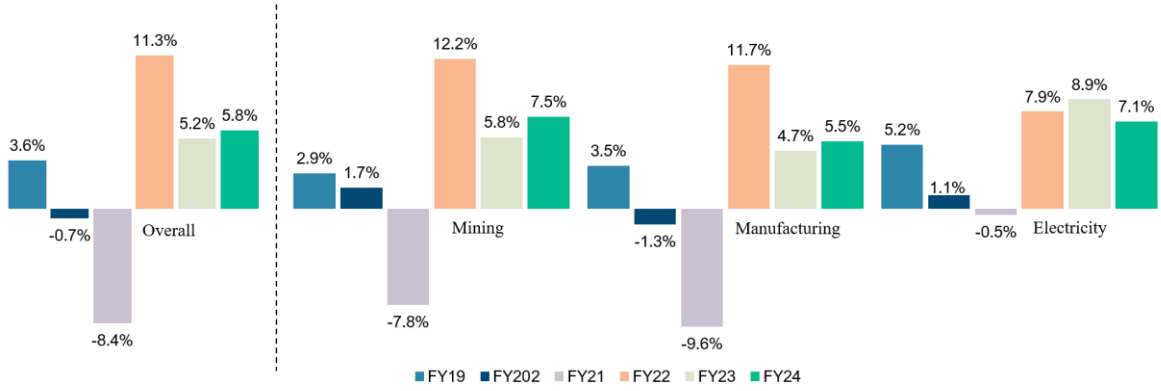


Source(s): International Monetary Fund

1.2.3. India's Index of Industrial Production (IIP) grew by 5.8% in FY24, up from 5.2% in FY23, showcasing a 0.6% growth

According to the Ministry of Statistics and Programme Implementation, India's Industrial Production (IIP) growth rate had a strong recovery in FY22 (11.3%), observed a 5.2% IIP growth in FY23 and a slight increase to 5.8% in FY24. Overall, the growth has increased from FY19 at 3.6% to 5.8% in FY24, reflecting 2.2% growth. This growth is attributed to rising domestic demand, increased foreign direct investment (FDI), government initiatives like 'Make in India', and growth in capital goods and infrastructure/construction sectors. In FY24, mining grew by 7.5%, manufacturing by 5.5%, and electricity by 7.1%, showcasing sector-specific advancements.

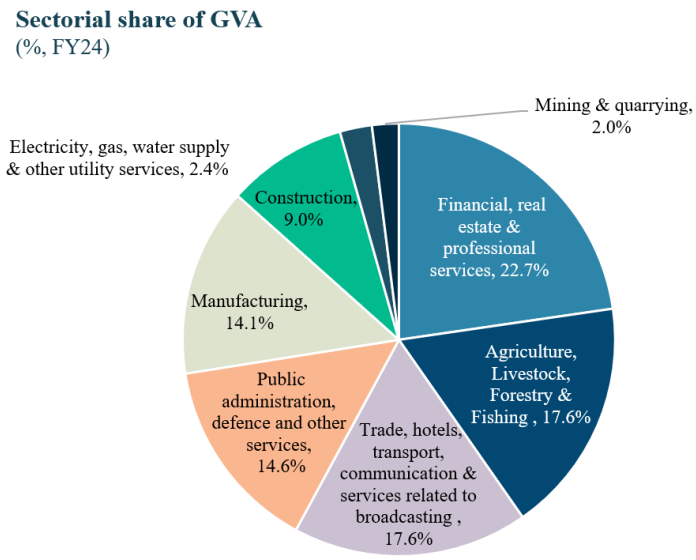
India's IIP growth – Sector-wise
(Y-o-Y growth %, FY19-24)



Source(s): Ministry of Statistics and Programme Implementation (MoSPI)

1.2.4. As of FY24, financial, real estate, and professional services holds 22.7% of the GVA followed by agriculture, livestock, forestry & fishing at 17.6%

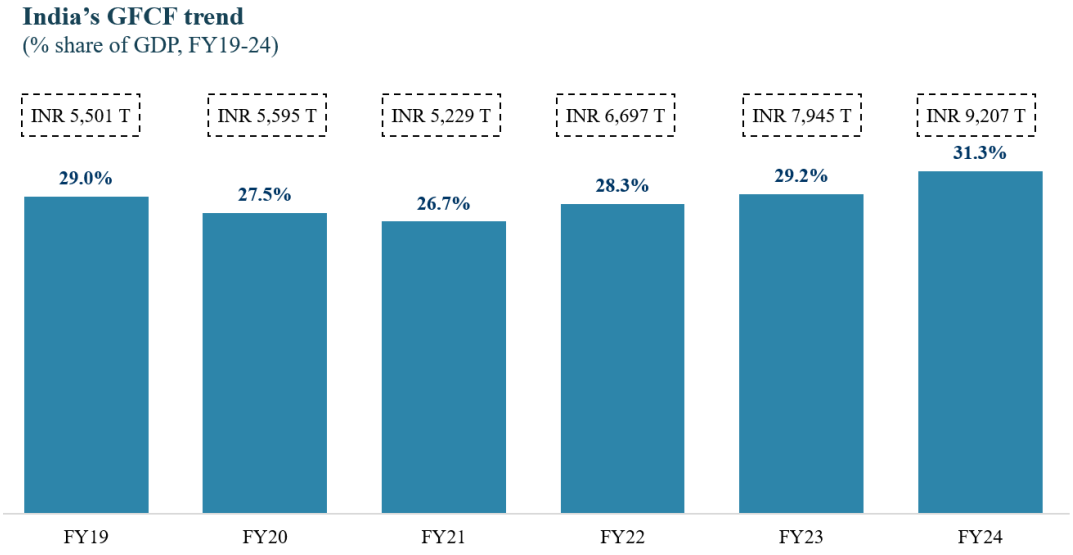
Financial, real estate and professional services hold the highest share of 22.7% in the overall GVA. Agriculture and allied industries contributes to 18% of the GVA share. The industry sector is expected to grow in FY25 given the manufacturing and construction boost.



Source(s): Ministry of Statistics and Programme Implementation (MoSPI)

1.2.5. Gross Fixed Capital Formation

Gross Fixed Capital Formation represents the total value of investments in tangible assets like machinery, buildings, and infrastructure, minus disposals, during a specific period. A higher GFCF-to-GDP ratio indicates increased investment in productive assets, leading to improved economic performance and competitiveness. This crucial economic indicator reflects the investment level in the economy, signifying growth potential and long-term development.



Source(s): Ministry of Statistics and Programme Implementation (MoSPI)

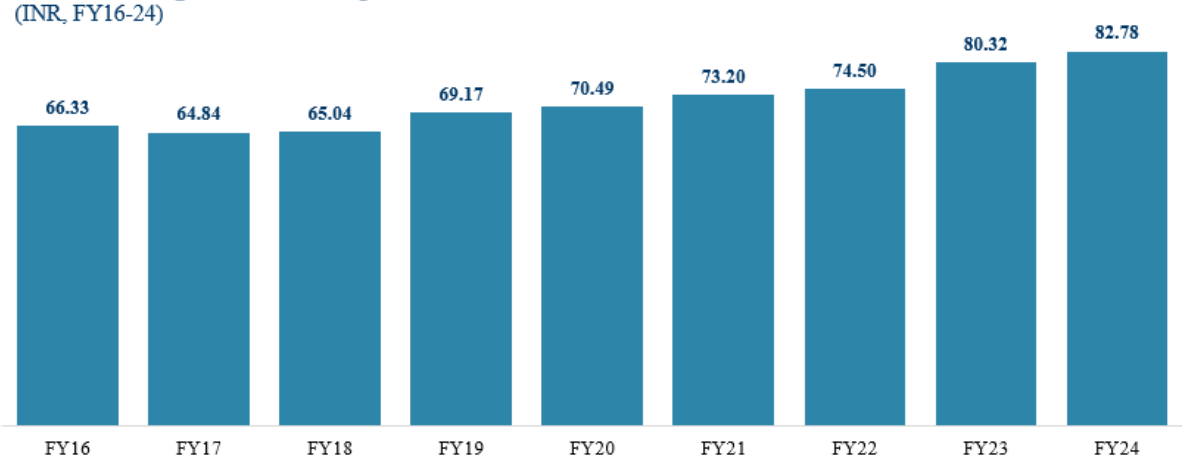
According to the Ministry of Statistics and Programme Implementation (MoSPI), GFCF as a percentage of GDP increased from 29.2% in FY23 to 31.3% in FY24, reflecting a 2% growth. Overall, GFCF has increased from 29.0% in CY'19 to 31.3% in CY'24, showcasing 1.3% growth. This increase is driven by both government and private sector investments in productive assets, infrastructure development, and capital projects, supported by initiatives like 'Make in India', 'Scheme for Special Assistance to States for Capital Expenditure', and 'Scheme for Special Assistance to States for Capital Investment', etc.

1.2.6. Indian Exchange rates

The Indian rupee has depreciated against the US$ from 1 US$ = INR 69.17 in FY19 to 82.78 in FY24, due to differences in economic growth and stability, influenced by global conditions, foreign investments, and fiscal

policies. Fluctuations in this exchange rate are affected by inflation, interest rates, policies, and market demand, impacting international trade and foreign investments, making it crucial for India's economy.

Indian exchange rates – INR equivalent of one US$
(INR, FY16-24)



Source(s): X-rate Monthly average

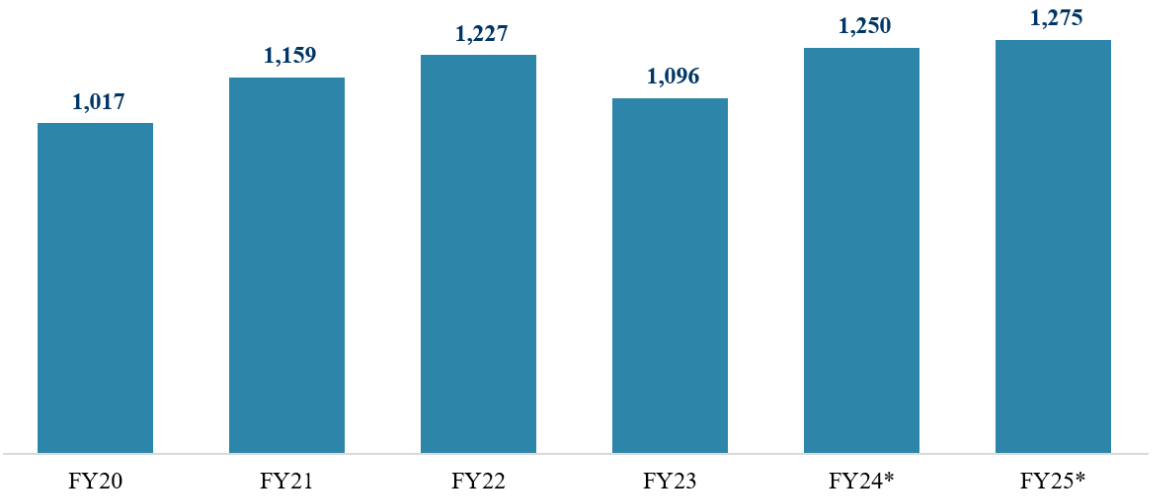
1.2.7. Agriculture is a major employment contribution sector in India

According to the Periodic Labour Force Survey (PLFS) conducted by the National Sample Survey Office (NSSO), Ministry of Statistics and Programme Implementation (MoSPI), approximately 45.76% of India's total workforce was engaged in the agriculture and allied sector during the FY23 period. The transition of the workforce from the primary (agriculture) sector to the secondary and tertiary sectors is a typical aspect of the development process seen in countries worldwide, including India. In FY24, agriculture contributes about 18% of India's Gross Value Added (GVA) to the total economy, with a growth rate of around 4.3% over the last six years.

1.2.8. Budget allocation towards agriculture in India

The Indian government has allocated a budget of INR 1,275B for the Ministry of Agriculture in FY25, slightly higher than the current fiscal year's INR 1,250B, marking an overall 2% increase in the budget. FY25 budget is divided into INR 1,170B for the Department of Agriculture, allocation aims to support agricultural growth and productivity by focusing on areas like crop insurance, expanding nano fertilizer coverage, and promoting self-sufficiency in oilseed production. The budget of India allocated INR 10,000 Cr to solar power projects in FY25, which is a 110% increase from the INR 47B allocated in FY24.

India's budget allocation for agriculture
(INR B, FY20-25*)



Note(s): FY20-23 are actual expenditures from budget, FY24-25* are budget estimates
Source(s): Ministry of Statistics and Programme Implementation (MoSPI)

1.2.9. Key government policies related to agriculture infrastructure

- **Agriculture Infrastructure Fund (AFI):** Aims to provide medium to long-term debt financing facility till FY26 through 3% interest subvention and credit guarantee support on loans for the creation of post-harvest management infrastructure and community farming assets.
- **Rashtriya Krishi Vikas Yojana (RKVY):** Focuses on developing pre and post-harvest infrastructure in agriculture, providing quality inputs and market facilities to farmers. It allows states flexibility to address local farmers' needs, aiming to bridge resource gaps in agriculture and allied sectors by offering financial support for activities that boost overall growth and farmers' income.
- **Pradhan Mantri Kisan Sampada Yojana (PMKSY):** Aims at modernizing and strengthening the food processing sector. It focuses on creating infrastructure facilities to reduce wastage and increase value addition in agricultural produce. PMKSY plays a significant role in boosting farmer incomes, reducing post-harvest losses, and promoting food security in the country.

1.3. Introduction of climate goals by countries to curtail the rapid climate changes

Climate change is increasing the frequency and intensity of extreme weather events like intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms, and declining biodiversity. Since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas. Greenhouse gas generated through burning fossil fuels act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures. Greenhouse gases like carbon dioxide and methane are mostly causing climate change.

Climate goals/targets are the limits that scientists and policymakers set in plans to combat climate change. These targets take different forms, from goals for limiting the Earth's warming to hard caps on greenhouse gas emissions. The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, is a treaty among governments that provides a foundation for global climate efforts. India, in pursuit of its sustainability goals, requires substantial climate finance, estimating the need for around US$ 170B per year for its climate change actions by CY30.

ESG-focused institutional investment is expected to grow by 84% to USD 33.9 trillion by CY26 globally, making up 21.5% of assets under management. ESG-focused equity funds in India have grown from US$ 330M in December 2019 to US$ 1.3B in June 2023. Major companies in India are making concerted efforts towards sustainability across various fronts. Hindalco Industries, Aditya Birla Group's flagship metal company, is experimenting with a combination of solar and wind sources to achieve its target of meeting 30% of its energy requirements via renewable sources by CY30. Radiance Renewables, backed by India's largest climate fund Eversource Capital, plans an investment of INR 1,245 Cr over the next three years in the hybrid energy space. NTPC Green Energy Ltd (NGEL) is expanding into solar, wind, and hybrid projects. It operates over 3.4 GW and has 26 GW in the pipeline, with 7 GW under implementation. Renew Power won the bid for developing 600 MW. ACME has built and operated 5,000+ MWp (Megawatt peak) solar power and has 10,000+ MWp under construction. Infosys is adopting clean technology in its operations and client solutions to minimize the impact on the environment.

India's solar power target is to achieve installed energy capacity of 300 GW by CY30, as of FY24 81.8 GW. The Indian government has introduced a Production Linked Incentive Scheme (PLI) for the National Programme on High-Efficiency Solar PV Modules to achieve a manufacturing capacity of Gigawatt (GW) scale in High-Efficiency Solar PV modules. This scheme has an outlay of INR 24,000 Cr to boost domestic manufacturing. Along with this, the government has a Solar Park Scheme that aims to establish 50 Solar Parks of 500 MW and above, with a cumulative capacity of approximately 38 GW by CY25-26.

The M-SIPS program aims to increase investment in electronics manufacturing by providing up to a 25% capital subsidy for new or expanded projects, with investments ranging from INR 1Cr- INR 5,000 crore. NEGL signed an MoU with Government of Maharashtra for development of Green Hydrogen and derivatives of ~ 1M Ton capacity/annum. This includes Pump Hydro Projects of 2 GW and development of RE projects with or without storage up to 5 GW in the state.

1.3.1. Kyoto Protocol in 1997

The Kyoto Protocol, adopted in 1997, aimed to reduce greenhouse gas emissions and mitigate global warming. The Kyoto Protocol was adopted under UNFCCC by 41 countries and European Union. It established mechanisms like emissions trading, clean development mechanisms, and joint implementation to help countries meet their targets cost-effectively.

The Kyoto Protocol only legally bound developed countries to reduce emissions, while developing countries were exempt from emission reduction targets. The protocol's overall impact on global emissions was modest, as major emitters did not ratify it, and developing countries were not required to reduce emissions.

1.3.2. Paris Agreement 2015

The Paris Agreement, adopted in CY15, is a legally binding international treaty on climate change. It aims to limit global warming to below 2°C, preferably 1.5°C, compared to pre-industrial levels. It requires all countries to set emissions reduction targets and strengthen them over time.

The Paris Agreement involves all countries, both developed and developing, in setting and achieving emission reduction targets, addressing the issue of limited participation in the Kyoto Protocol. Countries can determine their own contributions (Nationally Determined Contributions, NDCs) based on their national circumstances, providing flexibility but also requiring regular updates and increased ambition over time. It provides a framework for financial, technical, and capacity-building support to those countries who need it. With the Paris Agreement, countries established an enhanced transparency framework (ETF) within which countries will report transparently on actions taken and progress in climate change mitigation, adaptation measures and support provided or received.

1.3.3. Implication of climate goals on India

Under the Kyoto Protocol, India was not required to meet any binding emission reduction targets as it was classified as a developing country. This allowed India to continue its economic growth without immediate constraints on emissions or carbon goals. India still benefitted from the transfer of technology and additional foreign investments into renewable energy, energy generation and efficiency promotion when the Kyoto Protocol came into force.

Unlike the Kyoto Protocol, the Paris Agreement required all countries, including India, to take climate action and report on their progress, putting more pressure on India to control its rapidly growing emissions. To meet its Nationally Determined Contribution targets, India needed to strengthen its climate policies, promote renewable energy, improve energy efficiency, and implement other mitigation measures.

1.3.4. India's action plan to stay in line with Paris agreement

- **Nationally Determined Contributions (NDCs)**: India has set targets to reduce the emission intensity of its GDP by 45% by CY30 from CY05 levels and achieving 50% of its installed electricity capacity from non-fossil fuel sources by CY30.
- **Renewable energy push**: India has an ambitious target of installing 500 GW of renewable energy capacity by CY30, with current capacity at 190 GW. Achieving this requires an investment of ~INR 9,245Cr, in addition to the ongoing transmission network strengthening initiatives by the Central Electricity Authority (CEA).
- **Net Zero emissions**: India will achieve its target of Net Zero by CY70. For achieving the same, Net Zero target by CY30 by Indian Railways alone will lead to a reduction of emissions by 60 million tonnes annually. Similarly, India's massive LED bulb campaign is reducing emissions by 40 million tonnes annually. Global energy sector investment (currently at $2 trillion) falls far short of the required USD 5-7T for net-zero GHG emissions by 2030.
- **National Clean Air Programme**: India launched the National Clean Air Programme in CY19 to tackle air pollution across the country, which is expected to curb greenhouse gas emissions as well. To facilitate this, the Ministry of Environment, Forest, and Climate Change has allocated INR 10.4K Cr.
- **International Solar Alliance**: India has taken a leadership role in promoting the International Solar Alliance, a coalition of countries dedicated to increasing the deployment of solar energy worldwide. The Export Import Bank of India (EXIM Bank) has committed to provide financing for solar projects worth USD 1.4 Billion.
- **National Wind-Solar Hybrid Policy 2018**: Framework for the promotion of large grid-connected wind-solar photovoltaic (PV) hybrid systems for optimal and efficient utilization of wind and solar resources, transmission infrastructure and land.
- India will create an additional carbon sink of 2.5 to 3B tonnes of CO2 equivalent through additional forest and tree cover by CY30.
- India plans to bring down the carbon intensity of the economy to less than 45%.

While India is indeed implementing some actions to achieve its goals, for instance, India has one of the most rapidly developing renewable energy sectors in the world, but the Climate Action Tracker, which tracks the climate actions of 40 countries and their impacts, rates India's overall climate action as "highly insufficient" indicating that India's action needs to be more robust.

1.3.5. Adoption of solar energy-based irrigation and rooftop electricity generation will help reduce carbon footprint & achieve climate goals

India has almost 17.5 lakh sq km of arable land which is the highest in the world. Majority of the land in India is irrigated using groundwater pumps, which are majorly connected to the grid or diesel based. Solarization of irrigation is the use of solar energy to power irrigation pumps and drip irrigation systems will help government in achieving the climate goals along with ensuring easy accessibility and cost-effective alternatives to farmers. On similar lines, government has launched PM-KUSUM scheme to solarize irrigation with target to achieve solar power capacity addition of 34.8 GW by end of FY26 with total central financial support of INR 34.4K Cr

Advantages of solarization of irrigation and rooftops	
Reduced effect of greenhouse gases	• Solar-powered irrigation and rooftop systems helps reducing greenhouse gas emissions as they don't rely on fossil fuels
Reduced carbon emissions	• Through solarized irrigation and rooftop, India can achieve reduction in carbon emissions by 32 million tonnes
Increased accessibility	• Solar pumps and rooftops are beneficial for the remote areas in the country help improve easy access and same time reduce the power outage
Easing government's financial burden	• Adoption of solar powered irrigation helps reduce electricity subsidy for agriculture of INR 1L Cr+ and reduces oil import by 1.38 billion liters per annum
Cost-effective	• Solar pumps and rooftop solar are cost-effective over life-time with lower operating costs
Long operating life	• Solar water pumps offer long operating life due to their minimal moving parts and reliance on renewable solar energy
Flexible harnessing of water	• Solar pump systems enable round-the-clock water harnessing, allowing farmers to efficiently plan irrigation and other activities without being constrained by power supply availability
Curbing transmission & distribution losses	• Reduction in transmission & distribution losses by up to 20% with solarization of pumps and rooftops

Solar power generation is emission-free, helping lower greenhouse gas emissions, improve air quality, and contribute to India's renewable energy goals. Solar rooftops can significantly reduce electricity bills by up to 50%, saving households INR 15,000-18,000 annually and businesses over INR 2 crore. It is an economically viable and safe option for communities without reliable grid access, and the "PM-Surya Ghar: Muft Bijli Yojana" scheme aims to provide 300 units of free electricity per month to 10 million households through rooftop solar. These systems have a long lifespan of over 25 years, require minimal maintenance, and have no moving parts.

1Lattice

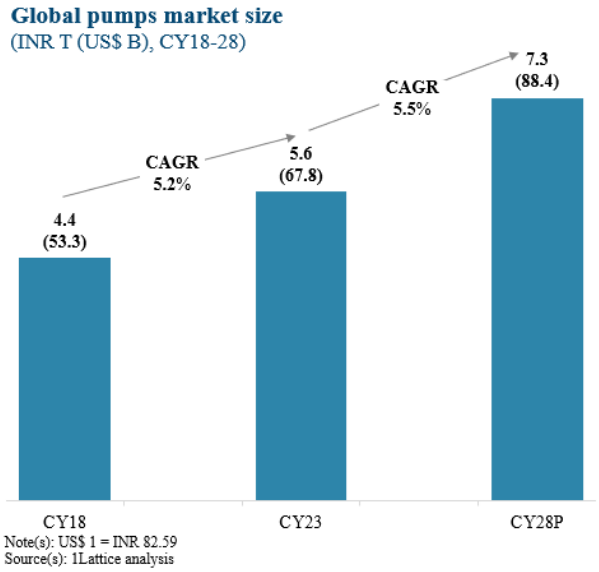
02

Global Pumps Market Outlook

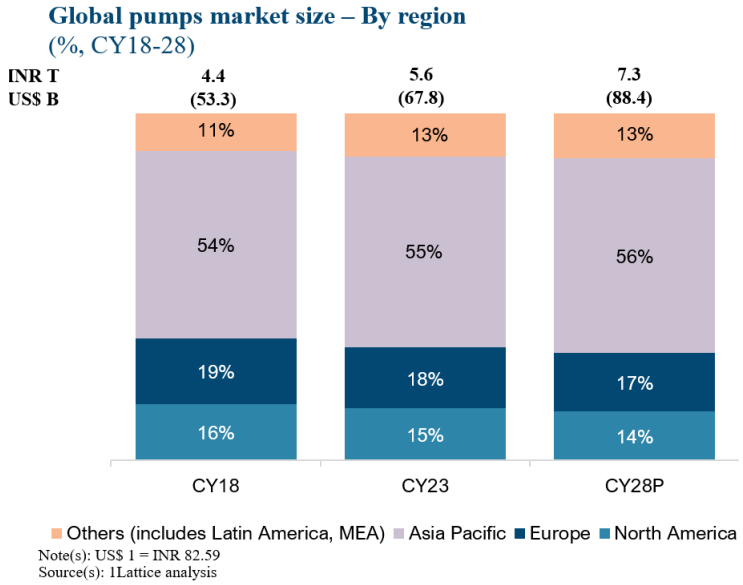
2. Global Pumps market Scenario & outlook

2.1. The global pump market was INR 5,6T in CY23 and is expected to reach INR 7.3T by CY28, growing at a CAGR of 5.5% between CY23-28

The pump industry plays a very pivotal role in sectors such as agriculture, manufacturing and residential. Increasing investments in the renewable energy sector like solar panels and advancements in pump manufacturing technology like smart pumps, pumps developed for specific use cases requiring highly specialized functions are poised to fuel growth for the global pump market in the future. This expansion will be supported by factors such as rapid urbanization, rising demand in the power sector, and a focus on water recycling and wastewater treatment, among other drivers.



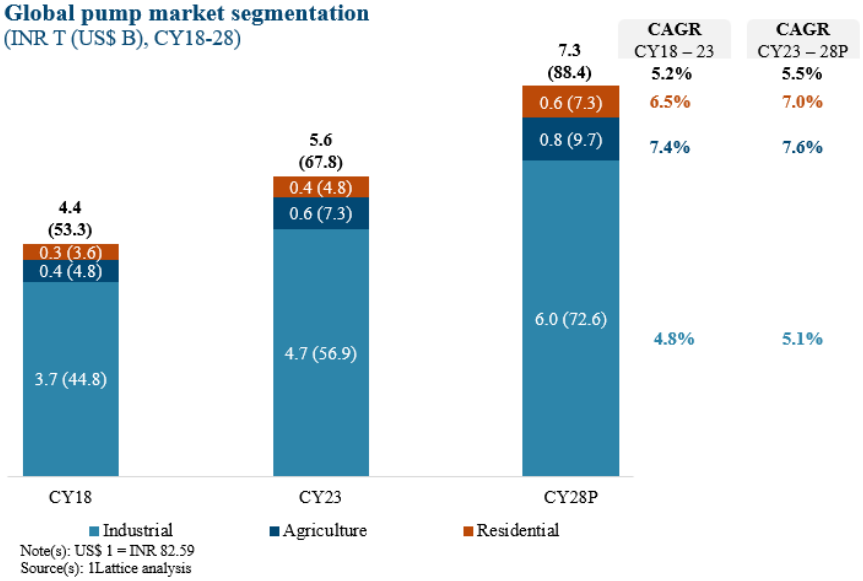
The global pump market grew at a CAGR of 5.2% from CY18-23, with the market being INR 5.6T in CY23 and expected to reach INR 7.3T by CY28, growing at a CAGR of 5.5% between CY23-28. The rapid industrialization in emerging economies, along with substantial infrastructure development, necessitates pumps for various purposes including water supply, wastewater treatment, and manufacturing operations. Furthermore, SDG 6 focuses on addressing water scarcity, poor water quality and inadequate sanitation globally, thereby requiring water pumps to meet the increased demand and handle water quality challenges.



The Asia-pacific pump market accounted for ~55% of the total market in CY23, which is the fastest growing market followed by Europe (18%), North America (15%) and Latin America & MEA (13%). The market share of Asia Pacific is expected to hold 56% of the total market by CY28. Rapid industrialization in developing Asia-

Pacific countries and increased investments in commercial and industrial projects have significantly contributed to the region's global growth. Additionally, the economies in the Asia-Pacific region are projected to thrive during the forecast period due to the ongoing expansion of end-use industries, such as the chemical industry, which is anticipated to drive up demand for liquid handling equipment.

2.1.1. The global pump market is segmented into industrial, agricultural and residential; Agricultural pump market is expected to grow at a CAGR of 7.6%, highest among all the segments



The industrial pump market size was INR 4.7T in CY23 and is expected to reach INR 6.0T market by CY28, projected to grow at a CAGR of 5.1%. This growth is driven by several factors, including industrialization in emerging economies, infrastructure development activities, and stringent regulations for wastewater treatment, among others. The agriculture pump market was INR 0.6T in CY23 and is expected to grow at a CAGR of 7.6% between CY23-28, reaching INR 0.8T by CY28. The main accelerators behind the market growth are the increasing adoption of solar pumps, demand for modern irrigation techniques and government support towards the adoption of modern agricultural equipment.

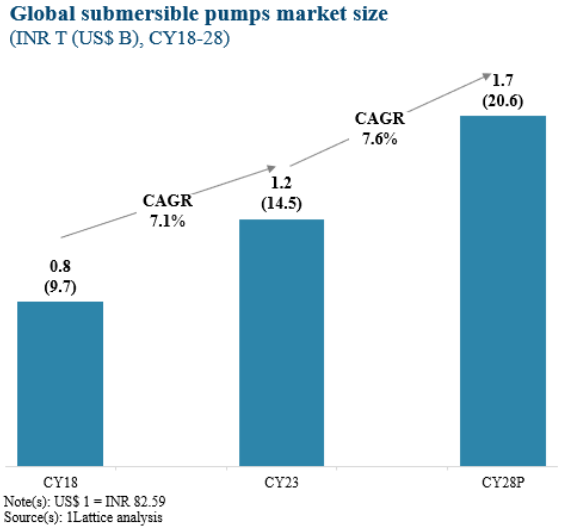
The pump market offers a variety of types to suit different applications.

- Submersible pumps are designed to operate underwater, ideal for wells and drainage systems.
- Monoblock pumps are compact and efficient, commonly used in agricultural and industrial settings.
- Centrifugal pumps, known for their simple design and reliability, are widely used for water supply and HVAC systems.
- Multistage pumps provide high pressure by utilizing multiple impellers, suitable for high-rise buildings and long-distance water transport.
- High-end precision pumps are engineered for accuracy and consistency, essential in pharmaceutical, food processing, and chemical industries.

Each type caters to specific needs, ensuring optimal performance across diverse sectors.

2.2. The global submersible pump market is expected to grow at a CAGR of 7.6% during CY23-28, reaching INR 1.7T by CY28

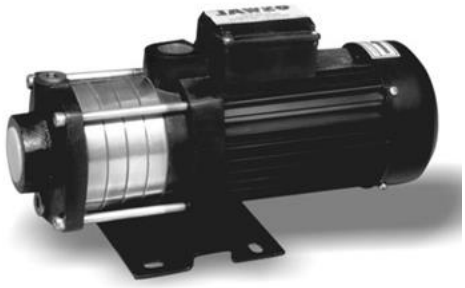
A submersible pump extracts water and debris while fully submerged inside the water source. Built to sustain complete immersion, these pumps are encompassed with protective measures to shield internal components from water damage. Encased within a watertight chamber, the motor remains safeguarded, preventing entry of harmful substances that could corrode its mechanisms. This design enhances operational efficiency and prolongs the pump's lifespan. These pumps are mainly used for, irrigation, waste water and sewage treatment, drilling rigs and oil wells to extract water from deep browells, removing water from flooded sites, etc.

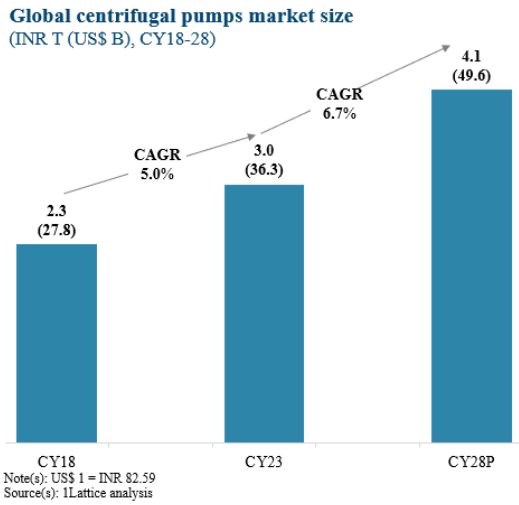


The global submersible pump market size was INR 1.2T in CY23 and is expected to reach INR 1.7T by CY28, growing at a CAGR of 7.6% from CY23-28. The increasing need for efficient water management systems in residential and commercial sectors, increasing demand for hydrocarbon products and agricultural activities will drive demand for submersible pumps.

2.3 The global centrifugal pump market is projected to grow at a CAGR of 6.7% between CY23-28 reaching INR 4.1T by CY28

Centrifugal pumps are installed on the ground and widely employed across industries for fluid conveyance. Centrifugal pumps comprise of pump head, shaft, and impeller and they function through a motor-driven rotation mechanism. They are operated by converting rotational energy into kinetic energy, propelling the fluid through the pump. These pumps are widely used in manufacturing, pharma, food & petrochemical industries, municipal facilities, residential areas for drinking water supply, power stations, irrigation as well as gas and oil sectors to remove oil, dirt, slurry and other materials.



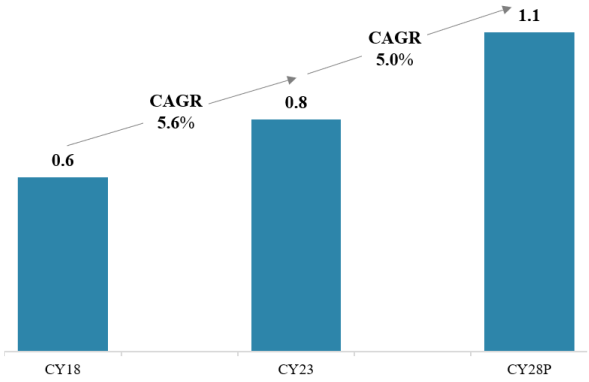


The global centrifugal pump market size was INR 3.0T in CY23. It is poised for significant growth at a CAGR of 6.7% and projected to reach INR 4.1T by CY28. Increasing demand for water and wastewater treatment, and rising investments in infrastructure projects are driving the demand for centrifugal pumps. Moreover, the growing emphasis on upgrading plant infrastructure across industries including pharmaceuticals, municipal services, and food & beverage is anticipated to bolster the sector in the upcoming period.

2.4. The global monoblock pump market is expected to reach INR 1.1T by CY28, growing at a CAGR of 5.0%

A monoblock pump is a type of centrifugal pump that has all its rotating components mounted on a single shaft. Fresh water and fluids that are not chemically aggressive to pump components are recommended for centrifugal monoblock pumps. It works well for domestic applications and is used in drinking water supply, gardens, apartments, etc. It is also used for small-scale agriculture.

Global monoblock pumps market size
(INR T, CY18-28)



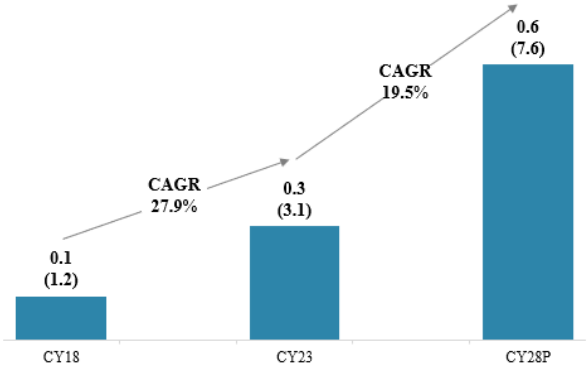
Source(s): 1Lattice analysis

The global monoblock pump market size was INR 0.8T in CY23. It is projected to grow at a CAGR of 5.0% between CY23-28, reaching INR 1.1T by CY28. This growth is fueled by the demand for effective fluid management solutions across sectors such as agriculture, construction, and water treatment. Furthermore, the expansion of urban areas and the increasing demand for energy-efficient pumping systems are contributing to the market's upward trajectory.

2.5. The solar pump market was INR 0.3T in CY23 and is anticipated to grow at a CAGR of 19.5% during CY23-28, reaching INR 0.6T by CY28

A solar pump is an electrical pump that uses electricity generated by solar panels to provide the energy needed for the motor to pump water out of the source. This pump can extract water from deep underground. Moreover, it also serves as a sustainable alternative to unreliable grid power and environmentally harmful diesel-powered pumps. Solar pumps are used in agriculture for irrigation, especially in regions with limited electricity access, domestic and community water supply.

Global solar pumps market size
(INR T (US$ B), CY18-28)



Note(s): US$ 1 = INR 82.59
Source(s): 1Lattice analysis

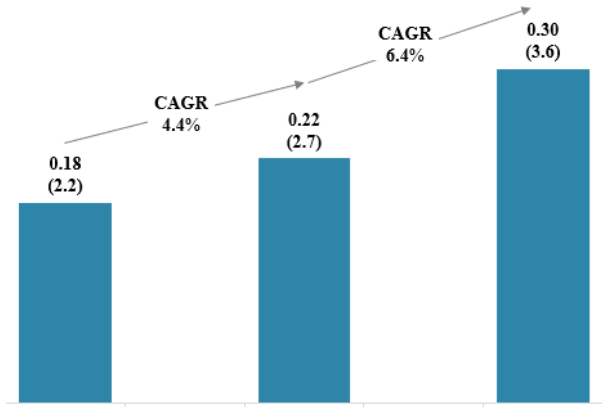
The global solar pump market was INR 0.3T in CY23 and is expected to grow at a CAGR of 19.5% between CY23-28, reaching INR 0.6T by CY28. This growth is attributed to several factors, including increasing government support through subsidies, energy efficiency and cost savings offered by solar pumps, and concerns regarding water scarcity climate change and erratic rainfall. The need to reduce reliance on diesel pumps, government subsidies offered in various nations like the PM-KUSUM scheme of India, Rural Energy for America

Program of the USA & Solar rebate Program of UAE, lower operating expenses compared to traditional pumps and adoption in remote areas with limited grid coverage are driving the demand for solar pumps. Additionally, government in different countries is providing grants, low-interest loans, and tax credits to individuals and businesses to promote the adoption of solar pumps and other renewable energy technologies.

2.6. The global booster pump market size was INR 0.22T in CY23 and is projected to reach ~INR 0.30T by CY28

A pressure booster pump helps augment the pressure of a fluid to a desired level. Booster pumps are present in both residential and commercial structures, serving to amplify diminished water flow within systems or machinery and facilitate the transfer of water from sources like lakes, ponds, or storage tanks to be utilized in households or commercial establishments. These pumps utilize a motor-driven impeller to draw water in through the inlet and expel it through the outlet. Booster pumps are essential for applications like watering your lawn or garden using an irrigation or sprinkler system or for increasing water pressure in a multi-story building or apartment complex, water supply for municipalities or buildings using well-water systems. It is also used in manufacturing industries requiring high-pressure water flow, mining and food processing industries

Global booster pumps market size
(INR T (US$ B), CY18-28)

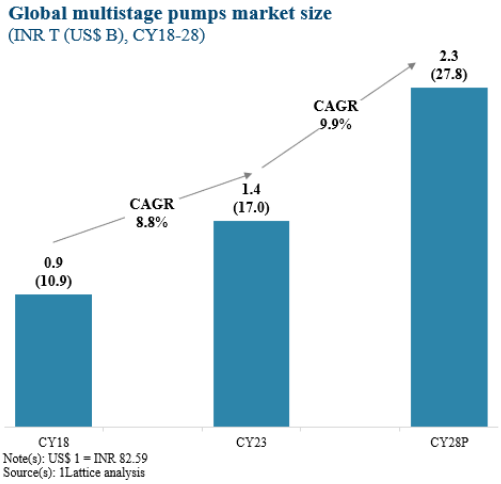


Note(s): US$ 1 = INR 82.59
Source(s): 1Lattice analysis

The global booster pump market was INR 0.22T in CY23. It is estimated to grow at a CAGR of 6.4% from CY23-28 and reach INR 0.30T by CY28. A surge in residential construction leading to high water consumption, and the launch of energy-efficient booster pumps are the key factors contributing to the growth and demand for pressure booster pumps. Also, regions facing water scarcity use pressure booster pumps to optimize water usage by efficiently distributing water resources.

2.7. The multistage market was INR 1.4T during CY23 and expected to grow at a CAGR of 9.9% during CY23-28

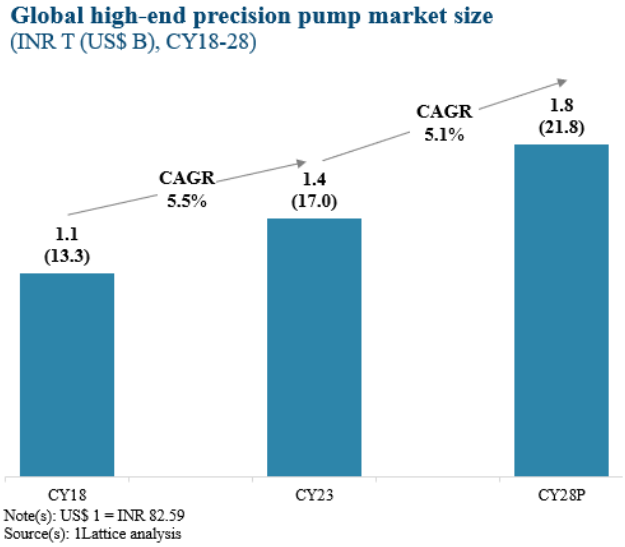
A multistage pump is characterized by the passage of fluid through a series of two or more impellers. Consequently, this type of pump has numerous liquid chambers or stages arranged in a series. Each stage includes an impeller, along with a diffuser and return guide vanes, all contained within a single casing. Multistage pumps are available in various types, including horizontal and vertical centrifugal pumps, submersible pumps, side channel pumps, split case pumps, and turbine pumps. These pumps are commonly used in applications requiring high pressures, such as high-rise building water delivery, irrigation, reverse osmosis, fuel delivery, oil and gas production, mining, and supplying boiler feed water in power plants.



Global multistage pumps market size was INR 1.4Tin CY23 and is expected to grow at a CAGR of 9.9% between CY23-28. The global multistage pump market is set for sustained growth, driven by industrial expansion, technological advancements, regulatory requirements, and rising demand for efficient water management solutions across multiple sectors.

2.8. Global high-end precision pump market was valued at INR 1.4T in CY23 and is projected to grow at a CAGR of 5.1% during CY23-28, with the market reaching INR 1.8T in CY28

High-end precision pumps are distinctly designed pumps and have operational attributes that make them particularly suitable for applications where precise fluid transfer and control are paramount. These pumps operate by capturing a fixed volume of fluid and then displacing it into the discharge pipe. These pumps can accommodate a wide range of fluids like corrosive, abrasive, etc. which makes them versatile for numerous applications. These pumps are designed to ensure a consistent flow rate even under high-pressure conditions, which is essential in various industries such as petroleum, gas, chemicals, food and beverages, and water treatment.



The global market size for high-end precision pumps was INR 1.4T in CY23 and is projected to reach INR 1.8Tby CY28, growing at a CAGR of 5.1% during CY23-28. Advancements in pump technologies, the expansion of industries like pharmaceuticals, and chemicals which require handling high-viscosity fluids such as heavy oils, slurries, etc are driving the market of high-end precision pumps. Pumps like Inline pumps are employed for circulating chilled water and hot water in commercial buildings. These pumps are widely used in both residential and commercial buildings applications, including hydronic heating systems and domestic hot water circulating systems.

2.9. Rising urbanization & industrialization, stringent government regulations & initiatives are some of the factors which will drive the global pump market

The pump industry is being propelled by rising urbanization and industrialization, along with strict government regulations regarding wastewater treatment. Grants provided by institutions like the World Bank for water infrastructure development and technological advancements in alternative solutions to conventional pumps, such as solar pumps, are expected to drive market growth. Moreover, the incorporation of technology and computer modelling in pump manufacturing has led to innovative advancements in pump design, repair, and replacement, fostering growth and paving the way for future opportunities.

Growth drivers	
Technological advancements	• Growing demand as **advanced technologies** like IoT and AI are revolutionizing pump manufacturing
Stringent government regulations	• Stringent regulations for **wastewater treatment** leading industries to invest in energy-efficient pumping solutions
Government initiatives	• Subsidies offered through Government initiatives like **PM KUSUM (India), REAP (USA)** and **Solar Rebate Program (UAE)** – REAP, USA: USDA announced US$ 145M in funding in 2023 for 700 loans and grants through REAP to help agricultural producers and rural small business owners make energy efficiency – Solar rebate program, UAE: Provides financial incentives or rebates to individuals or businesses for installing solar panels
Rapid industrialization	• Industrial growth in **mining, petrochemicals**, etc. drives demand for efficient pumping systems for water supply & fluid transfer
Rising urbanization	• Rising **need for water in residential** and **commercial sectors** requires investments in water treatment & sewage systems – **Increasing residential construction activities** such as high-rise buildings demand need for efficient water supply and waste management
Infrastructure development	• High focus on infrastructure development, particularly in **developing countries results** to an increased usage of pumping systems
Grants and loans	• Grants and assistance from **organizations like the World Bank** to governments for enhancing and expanding water infrastructure

03

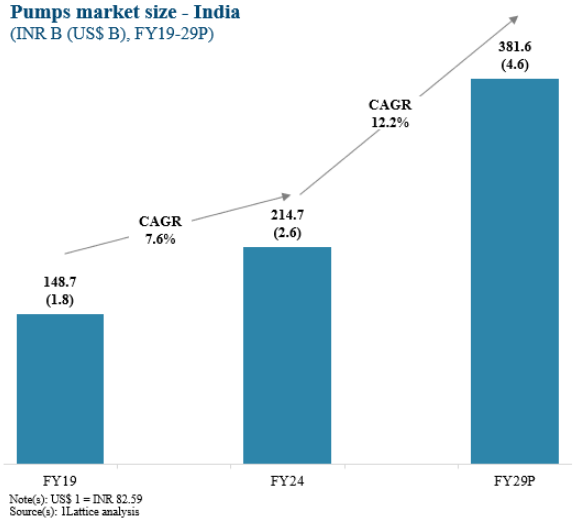
Indian Pumps Market Outlook

3. Indian pumps market Scenario & outlook

3.1. Indian pumps market attractiveness

3.1.1. The Indian pump market was INR 214.7B in FY24 and is expected to reach INR 381.6B by FY29, growing at a CAGR of 12.2% between FY24-29

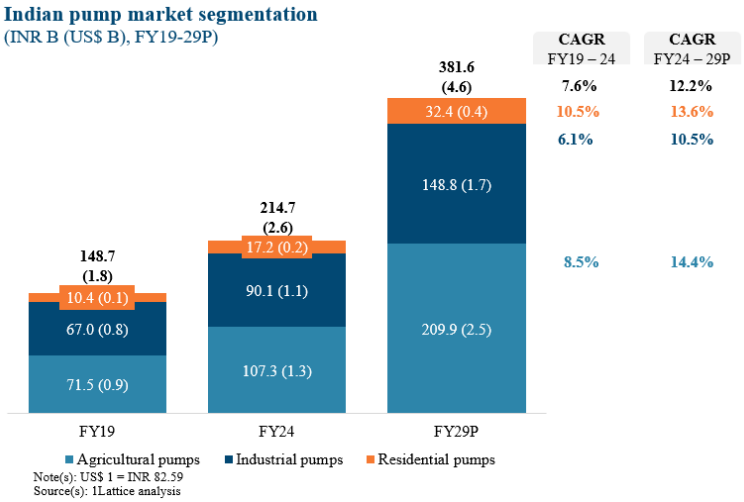
Pumps are vital across various sectors in India, including agriculture, industrials and infrastructure, making the pump industry a key contributor to the nation's growth. This sector has experienced significant growth in recent years, driven by the expansion of domestic infrastructure projects and water-intensive industries. Advancements like built-to-suit pumps for specific applications in various industries and customization that optimizes pump performance for unique processes are also gaining potential. The increasing demand in these areas underscores the essential role of pumps in supporting India's development and economic progress. Government initiatives like Jal Jeevan Mission and Swachh Bharat Mission are also driving growth in the pump market by increasing demand for water supply infrastructure and sanitation solutions.



The Indian pumps market was ~INR 214.7B in FY24, expected to reach ~INR 381.6B by FY29, growing at a CAGR of 12.2% between FY24-29. India currently has just ~5% share in global pumps market, indicating a significant opportunity for growth Agriculture drives growth in the Indian pumps market through increasing demand for efficient irrigation solutions, boosted by government initiatives, increasing adoption of solar pumps and rising need for reliable water supply to enhance crop yields. Rapid industrialization, coupled with significant infrastructure development, drives the need for pumps for water supply, wastewater treatment, and manufacturing operations. Urbanization in India is also driving the growth of pumps due to increased demand for water management, construction, and industrial activities in expanding urban areas.

Electric motors are devices that transform electrical energy into mechanical energy, usually resulting in rotational movement. These motors are used in consumer electronics, automotive industry, industrial applications, agriculture, pumps, etc. The global electric motor market is projected to grow at a CAGR of ~7% from CY24-29, with the market being valued at ~US$ 207.0B by CY28 The electric motor market in India was estimated at US$ 3.6B in FY24 and is expected to reach US$ 1.1B in FY29, growing at a CAGR of 14.5% from FY24-29. Induction motors, also known as asynchronous motors, are a type of alternating current electric motor that operates based on the principle of electromagnetic induction, Induction motors are extensively utilized in numerous applications with pumps being of it. The induction motor market in India was estimated at ~US$ 0.7B in FY24 and is expected to grow at a CAGR of ~14.0% from FY24-29, with the market being valued at ~US$ 1.4B in FY29. A vibrator motor is an electric motor design to create vibrations. It is mainly used in construction industry, good. feed and flour factories

3.1.2. The Indian pump industry is segmented into agricultural pumps, industrial pumps, and residential pumps; Agricultural pumps sector is expected to grow at a CAGR of 14.4%, highest amongst all.



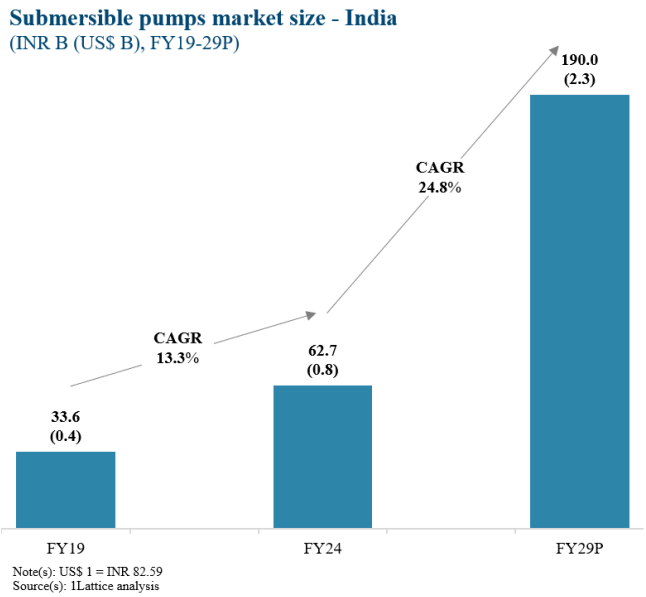
Industrial pumps sector: The Indian pump industry has significantly broadened its presence across various industrial sectors. It forms ~2% of the global industrial pumps market in FY24. Water treatment, oil and gas, power generation, and chemical pharmaceuticals, automotive and food processing industries, depend heavily on pumps for essential operations. These sectors utilize pumps for processes such as fluid transportation, cooling, lubrication, and water management, underscoring the critical role of the pump industry in supporting industrial activities and overall economic growth. KBL, KSB, Lubi pumps, Flowserve, CRI pumps and WPIL are the key players in Industrial pumps market Industrial pumps sector forms 42% of Indian pump industry in FY24 and is expected to grow at a CAGR of 10.5% by FY29.It would form 38% of Indian pump industry in FY29

Agricultural pumps sector: Agriculture stands as a crucial sector propelling the demand for pumps in India, given the nation's expansive agricultural terrain. Pumps play a pivotal role in irrigation and water management, facilitating efficient water distribution across farmlands. India forms ~18% of the global agricultural pumps market in FY24. Agriculture's vital role in India necessitates pumps for irrigation and efficient water use, making them essential for farm output and livelihoods. Also, farmers are increasingly turning to solar pumps for irrigation. This is driven by both cost savings on electricity or diesel and reduced environmental impact, making them a sustainable solution for water needs. KL, Oswal pumps and Shakti pumps are the major players in the agriculture pumps market. As per statistics, the agricultural pumps sector forms 50% of Indian pump industry in FY24 and is expected to grow at a CAGR of 14.4% by FY29.It would form ~53% of Indian pump industry in FY29.

Residential pumps sector: The residential pumps sector, forming ~4% of the global residential pumps market in FY24, is pivotal for the pumps industry in India as the demand for residential properties continues to surge. This upsurge drives a corresponding increase in the demand for residential pumps and motors. The growth in residential construction projects underscores the essential role of pumps in supporting household water supply, heating, and ventilation systems, highlighting the significance of this sector for the pumps industry. While KBL and CRI are among the largest pump players in the residential pumps market, it is largely dominated by small local players. As per statistics, the residential pumps sector forms 8% of Indian pump industry in FY24 and is expected to grow at a CAGR of 13.6% by FY29. It would from ~9% of Indian pumps industry in FY29

3.1.3. The Indian submersible pump market is expected to grow at a CAGR of 24.8% during FY24-29, reaching INR 190.0B in FY29

The submersible pumps market in India is experiencing growth, with bore wells emerging as a significant segment due to reducing water table. The growth is also driven by increased applications in water treatment and mining sectors across the country. These pumps also play a pivotal role in household water supply, finding strong demand even in Tier-3 cities. The submersible pump market grew at a CAGR of 13.3% between FY19-24 and was valued at ~INR 62.7B in FY24, forming ~5% of the global submersible pumps market. It is expected to reach ~INR 190.0B by FY29, growing at a CAGR of ~24.8% from FY24-29.



Grid-connected submersible pumps are water pumping systems that utilize electricity directly from the grid, instead of depending on batteries or independent solar panels. The market for grid-connected submersible pumps in India was estimated at US$ 14.2B in FY24 and is expected to grow at a CAGR of 13.7% between FY24-29.

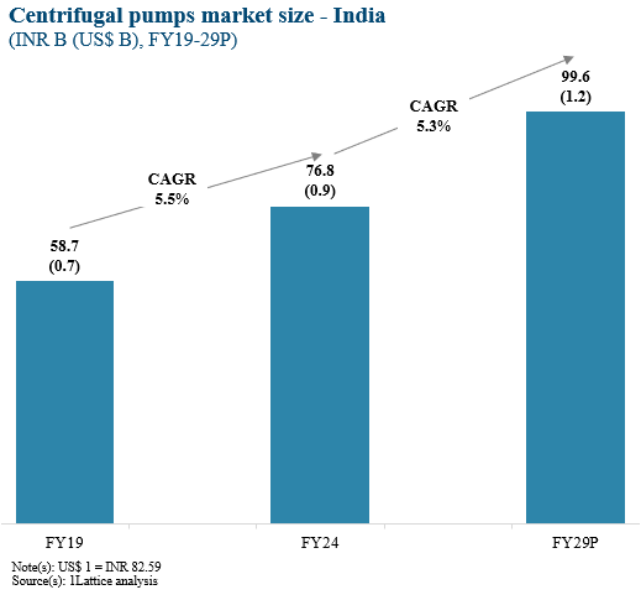
Key growth drivers for submersible pump market are:

- Technological advancements that boost efficiency across products and services, including innovations in materials, manufacturing, and digital tech
- Government incentives and regulations, such as PM KUSUM scheme which mandates usage of submersible pumps
- Declining groundwater levels increase the demand for submersible pumps, which can operate deep within water sources
- Additionally, rising construction activities and the water needs of residential complexes further drive demand for these pumps in residential / domestic sector
- Urbanization in India is driving the growth of submersible pumps due to the increased demand in densely populated urban areas and rising high rise buildings.
- The increasing demand for wastewater management in India is driving growth for submersible pumps due to their efficiency and reliability in handling sewage and drainage systems.

A submersible motor is a crucial part of a submersible pump, engineered to function underwater. This electric motor is hermetically sealed and directly attached to the pump body, enabling the entire unit to be submerged in the fluid being pumped. The Indian submersible motor market was estimated at ~US$ 37.6B in FY24 and is expected to exhibit a growth of 17.8% in FY24-29, with the market being valued at ~US$ 85.5B in FY29.

3.1.4. The Indian centrifugal pump market is valued at INR 76.8B in FY24 and is expected to grow at a CAGR of 5.3% during FY24-29, reaching INR 99.6B by FY29

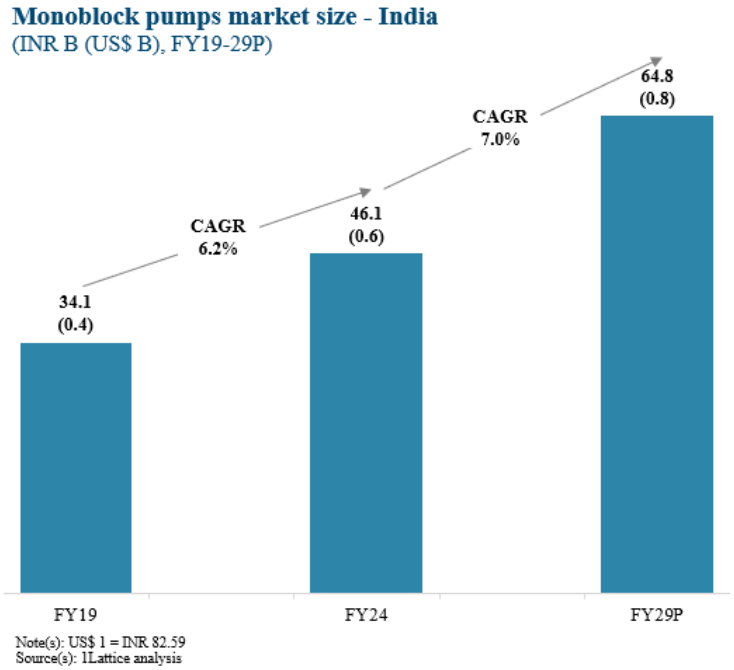
Centrifugal pumps are utilized for transferring fluids both within and between facilities. They efficiently handle a range of fluid viscosities, from medium to high viscosity liquids, liquefied gases, and water-like fluids. Due to the diverse nature of transfer operations, it's crucial to select the most versatile, reliable, and efficient pumping technology available. The market has benefited significantly from advancements in the materials used to manufacture these pumps over the years.



The centrifugal pump market grew at a CAGR of 5.5% between FY19-24 and was valued at ~INR 76.8B in FY24, forming ~3% of the global centrifugal pumps market. It is expected to reach ~INR 99.6B by FY29, growing at a CAGR of 5.3% from FY24-29. The growth is also being driven by technological advancements, rising infrastructure projects, increasing industrial applications, and growing demand for efficient water and wastewater management.

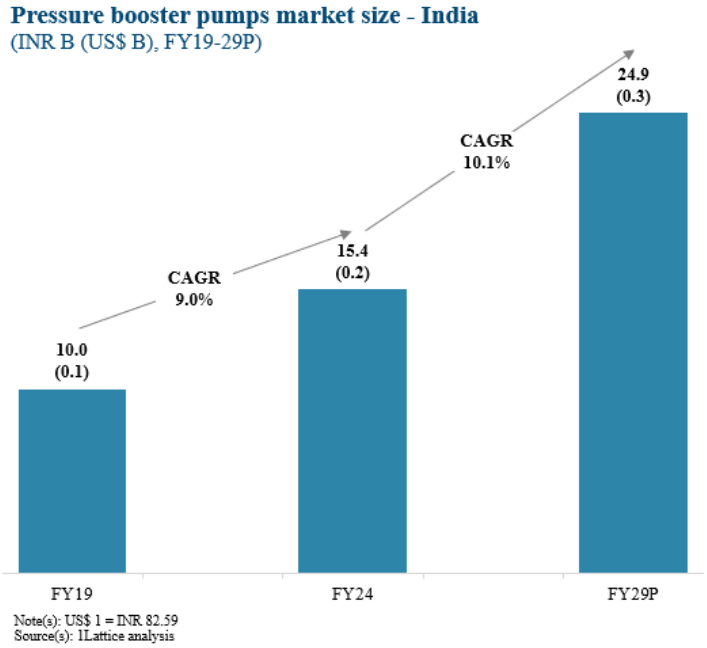
3.1.5. The Indian monoblock pumps market is expected to grow at a CAGR of 7% during FY24-29, from INR 46.1B in FY24 to INR 64.8B in FY29

The monoblock pump, a centrifugal pump variant, finds extensive use across water supply, irrigation, agriculture, and industrial applications. Over recent years, the monoblock pump market has seen substantial growth in India. The monoblock pump market grew at a CAGR of 6.2% between FY19-24 and was valued at ~INR 46.1B in FY24, forming ~6% of the global monoblock pumps market. It is expected to reach ~INR 64.8B by FY29, growing at a CAGR of ~7% from FY24-29. The Indian monoblock pumps market is thriving due to their strong demand in the rural areas. They are popular in agricultural usage for their compact design, easy installation, and efficient irrigation. This growth trend has prompted a surge in product offerings, catering to diverse demands across sectors and driving innovation uptake in the market.



3.1.6. The Indian pressure booster pumps market is INR 15.4B in FY24 and is expected to reach INR 24.9B in FY29, growing at a CAGR of 10% between FY24-29

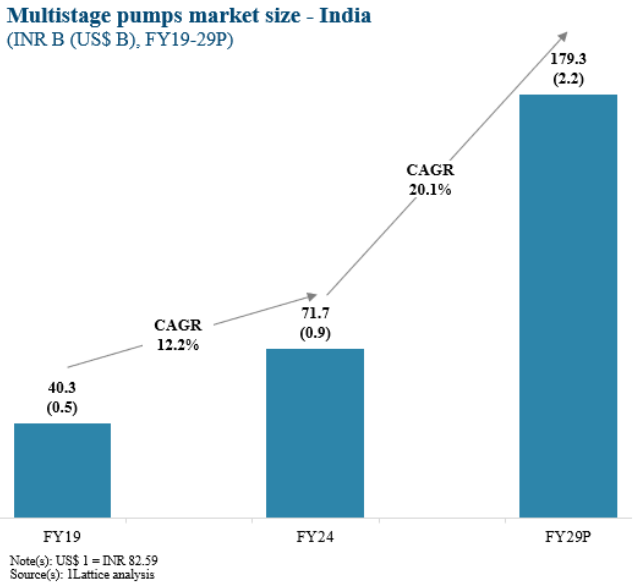
Pressure booster pumps offer a comprehensive solution for enhancing water pressure, meticulously designed for seamless performance. These systems maintain consistent water pressure across all outlets, automatically starting or stopping the pump based on pressure fluctuations. They are predominantly utilized in high-rise buildings for water transport, in irrigation systems, and in industrial applications such as filtration and reverse osmosis. The booster pumps are also used in municipal supply to tackle low water pressure issues in buildings or areas further from the main supply.



The pressure booster pump market grew at a CAGR of 9% and was valued at ~INR 15.4B in FY24, forming ~7% of the global booster pump market. It is expected to reach ~INR 24.9B by FY29, growing at a CAGR of ~10% from FY24-29. The market is driven by factors such as increasing urbanization, rising high-rise building construction, and the need for consistent water pressure in residential, commercial, and industrial sectors.

3.1.7. The Indian multistage pump market is INR 71.7B in FY24 and is expected to grow at a CAGR of 20.1% between FY24-29, reaching INR 179.3 by FY29

In a multistage pump, each impeller functions as an independent single-stage centrifugal pump. This design allows multistage pumps to generate higher power and pressure with smaller motors, leading to significant energy



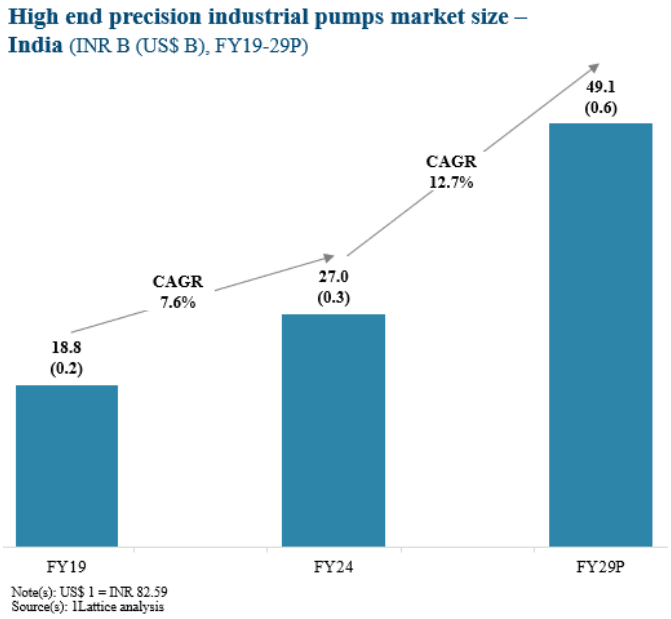
savings. Consequently, these pumps are increasingly favoured for their efficiency and performance in various applications.

The multistage pump market grew at a CAGR of 12.2% between FY19-24 and was valued at INR 71.7B in FY24, forming ~5% of the global multistage pump market. It is expected to reach INR 179.3B by FY29, growing at a CAGR of 20.1% from FY24-29. The Indian multistage pumps market is flourishing due to a few reasons:

- Growing industrial activity that demands high-pressure fluid transfer in processes like power generation and chemical processing.
- Falling water tables driving demand for advanced water extraction systems.

3.1.8. The Indian high end precision industrial pumps market is expected to grow at a CAGR of 12.7% between FY24-29, from INR 27B in FY24 to INR 49.1B in FY29

High-end precision pumps are vital to key sectors of the Indian economy, including oil and gas refining, nuclear power plants, and pharmaceuticals. These industries demand pumps that offer exceptional accuracy, reliability, and resistance to harsh materials and conditions, ensuring optimal performance and safety.



They handle a wide range of viscosities and temperatures, making them ideal for applications requiring precise flow control and reliability, such as in oil and gas, pharmaceuticals, and food processing industries. The high-end precision industrial pumps market grew at a CAGR of 7.6% between FY19-24 and was valued at INR 27B in FY24, forming ~2% of the global high-end precision industrial pumps market and is expected to reach INR 49.1B by FY29, growing at a CAGR of 12.7% from FY24-29.

3.1.9. Different type of Industrial pumps and classification

Helical Rotor Pump

A helical rotor pump is a type of positive displacement pump that operates by rotating a helical-shaped rotor, which moves specific volumes of liquid through the pump with each rotation. It is used in food processing industries, and sewage and water treatment systems to pump sludge and chemicals. Indian helical rotor pump market was valued at INR 16B in FY24. It is expected to reach INR 31B by FY29 growing at ~13% CAGR

Progressive Cavity Pumps

A Progressive Cavity Pump (PCP) is a type of positive displacement pump engineered for the accurate and efficient transfer of fluids, from low-viscosity liquids to highly viscous materials. Their adaptability and effectiveness in handling diverse substances make them essential across multiple industries, such as oil and gas, food processing, wastewater treatment, etc. Indian PCP market was valued at ~ INR 7B in FY24 and is projected to grow at a CAGR of ~12% from FY24-29 reaching INR 12B. PCP screw pumps are employed in paint shops, oil and gas industries, as well as in industries handling viscous fluids and ship operations.

Industrial centrifugal Pump

They are extensively used in industries such as wastewater and water supply treatment, oil and gas industry, power generation, chemical industries, etc. The industrial centrifugal pump market in India was valued at ~INR 28B in FY24 and is estimated to grow at a CAGR of ~15% from FY24-29 reaching INR 55B. In chemical industries Chemical pumps are used in the chemical processing industry to transfer chemicals and other fluids during the p roduction process. Chemicals such as acids, alkalis, and solvents require special pumps to handle their corrosive nature.

Pressure pumps

High-pressure pumps and compressors are devices designed to generate and maintain high pressures, as well as facilitate circulation in high-pressure unit operations. These are used in applications where a constant flow rate is required, such as firefighting or industrial process control. Indian pressure pump market is INR 5B and is expected to grow at a rate of ~12% from FY24-29, with the market being valued at INR 9B in FY29.

Reciprocating pumps

A reciprocating pump is a type of positive displacement pump that traps a fluid in a chamber and then expels a precise volume of it using mechanical pressure. These pumps find application in various domains, including municipal water systems, irrigation, firefighting, air conditioners, water circulation, boiler feeds cooling towers as well as fuel transfer. Indian reciprocating pumps market valued at INR 13B in FY24 and is expected to grow at a CAGR of ~13% from FY24-29 reaching INR 24B in FY29

3.1.10. Demand drivers in each end user industry

The growth of Indian pump industry is driven by various factors which differ basis the end user industry.

(a) Industrial sector:

The demand drivers for pumps in India stem from various key areas, reflecting the critical role pumps play in facilitating essential processes, thus contributing to sustained demand growth.

i) **Water and Wastewater Management:** Pumps play a vital role in regulating water supply by moving water from lower to higher levels and facilitating sewage pumping and treatment processes. Increasing projects by states and municipal corporations for sewage collection, treatment, and water supply systems are boosting pump demand.

ii) **Power Generation:** In the power industry, pumps are used for processing, lubrication, and cooling. Different activities within the sector require various pumping solutions, such as boiler feed water pumps, booster pumps, and high-pressure boiler feed pumps, driving demand diversity.

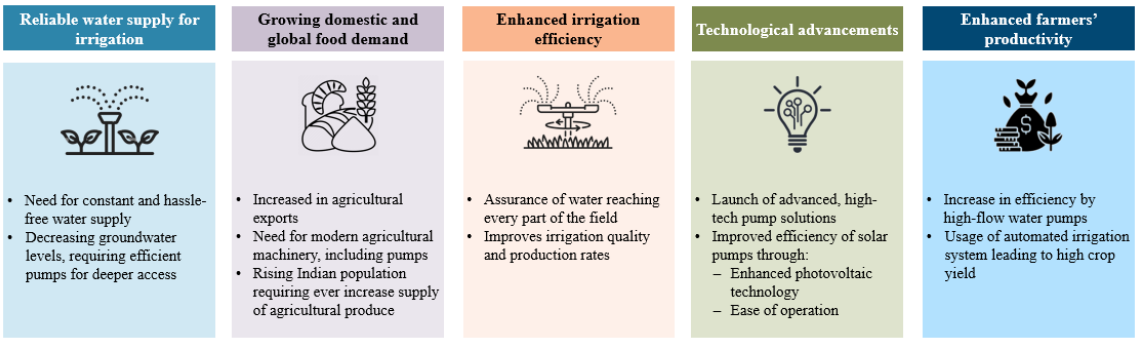
iii) **Oil and Gas Operations:** Effective pumping systems are essential at various stages of oil and gas processes, including extraction, transportation, and refining. Pumps are indispensable for moving fuel from the refineries, or storage facilities, driving continuous demand in this sector.

iv) **Chemical Industry:** The rapid growth of the Indian chemical market has significantly increased the demand for high-quality industrial pumps. As the chemical industry expands, there is a heightened need for reliable and efficient pumping solutions to handle various processes, such as the transfer of chemicals, handling of corrosive substances, and maintaining production efficiency.

v) **Pharmaceutical Industry:** Pumps play a crucial role in various stages of pharmaceutical manufacturing. They move liquids between tanks during mixing, sterilization, and purification. They also meter exact amounts of fluids for accurate ingredient ratios in medications.

(b) Agricultural sector:

The demand drivers for agricultural pumps include reliable irrigation water supply, rising food demand, improved irrigation efficiency, technological advancements, and enhanced farmer productivity. These factors collectively bolster the market growth for agricultural pumps by enhancing irrigation capabilities, supporting increased agricultural production, and integrating advanced technology.



(c) Residential sector:

The demand for residential pumps is driven by increasing population and urbanization, continuous technological advancements improving efficiency, growing environmental awareness promoting eco-friendly solutions, and supportive government regulations and incentives.

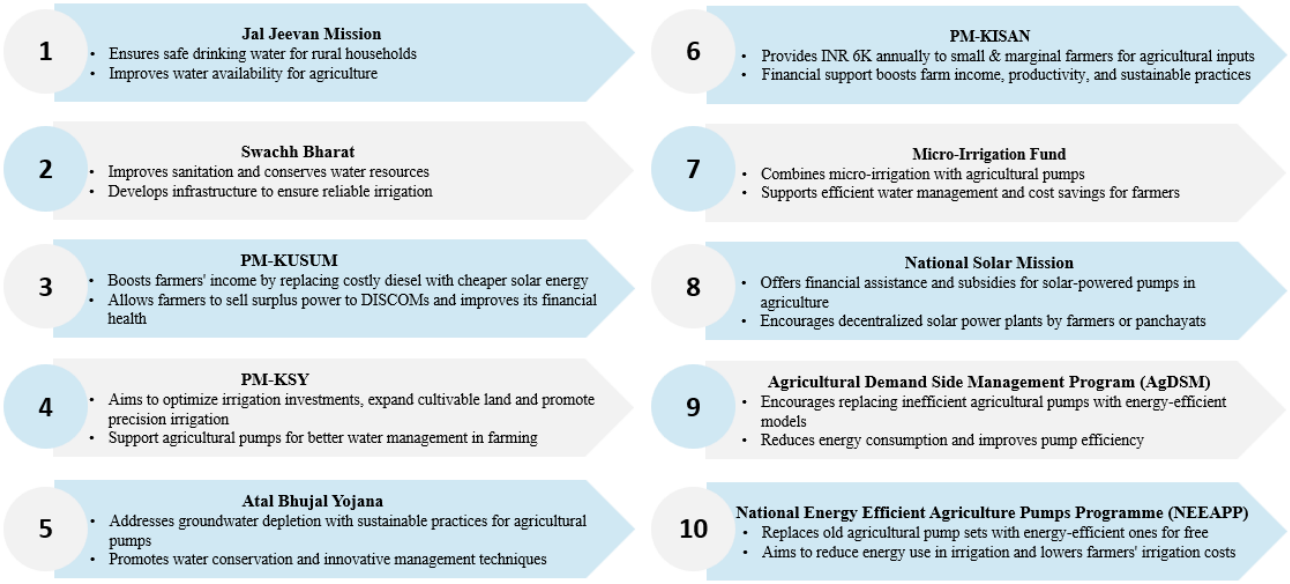
i) **Increasing Demand:** Population growth, urbanization, and changing consumer preferences drive the rising demand for residential pump products and services.

ii) **Technological Advancements:** Ongoing innovations in materials, manufacturing processes, and digital technologies improve the efficiency and effectiveness of residential pumps.

iii) **Enhancing Water Pressure in Modern Buildings:** Traditional systems often fail to deliver sufficient water pressure to upper floors in high-rise buildings. Pressure booster pumps ensure adequate pressure throughout. In large mixed-use developments, multistage pumps use multiple impellers to maintain pressure across extensive layouts and long pipelines.

3.1.11. Key initiatives driving growth in agricultural pumps segment:

Several initiatives collectively contribute to the growth of agricultural pumps in India by addressing affordability, sustainability, efficiency, and usability concerns among farmers.



3.1.12. Investments in the pump sector:

The pump industry continuously invests in research and development, with significant funding allocated by industry players. This ongoing R&D effort drives innovation and technological advancements, enhancing product efficiency and reliability across various applications.

- KBL has been investing heavily in R&D. In FY23, it invested INR 251M. Among the recent innovations, KBL has a range of API and Non-API pumps and steam turbines, which have been exhibited at ADIPEC exhibition, Abu Dhabi, drawing significant attention from industry professionals. It also has the advanced DBxe & LLC pump systems, optimized for oil and gas applications, along with usage of Augmented Reality (AR) technology.
- KBL has a subsidiary joint venture with Corrocoat Ltd. UK, which manufactures coatings at its advanced facility in Kirloskarvadi, Maharashtra, and handles turnkey projects for the supply and application of coatings on various equipment. KBL also has a joint venture with Ebara Corporation, Japan, and together they manufacture and supply rotary equipment like process pumps, boiler feed water pumps, steam turbines for mechanical drive and steam turbine generators, etc. required for hydrocarbon processing industries and power generation.
- CRI, recognized by India's Ministry of Science & Technology, boasts a strong R&D wing and leads in combination model pumps. They recently launched new HVAC, solar, and pressure booster pump series, investing INR 121M in R&D for FY23.
- Shakti Pumps (India) Limited, a leading energy-efficient pump and motor manufacturer, received its 7th patent from the Indian Patent Office for a "Grinder Pump Assembly with Adjustable Impeller." This innovation enhances wastewater treatment by efficiently grinding solid waste into smaller particles, improving downstream processes like sedimentation, biological treatment, and filtration
- KSB Pumps has recently launched multiple new pumpsets for various applications like dewatering in sewage, oil & water applications, low voltage applications, high head applications and various other water handling applications. In FY23, it invested INR 5.8M in R&D for pumps.
- Roto Pumps has inaugurated its new subsidiary, Roto Energy Systems Ltd, marking a major step into the rapidly growing solar submersible pumping solutions market. This expansion reflects the company's commitment to innovation and sustainable energy technologies.

3.2 India Market and Business Characteristics Related to Pump

3.2.1 Submersible pumps: Brief snapshot on end-use sectors:

Submersible pumps are used for various use cases, of which farm irrigation, flood risk mitigation, wastewater treatment, usable water pumping and oil extraction are the major ones.

i) **Farm irrigation:** Deep-well submersible pumps and vertical turbine pumps are widely utilized configurations of submersible pumps for irrigation purposes. Both configurations play vital roles in agricultural irrigation systems, offering reliable water supply solutions for various farming operations.

- Deep-well submersible pumps are designed for submerged operation in deep boreholes, efficiently lifting water to the surface.
- Vertical turbine pumps, on the other hand, are suited for applications where the water source is relatively shallow and requires less submersion depth.

ii) **Portable water pumping:** Instrumental in extracting portable water from wells and boreholes for domestic use. Extracting water from considerable depths does not strain their efficiency as they consume minimal power.

iii) **Flood risk mitigation:** Plays a crucial role in diverting water away from structures, mitigating the risk of flooding and water-related damage. Particularly in flood-prone areas, they serve as indispensable tools for flood prevention.

iv) **Wastewater treatment:** Employed for solids and waste extraction from water bodies, water and sewage treatment facilities rely on them for efficient separation of solid waste from water.

v) **Oil extraction:** Engineered to handle diverse viscosity levels, temperature fluctuations, and depth variations.

3.2.2 Centrifugal pumps: Brief snapshot of end-use sectors:

Centrifugal pumps are very important for various operations in the agricultural and industrial sectors, with agricultural irrigation, wastewater treatment, municipal water supply and HVAC (Heating, Ventilation and Air Conditioning) systems being the major ones.

i) **Agricultural irrigation:** Integral for providing a steady supply of water to crops. Whether drawing water from wells or reservoirs, these pumps play a vital role in maintaining irrigation systems

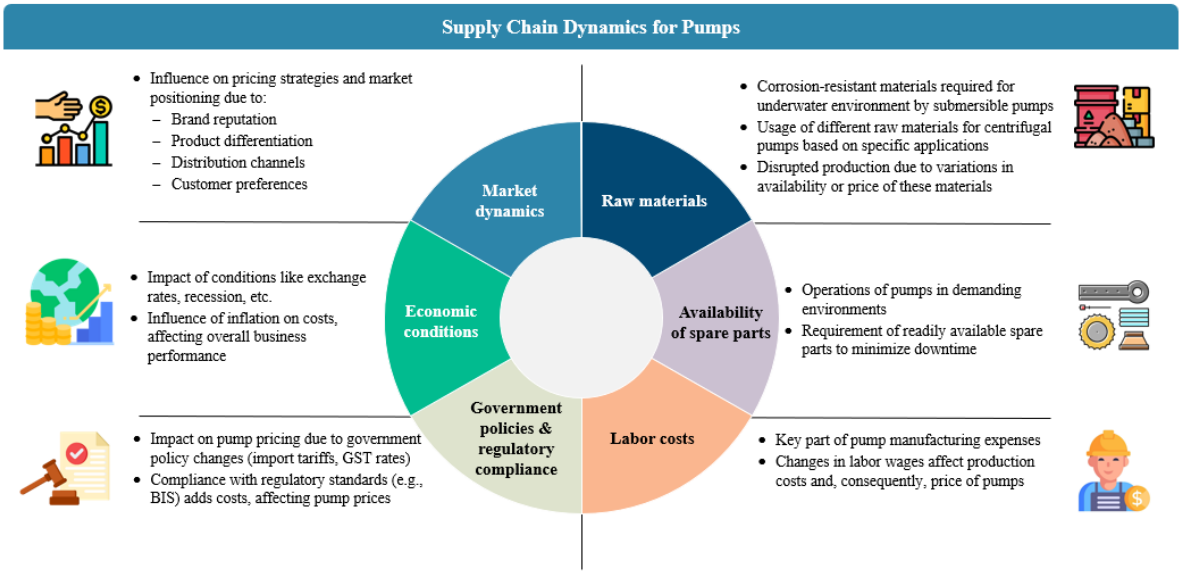
ii) **Wastewater treatment:** Within wastewater treatment facilities, centrifugal pumps play a critical role in advancing wastewater through multiple treatment processes. These stages typically include screening, sedimentation, filtration, and disinfection, where pumps ensure the continuous movement of wastewater for effective treatment.

iii) **Municipal water supply:** Essential components of urban water distribution networks, sourcing water from diverse locations such as wells, reservoirs, or rivers. Centrifugal pumps pressurize sourced water, enabling the efficient distribution of water to various destinations.

iv) **HVAC system:** Centrifugal pumps are crucial components of HVAC systems where they circulate water or coolant to regulate the building temperature and enhance thermal comfort within the building.

3.2.3 Key supply chain dynamics for pumps:

The supply chain dynamics of both submersible and centrifugal pumps are influenced by a multitude of factors, including the availability of specialized raw materials, the accessibility of spare parts, government policies & regulatory compliances, economic conditions and market dynamics. These factors collectively shape the procurement, production, and distribution processes within the centrifugal pump industry, impacting efficiency, flexibility, and cost-effectiveness. Pump manufacturers require skilled engineers, mechanists, welders, and assemblers to build and maintain the machines that create pumps, ensuring precise components throughout the supply chain.



Apart from these, customization vs. standardization and geographical dispersion also affect the centrifugal pump supply chain

- **Customization vs. standardization**: Need for customization to meet specific performance requirements, balancing production efficiency with customization adds complexity
- **Geographical dispersion**: Centrifugal pump manufacturing is geographically dispersed as different regions specialize in specific pump types or sizes. For example, Japan specializes in heat pumps, while Germany and Italy provide customized pumping solutions for chemical industries. This specialization adds complexity to the supply chain.

3.2.4 Pump type-wise analysis:

Pumps are classified based on end-use industry, raw materials used, and energy source used. Based on the end-use industry, pumps are categorized into agriculture & residential, and industrial sectors. There are two types of pumps basis raw materials – cast iron (CI) and stainless steel (SS) pumps. Depending on the energy source used to operate the pumps, there are three types – grid-based, diesel-based and solar pumps.

(a) <u>Based on end-use industry:</u>

Agriculture and residential account for 47% of the Indian pump market. The industrial sector, constituting the remaining 43%, encompasses industries such as Water & Sewage Treatment, Power Generation, Oil & Gas, Metals & Mining, and others. With its technological complexity, the industrial sector poses challenges for SMEs seeking entry into the pump market.

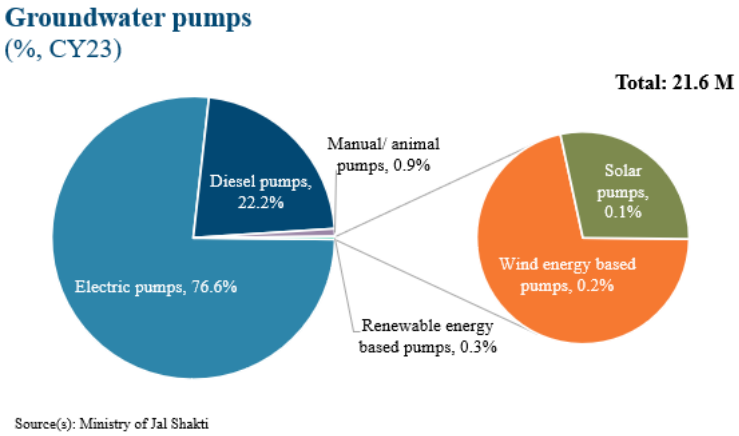
(b) <u>Based on raw materials:</u>

Cast iron and stainless steel are key materials in pump manufacturing. Cast iron pumps are favored for general water supply and drainage, whereas stainless steel pumps are preferred in corrosive environments like the chemical industry. Stainless steel centrifugal pumps offer notable advantages, including higher hydraulic efficiency resulting in reduced energy consumption and resistance to corrosion. In India 35-40% of the pumps use stainless steel material compared to ~60% of newly manufactured pumps globally. Despite being pricier by 20% to 30%, stainless steel pumps are gaining traction due to their superior performance, although currently less prevalent than cast iron pumps.

(c) <u>Based on energy source:</u>

In India, groundwater is the major source of irrigation in the agricultural sector. Almost 60% of the total irrigated area in India relies on groundwater pumping. Grid-based and diesel-based pumps are the predominant choices for irrigation in India, with solar pumps gradually emerging. Grid-based pumps and diesel pumps offer quick installation and low initial investment but entail high maintenance costs and generate noise and air pollution. Grid-based pumps, leveraging electricity, are particularly favored due to their convenience, especially for accessing deeper water sources. Conversely, solar pumps boast lower maintenance costs and longer lifespans despite their higher initial investment compared to traditional options. India currently has ~21.6 million groundwater pumps in operation, with electric pumps comprising

a substantial majority at ~77%, followed by diesel pumps at 22%. Notably, solar pumps represent a mere 0.1% of the total, indicating a significant opportunity for growth and adoption of renewable energy solutions in the agricultural pumping sector.



Source(s): Ministry of Jal Shakti

3.3 Export scenarios of pumps:

Amid growing global investments in irrigation, water management, mining, and chemicals, Indian pumps are gaining significant traction internationally. With exports to over 190 countries surging by more than 20% post-COVID, Indian pumps are recognized for their cost-effectiveness and efficacy in addressing the rising demand for clean water and wastewater solutions worldwide. Furthermore, Indian-made submersible pumps are carving a niche in the oil and gas sector, offering corrosion-resistant solutions suitable for offshore applications, underscoring India's substantial export potential of INR 113.1B in FY24, which currently sees around 16% of its manufacturing capacity dedicated to exports.

Indian pump manufacturers often enjoy a cost advantage over international players due to several factors.

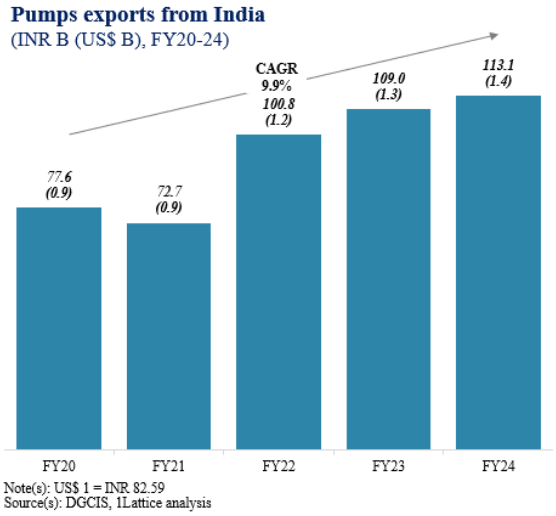
(a) **<u>Lower Manufacturing Costs:</u>** India has a readily available workforce (594M as of 2023) with competitive wages, leading to lower production costs compared to developed nations

(b) **<u>Government Incentives:</u>** The Indian government provides subsidies and encourages domestic production through initiatives like 'Make in India', further reducing costs for Indian manufacturers.

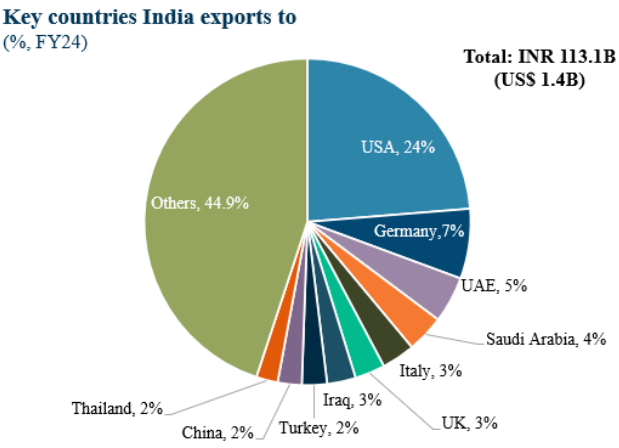
(c) **<u>Localized Supply Chains:</u>** Indian players often have well-established domestic supply chains for raw materials and components, minimizing import dependence and associated costs.

3.3.1 Key countries India exports to:

Indian pump industry has seen a 9.9% CAGR growth in exports from INR 77.6B in FY20 to INR 113.1B in FY24. The USA is the largest importer of pumps, importing 24% of the total pump exports from India, followed by Germany (7%) and UAE (5%). The top 10 countries importing from India form ~55% of the total pump exports.

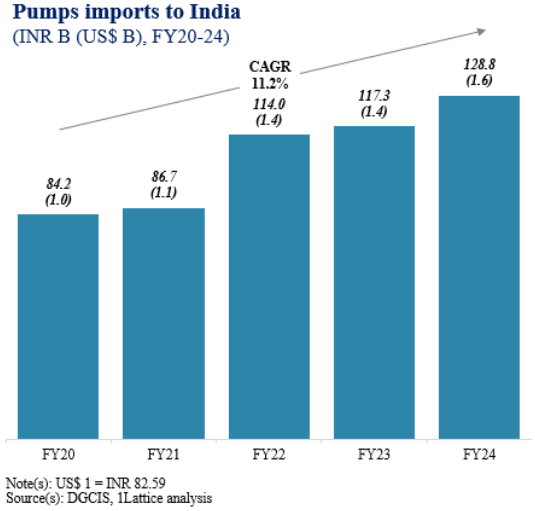


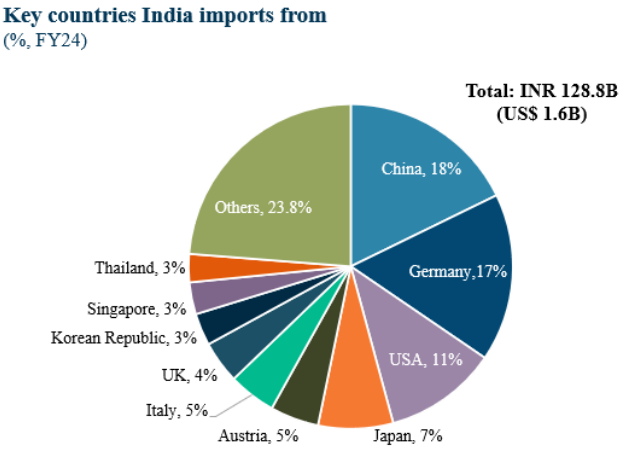
Note(s): US$ 1 = INR 82.59
Source(s): DGCIS, 1Lattice analysis



Key countries India imports from:

Indian pump industry has seen a 11.2% CAGR growth in imports from INR 84.2B in FY20 to INR 128.8B in FY24. China is the largest exporter of pumps, exporting 18% of the total pump imports to India, followed by Germany (17%) and USA (11%). The top 10 countries exporting to India form ~76% of the total pump imports.





3.3.2 Export and import analysis by type of pump:

Centrifugal pumps play a key role in India's pump exports, owing to their versatile usage in diverse industries. As global demand rises for water treatment and irrigation solutions, India's expertise in corrosion-resistant submersible pumps presents another promising export avenue. Companies that specialize in industrial and process pumps, target niche export markets catering to specific applications.

India predominantly imports air and vacuum pumps, with China emerging as the primary exporter of these products. Additionally, India imports various pump spare parts such as valves and taps to support its pump manufacturing and maintenance industries. These imports play a crucial role in ensuring the availability of essential components for the operation and upkeep of pumps across various sectors including manufacturing, agriculture, and infrastructure development.

3.3.3 Key exporters of pump:

Indian pump market is dominated by some key major players, including Kirloskar Brothers Limited (KBL), CRI Pumps, Oswal Pumps, Texmo Industries Ltd., Jyoti Pumps Ltd. and WPIL Ltd.

- KBL leads pump exports, capitalizing on their renowned brand and extensive global network, offering centrifugal pumps to diverse international industries.
- CRI Pumps, with a strong global footprint, exports pumps for industrial, agricultural, and domestic uses, prioritizing innovation and energy efficiency.
- Oswal pumps, solar pump manufacturer, supplier and exporter, exports solar pumps and motors and submersible and centrifugal pumps.
- Shakti pumps is also a leading exporter of solar pumps, having an in-house manufacturing unit for a wide range of products.
- Texmo specializes in customized industrial and process pumps, excelling in chemical, pharmaceutical, and sugar applications worldwide.
- Jyoti exports centrifugal pumps for global water supply, irrigation, and power sectors, focusing on R&D for cutting-edge solutions.
- WPIL, a submersible pump specialist, exports solutions for agriculture, wastewater treatment, and dewatering, known for its corrosion-resistant expertise in challenging environments.

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04

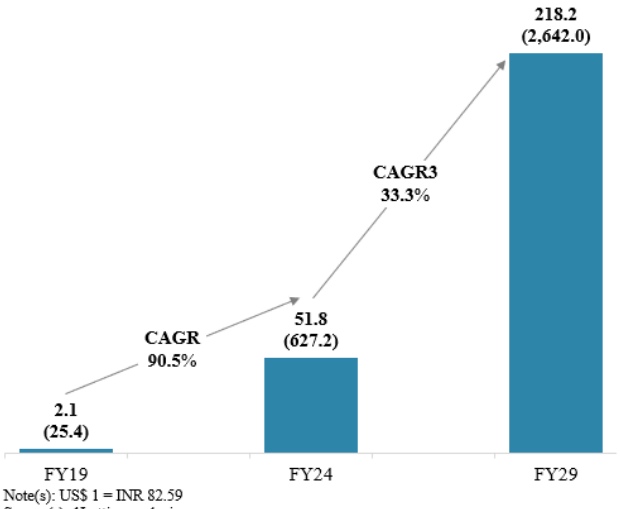
Indian Solar Pump Market Overview

4. Solar pump market overview

4.1 Indian solar pump market was valued at INR 51.8B in FY24 and is expected to grow at a CAGR of 33.3% between FY24-29, expected to reach INR 218.2B by FY29

Solar pumps are environment-friendly and sustainable alternatives to diesel / grid-connected pumps. These cost-effective pumps provide energy access in remote areas with scarce electricity. It is important for sustainable agriculture in India, which contributes to ~18% of India's GDP. Solar pumps are widely used in agricultural activities for irrigation, drip irrigation, livestock watering, aquaculture, and rainwater harvesting.

Overall solar pump market
(INR B (US$ M), FY19-29)

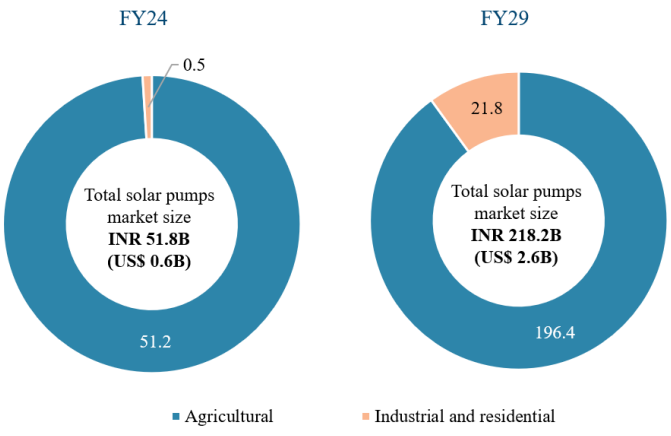


Note(s): US$ 1 = INR 82.59
Source(s): 1Lattice analysis

The Indian solar pump market has witnessed a remarkable growth trajectory increasing from INR 2.1B in FY19 to INR 51.8B in FY24 and is expected to reach INR 218.2B by FY29, growing at a CAGR of 33.3% over FY24-29 expected to attribute to ~57% of total pumps market by F29. The market growth is largely driven by government initiatives; incentives like PM-KUSUM, enabling farmers to get subsidized solar pumps. Increased focus on reducing carbon emissions, emphasis on energy-efficient resources and technological advancements rising diesel costs, reduced dependency on stable electricity supply and protection from motor damage due to voltage fluctuations are other factors driving the solar pump market in India.

4.1.1 Agriculture accounted for 99% of the total solar pump market in FY24

Solar pump market segmentation



Note(s): US$ 1 = INR 82.59
Source(s): 1Lattice analysis

The Indian agricultural solar pump market accounted for 99% of the total market in FY24. By FY29 this share will be ~90% of the market. The remaining 10% share would be for industrial and residential sectors due to the increasing awareness and usage of solar pumps in these sectors. In the industrial sector, the solar pumps will be increasingly utilized in several use cases including the food and beverage industry, wastewater treatment plants, amongst others.

Market potential for installing solar pumps			
S.No	**Parameters**	**Unit**	
A	Total farmers in India	M	144
B	# farmers with access to pumps- electricity, diesel and solar	M	30
C	# farmers running their pumps on diesel	M	8
D	Avg cost of pump	INR	1,50,000
E = C*D	Opportunity for replacement of existing diesel pumps	INR B	1,200 (US$ 14.5B)
F = (A-B)	Farmers with no access	M	114
G	Farmers who own > 1 hectare of land (Marginal farmers)	%	32%
H = (A*G-B)	Total marginal farmers - farmers who already own pumps	M	16.08
I = H*D	Untapped Opportunity for farmer without pumps	INR B	2,412 (US$ 29.1B)

India has a vast potential for installation of solar pumps. India has a total of 144M farmers, out of which ~30M have access to water pumps powered by electricity, diesel, or solar energy. 30% of the farmers are currently using diesel-powered pumps indicating ~8M of these farmers currently rely on diesel pumps. Given the average cost of a solar pump is INR 150,000, the potential market for replacing diesel pumps alone is valued at INR 1,200B (US$ 14.5B). This transition presents a dual advantage: reducing dependency on diesel and promoting sustainable energy use., while the remaining 114 million farmers do not have access to pumps and among these, 70% of farmers reside in areas with limited access to natural water sources such as canals or rivers. This presents an opportunity for the widespread adoption of solar pumps to address the unmet agricultural water needs of a significant portion of India's farming community

Furthermore, there are 114M farmers without any access to pumps, highlighting another substantial market segment. Out of these, ~32% are marginal farmers with landholdings exceeding one-hectare potential customers for solar pumps. The untapped market for providing pumps to these farmers is estimated at ~INR 2,400B (US$ 29.1B).

These pumps typically undergo replacement every five years, offering substantial growth opportunities to replace grid-connected and diesel-fed pumps with agri solar pumps. Solar pumps offer several benefits compared to traditional diesel-fed and grid-connected pumps, including reduced dependency on grid power-cost effectivenesss for farmers in view of rising diesel prices, low maintenance costs, increased reliability and environmentally friendly operations. The replacement pump market is estimated to be around ~INR 65B in FY24, highlighting significant potential for the replacement of existing pumps which is expected to rise further to ~INR 143B by FY29 growing at CAGR of ~17%

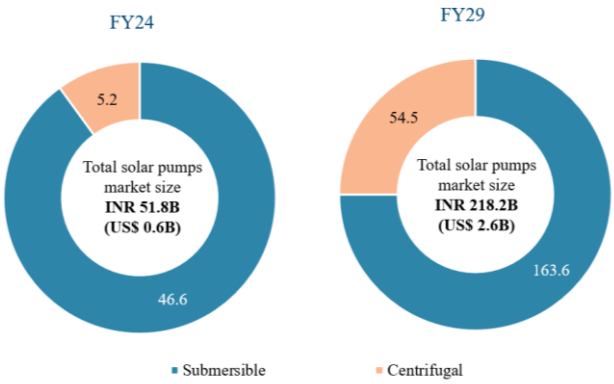
In total, the combined market potential for installing solar pumps, encompassing both the replacement of diesel pumps and providing pumps to those without access, stands at an impressive ~INR 3,600B. This substantial opportunity underscores the economic and environmental benefits of promoting solar pumps in India's agricultural sector, addressing the needs of millions of farmers and contributing to sustainable development.

4.1.2 Submersible solar pumps dominate the market, accounting for ~90% of the total solar pumps market

The submersible solar pump market accounts for 90% of the total solar pump market. These pumps are predominantly used for irrigation as they are highly efficient in drawing water from drip wells and boreholes. However, the market share of centrifugal solar pumps is expected to rise by ~15% between FY24-29, due to its increased usage beyond agricultural activities and adoption of solar pumps beyond the government schemes. The market is expected to grow at a CAGR of ~29.0% between FY-29, with the market reaching to ~US$ 163.0B in

FY29. Whereas solar monoblock pump market in India was valued at ~US 5.2B in FY24 and is projected to reach ~US$ 38.1, growing at a CAGR of 49.0% between FY24-29.

Solar pump market segmentation



Note(s): US$ 1 = INR 82.59
Source(s): 1Lattice analysis

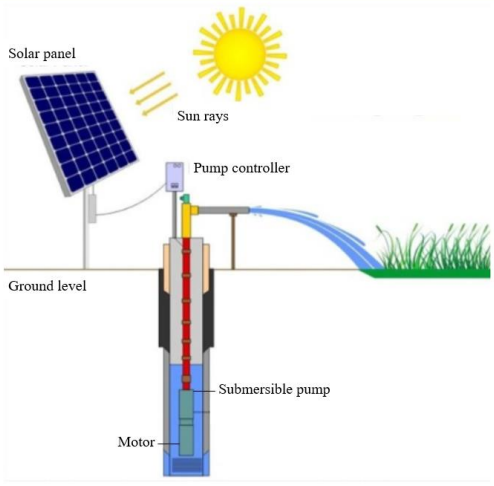
4.1.3. A Solar pumping system is eco-friendly, has long operational lifespan and is easy to operate and maintain

A solar pumping system offers an environmentally sustainable and cost-efficient solution for water supply, particularly in off-grid areas. Utilizing solar energy, the system powers a pump that extracts water from sources such as wells, rivers, or lakes, serving applications in irrigation, livestock watering, and domestic use.

The main components of the solar pumping system

- **Solar panel -** It converts sunlight into electrical energy to power the water pump. It is composed of photovoltaic cells, that transform sunlight into electricity.
- **Solar pump -** It transfers water from one location to another. There are two main types of solar pumps - submersible solar pump and surface pump. These pumps uses two types of current- AC and DC.
- **Motor –** It converts electrical energy into mechanical energy to drive the pump and lift water. It is specifically engineered to function underwater.
- **Pump controller -** This device regulates the solar water pump system, ensuring its efficient and safe operation. It monitors water levels and prevents the pump from running dry, protecting it from potential damage.

Solar pump working diagram



4.1.4. Key trends, growth drivers and challenges of the Indian solar pump market

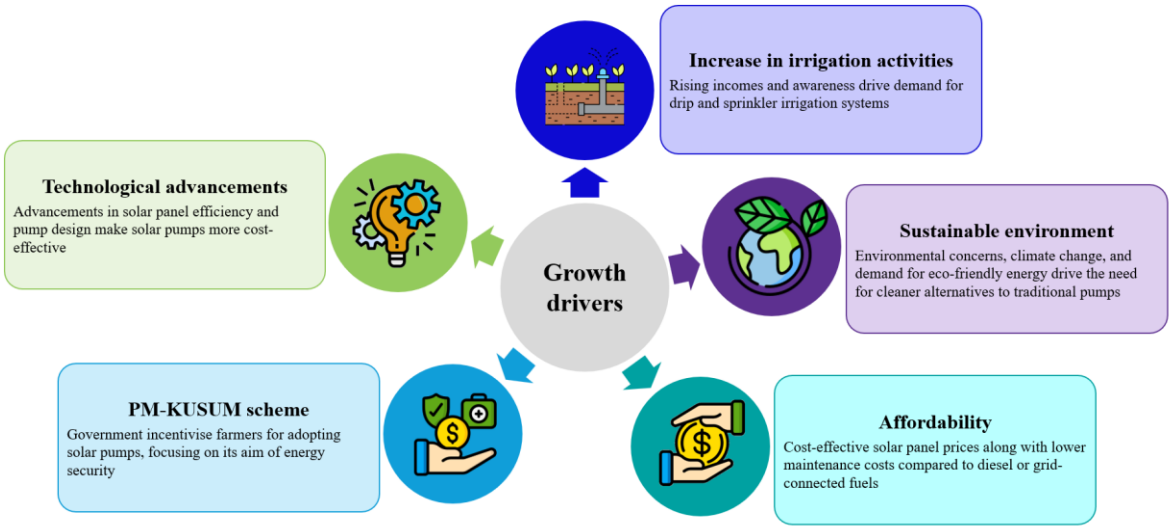
4.1.4.1. Key trends

Key trends in India's solar pump market include increased adoption of IoT and ML, emergence of hybrid systems, and declining solar panel costs driving widespread adoption.

Key trends	
Smart Controllers	• IoT-integrated controllers help monitor the pump surroundings, get data on over-extraction of groundwater on mobile application
Cost-effective solar panels	• Reducing solar panel costs boost adoption and accelerate the shift to renewable energy
AI / ML adoption	• ML algorithms analyze sensor data to forecast crop water needs and detect anomalies, aiding farmers in making informed decisions
Hybrid solar pumping system	• Hybrid solar pumping systems, blending solar & wind power, offer enhanced reliability & efficiency, catering to diverse energy needs

4.1.4.2. Growth drivers

The solar pump market in India is booming due to government initiatives like PM-KUSUM, technological advancements, focus on environmental friendly energy, rising irrigation demand, and diminishing solar panel costs. These factors make solar pumps more affordable, efficient, and attractive for farmers.



4.1.4.3. Challenges

The solar pump market in India faces challenges including high initial costs, limited awareness and the requirement of high working capital.

Key trends	
Cost barrier	• Significant initial investment & higher upfront cost compared to diesel pumps due to high components' cost • Financial constraint for small & marginal farmers
Knowledge gap	• Training needed due to limited awareness and skills in solar pump installation and maintenance
High working capital	• Time lag between pump installation and subsidy release create financial burden for manufacturers & suppliers

4.2. Solar pumps offer more longevity and have lower maintenance costs compared to grid-connected / diesel pumps; Even without subsidy, solar pumps have lower total costs and are beneficial compared to grid-connected pumps

Cost of operation for 5 HP submersible pump for 10-year period							
Particulars	Units	Diesel pump	Grid-connected pump		Solar pump		
			Without electricity subsidy	With electricity subsidy	Without PM KUSUM	PM KUSUM scheme subsidy	
						30% state 30% centre	50% state 30% centre
(i) Cost of pump plus accessories	INR	1,00,000	1,00,000	1,00,000	2,40,000	3,00,000	3,00,000
Subsidy	%	0%	0%	0%	0%	60%	80%
(ii) Subsidy offered	INR	0	0	0	0	1,80,000	2,40,000
(a) Cost of pump plus accessories to farmer = (i)-(ii)	INR	1,00,000	1,00,000	1,00,000	2,40,000	1,20,000	60,000
(b) 10-year maintenance cost	INR	40,000	30,000	30,000	5,000	5,000	5,000
(c) 10-year Electricity / fuel cost	INR	12,82,638	2,51,295	2,51,295	0	0	0
(d) Subsidy	INR	0	0	2,51,295	0	0	0
(e) 10-year Electricity / fuel cost after subsidy	INR	12,82,638	2,51,295	0	0	0	0
(f) Total cost of ownership for 10 years for farmer = (a)+(b)+(e)	**INR**	**14,22,638**	**3,81,295**	**1,30,000**	**2,45,000**	**1,25,000**	**65,000**
(g) Total cost of ownership for 10 years for Govt = (d)+(ii)	**INR**	**0**	**0**	**2,51,295**	**0**	**1,80,000**	**2,40,000**
(h) Total cost of ownership for 10 years for farmer and Govt = (f)+(g)	**INR**	**14,22,638**	**3,81,295**	**3,81,295**	**2,45,000**	**3,05,000**	**3,05,000**
Residual life after 10 years usage	# years	Need replacement	3-5 years	3-5 years	5-10 years	5-10 years	5-10 years

1. **Diesel Pumps:** These pumps have the highest total cost of operation and need to be replaced after being used for ~10 years, making them less economical and sustainable.
2. **Grid-connected pumps:** These pumps are expensive for farmers. The total cost to farmers can be low with electricity subsidies, but the burden on the government is high. Additionally, for a 5HP pump, the residual life after 10 years of usage is only 3-5 years.
3. **Solar pumps:** These pumps have higher initial costs, but the operational cost is much lower compared to grid-connected or diesel pumps.

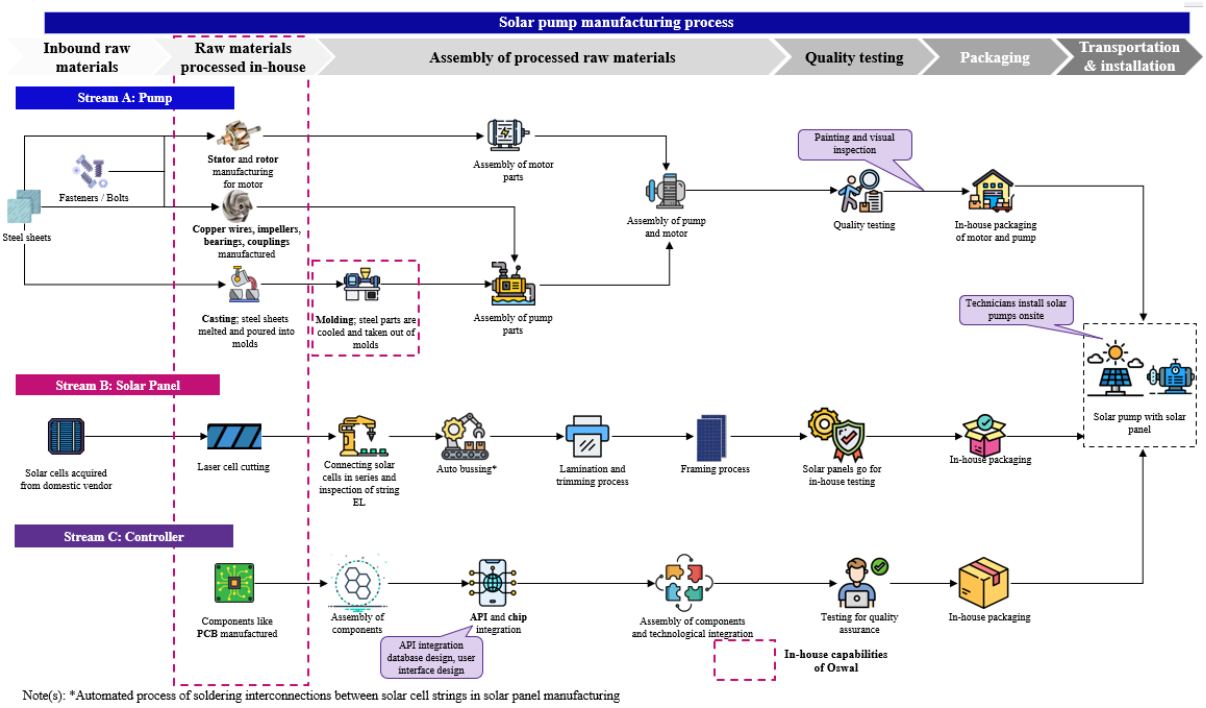
The price of solar pumps under the non-PM KUSUM scheme is more affordable because they use non-DCR panels, which are not subject to domestic manufacturing requirements and are thus 10-15% cheaper. Additionally, the PM KUSUM scheme employs a 360-degree dual-axis rotating structure, which increases installation and commissioning costs by 10%.

Under the PM KUSUM scheme, the total cost borne by the government in the form of subsidies is lower than the electricity subsidies provided to the farmers. Moreover, solar pumps have a longer residual life compared to other pump types. For a 5HP solar pump, it is 5-10 years after 10 years of usage.

At an overall level, solar pumps are more beneficial than grid-connected or diesel pumps in terms of long-term costs and sustainability. For grid-connected pumps, even though there is a 100% electricity subsidy, the option is not lucrative enough due to high operational costs and limited electricity availability. Solar pumps, with or without the PM KUSUM scheme present a cost-effective and sustainable solution with a substantial residual life, making them advantageous for both farmers and the government.

4.3. Oswal Pumps specializes in the comprehensive manufacturing process of solar pumps and solar panels, providing end-to-end services; Installation services for solar pumping system are also offered to customers

Oswal Pumps is one of the leading players in solar pump manufacturing. The company has complete control over the entire value chain, from design and manufacturing to installation and commissioning. From the initial stages of sourcing and refining raw materials to the final assembly, quality testing and packaging, Oswal Pumps maintains complete control over each step of the production chain.



The company has in-house plants for manufacturing various components such as winding wires, cables, casting, solar cell cutting and solar structure etc. This allows for precise control over the manufacturing process of solar pumps, solar panels & controllers and ensures that all components meet the highest standards. The company's manufacturing facility includes modern machinery for assembly and quality testing. This ensures that each product meets the highest standards before being packaged and shipped. Furthermore, customers benefit through comprehensive support from initial installation to the final commissioning of the system. Additionally, the company has a dedicated customer service team that provides support and maintenance services to ensure that customers receive the best possible experience with their solar pumps. Oswal is the one of the only player compared to other players providing comprehensive solutions across the spectrum for Solar pump systems

Company benchmarking

Parameters	Solar PV module manufacturing	Cables and winding wires	Impeller and bearing manufacturing	Controller manufacturing	Tech integration in controller	Installation services
OSWAL	✓	✓	✓	✓	✓	✓
SHAKTI	✗	✓	✓	✓	✓	✗
Kirloskar	✓	✓	✓	✓	✓	✗
C.R.I. PUMPS	✗	✓	✓	✓	✓	✗
Lubi	✓	✓	✓	✓	✓	✗

Oswal Pumps is one of the only integrated scale solar pumps manufacturer players as it is involved in all stages of production and service / installation delivery and has end-to-end integration capabilities across value chain. Oswal is one the few fully integrated turnkey solar pumping system providers players in India with the capabilities to manufacture agri-solar pumps, solar modules and pump controllers and provide installation service for Solar pump systems. This includes manufacturing solar PV modules, cables and winding wires, impellers and bearings, controllers, and integrating technology into the controllers. Notably, Oswal Pumps offers installation services, positioning itself as a complete EPC player. This end-to-end service capability differentiates Oswal Pumps from its competitors, enabling it to provide comprehensive solutions to its customers. Through its wide distribution network across India, the company provides a wide range of offerings.

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05

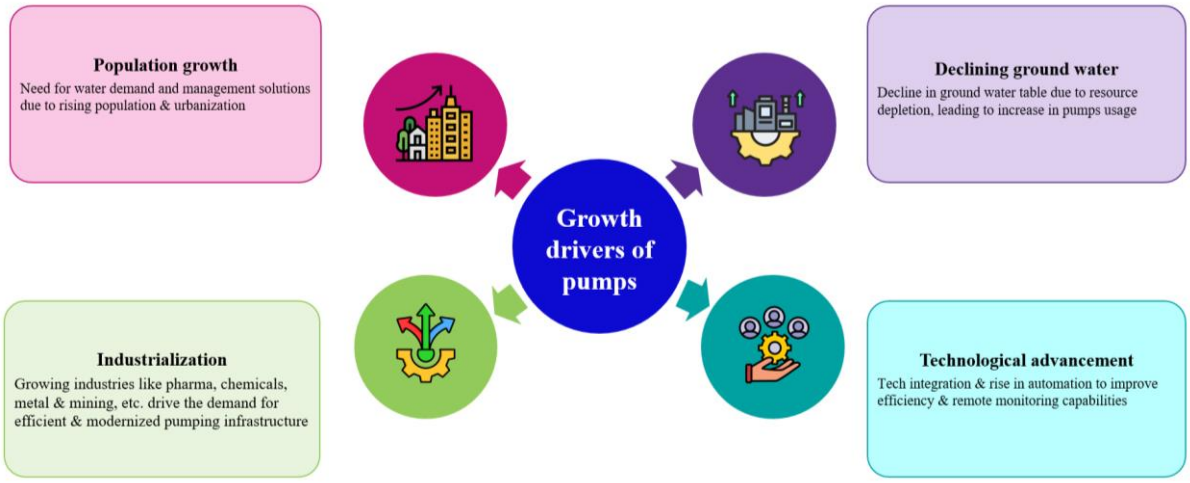
Key Factors Impacting Domestic Market

5. Key factors impacting the domestic market

5.1 Overview of the Indian pump market:

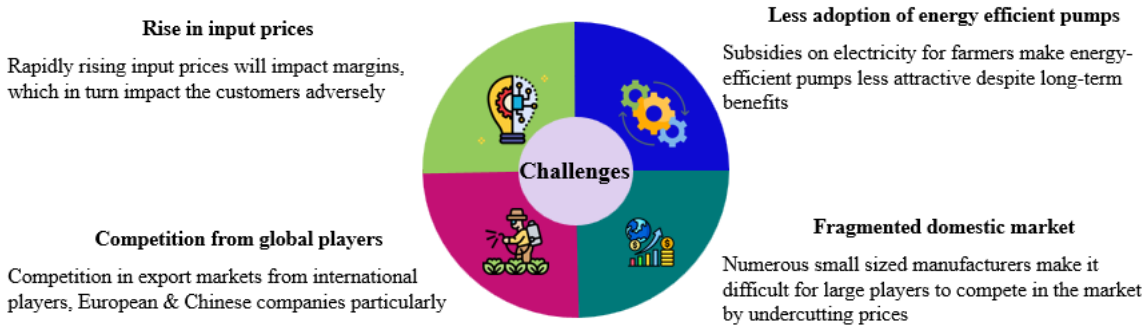
5.1.1 Growth drivers:

Urbanization, rapid industrialization, and declining groundwater levels are driving demand for water management solutions leading to growth in pump usage. Government initiatives aimed at improving water infrastructure further propel growth, as these projects rely heavily on pumps for efficient water transfer.



5.1.2 Challenges in the Indian pump market:

Despite its growth, the Indian pump market faces hurdles in terms of rising input prices, lower adoption of energy efficient pumps, dominance of larger companies and fragmented domestic market lead.



5.1.3 Key trends:

The Indian pump market is witnessing a shift towards diversification, with an increased expansion in a range of industries beyond their traditional roles in agriculture. A growing focus on energy efficiency is leading manufacturers to develop pumps with improved designs and materials to reduce energy consumption. Smart pumps with integrated sensors and controls are gaining traction, allowing for remote monitoring and optimized operation. Moreover, increase of solar pump adoption due to its lower environmental impact is a growing trend.

5.2 Government initiatives, regulations and policies

5.2.1 The Production-Linked Incentive (PLI) Scheme

The Production Linked Incentive (PLI) Scheme, introduced by the Government of India in CY20, involves an investment of INR 2.25L Cr over five years, covering 14 industries including textiles, food processing, PV solar, and automobiles. This scheme offers financial incentives based on incremental sales from products manufactured in India. Allocation of INR 14,007 Cr for 39,600 MW of domestic solar PV module manufacturing, incentivizes local production, enhancing India's self-sufficiency and reducing dependence on imports, particularly from China.

Enhanced local manufacturing of solar PV modules under the PLI Scheme directly benefits solar pump production by ensuring a stable supply of critical components. This scheme will attract significant investment in advanced technologies, boosting the competitiveness of Indian manufacturers. Rise in domestic production can lead to increased efficiency, economies of scale, and a stronger position in global markets.

5.2.2 Atmanirbhar Bharat

Launched in 2020, Atmanirbhar Bharat aims to make India self-reliant. It includes schemes such as PM Kisan Yojana and PM Krishi Sinchai Yojana, which empower farmers through financial and infrastructural support at the same time fostering local manufacturing capabilities and reducing dependency on imports. These initiative strengthens the production of solar panels and efficient water pumps. Policy reforms under this initiative also promote investments in key sectors like solar PV and advanced battery manufacturing. Reforms in areas such as FDI and ease of doing business facilitate investment in solar and pump manufacturing, enhancing production capacities.

5.2.3 Highlights of union budget 2024

The Union Budget 2024 emphasizes renewable energy and agricultural support. Key allocations include direct financial assistance to 11.8 Cr farmers under PM-KISAN and crop insurance for 4 Cr farmers under PM Fasal Bima Yojana. The introduction of the PM Surya Ghar Muft Bijli Yojana aims to provide up to 300 units of free electricity per month to 1 Cr households, with an outlay of INR 10,000 Cr to promote rooftop solar installations.

5.2.4 FTA Agreements

Indian Govt has formed a free trade agreement with ASEAN (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam) to import solar modules into India to meet the demand. Under the free trade agreement, India could add 15 GW of annual module imports by 2025 to meet the demand-supply gap in India. Reduced tariffs lower the cost of imported components, making solar pumps more affordable and boosting their adoption in agriculture and other sectors.

5.2.5 Jal Jeevan Mission

Aims to provide safe and adequate drinking water through individual household tap connections by CY24, supported by substantial government funding. The mission drives demand for high-efficiency water pumps, including solar-powered options, to ensure sustainable water supply. Particularly in rural and remote areas, this mission supports improved living standards and health outcomes.

Investments in water infrastructure with an outlay of INR 3.6L Cr create opportunities for pump manufacturers to supply the necessary equipment., the mission offers a significant market for both conventional and solar water pumps, fostering growth and innovation in the pump industry.

5.2.6 Swachh Bharat Mission

This mission focuses on sanitation and cleanliness, providing substantial funding to build sanitation infrastructure. Efficient pumps are essential for maintaining sanitation facilities. The mission's large-scale infrastructure projects drive demand for various types of water pumps. The budget of INR 1.41L Cr for this mission creates substantial demand for water management solutions, providing significant opportunities for pump manufacturers to expand their operations.

5.2.7 PM KUSUM Scheme

5.2.7 (a) Overview of the components under the PM KUSUM Scheme

In March, 2019, the Government of India launched the Pradhan Mantri Kisan Urja Suraksha evan Utthaan Mahabhivan Scheme (“PM Kusum Scheme”), with total INR 344B (US$ 4.1B) central financial support with the objective of installing 1.40 million standalone solar agriculture pumps in off-grid areas to provide energy security for farmers, reduce the consumption of diesel, promote the use of renewable energy in the agricultural sector and reduce environmental pollution. The PM Kusum Scheme also focuses on the solarization of 3.50 million existing grid-connected agricultural pumps and provides subsidies to individual farmers who have grid-connected pumps to retrofit their pumps with solar panels

The Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) Scheme, launched in March 2019 with total INR 344B (US$ 4.1B) central financial support, aims to provide energy security to farmers, de-dieselize and promote the use of renewable energy in the agricultural sector, and reduce environmental pollution. PM Kusum Scheme focuses on solarizing 14L grid-connected agricultural pumps and provides subsidies to individual farmers who have grid-connected pumps to retrofit their pumps with solar panels

It consists of three main components:

Component A	Component B	Component C
• Set up 10 GW of decentralized ground or stilt-mounted grid-connected solar/renewable power plants on barren or cultivable land. • Solar power generated will be purchased by DISCOMs at a Feed-in-Tariff (FiT) determined by SERC**.	• Target to install 14L standalone off-grid solar water pumps in off-grid areas to replace diesel pumps • Individual farmers will be supported to install standalone solar agriculture pumps of capacity up to 7.5 HP in off-grid areas.	• Solarize 35L existing grid-connected agricultural pumps, reducing dependency on grid power and providing reliable, sustainable energy for irrigation.

For the pump cost, under component B, the central government will cover 30% of the cost for standalone solar agricultural pumps, with the state government providing at least 30% as well. Farmers are responsible for the remaining 40% at most. However, in few cases, additional support is provided by either centre / state government. For example, for north eastern states, Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttarakhand, Lakshadweep and A&N Islands, CFA of 50% of the benchmark cost or the tender cost, whichever is lower, of the stand-alone solar pump will be provided by the central government taking the subsidy amount to 80% of total pump cost, while the farmers' share is reduced to a maximum of 20%.

State-wise share of pump cost among the central government, state government and the farmer

States/ Contribution	Central	State	Farmer
Andhra Pradesh	30%	30%	40%
Arunachal Pradesh	30%	30%	40%
Assam	30%	30%	40%
Bihar	30%	30%	40%
Chhattisgarh	30%	30%	40%
Delhi	30%	30%	40%
Goa	30%	30%	40%
Gujarat	30%	30%	40%
Haryana	**30%**	**45%**	**25%**
Himachal Pradesh	**50%**	**30%**	**20%**
Jammu & Kashmir	**50%**	**30%**	**20%**
Jharkhand	**30%**	**64%**	**6%**
Karnataka	**30%**	**50%**	**20%**
Kerala	30%	30%	40%
Ladakh	30%	30%	40%
Madhya Pradesh	30%	30%	40%

States/ Contribution	Central	State	Farmer
Maharashtra	30%	30%	40%
Manipur	30%	30%	40%
Meghalaya	30%	30%	40%
Mizoram	30%	30%	40%
Nagaland	30%	30%	40%
Odisha	30%	30%	40%
Puducherry	30%	30%	40%
Punjab	30%	30%	40%
Sikkim	**50%**	**30%**	**20%**
Rajasthan	30%	30%	40%
Tamil Nadu	30%	30%	40%
Telangana	30%	30%	40%
Tripura	30%	30%	40%
Uttar Pradesh	30%	30%	40%
Uttarakhand	**50%**	**30%**	**20%**
West Bengal	30%	30%	40%

Text in Bold Red **Deviation from standard contribution**

5.2.7 (b) Implications of PM-KUSUM scheme:

The major beneficiaries of the PM KUSUM scheme are individual farmers, farmer cooperatives, panchayats, and Farmer Producer Organizations (FPOs). The scheme provides financial support for the installation of solar pumps and promotes sustainable agricultural practices.

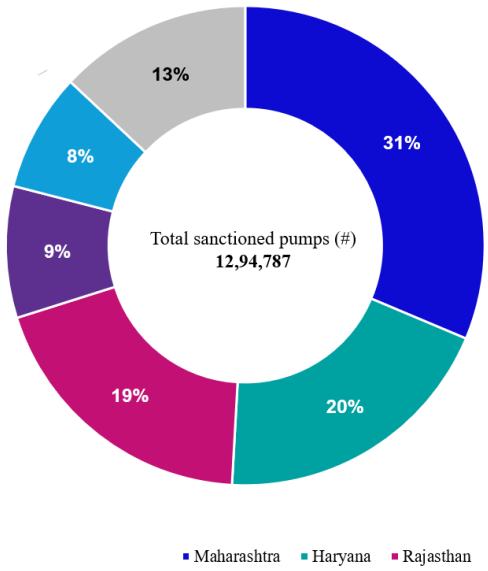
State and central governments also benefit from the PM KUSUM scheme through decentralized solar power and subsidy reduction. The scheme supports broader socio-economic and environmental goals, contributing to sustainable development in rural areas.

1. **Reduction in Electricity Costs:** By installing solar-powered pumps, farmers can harness free solar energy, leading to substantial savings on electricity and fuel costs for both farmers and government.
2. **Enhanced Irrigation Efficiency:** Solar pumps ensure a consistent water supply during the day, which is beneficial in regions with uncertain electricity supply during daytime. This reliability allows farmers to irrigate their crops more efficiently, leading to better crop yields and more consistent agricultural output.
3. **Energy Independence:** Solar installations provide farmers with greater control over their energy resources, reducing their dependency on grid power or expensive diesel generators.
4. **Long-term Financial Benefits:** Solar pumps and installations have low operational and maintenance costs compared to traditional diesel pumps. The long lifespan of solar equipment translates to lower long-term costs, further enhancing the economic viability for farmers.

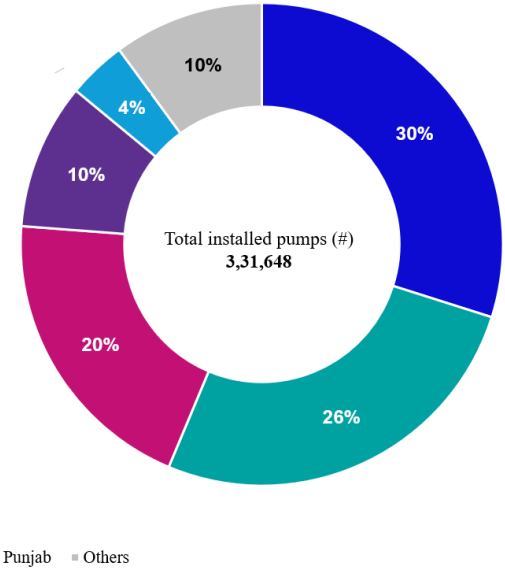
5.2.7 (c) 0.42M solar pumps are installed at ground level, out of which 0.33M solar pumps RMU data was synchronised with national portal data of MNRE / PM Kusum with the total central financial support of INR 344B (US$ 4.1B)

The installation under each component of the PM KUSUM scheme varies across states, with a focus on promoting renewable energy adoption in agriculture. The future visibility of the scheme includes scaling up solar capacity and enhancing energy efficiency in the agricultural sector.

 # pumps sanctioned under component B of PM-KUSUM scheme



 # pumps installed under component B of PM-KUSUM scheme



Maharashtra Haryana Rajasthan Uttar Pradesh Punjab Others

Note(s): *As of 30th April, 2024
Source(s): PM-KUSUM website, 1Lattice analysis

As per the PM KUSUM website as of 30th April 2024 1.294M turnkey solar pumping system sanctioned by the government for all the states of which 0.331M turnkey solar pumping pumps have been installed representing 25.6% of the total sanctioned turnkey solar pumping systems. In addition, the PM Kusum Scheme focuses on the solarization of 3.50 million existing grid-connected agricultural pumps and provides subsidies to individual farmers who have grid-connected pumps to retrofit their pumps with solar panels. There are around ~0.1M solar pumps in process of installation or installed under PM KUSUM scheme but waiting for final PBG (performance-based guarantee) letter from Nodal agency to be counted as complete. While this is a significant achievement, it represents only a portion of the targeted 1.4M pumps. The PM Kusum Scheme is still in its early stage, indicating a significant untapped market for agri-solar pump installations

States like Maharashtra, Haryana, Rajasthan, & Uttar Pradesh and Punjab constitute ~87% of the total sanctioned pumps under component B of PM-KUSUM scheme followed by states like Jharkhand, Karnataka, Madhya Pradesh and Gujarat attributing to ~8% of sanctioned pumps. ~30% of the total installed pumps are installed in Maharashtra. Haryana & Rajasthan comprise of ~20% of installed pumps each. Other major states include Jharkhand, Madhya Pradesh, Gujarat, Tamil Nadu etc. The low installation percentage is attributed to insufficient manufacturing capabilities, suggesting a substantial untapped potential for Oswal pumps owing to their integrated manufacturing capabilities. Of the estimated 0.42 million agri-solar pumps installed at ground level in various states under the PM Kusum Scheme, as of March 31, 2024, Oswal pumps have directly and indirectly supplied 0.184M agri-solar pumps, representing ~43.8% of the total agri-solar pumps installed. Within four years of supplying agri-solar pumps, in FY24 and FY23 Oswal emerged as one of the largest suppliers of agri-solar pumps under the PM Kusum Scheme, providing turnkey solar pumping systems directly under the PM Kusum Scheme to farmers, providing turnkey solar pumping systems to players participating in the PM Kusum Scheme, and supplying only solar pumping system(includes solar pumps sets, solar modules, structures and BOS kits and excludes installation services) to players participating in the PM Kusum Scheme.

5.2.7 (d) PM KUSUM Project Execution Process

Understanding the project execution process of the PM KUSUM scheme involves detailing the steps involved in setting up decentralized renewable energy power plants, installing solar agriculture pumps, and solarizing existing grid-connected pumps.

The steps of project execution process are as follows:

1. **Farmer Interest Submission**: Farmers express interest in solar equipment and contribute 20-40% to the State Nodal Agency.
2. **MNRE Contribution:** The Ministry of New and Renewable Energy (MNRE) contributes 30% to the State Nodal Agency (controlled by the Central Government).
3. **State Government Contribution:** State governments contribute 30-50% to the State Nodal Agency. State governments also help in getting subsidized loans for farmers
4. **Vendor selection:** The State Nodal Agency issues a tender and empanels vendors based on the bidding process. Once the portal opens, farmers can select from the list of these empanelled vendors, who have participated and been selected through the tender process
5. **Tender and Work Order:** The State Nodal Agency opens a tender and issues a work order to the selected bidder.
6. **Installation by Bidder:** The bidder supplies materials to farmers and completes the installation.
7. **Completion Report:** The bidder submits material, work order, and a completion report, including payment details.

State government contributes 30-50% to the nodal agency followed by central government (30%) and farmer (20-40%) for obtaining solar pumps

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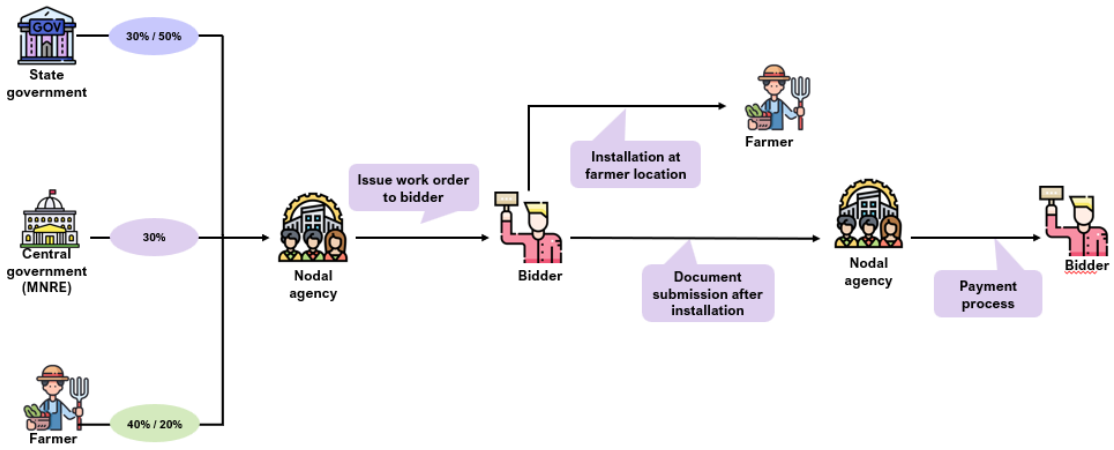


5.2.7 (e) L2 and L3 Bidders have opportunity to participate in the supply process by providing goods at the price quoted by L1 bidder

The terms L1, L2, and L3 refer to the ranking of bidders based on their bid amounts, where L1 is the lowest bidder, L2 is the second lowest, and L3 is the third lowest.

- The L1 bidder is the participant who offers the lowest price in the tendering process.
- Once the bids are evaluated, the L1 bidder is usually selected as the primary supplier for the project.
- The L1 bidder is mandated to supply the required goods or services at the price they quoted.
- The L2 bidder is the one who submits the second-lowest bid, while the L3 bidder submits the third-lowest bid.
- Although L2 and L3 did not offer the lowest prices, they may still have the opportunity to participate in the supply process by supplying the goods or services at the price quoted by the L1 bidder.

5.2.7 (f) Differentiation between suppliers with fully integrated capabilities vs suppliers dependent on third-party vendors

Parameters	EPC players	Pump Manufacturers	PV Module Manufactures	Integrated manufacturing players
Operations	• Outsource materials from vendors • Carry out only designing. commissioning and installation of entire pumping system	• Manufacture pump set and motor • Outsource PV modules from vendors • Carry out designing and commissioning of entire pumping system	• Manufacture PV modules • Outsource pump set and motors from vendors • Carry out designing and commissioning of entire pumping system	• Manufacture entire pumping system including pump set, motor and PV modules • Carry out designing and installation of entire pumping system
Manufacturing capabilities	• No manufacturing capabilities	• Partially integrated manufacturing capabilities	• Partially integrated manufacturing capabilities	• Fully integrated manufacturing capabilities
Companies	GK ENERGY, Rite water SOLUTIONS	SHAKTI PUMPS, C.R.I. PUMPS	TATA POWER SOLAR	OSWAL PUMPS & MOTORS

EPC players, such as GK Energy and Rite Water Solutions, have installation capabilities but outsource the manufacturing capabilities, they procure all critical parts, including the pumping system and PV modules, from third parties. Their role is limited to designing, commissioning, and installing the systems, which adds less value compared to manufacturers.

On the other hand, integrated players like Oswal Pumps provides a lot value-addition. They manufacture all critical components in-house, including the pump set, motor, and PV modules, and provide comprehensive EPC services. This integrated approach allows them to offer a complete solution and capture more value in the supply chain.

5.3 Key tenders for solar pumps by various state nodal agencies beyond PM Kusum scheme

Some of the key tenders by the state nodal agencies of different states are as follows:

- Maharashtra: Bids for installation and commissioning of 50,000 submersible solar water pumping systems were invited by Maharashtra Energy Development Agency (MEDA) in 2022.
- Haryana: Haryana Renewable Energy Development Agency (HAREDA) invited bids for installation and commissioning of 24,484 solar water pumping systems of different capacities in 2024
- Chhattisgarh: Tender for bidding for installation and commissioning of 20,000 submersible solar water pumping systems of different capacities was issued by Chhattisgarh Renewable Energy Development Agency (CREDA) in 2024.
- Jharkhand: Bids for installation and commissioning of 8,000 submersible solar water pumping systems were invited by Jharkhand Renewable Energy Development Agency (JREDA) in 2024.

5.4 Standard supply practices of pump manufacturer:

i. Need assessment: Pump manufactures determine specific needs based on the application (e.g., type of fluid, flow rate, pressure requirements) and create detailed technical specifications including material, size, capacity, and special requirements.
ii. Market research: Pump manufacturers also conduct market research to identify potential opportunities within industries or countries. They analyse factors such as government-backed initiatives, emerging trends, and industry demands. This research helps them understand the market landscape and align their product development and marketing strategies accordingly.
iii. Vendor / supplier identification: Pump manufacturers identify potential vendors / suppliers based on their experience, track record, financial stability, technical capabilities, and compliance with relevant quality standards and certifications.
iv. Negotiation & contracting: Negotiate terms of purchase including price, payment terms, delivery schedule, warranty, and after-sales support between the manufacturer and the vendor / supplier. They finalize and sign the purchase agreement or contract.
v. Logistics & installation: The manufacturer coordinates the delivery schedule and inspect pumps for compliance with specifications and contract terms. The manufacturer also arrange for installation and conduct performance testing to ensure proper operation at the installation site, particularly in case of solar pumps.
vi. Payment & post-installation support: Post-installation support provided by the manufacturer includes troubleshooting, providing repair services, ensuring spare parts availability, processing warranty claims, collecting feedback, and developing a proper maintenance schedule.

5.5 Legal / Statutory Compliances and Environmental / Ecology Norms

To demonstrate a commitment to environmental protection, cleanliness, employee health and safety, and overall welfare, as well as to meet customer quality expectations, both solar and submersible pump manufacturers must adhere to the following standards:

ISO 9001:2015
ISO 9001:2015 is the Quality Management System (QMS) standard that ensures the quality of products and services. For solar or submersible pumps manufacturers, this standard is crucial for ensuring the quality of their products. It provides a framework and set of principles that ensure a common-sense approach to the management of an organization to consistently satisfy customers and other stakeholders. Key benefits include improved consistency and quality of products and services, enhanced customer satisfaction and loyalty, reduced operational costs, improved risk management, & increased market opportunities

ISO 14001:2015
ISO 14001:2015 is the Environmental Management System (EMS) standard that ensures the organization's environmental impact is minimized. For solar or submersible pumps manufacturers, this standard is crucial for reducing their environmental footprint. Reduction in waste and resource use, improved regulatory compliance. lowered environmental impact, enhanced corporate reputation and stakeholder trust, cost savings through improved efficiencies are the key benefits under this compliance.

ISO 45001:2018
ISO 45001:2018 is the Occupational Health and Safety Management System (OHSMS) standard that ensures a safe working environment. For solar or submersible pumps manufacturers, this standard is crucial for ensuring the safety of their employees. Key benefits include reduced workplace incidents and injuries, improved OH&S risk management, compliance with legal and regulatory requirements, enhanced worker engagement and safety culture, reduced absenteeism and turnover.

5.6 Growth Outlook of the end-use industries that the pump manufactures cater to:
Agriculture: The agriculture sector in India contributes 18% of India's overall GDP. It is expected to grow significantly due to increased investments in infrastructure, genetically modified crops, and food safety mechanisms. Additionally, the Ministry of Food Processing Industries' PMKSY scheme will boost the food processing industry with INR 4,600 Cr (US$ 559.4M) allocated until FY26.

Chemicals: India is the 6th largest producer of chemicals in the world and 3rd in Asia. The growth in this industry is driven by rising demand in the end-user segments for speciality chemicals and petrochemicals. The government has implemented policies like the Petroleum, Chemical, and Petrochemical Investment Regions (PCPIRs) to boost the sector.

Pharmaceuticals: Indian Pharma industry is expected to reach US$ 57B by FY25 and US$ 130B by FY30. India is the 12th largest exporter of medical goods in the world. Indian drugs are exported to more than 200 countries in the world, with the US being the key market.

Real estate: The real estate sector valued at US$ 350B in FY24 is expected to grow to US$ 819B by FY29 with a projected CAGR of ~19% . Urbanization, rental market expansion, and property price appreciation are expected to drive growth in CY24. The Government has allowed FDI of up to 100% for townships and settlements development projects. In the FY25 interim Budget, Finance Minister Ms. Nirmala Sitharaman announced a boost for India's affordable housing sector by adding 2 Cr more houses to the flagship scheme PMAY-U.

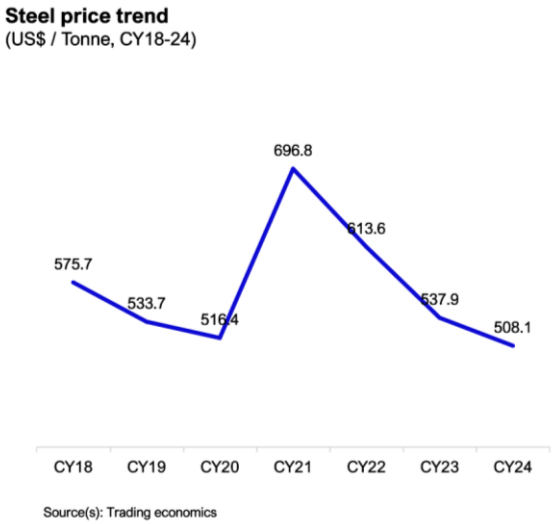
Metals & mining: The Indian metals and mining industry is expected to grow significantly in the coming years, driven by increasing demand for steel, zinc, and aluminum. The industry is expected to reach a market size of US$ 300M tonnes per annum (MTPA) and a total crude steel demand/production of 255 MTPA by CY31. The government has implemented several initiatives to boost the sector, including the PLI Scheme for Specialty Steel and the development of new mining projects.

Sewage & water treatment: With increasing urbanization and growing awareness of water conservation, investments in sewage and water treatment infrastructure are expected to rise. The sewage and water treatment industry in India is witnessing rapid growth due to increasing urbanization and government initiatives to ensure water security and sustainable water management schemes such as the Jal Jeevan Mission and AMRUT, aiming to improve water supply and sanitation services across urban and rural areas. This sector presents significant opportunities for pump manufacturers as demand for efficient water management and treatment systems rises

Hotels, malls & corporates: The commercial sector, including hotels, malls, and corporate buildings, relies heavily on pumps for HVAC (heating, ventilation, and air conditioning), water supply, and sewage systems. With the growth in urbanization, increased tourism, and the expansion of commercial spaces, the demand for reliable and efficient pump systems in these establishments is expected to rise. The commercial real estate sector's growth, alongside initiatives to enhance energy efficiency and sustainability, will drive the demand for advanced pumping solutions.

5.7 Raw material price trend analysis:

5.7.1 Steel:



In CY21, the steel price peaked significantly at US$ 696.8 per tonne. This sharp increase can be attributed to various factors, including post-pandemic recovery in demand, supply chain disruptions, and increased raw material costs. After reaching the peak in CY21, steel prices began to decrease again, dropping to US$ 613.6 per tonne in CY22, US$ 537.9 per tonne in CY23, and declined to US$ 508.1 per tonne in CY24. The gradual decline may reflect stabilization in the market and supply chain recovery.

5.7.2 Copper:

In CY21, copper prices surged dramatically to US$ 9,495.7 per tonne. This spike is driven by COVID-19 supply chain disruption and increased demand for copper in electronics and renewable energy sectors. After the spike in CY21, copper prices decreased to US$ 9,044.0 per tonne in CY22 and further to US $ 8,610.0 per tonne in CY23. The price has slightly increased to US$ 9,257.9 per tonne in first 5 months of CY24.

1Lattice

06

Competitor Benchmarking

6.1 Operational benchmarking:

Oswal pumps offering caters to across various industries in line with other leading players in the pump industry. Oswal pumps offering wide variety of pumps in line to other leading players in the pump industry. Oswal pumps operate a manufacturing facility located in Karnal, Haryana, which is one of India's largest single-site facilities for manufacturing pumps covering an area of 41,076 sq.m in FY24. Oswal's manufacturing facility is strategically located near major agricultural states such as Haryana, Punjab and Uttar Pradesh.

Key industries	OSWAL	Kirloskar	KSB	SHAKTI	WPIL Limited	Roto pumps	C.R.I. PUMPS	Lubi
Oil and gas	✓	✓	✓	✓	✓	✓	✓	✓
Power generation	✓	✓	✓	✓	✓	✓	✓	✓
Agriculture	✓	✓	✓	✓	✓	✓	✓	✓
Building and Construction	✓	✓	✓	✓	×	×	✓	✓
Wastewater treatment	✓	✓	✓	✓	✓	✓	✓	✓
Chemical industry	✓	✓	✓	✓	✓	✓	×	✓
Pharmaceutical industry	✓	✓	✓	✓	×	×	×	✓
Other industrial services	✓	✓	✓	✓	×	✓	✓	✓
Municipal projects	✓	✓	×	✓	×	×	✓	✓

Source(s): Company website and annual reports

Key Products	OSWAL	Kirloskar	KSB	SHAKTI	WPIL Limited	Roto pumps	C.R.I. PUMPS	Lubi
Submersible pumps	✓	✓	✓	✓	✓	✓	✓	✓
Monoblock pumps	✓	✓	✓	✓	✓	×	✓	✓
Pressure booster pumps	✓	✓	✓	✓	✓	×	✓	✓
Centrifugal pumps	✓	✓	✓	✓	✓	✓	✓	✓
Solar pumps	✓	✓	✓	✓	×	×	✓	✓
Positive displacement pumps	✓	✓	✓	✓	✓	✓	✓	✓

Source(s): Company website and annual reports

Parameters		OSWAL	Kirloskar	KSB	SHAKTI	WPIL Limited	Roto pumps	C.R.I. PUMPS	Lubi
Export as % of revenue		5%	7%	12%	24%	35%	66%	17%	20%
Manufacturing area (sq. m.)		51,193	NA	NA	1,27,169	1,45,000	20,000	3,00,000	3,50,000
Location & concentration of states	National	28 states and 8 union territories	28 states and 8 union territories	28 states and 8 union territories	28 states and 8 union territories	27 states	28 states and 8 union territories	28 states and 8 union territories	28 states and 8 union territories
	Inter - national	19+ countries	120+ countries	NA	100+ countries	22 countries	55+ countries	120+ countries	80+ countries

Source(s): Company website and annual reports

6.2 Financial benchmarking:

Oswal is the fastest growing vertically integrated solar pump manufacturer in Indian in terms of revenue growth during the last three fiscals, , with revenues growing at a CAGR over 45.07% over FY22-24. Oswal Pumps has second highest EBITDA margin compared to peers in FY24

Parameters	Company	FY22	FY23	FY24
Revenue from operations (INR M)	Oswal Pumps	3,603.84	3,850.36	7,585.71
	Kirloskar	30,576.28	37,302.21	40,011.99
	Shakti Pumps	11,785.35	9,676.83	13,707.39
	WPIL Limited	11,812.78	16,054.59	16,644.04
	KSB Pumps	14,972.91	18,219.60	22,472.38
	Roto Pumps	1,755.88	2,257.81	2,744.96
	CRI Pumps	15,742.94	16,783.60	NA
Gross margin[1] (INR M)	Oswal Pumps	1,061.85	1,181.94	2,556.05
	Kirloskar	13,773.26	17,756.04	20,181.62
	Shakti Pumps	2,738.91	2,243.18	4,510.81
	WPIL Limited	8,999.31	12,592.48	13,169.39
	KSB Pumps	7,048.66	8,339.59	9,697.28
	Roto Pumps	1,195.29	1,513.54	1,786.49
	CRI Pumps	4,461.14	4,250.16	NA
Gross margin[2] (%)	Oswal Pumps	29.46%	30.70%	33.70%
	Kirloskar	45.05%	47.60%	50.44%
	Shakti Pumps	23.24%	23.18%	32.91%
	WPIL Limited	76.18%	78.44%	79.12%
	KSB Pumps	47.08%	45.77%	43.15%
	Roto Pumps	68.07%	67.04%	65.08%
	CRI Pumps	28.34%	25.32%	NA
Operating EBITDA[3] (INR M)	Oswal Pumps	385.23	578.19	1,501.24
	Kirloskar	2188.76	4,054.61	5,363.65
	Shakti Pumps	1,104.51	665.60	2,248.32
	WPIL Limited	2,115.88	2,701.29	3,035.96
	KSB Pumps	2,158.87	2,544.72	3,029.80
	Roto Pumps	447.15	532.61	655.50
	CRI Pumps	1,995.39	1,333.83	NA
Restated Profit for the Year (INR M)	Oswal Pumps	169.29	341.99	976.65
	Kirloskar	943..77	2,357.66	3,496.80
	Shakti Pumps	648.16	241.32	1,417.09
	WPIL Limited	1,180.14	1,778.70	1,930.15
	KSB Pumps	1,493.89	1,827.41	2,087.33
	Roto Pumps	302.41	331.15	394.15
	CRI Pumps	1059.13	683.22	NA
Operating EBITDA[4] (%)	Oswal Pumps	10.69%	15.02%	19.79%
	Kirloskar	7.16%	10.87%	13.14%
	Shakti Pumps	9.37%	6.88%	16.40%
	WPIL Limited	17.91%	16.83%	18.24%
	KSB Pumps	14.42%	13.97%	13.48%
	Roto Pumps	25.47%	23.59%	23.88%
	CRI Pumps	12.67%	7.95%	NA
PAT[5] (%)	Oswal Pumps	4.69%	8.83%	12.83%
	Kirloskar	3.05%	6.27%	8.61%
	Shakti Pumps	5.47%	2.49%	10.31%
	WPIL Limited	9.92%	10.92%	11.40%
	KSB Pumps	9.76%	9.80%	9.16%
	Roto Pumps	16.81%	14.39%	14.13%
	CRI Pumps	6.67%	4.02%	NA

Return on Net Worth[6] (%)	Oswal Pumps	58.88%	80.91%	88.73%
	Kirloskar	8.28%	18.22%	22.30%
	Shakti Pumps	17.67%	5.95%	24.15%
	WPIL Limited	20.05%	24.63%	18.78%
	KSB Pumps	15.71%	16.97%	17.07%
	Roto Pumps	25.39%	22.30%	21.95%
	CRI Pumps	15.53%	9.61%	NA
Return on Capital Employed[7] (%)	Oswal Pumps	27.01%	45.47%	81.85%
	Kirloskar	11.95%	22.91%	29.58%
	Shakti Pumps	21.58%	10.49%	31.72%
	WPIL Limited	24.04%	30.27%	25.91%
	KSB Pumps	20.45%	22.70%	22.82%
	Roto Pumps	32.96%	28.58%	27.21%
	CRI Pumps	16.90%	11.46%	NA
Net Debt to Equity Ratio[8]	Oswal Pumps	1.83	0.70	0.42
	Kirloskar	0.21	0.02	(0.06)
	Shakti Pumps	0.19	0.15	(0.14)
	WPIL Limited	0.25	0.16	(0.18)
	KSB Pumps	(0.06)	(0.03)	(0.09)
	Roto Pumps	(0.04)	0.07	0.06
	CRI Pumps	0.40	0.31	NA
Net Debt to Operating EBITDA Ratio[9]	Oswal Pumps	2.08	0.96	0.50
	Kirloskar	1.10	0.08	(0.21)
	Shakti Pumps	0.67	0.94	(0.48)
	WPIL Limited	0.75	0.48	(0.76)
	KSB Pumps	(0.26)	(0.13)	(0.39)
	Roto Pumps	(0.11)	0.20	0.17
	CRI Pumps	1.37	1.74	NA
Cash Conversion Cycle[10] (Days)	Oswal Pumps	71	66	91
	Kirloskar	70	90	65
	Shakti Pumps	81	172	113
	WPIL Limited	115	143	139
	KSB Pumps	99	137	118
	Roto Pumps	114	127	116
	CRI Pumps	123	116	NA
Gross Block[11] (INR M)	Oswal Pumps	742.11	917.92	1,148.28
	Kirloskar	12,537.86	13,057.93	14,490.47
	Shakti Pumps	2,851.74	2,999.29	3,203.27
	WPIL Limited	4,457.03	4,921.61	4,365.97
	KSB Pumps	6,999.17	7,780.95	8,597.81
	Roto Pumps	933.20	1,143.74	1,571.72
	CRI Pumps	NA	NA	NA
Addition to Property, Plant & Equipment[12] (INR M)	Oswal Pumps	172.95	175.81	284.70
	Kirloskar	1,098.01	618.79	1,588.84
	Shakti Pumps	211.37	236.28	210.98
	WPIL Limited	260.03	741.08	412.14
	KSB Pumps	335.46	827.99	972.26
	Roto Pumps	80.55	247.93	463.32
	CRI Pumps	NA	NA	NA
	Oswal Pumps	6.51	4.96	8.33

Fixed Asset Turnover Ratio[13]	Kirloskar	5.51	6.37	6.26
	Shakti Pumps	8.01	6.57	8.16
	WPIL Limited	2.75	3.55	3.58
	KSB Pumps	4.32	5.03	5.44
	Roto Pumps	2.98	2.45	2.34
	CRI Pumps	4.59	5.13	NA
Total Borrowings[14] (INR M)	Oswal Pumps	875.40	592.84	754.22
	Kirloskar	3,751.96	2,527.87	1,549.11
	Shakti Pumps	1,050.11	734.01	829.11
	WPIL Limited	2,790.85	2,262.23	2,065.17
	KSB Pumps	0	0	0
	Roto Pumps	144.88	385.35	357.81
	CRI Pumps	2,754.99	2,344.22	NA

Parameters	Company	FY22-24 CAGR
Revenue from operations (INR M)	Oswal Pumps	45.08%
	Kirloskar	14.39%
	Shakti Pumps	7.85%
	WPIL Limited	18.70%
	KSB Pumps	22.51%
	Roto Pumps	25.03%
EBITDA (INR M)	Oswal Pumps	97.41%
	Kirloskar	56.54%
	Shakti Pumps	42.67%
	WPIL Limited	19.78%
	KSB Pumps	18.47%
	Roto Pumps	19.47%
PAT (INR M)	Oswal Pumps	140.19%
	Kirloskar	92.49%
	Shakti Pumps	47.86%
	WPIL Limited	27.89%
	KSB Pumps	18.21%
	Roto Pumps	14.16%

Note(s):

1. *Gross margin is the Revenue from Operations of the Company as reduced by the purchases of stock in trade and Changes in Inventories of finished goods, work in progress and stock-in-trade and Cost of Materials Consumed*
2. *Gross margin (%) is Gross Margin divided by Revenue from Operations*
3. *Operating EBITDA is calculated as restated profit for the year plus finance cost and depreciation and amortization costs and tax expenses as reduced by other income*
4. *Operating EBITDA Margin on revenue from operations refers to the EBITDA as a % of Revenue from Operations during a financial year*
5. *PAT Margin as against Revenue from Operations is calculated as the restated profit as a % of Total Income*
6. *Return on Net Worth is calculated as restated profit during the year as a percentage of average of net worth of the company during the year. Net worth means the aggregate value of paid-up share capital and other equity created out of the profits, securities premium account and debit or credit balance of profit and loss account, after deducting the aggregate value of the accumulated losses, deferred expenditure and miscellaneous expenditure not written off, derived from the Restated Consolidated Financial Information, but does not include reserves created out of revaluation of assets, write-back of depreciation and amalgamation*
7. *Return on capital employed is calculated as the EBIT divided by the average capital employed of the company during the year. Capital employed is calculated as the sum of Tangible Net Worth plus Total Debt as reduced by Deferred Tax Assets and Other Intangible Assets.*
8. *Net Debt to Equity is calculated as Net Debt divided by total equity of the company during the year. Total equity is the sum of Share Capital and other Equity. Net Debt is calculated as Total Borrowings reduced by Cash and Cash Equivalents.*
9. *Net Debt to operating EBITDA as calculated as Net Debt divided by operating EBITDA. Net Debt is calculated as Total Borrowings reduced by Cash and Cash Equivalents*

10. *Cash Conversion Cycle calculated as adding Accounts Receivables days to Inventory Outstanding days reduced by Accounts Payables days.*
11. *Gross Block represents the total worth of all property plant and equipment*
12. *Addition to Property, Plant and Equipment represents the cumulative addition to the Gross Block in the period*
13. *Fixed Asset Turnover Ratios as Revenue from Operation during the year divided by average fixed assets during the year*
14. *Total Borrowings as Current borrowings added to Non-Current borrowings for the year.*

KSB Pumps data if for CY21, CY22 and CY23

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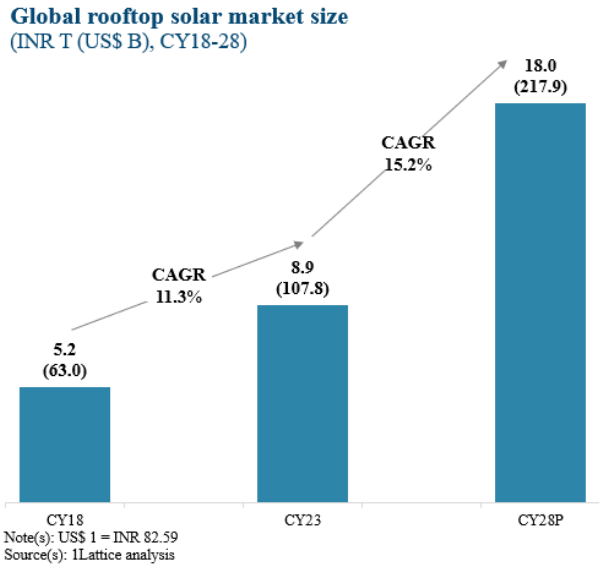
07

Rooftop Solar Market Overview

7. Rooftop Solar market overview

7.1 The Global rooftop solar market was INR 8.9T in CY23 and expected to grow at a CAGR of 15.2% during CY23-28

A rooftop solar system, commonly known as a photovoltaic system, is a configuration of solar panels mounted on the roof of a building to generate electrical power. The panels convert energy from the sun into electricity, offering a sustainable and cost-friendly solution for electricity generation. It consists of solar panels, an inverter and a monitoring system. It requires less maintenance, and can be installed on residential, commercial & industrial buildings for power supply, heating water, running electric generators, etc.



In CY23, the global rooftop solar market size was INR 8.9T and is expected to reach INR 18T by CY28, growing at a CAGR of 15.2%. Supportive government initiatives in terms of subsidies and tax exemptions for the installation of rooftop solar panels in various countries, a rise in awareness of carbon emissions in the environment, and declining installation costs are some of the factors which are contributing to the growth of the rooftop solar market.

7.2 Rooftop Solar Market in India is expected to reach INR 295.8B by FY29, growing at a CAGR of ~17.9%

India is currently experiencing a significant transition towards renewable energy sources which is fueled by both necessity and opportunity. The country faces a dual challenge of meeting its rising energy demand while grappling with the adverse impacts of fossil fuels on the environment and public health. The government stands strong in its conviction of reducing dependence on non-renewable energy sources and is actively working to achieve targets such as

- Reaching a non-fossil fuel energy capacity of 500GW by CY30
- Fulfilling at least 50% of the country's energy requirements via renewable energy by CY30
- Reducing carbon emissions by 1 billion tons by CY30
- Reducing carbon intensity below 45% by CY30
- Finally paving the way for achieving a Net-Zero emission target by CY70

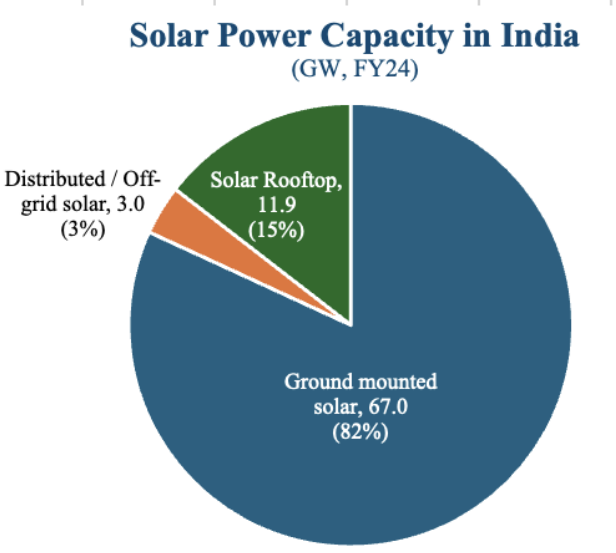
In India, solar energy is a top renewable resource due to its equatorial location, offering 250 to 300 sunny days annually and irradiation between 1600 and 2200 kWh/m² per year. If efficiently used, the country could potentially generate about 6 million GWh of electricity annually, while the total electricity consumption in FY23 was ~1.4 million GWh. India has been demonstrating significant advancements in solar energy adoption, with the total solar power capacity of the country currently standing at 81.8GW, growing at a CAGR of 23% (FY19-24). Solar rooftops which contribute to 18% of the total solar power capacity are roof-mounted solar systems which are installed on roofs of residential and commercial buildings. These systems are typically on-grid or off-grid i.e., they are either connected to a local power grid and any excess electricity generated is transferred to the grid or they have a battery connected to them which stores any excess electricity produced.

India has demonstrated significant advancements in solar energy, notably within the rooftop solar sector. This is fuelled by the increased uptake of solar energy solutions and growing awareness. A crucial initiative that has been instrumental in this progress is the International Solar Alliance (ISA), which encompasses several key programs, including the One Sun One World One Grid (OSOWOG):

International Solar Alliance (ISA)
Launched at the United Nations Climate Change Conference in Paris in November 2015, the International Solar Alliance (ISA) is an initiative proposed by Prime Minister Narendra Modi and launched along with the President of France. It is a member-driven platform to increase solar energy deployment, facilitate energy access, ensure energy security, support energy transition, and promote low-carbon growth, especially in Least Developed Countries (LDCs) and Small Island Developing States (SIDS). The ISA aims to combat climate change through solar energy solutions.

- **One Sun One World One Grid (OSOWOG)**
  Proposed by Prime Minister Narendra Modi during the 2018 International Solar Alliance (ISA) assembly, the One Sun One World One Grid (OSOWOG) is a global electricity grid intended to provide worldwide power supply. It ensures reliable solar power by facilitating energy transfer from daylight areas to those without. As part of the Global Green Grid Initiative (GGI) spearheaded by the UK, the GGI-OSOWOG, a joint effort involving ISA, India, France, and the UK, aims to establish a global green energy grid, emphasizing solar and wind energy.
- **World Solar Bank (WSB)**
  During the UN Climate Change Conference (COP26) in Glasgow in November 2021, the International Solar Alliance (ISA) proposed the establishment of the World Solar Bank (WSB). The WSB aims to finance solar home, grid, and pump projects in ISA member countries, emphasizing its crucial role in supporting financially constrained nations in renewable energy. With an expected capital of around USD 10 billion, the WSB will pool global resources to fund solar initiatives, advocating for solarization amidst green financing discussions.

As of 31st March 2024, the total rooftop solar installations stood at 12GW, accounting for ~15% of the nation's overall installed solar power capacity of 81.8GW.

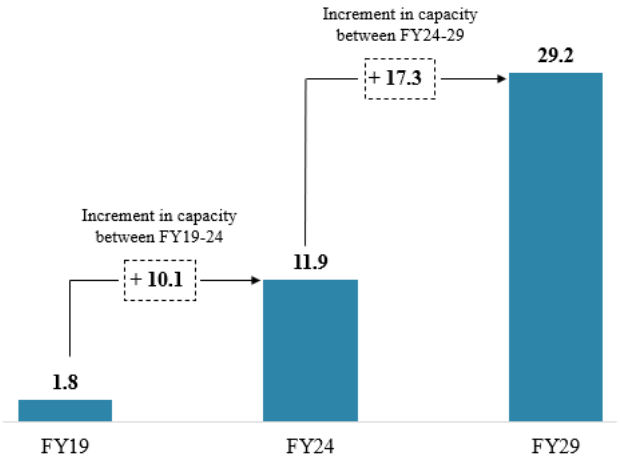


Source(s): Misitry of New and Renewable Energy (MNRE)

India to add 17.3GW solar rooftop capacity over the next 5 years reaching 38.5GW.

In the last 5 years, FY19-24, the nation's solar power capacity increased by 52.7GW to reach 81.8GW. India added 10.1GW of total solar rooftop capacity in the last 5 years, resulting in a total installed capacity of 11.9GW as of FY24. Going ahead, during the next 5 years, additional solar rooftop capacity is likely to increase by 17.3GW, pushing the total installed solar rooftop capacity to 29.2GW by FY29. This is likely to be driven by government initiatives promoting the usage of renewable energy, increased awareness of environmental concerns, and cost-effectiveness of solar-generated electricity

Projected Solar Rooftop Capacity - India
(GW, FY19-29P)

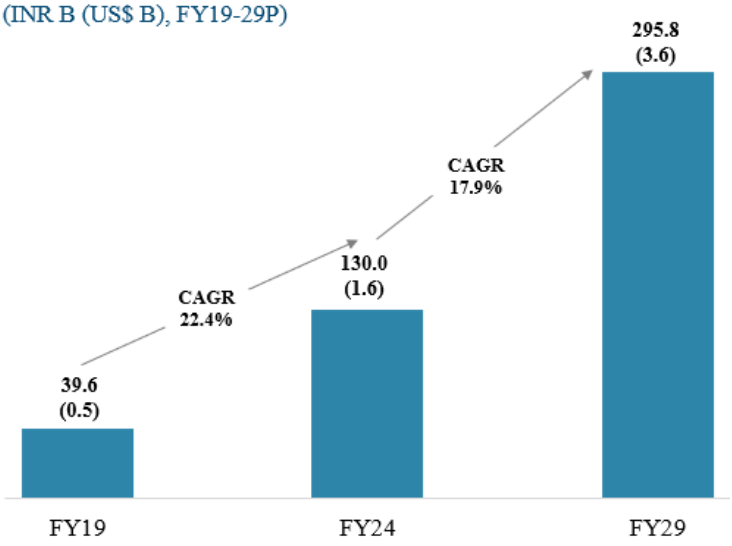


Source(s): Ministry of New and Renewable Energy (MNRE), 1Lattice analysis

Solar rooftops have gained significant traction in recent years due to their potential to address both energy security and environmental concerns and are expected to provide a further push for solar energy adoption in both residential and commercial zones. The solar rooftop market in India is valued at INR 130.0B in FY24 and is expected to reach INR 295.8B by FY29, growing at a CAGR of ~17.9% during the period FY24-29.

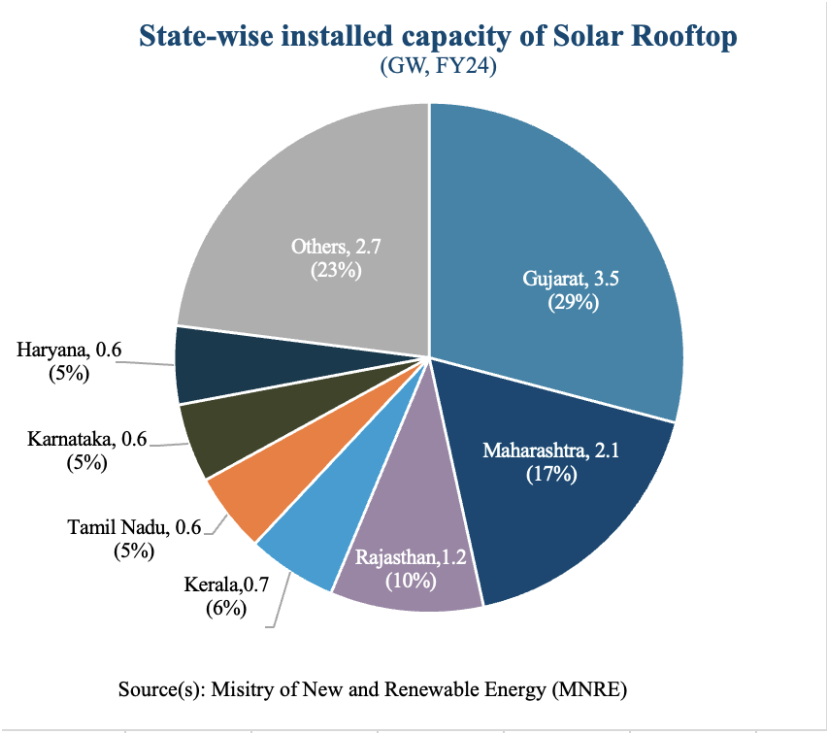
This expansion is backed by unwavering government commitment, escalating environmental consciousness among consumers and supportive policies such as the PM Suryaghar Muft Bijli Yojna with a budget allocation of INR 75,000 Cr, which aims to provide 10 million households with interest-free loans and substantial subsidies to install rooftop solar electricity systems, to give households benefit of up to 300 units of free electricity every month.

Solar Rooftop Market in India
(INR B (US$ B), FY19-29P)



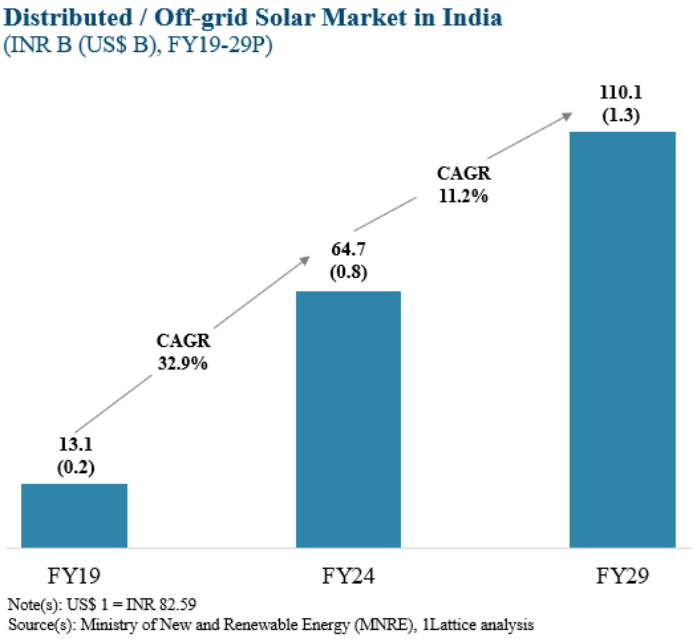
Note(s): US$ 1 = INR 82.59
Source(s): Ministry of New and Renewable Energy (MNRE), 1Lattice analysis

As of FY24, the top 5 states account for 67% of the total installed rooftop capacity in the country. Gujarat leads the nation with the highest solar rooftop capacity, with a total installed capacity of 3.5 GW, followed by Maharashtra with a capacity of 2.1GW and Rajasthan with 1.2GW. Kerala and Tamil Nadu follow with an installed capacity of 0.7GW and 0.6GW respectively.



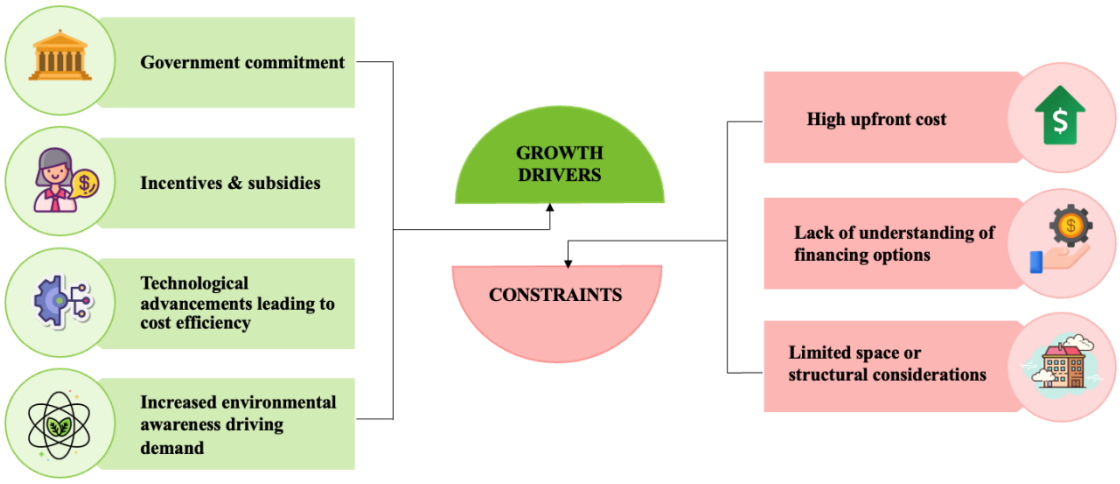
Source(s): Misitry of New and Renewable Energy (MNRE)

Distributed / off-grid solar market in India is valued at INR 64.7B in FY24, growing at a CAGR of 32.9% from FY19-24. The government has been actively contributing to the growth of the market through the implementation of schemes such as PM KUSUM which provides financial assistance to farmers to install decentralized solar agriculture pumps or solarize existing grid connected pumps. Such schemes and rising awareness about the benefits of switching to solar energy are expected to take the market of distributed / off-grid solar to INR 110.1B by FY29, growing at a CAGR of 11.2% during the period FY24-29.



Note(s): US$ 1 = INR 82.59
Source(s): Ministry of New and Renewable Energy (MNRE), 1Lattice analysis

7.3 Factors driving solar rooftop growth and constraints in the next 5 years:



The solar rooftop infrastructure in India has experienced rapid expansion over the past five years and is poised to grow further over the next five years as well. While this progress will be driven by various growth drivers, it will simultaneously encounter specific constraints inherent to the industry.

(a) Growth drivers

i) **Government commitment:** The government's efforts to cut carbon emissions by implementing strategies like the NAPCC (National Action Plan on Climate Change), which aims to make the country more environmentally sustainable, would encourage higher adoption and use of clean energy like solar power.

ii) **Initatives and subsidies:** National and state pro-solar subsidies and schemes launched by the government like the PM-Surya Ghar: Muft Bijli Yojana, which targets installing rooftop solar in one crore houses and Grid-Connected Rooftop Solar Scheme and the solar park scheme will propel the adoption of solar rooftop installations across the nation. Besides this, the key initiatives taken by the government will further promote solar growth and adoption. These initiatives include:

- Setting up of Project Development Cell for attracting and facilitating investments
- Permitting 100% FDI without prior government approval
- Waiver of Inter-State Transmission System (IST) charges for interstate sale of solar power for projects to be commissioned by 30th June 2025
- Declaration of trajectory for Renewable Purchase Obligation (RPO) up to FY30 which outlines the annual targets for renewable energy procurement by DISCOMs and other obligated entities
    - Launch of Green Term Ahead Market (GTAM) to facilitate the sale of renewable energy power including solar power through exchanges

iii) **Technological advancements leading to cost efficiency:** Technological advancements like higher solar cell efficiency and longer panel durability deliver more cost-effective solutions to consumers, accompanied by enhanced performance. As competition intensifies within the industry, optimization of production processes by manufacturers will result in reduced overall installation costs for consumers. Solar module prices have declined over the years from US$ 0.22Wp in FY21 to US$ 0.19Wp by mid FY24.

Along with reduced installation cost, solar rooftop installations also reduce consumers' electricity expenses and additionally provide income through net metering, wherein surplus electricity generated is transferred to the grid and reimbursed. This results in a breakeven point for the investment within 3-4 years. After this period, consumers enjoy the dual benefit of reduced expense and additional income.

The breakup of cost-benefit analysis for solar rooftop installation in an average household in India:

Cost-benefit analysis item	Calculations / Assumptions	Details
Monthly electricity consumption	Average HH electricity consumption (A)	250 units
Annual electricity bill	INR 7 per unit	INR 21,000
Cost of Installation (3kW)	B	INR 1,80,000
Subsidy*	C	INR 78,000
Net Investment	D = B-C	INR 1,02,000
Monthly electricity generation through solar setup	E	360 units
Net metering	F = E-A	110 units
Annual amount credited	INR 7 per unit (G)	INR 9,240
Annual electricity bill reduction after solar setup	Units consumed less than generated (H)	INR 21,000
Total annual benefit	I = G+H	INR 30,240
Approximate breakeven point	J = D/I	3.4 years

Source(s): 1Lattice analysis

Note: *Subsidy is capped at INR 78,000 for 3kW & higher solar rooftop installations

iv) **Increased environmental awareness driving demand:** Growing environmental conscience and responsibility among consumers and a higher number of national awareness campaigns would further drive rooftop solar demand.

(b) Constraints

i) **High upfront cost:** Despite the availability of subsidies, the initial cost of installing solar rooftops remains a major obstacle, especially for lower and middle-class households. However, increased awareness of the long-term benefits and savings can motivate people to overcome this hurdle and adopt solar energy.

ii) **Lack of understanding of financing options**: Consumers lack sufficient information regarding the diverse financing options available to them and are apprehensive when considering the decision to proceed with system installation; rising awareness through new start-ups and government programs on solar financing can alleviate this concern.

iii) **Limited space or structural considerations**: Several existing residential establishments lack sufficient space for the installation of rooftop solar systems. New and innovative space-saving solar technologies tailored for such issues can address this challenge.

7.4 Investments and Regulations in the Solar Rooftop Industry

The government has had a continuous focus on the growth of the Solar Rooftop Industry in the country and has introduced several initiatives and schemes to provide the necessary impetus to this industry. The interim budget for FY25, introduced a significant boost for the rooftop solar sector, with a budget allocation of INR 10,000 Cr. This was a 110% increase from INR 4,757 Cr allocated in FY24.

The government launched its new solar rooftop initiative PM Suryaghar Muft Bijli Yojna in February 2024. The scheme aims to install solar rooftops in 10 million households that would be able to receive up to 300 units of complimentary electricity monthly through it. The scheme focuses on the household segment with up to a 3KW system, covering a significant portion of residential consumers in India. The subsidy program offers a 60% subsidy on systems up to 2KW capacity and a 40% subsidy on systems between 2-3KW, with no financial assistance provided for capacities exceeding 3KW. Eligible beneficiaries can receive a subsidy of INR 30,000 for 1KW systems, INR 60,000 for 2KW systems, and INR 78,000 for 3KW systems or higher. This initiative is projected to entail an investment of INR 75,000Cr.

Government regulations governing solar rooftops:

a) **Central and State-specific subsidy:** Both central and state governments offer subsidies to encourage solar rooftop installations. The central government provides a 30% subsidy for general category states and up to 70% for special states like Uttarakhand, Sikkim, Himachal Pradesh, Jammu & Kashmir, and Lakshadweep. State subsidies, on the other hand, vary. For instance, the Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA) offers INR 15,000 per KW with a maximum limit of INR 30,000 per consumer for residential rooftop solar projects, while the Kerala State Electricity Board (KSEB) offers up to 40% solar subsidy for projects up to 10KW.

b) **Quality standards and certifications:** The Bureau of Indian Standards (BIS) and the Ministry of New and Renewable Energy (MNRE) have established precise guidelines for solar photovoltaic systems. These guidelines include –
   - Compulsory registration for solar PV systems, devices, and components to ensure quality and safety
   - Approval of module models and manufacturers
   - Issuing installation guidelines for grid-connected PV systems

c) **Net Metering:** The Ministry of Power permits net metering which is a billing mechanism that credits solar energy system owners for the electricity they add to the grid, for loads up to 500KW or up to the sanctioned load, whichever is lower. Almost all states and union territories in India have introduced net metering policies. This policy encourages individuals to adopt solar energy systems by offering a method to balance their energy consumption and potentially earn savings or income from surplus electricity generated by their solar panels.

d) **Implementation of BCD (Basic Customs Duty):** Under the implementation of BCD by the government, any import of solar PV modules attracts a BCD of 40% and the import of solar PV cells attracts a BCD of 25%. This in turn supports and boosts indigenous manufacturing of solar PV modules and cells.

List of some of the PE/VC deals conducted between FY21-24:
Strong government commitment and support have boosted investor confidence in the solar sector, leading to a surge of private equity (PE) and venture capital (VC) investments in solar rooftop companies across the country.

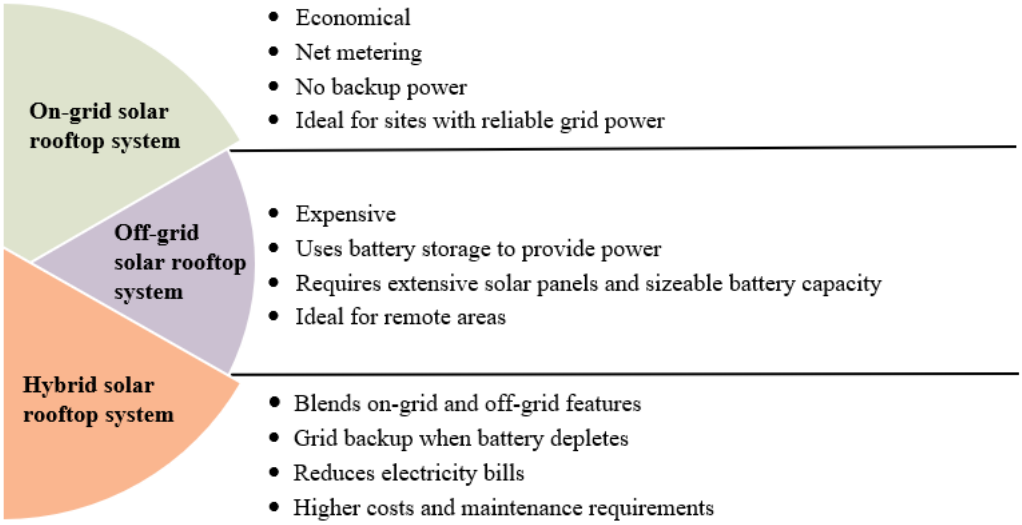
Some of the key deals that took place during FY21-24 are:

Company	Description	Amount (US$ M)	Round	Stage	Investors	Year
SB energy	A renewable energy platform focused on utility-scale solar, storage, and AI-enabled 24/7 energy management	450	Debt	Debt	MUFG, Mizuho Americas, SMBC, CIBC, Fifth Third Bank, Societe Generale	2023
Clean Max Enviro Energy Solutions	Sustainable energy solutions for corporates and industries	360	PE	Late	Brookfield Renewable Partners	2023
ReNew Energy	A global renewable company offering clean & green energy	268	PIPE	PIPE	Canada Pension Plan Investment Board	2023
Clean Max Enviro Energy Solutions	Sustainable energy solutions for corporates and industries	222	Exit	Exit	Augment Infrastructure (Acquirer), Warburg Pincus (Exiting investor), IFC (Exiting investor)	2021
Azure Power	Sustainable energy solutions provider and power producer	219	PIPE	PIPE	OMERS Infrastructure Management	2021
ReNew Energy	A global renewable company offering clean & green energy	139	PIPE	PIPE	Canada Pension Plan Investment Board	2023
Fourth Partner Energy	Integrated Renewable Energy Solutions Company	125	Series C	Growth	Norfund, TPG Capital	2021
ReNew Energy	A global renewable company offering clean & green energy	84	Debt	Debt	Standard Chartered Bank Korea	2024
Azure Power	Sustainable energy solutions provider and power producer	73	Buyout	Buyout	Eversource Capital	2021
Fourth Partner Energy	Integrated Renewable Energy Solutions Company	42	Series C	Growth	Norfund	2023
Clean Max Enviro Energy Solutions	Sustainable energy solutions for corporates and industries	34	Series D	Growth	IFU	2021
Fourth Partner Energy	Integrated Renewable Energy Solutions Company	15	Debt	Debt	responsAbility Investments AG	2020
Fourth Partner Energy	Integrated Renewable Energy Solutions Company	10	Debt	Debt	British International Investment	2022
Freyr Energy	Rooftop solar experts for residential and commercial solar solutions	7	Series B	Growth	EDFI ElectriFI, Schneider Electric Energy Asia Fund, Lotus Capital LLC, Maybright Ventures, VT Capital	2023
MYSUN	An online platform lead rooftop solar company	4	Pre-Series A	Early	Others	2020
Freyr Energy	Rooftop solar experts for residential and commercial solar solutions	2	Series A	Early	C4D Partners	2021
MYSUN	An online platform lead rooftop solar company	2	Debt	Debt	Tata Cleantech Capital	2021

Source(s): Media Reports, 1Lattice Deal Database, 1Lattice analysis

7.5 Overview of solar rooftop systems

Rooftop solar power systems can be categorized based on their configuration, application, and functionality. Following are the different types of rooftop solar power systems:



a) **On-grid solar rooftop system:** This system uses rooftop solar panels to generate electricity, which an inverter converts to AC power. Excess electricity is fed into the grid, earning credits through net metering and reducing bills. These systems are cost-effective as they don't require batteries and seamlessly draw power from the grid when solar output is insufficient. They are ideal for urban areas with reliable grid access.

b) **Off-grid solar rooftop system**: This system uses battery storage to provide power during outages and periods without sunlight. These aren't connected to an electricity grid and are usually installed in remote areas where grid supply is not available. The solar power generated from the rooftop solar system charges the battery which is then used to power various applications. Off-grid systems are generally more expensive than on-grid systems since they require additional equipment like batteries and charge controllers.

c) **Hybrid rooftop system:** This system combines on-grid and off-grid features, using batteries to provide backup during power outages while still connecting to the grid. It allows excess electricity to be sent to the grid for credit, reducing electricity bills. This system stores power generated during the day for night-time use, and if battery power runs out, the grid provides backup. While offering the benefits of both systems, it comes with higher costs and maintenance requirements.

7.6 Key trends in the solar rooftop industry

The Indian solar rooftop industry has witnessed significant growth and advancements in recent years, driven by various factors such as technological innovations, government incentives, and increasing adoption by the commercial and industrial sectors. The key trends in the Indian solar rooftop industry include:

a) **Renewable Purchase Obligation (RPO)**: The Renewable Purchase Obligation (RPO) requires electricity companies and large power users to buy a certain percentage of their power from renewable sources, with penalties for non-compliance. Most states have specified RPO targets. Further, the Draft Electricity Amendment Act 2020 is intended to apply this rule nationwide and is expected to boost the use of rooftop solar panels by commercial and industrial users.

b) **Rise of Third-Party Financing**: Third-party financing models like power purchase agreements (PPAs) and leasing arrangements are growing in the C&I rooftop solar sector. They enable businesses to install solar panels with minimal upfront costs, shifting financial responsibility to third-party developers or investors. This trend increases solar energy access for smaller businesses with limited capital.

c) **Financial Innovation and Risk Mitigation:** Financial institutions are creating innovative solutions for financing C&I rooftop solar projects, including green loans, asset-backed securities, and risk-sharing

mechanisms. These products help lenders manage risks effectively and offer competitive financing options to businesses.

d) **Adoption of Battery Storage in Rooftop Solar:** Battery energy storage systems (BESS) allow electricity to be stored in a battery for future use. The adoption of battery integration has been gaining traction, especially amongst commercial and industrial (C&I) consumers to ensure uninterrupted power supply. Some of the factors driving battery storage in India are increasing diesel cost, falling battery prices, along with the amendment of Electricity (Rights of Consumers) Rules, 2020, requiring customers to use battery systems rather than diesel generators for backup power. The attractiveness of BESS is also higher in states that have higher grid tariffs.

Solar rooftop systems have become increasingly popular, driven by trends such as third-party financing, virtual net metering, peer-to-peer trading mechanisms, etc. Despite this growth, the industry still faces significant challenges, including substantial initial investment cost, limited understanding of financing options, and restricted installation space. Solutions are emerging to address these issues. Increased awareness of the long-term benefits and savings can motivate people to overcome the initial cost hurdle and adopt solar energy, while raising awareness through new startups and government programs on solar financing can alleviate concerns about the lack of understanding of financing options. Additionally, new and innovative space-saving solar technologies tailored for limited space issues can effectively address the challenge of lack of installation space.

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08

Solar Module Equipment Manufacturing

8 Solar Module Manufacturing in India and Globally

In recent years, India has redirected its efforts towards increasing reliance on renewable energy sources, particularly solar energy, to achieve sustainability goals such as reaching non-fossil fuel enery capacity of 500GW by CY30. This has led to a significant emphasis on developing a robust solar module manufacturing value chain.

India added 49.5GW of solar module manufacturing capacity between CY20-23 growing from 15GW in CY20 to 64.5GW in CY23, and is expected to reach 150 GW by CY26. 2.8GW of cell manufacturing capacity growing from 3GW in CY20 to 5.8GW in CY23, and expected to reach 75 GW by CY26.
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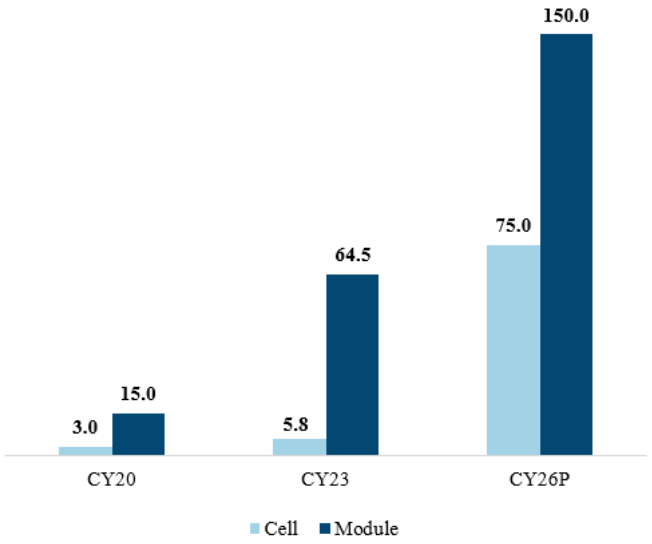
Solar cell and module manufacturing capacity in India
(GW, CY20-26P)

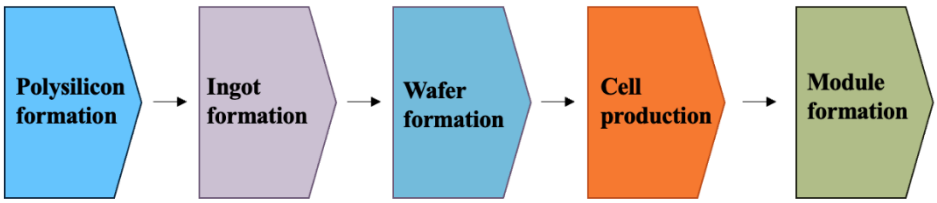


Note(s): P - Projected value
Source(s): Mercom, Institute for Energy Economics and Financial Analysis (IEEFA)

8.1 Overview of Solar Module Manufacturing Value Chain in India

The solar value chain has a high degree of global dependence as several initial manufacturing stages occur in other countries or are import-dependent. For instance, in India, input components like wafers and cells are imported for late-stage manufacturing processes. Manufacturing wafers requires significant capital investment, and India currently lacks both the resources and expertise to keep pace with the rapid technological advancements in this field and absence of economies of scale. However, the outlook remains optimistic as under the PLI scheme, the government aims to support companies in building the infrastructure for manufacturing polysilicon in India within the next few years.

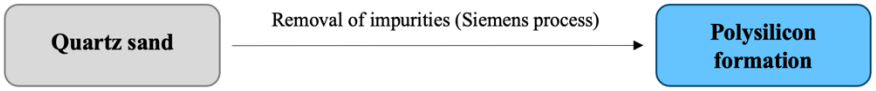
Value chain of solar module manufacturing



The entire value chain can be broken down into the following key processes:

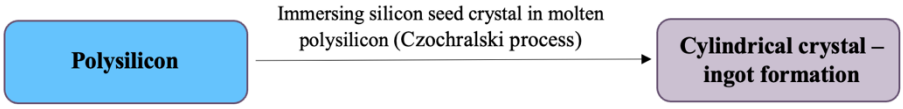
i) **Polysilicon formation**
Silicon is the fundamental material for the entire process. The process typically begins with the extraction of silicon from quartz sand through a series of chemical and thermal treatments. The dominant method

for producing high-purity silicon is through the Siemens process. The process separates all impurities such as iron, aluminium, and other materials leading to the formation of polysilicon.



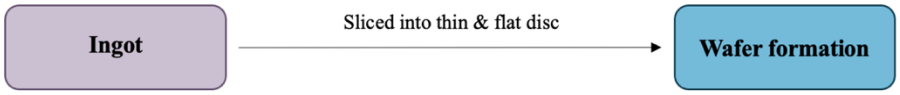
ii) Ingot formation

The polysilicon is then subjected to high temperatures to convert it into a cylindrical ingot through the Czochralski process. This process involves heating the silicon seed crystal and immersing it into molten polysilicon and slowly pulling it out while rotating, which gradually solidifies the molten polysilicon around the seed crystal to form a cylindrical crystal. The rotation helps to ensure the crystal grows uniformly and keeps impurities low.



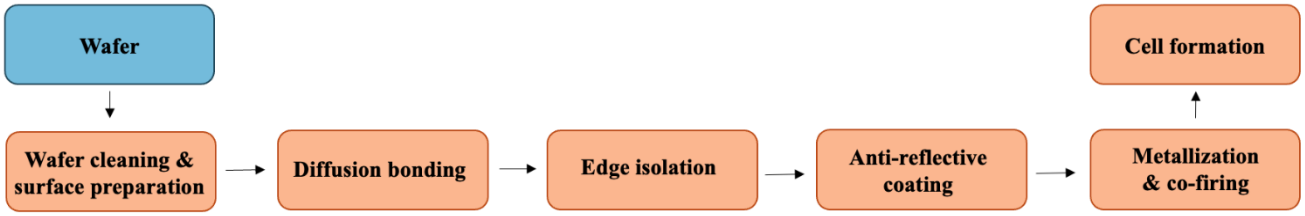
iii) Wafer formation

The ingots are sliced into thin, flat discs depending on the geometrical shape requirements. These discs are inspected for defects such as scratches, cracks, and contamination. Defect-free discs are then tested for their electrical properties, such as resistivity and carrier concentration, to ensure they are suitable for semiconductor devices.



iv) Cell formation

The wafers formed undergo several processes before they make up a solar cell:



a) **Wafer cleaning and surface preparation:** The wafers undergo thorough cleaning to remove impurities before any further processing. They are polished and ground to ensure flatness and uniform thickness, vital for semiconductor device performance.

b) **Diffusion bonding:** This process involves doping the wafer with impurities such as boron and phosphorous at a high temperature to form p-n junctions, essential for the photovoltaic effect.

c) **Edge isolation:** Removal of diffusion layer formed on the peripheral surface of the silicon wafer during diffusion bonding. This peripheral diffusion layer can create a short circuit between the upper and lower electrodes of the solar cell, so it is removed.

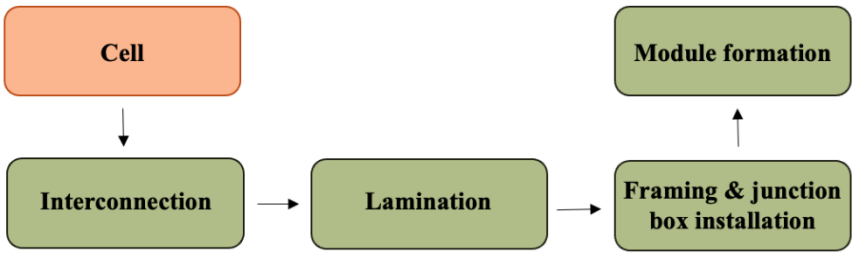
d) **Anti-reflective coating:** An anti-reflective coating is deposited on the solar cell surface. The coating reduces surface reflection and increases light absorption, improving the solar cell's efficiency.

e) **Metallization and Co-firing:** Metal contacts are printed on the front and back surfaces of the solar cell using screen printing or other techniques. The front contacts are designed to be thin and narrow to minimize shading, while the back contacts cover the entire surface.

Solar cells formed are tested for their efficiency and other performance parameters. The cells are then sorted and classified based on the test results.

v) Module formation

Photovoltaic modules or solar panels, consist of 36 to 72 solar cells electrically connected. They are formed by a sequence of steps and processes.



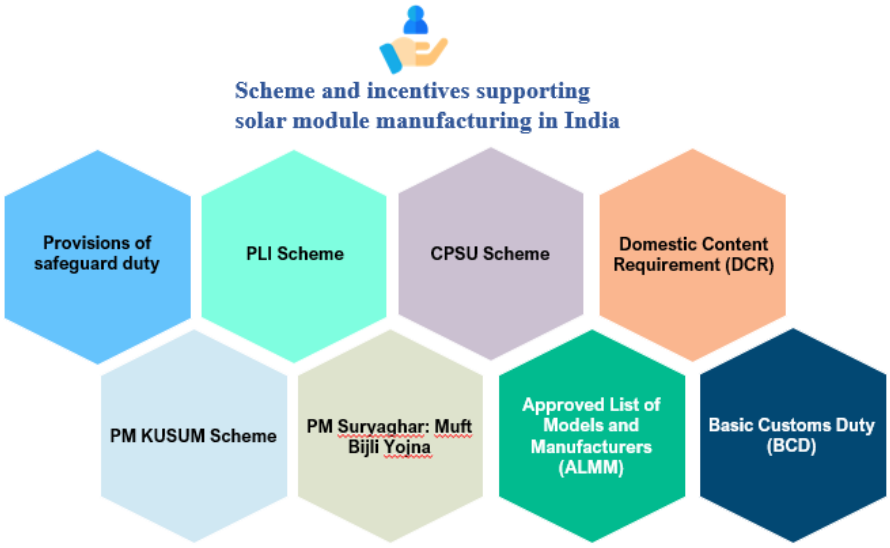
a) **Interconnection**
Solar cells which are similar in terms of electrical performance and optical aesthetics are used for the fabrication of a PV module. The negative contact of one solar cell is connected to the positive contact of the next cell.

b) **Lamination**
The entire stack of cells is then laminated at a high temperature of ~200 °C for 10-15 minutes to form a solid module.

c) **Framing and junction box installation**
The module is framed using aluminium frames to ensure robustness under extreme weather conditions. A junction box is connected at the back of the module, containing the electrical strings coming out for connection.

8.2 Govt. has introduced various schemes and incentives to support domestic solar module manufacturing

The Indian government has implemented several schemes and incentives to promote domestic solar module manufacturing as part of its broader goal to increase renewable energy capacity and reduce dependence on imported solar components. These are some of the key initiatives:



8.2.1 Provisions of Safeguard Duty

In July 2018, India imposed a two-year safeguard duty on solar cells and modules, following Directorate General of Trade Remedies's (DGTR) recommendation, to protect domestic manufacturing. The duty, affecting imports from China, Malaysia, and Taiwan, started at 25% for the first year beginning in July 2018, decreased to 20% for the first six months of the second year, and further reduced to 15% for the final six months. This also applies to imported cells assembled into modules or panels. However, it was extended multiple times beyond the initially decided end period. Safeguard duties aim to shield Indian photovoltaic (PV) manufacturers from cheap imports and spur competitiveness. India's solar energy deployment surged impressively from 3 GW in FY16 to 81.8 GW in FY24, driven by the ambitious target of achieving 300 GW by CY30. While the domestic PV manufacturing sector faces competitive challenges, the government's proactive measures, including safeguard duties, aim to bolster local production. Despite the reliance on imports, these efforts reflect a commitment to strengthening the domestic industry and fostering a more self-reliant solar energy market.

8.2.2 PLI Scheme

In March 2020, the Indian government launched the Production Linked Incentive (PLI) Scheme as part of the National Programme on High-Efficiency Solar PV Modules. Its goal is to establish a domestic manufacturing capacity of gigawatt (GW) scale in high-efficiency solar PV modules and cells, with an allocation of INR 24,000Cr. This initiative offers a production-linked incentive to chosen manufacturers for five years post-commissioning, rewarding them for manufacturing and selling high-efficiency solar PV modules. The scheme is implemented in two tranches. Tranche-I has an outlay of INR 4,500Cr, under which Letters of Award have been issued to three successful bidders for setting up of 8,737 MW of fully integrated solar PV module manufacturing units. For Tranche-II with an outlay of INR 19,500Cr, Letters of Award (LoAs) had been issued to 11 bidders for setting up 39,600 MW of fully / partially integrated solar PV module manufacturing.

8.2.3 Modified Special Incentive Package Scheme (M-SIPS)

The M-SIPS aims to boost electronics manufacturing investment by offering up to 25% capital subsidy for new or extended projects, ranging from INR 1Cr to INR 5,000Cr. It covers 29 electronics verticals, including solar equipment like inverters, DC converters, and more. The subsidy rates vary - 20% for investments in SEZs and 25% for non-SEZs. Applications for this scheme were accepted until December 2018, with coverage for solar PV cells, modules, EVA, back sheets, and solar glass.

8.2.4 CPSU scheme

The Central Public Sector Undertaking (CPSU) aims to support domestic solar module manufacturing; setting up solar PV projects using domestic cells and modules in a World Trade Organization -compliant manner to enhance national energy security and environmental sustainability. Launched in 2015, it aims to build 12GW of solar power projects using domestic materials and being funded by the government. Out of a total goal of 12GW, 9.5GW has been planned by various authorities (SECI, NTPC, IREDA and APDCL). So far, 7GW has been assigned to projects, with NTPC (National Thermal Power Corporation) getting about 53% of these projects.

8.2.5 Domestic Content Requirement (DCR)

Domestic content requirement (DCR) mandates the use of both solar cells and modules manufactured domestically as per specifications and testing requirements fixed by the Ministry of New and Renewable Energy (MNRE). They are regulations enacted by the government mandating a particular percentage of a product's value to be sourced locally. As of January 2024, DCR modules (Mono PERC) were priced at approximately INR 22-23/Wp, while non-DCR modules were priced at around INR 16-17/Wp, creating a gap of about INR 6/Wp, which is approximately 30% of the price. DCR solar panels find extensive application in various governmental projects, government-assisted initiatives, schemes, programs, as well as in open access and net-metering projects. DCR modules are also mandatory to use under PM Surya Ghar Yojana. and component B & C of PM-KUSUM scheme. However, in August 2024, the government relaxed the DCR norms for solar cells used for feeder-level solarization (FLS) under component C of PM-KUSUM until March 31, 2024.

8.2.6 PM KUSUM Scheme

The PM KUSUM (Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan) Scheme, launched in March CY19, aims to provide financial support to farmers for three purposes:

1. Installing standalone solar pumps
2. Solarizing existing grid-connected agriculture pumps
3. Helping farmers become solar entrepreneurs by setting up solar power plants on unused agricultural land

The scheme aims to increase solar capacity by 34.80 GW by March 2026 and has a total budget of INR 34,422Cr, including service charges of 2% on eligible Central Financial Assistance (CFA) to implementing agencies.

8.2.7 PM Surya Ghar: Muft Bijli Yojana

PM Surya Ghar: Muft Bijli Yojana is a government scheme that aims to provide free electricity to households in India. The scheme was launched by Prime Minister Narendra Modi on February 15, 2024. Under the scheme, households will be provided with a subsidy to install solar panels on their roofs. The subsidy will cover up to 40% of the cost of the solar panels. The scheme is expected to benefit 1 crore households across India. It is estimated that the scheme will save the government INR 75,000Cr per year in electricity costs.

8.2.8 Approved List of Models and Manufacturers (ALMM)

ALMM is list of solar cell and module types of manufacturers in India that have been certified by the BIS (Bureau of Indian Standards). Presently there are 78 enlisted manufacturers in the ALMM list. The list contains all the relevant certifications in specific BIS certification and manufacturing capabilities data of enlisted manufacturer. The BIS certification is mandatory for solar modules & inverters.

8.2.9 Basic Customs Duty (BCD)

Basic Customs Duty scheme, launched in CY22, aims to protect and encourage local manufacturing of solar cells and modules in India. This will significantly **increase** the import costs for these key solar components. Previously, imported solar modules and cells did not attract any import duty. JMK Research reports that in Q3 2022, India's solar module imports dropped by 64% from the previous quarter, while solar cell imports increased by the same amount. From April 1, 2022, the Indian government imposed a 40% basic customs duty (BCD) on imported solar modules and a 25% BCD on imported solar cells.

8.2.10. New Solar Power Scheme for Vulnerable Tribal (PM JANMAN)

Government announces INR 515 Cr solar power scheme for electrification of 100,000 un-electrified households in tribal areas by providing off-grid solar solutions free of cost

8.3 Govt. launched the PLI scheme structured in multiple tranches in March 2020, to boost domestic solar manufacturing capability in India

PLI scheme launched in March 2020, to scale up domestic solar manufacturing capability, reduce dependence on imports and generate employment. Under the PLI scheme, companies receive financial rewards for manufacturing in India, based on a percentage of their revenue over up to five years. This scheme has a provision for Production Linked Incentive (PLI) to the selected solar PV module manufacturers for five years post commissioning, on the manufacture and sale of high-efficiency solar PV modules. The scheme is being implemented in two tranches.

Winners of Tranche I: The first tranche of the PLI Scheme for PV Modules was launched in April 2021, with a budget of INR 4,500Cr. In November and December 2021, Indian Renewable Energy Development Agency (IREDA) concluded PLI tranche-I to award INR 4,500Cr to SSE (Shirdi Sai Electricals), Reliance New Energy Solar and Adani Infrastructure for an ~8.7 GW integrated capacity.

Winners of Tranche II: The second tranche of the PLI scheme, focused on setting up manufacturing capacities for high-efficiency solar PV modules in India. The total outlay for Tranche II was INR 19,500Cr. The bidding for PLI Tranche II was concluded in February 2023. As per the results, Letters of Award (LoAs) were issued to 11 bidders for setting up 39.6GW of fully / partially integrated solar PV module manufacturing. Shirdi Sai Electricals, through its subsidiary Indosol Solar, secured the highest PLI amount of INR 3,300 Cr for an integrated polysilicon to module manufacturing capacity of 6GW. Other prominent winners include Reliance (6GW), Waaree (6GW), ReNew (4.8GW), Vikram Solar (2.4GW) and Tata Power Solar (4GW).

The scheme has been a tremendous success in boosting solar manufacturing output and thereby, reducing import. There is significant scope for this to rise given the surge in PLI-related investment, which rose from US$ 1.1B in FY22 to US$ 5.5B in FY23. PLI-related investment could peak at US$ 20B in FY26, accounting for 40% of total investment.

Summary	Tranche I	Tranche II
Total PLI allocated (INR Cr)	4,455	13,938
Total Manufacturing Capacity allocated (GW)	8.7	39.6

Source(s): Ministry of New and Renewable Energy (MNRE)

Tranche II - Basket 1 (P+W+C+M)		
Name of Company	**Manufacturing capacity to be installed (GW)**	**Cumulative PLI (INR Cr)**
Indosol Solar Private	6.0	3,300
Reliance New Energy Solar	6.0	3,098
FS India Solar Ventures	3.4	1,178
Total	**15.4**	**7,576**

Note(s): P = Polysilicon, W = Wafer, C = Cell, M = Module
Source(s): Ministry of New and Renewable Energy (MNRE)

Tranche II - Basket 2 (W+C+M)		
Name of Company	Manufacturing capacity to be installed (GW)	Cumulative PLI (INR Cr)
Waaree Energies	6.0	1,923
Avaada Ventures	3.0	962
ReNew Solar	4.8	1,539
JSW Renewable Technologies	1.0	321
Grew Energy	2.0	567
Total	**16.8**	**5,311**

Note(s): W = Wafer, C = Cell, M = Module
Source(s): Ministry of New and Renewable Energy (MNRE)

Tranche II - Basket 3 (C+M)		
Name of Company	Manufacturing capacity to be installed (GW)	Cumulative PLI (INR Cr)
Vikram Solar	2.4	529
AMPIN Solar One	1.0	140
TP Solar	4.0	383
Total	**7.4**	**1,051**

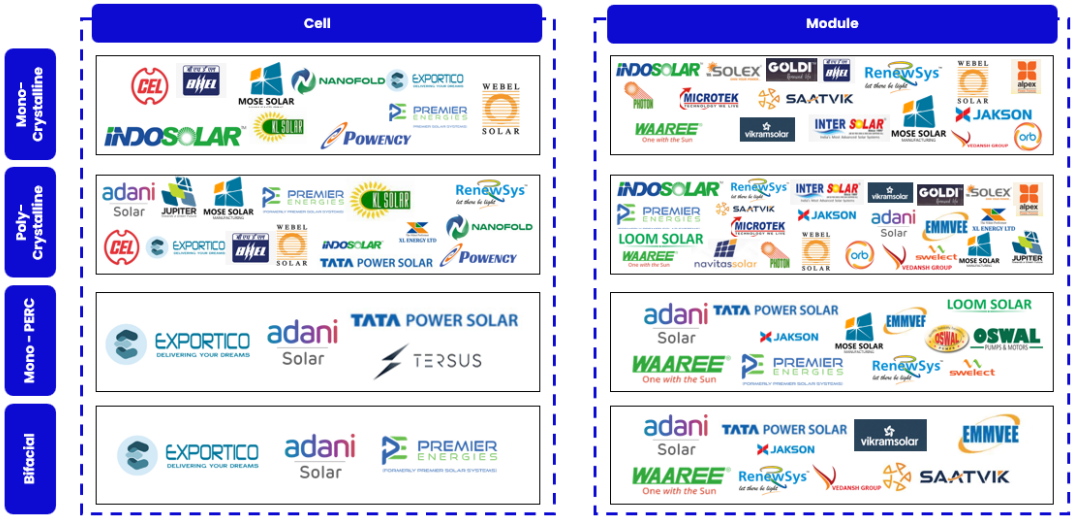
Note(s): C = Cell, M = Module
Source(s): Ministry of New and Renewable Energy (MNRE)

8.31. Challenges in backward integration due to a lack of technological know-how and large capital expenditure

The value chain for solar module production involves several key processes. Module manufacturing complexity grows as we move upstream to components like ingots and wafers. The process involves high-grade, sophisticated technologies demanding substantial capital investment. Consequently, many solar manufacturing companies in the country focus solely on module manufacturing rather than solar cells. This trend is reflected in India's manufacturing capacities: as of CY23, the cumulative solar module manufacturing capacity stood at 64.5GW, significantly surpassing the solar cell capacity of 5.8GW.

This disparity is primarily due to India's current inability to achieve economies of scale and justify the high capital demands associated with the complex and ever-evolving technology required for manufacturing solar cells, as well as upstream components like ingots and wafers. Consequently, there are more companies engaged in module manufacturing across various technologies compared to those involved in cell production. Hence, achieving full backward integration poses a challenge for the country due to its inability to execute the initial processes of the value chain.

In India, more companies manufacture modules as compared to solar cells:



8.4 Solar cell and module imports in India spiked by 3x in FY24 despite growing domestic manufacturing capability

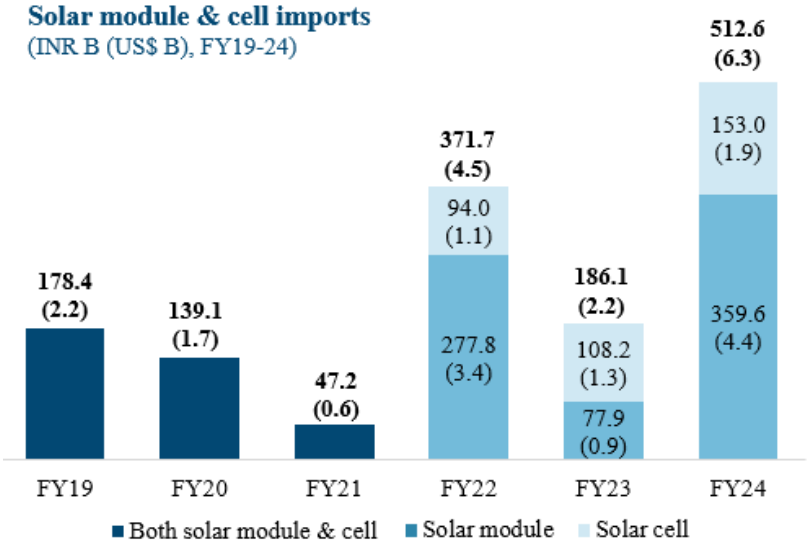
India added 20.8 GW of solar module manufacturing capacity in CY23. With this addition India's cumulative solar module manufacturing capacity reached 64.5GW. Gujarat led the country's module manufacturing capacity among the states, accounting for 46.1% of the total. Rajasthan and Tamil Nadu accounts for 9.3% and 7.6%, respectively. As for solar cells, India added 3.2 GW of capacity in CY23 taking the total solar cell manufacturing capacity to 5.8GW. This surge in capacity addition during CY23 was due to increasing government support and rising demand.

Despite this addition, India still trails behind top solar manufacturing nations like China, which commands a major share of the global capacity. The limited solar module manufacturing capacity in India led to a surge in the import of solar modules to a record 16.2GW in CY23, marking a 57.2% increase from the previous year. The trend of increasing module imports continues, with imports totalling over 11 GW in Q1 CY24, marking the highest quarterly figure to date. According to the Ministry of Commerce's data, China accounted for 63% of solar module imports in India until January 2024.

As for solar cells, India is still heavily dependent on imports to meet its demand as the manufacturing capacity in India is limited and largely restricted to the last stage of manufacturing. Cell manufacturing requires the use of silicon wafers. Wafer manufacturing is a complex process and the infrastructure for their manufacturing requires significant capital investment. India currently lacks the resources and expertise to keep pace with the rapid technological advancements in this field leading to a low manufacturing capacity.

This lack of manufacturing capacity led to a surge in the import of solar cells to 15.6GW in CY23, marking a 169% increase from the previous year. According to the Ministry of Commerce's import and export data, China accounted for 53% of solar cell imports in India until January 2024. This was mainly because of their cost competitiveness, advanced manufacturing technology and availability of a complete solar supply chain. The lower cost of power supplied to the industry was another major factor boosting their manufacturing, as electricity accounts for more than 40% of production costs for polysilicon and almost 20% for ingots and wafers.

India's solar module imports recorded US$ 4.4B in FY24, which was ~30% up from US$ 3.4B in FY22. Solar cell import was at US$ 1.9B which was ~75% higher in value than US$ 1.1B in FY22.



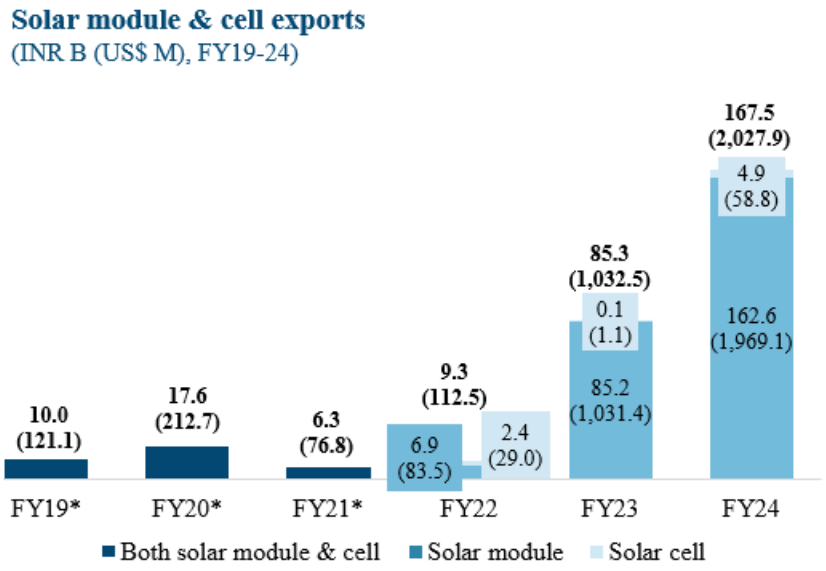
Note(s): *Only cumulative data on export of solar modules & cells is available, US$ 1 = INR 82.59
Source(s): Ministry of New and Renewable Energy (MNRE)

To curb this influx of cheaper imports, the government has been constantly making efforts and launched the PLI scheme to boost domestic manufacturing across the solar supply chain. It also introduced a 40% Basic Customs Duty (BCD) on the import of solar modules and 25% on solar cells, supporting domestic manufacturers and fostering price competitiveness while reducing dependency on imports.

8.5 China-US trade disputes present large export opportunities for India

Although China is the largest producer of solar modules globally, it confronts various obstacles such as trade disputes with the US and EU, escalating labour expenses, and environmental issues which have led to a decline in imports from the US. In CY23, the US imported a total of around 54GW of solar modules, with China contributing to only 563MW of the total. These hurdles are increasingly hampering Chinese solar module manufacturers' competitiveness on the global stage. Consequently, this situation presents an opening for Indian solar module producers to expand their market presence. India's solar module exports surged 91% to reach US$ 1.97B in FY24. The USA was the biggest destination with module shipments to the nation totalling US$1.94 B which was 98.5% of India's total solar module exports. This surge was largely attributed to the trade barriers imposed by the USA on Chinese solar modules. US Solar module market is estimated to be US$ 19B in CY23 and expected to grow to 38B in CY28 whereas Europe Solar module market is estimated to be US$ 20B in CY23 and expected to grow to US$ 37B in CY28

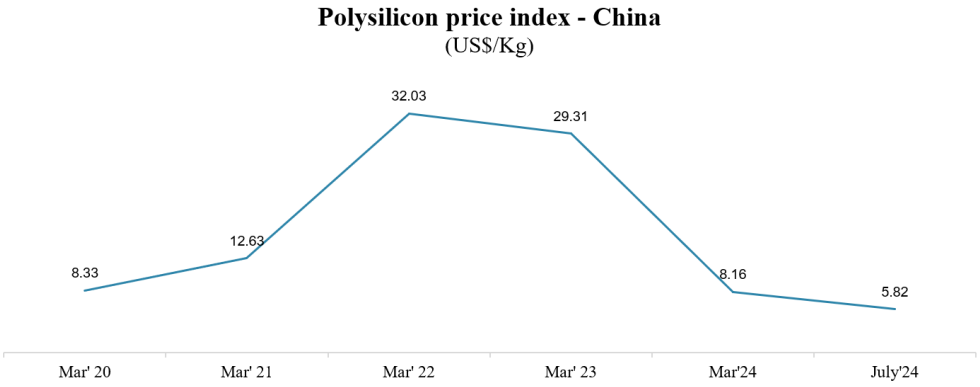
The US imported US$ 12.5B worth of solar products from South East Asia in CY23 with a majority of them being dumped at about half the price. Certain solar cells and modules from these countries circumvent the existing orders on solar cells and modules from China. This led to the initiation of the anti-dumping duty and countervailing duty investigations by the US on solar cells and modules imported from Cambodia, Malaysia, Thailand and Vietnam in April 2024 which has further expanded opportunities for Indian solar exports.



Note(s): *Only cumulative data on export of solar modules & cells is available, US$ 1 = INR 82.59
Source(s): Ministry of New and Renewable Energy (MNRE)

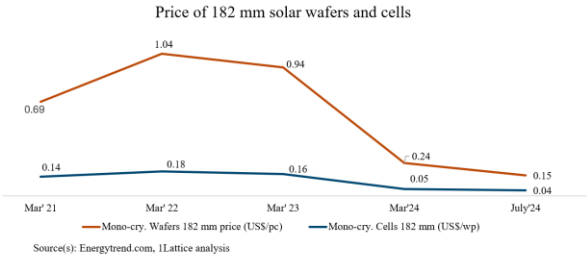
8.6 Prices of solar PV cells and other components reduced in FY24 on account of oversupply of polysilicon

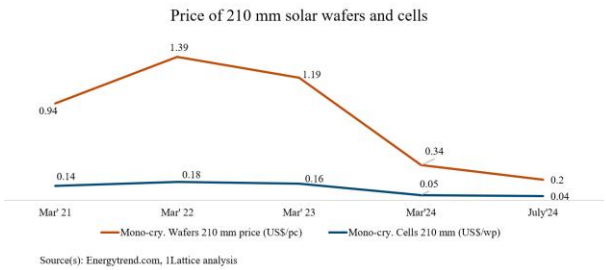
Module prices surged 22% in FY22 and 7% in FY23 but dropped 21% in the first five months of FY24 to US$ 0.19 per Wp, due to an oversupply of upstream components, especially polysilicon. In India too, domestic module prices fell from US$ 0.30 per Wp to US$ 0.25 per Wp, driven by India's reliance on imported cells.



Source(s): Businessanalytiq, 1Lattice analysis

Globally, the polysilicon base expanded by 68% year-on-year by the end of December 2022, reaching a range of a little over 1,000MT from the previous 600-650MT. In the first half of 2023, weakened demand and lower consumption in China, along with oversupply, led to a steep price decline from US$ 32 per kg in March '22 to US$ 9.6 per kg in July '23. Prices have continued the downward trend, touching US$ 8.2 per kg in March '24, down by ~70% from US$ 29.31 per kg in March '23. The price fell to US$ 5.82 per kg in July'24





Weakened demand and lower consumption in China in early 2023, coupled with oversupply, caused a dramatic price drop of 72%, from US$ 28 per kg in December 2022 to US$ 8 per kg in July 2023. Consequently, wafer prices also plummeted by 50-55%, from US$ 0.70 per piece to US$ 0.35 per piece. The polysilicon oversupply led the largest monocrystalline solar wafer supplier to cut photovoltaic wafer prices twice between April and May 2023, reducing prices by 33% as cell manufacturers aimed to meet order requirements. In July 2023, cell prices dropped 43% to US$ 0.09 per Wp from December 2022, while module prices fell 25%. Spot prices for bifacial mono PERC modules declined to US$ 0.18 per Wp in early August 2023 as suppliers cleared inventory. Weak European demand and accumulated Chinese inventory are expected to keep global module prices low this fiscal year.

8.7 Govt. launched Standards & Labelling Programme in October 2023 to ensure transparency in efficiency ratings across solar panels

The Indian Government introduced the "Standards & Labelling Programme" for solar panels in October 2023. The programme provides ratings from 1-5 stars based on the efficiency of modules. This initiative aims to assist citizens in making well-informed decisions when purchasing and installing solar panels, enabling them to better differentiate among different models of solar panels which at present look alike. The star labelling scheme, crafted by the Bureau of Energy Efficiency (BEE), has been in effect from January 1, 2024, to December 31, 2025, with no labelling fees during this period.

According to the Bureau of Energy Efficiency (BEE), implementing higher efficiency solar panels can result in an additional electricity generation of about 33 GWh (Gigawatt-hours) per year. This increased generation capacity means that more renewable energy is fed into the grid, reducing the need for power from carbon-intensive sources. Consequently, this performance improvement is expected to offset 27,000 tonnes of carbon emissions annually, this aligns with the government's broader objective of increasing the proportion of renewable energy and decreasing the emission intensity of GDP by 45% by 2030.

Star level	Effective Efficiency η_{eff} (%)
1 Star ★	>=17% & <=18%
2 Star ★★	>18% & <=20%
3 Star ★★★	>20% & <=21%
4 Star ★★★★	>21% & <=22%
5 Star ★★★★★	>22%

8.8 Financing Models for Solar Projects

Solar energy projects come with high initial costs, including the purchase and installation of solar panels, inverters, mounting systems, and other necessary equipment. Securing the right financing solutions is vital to manage these upfront expenses and ensure the financial sustainability of these projects. There are various financing options available, such as loans, power purchase agreements, and innovative funding models, to support the development of solar energy infrastructure.

The solar sector provides innovative investment opportunities through three financing models:

i) Capital Expenditure (CAPEX)

In this model, the solar installer sets up a solar power plant at the consumer's location, with the consumer covering all upfront and maintenance costs. The cost of a solar plant and the cost of electricity are the lowest in this model when switching to solar. It avoids long-term interest payments, offers high ROI, and benefits from GST, depreciation, and state subsidies. The payback period under this model is less than four years. Consumers enjoy a low-levelized cost of energy (LCOE) under the CAPEX model.

ii) Operational Expenditure (OPEX)

This model allows consumers to install a solar plant without purchasing it. The solar installer owns and maintains the plant, and the consumer signs a Power Purchase Agreement (PPA) to buy the electricity at a fixed tariff for 10-25 years depending upon the contract. The solar developer will be the solar plant's owner for its lifetime and is responsible for the operation and maintenance of the plant throughout, eliminating the consumer's upfront capital expense. Drawbacks include no tax depreciation, no GST input credit benefits, and a higher levelized cost of energy (LCOE). Installers typically offer the OPEX model for medium to large-scale projects to ensure project viability.

iii) Deferred Payment Agreement (DPA)

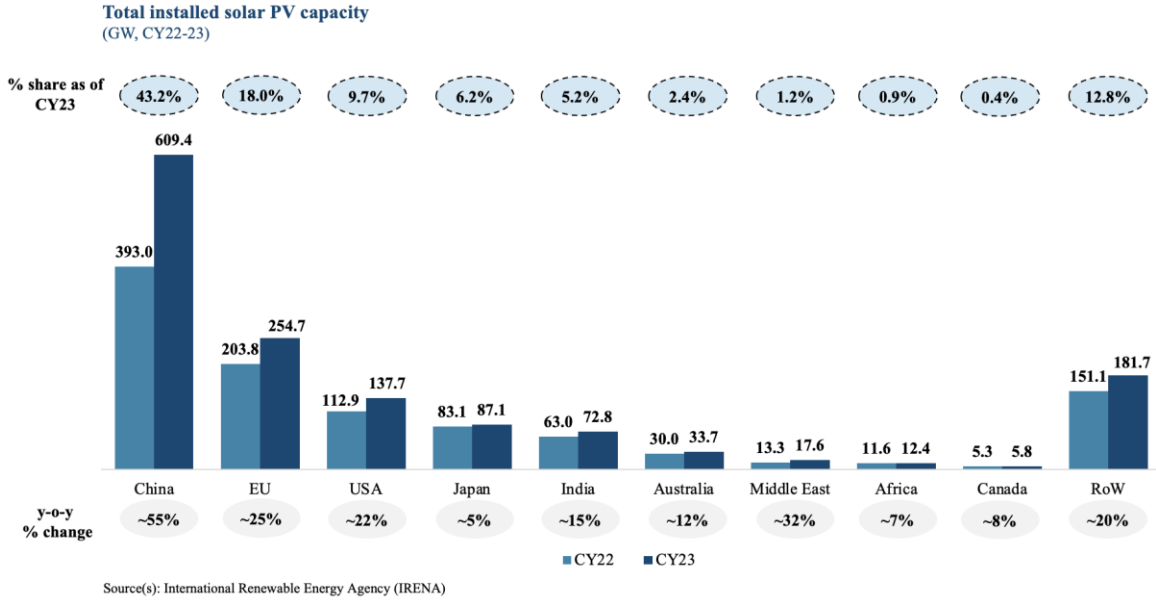
This model enables a business to defer the capital cost of the system over a period of time, providing flexibility and allowing for easy instalment payments over 3-5 years. With a minimum payment of 25-30%, businesses can enjoy all the benefits, such as reduced electricity expenditures and accelerated depreciation. By splitting the cost over a few years, the monthly instalments under DPA attract a minimum interest rate.

8.9 Overview of Global Solar PV Market

The global photovoltaic (PV) solar market has experienced significant growth over the past year, installing 345.5 GW of solar capacity worldwide in CY23, a ~32% increase compared to CY22. This growth is driven by various factors such as rising demand for cost-effective electricity, increased investments in solar energy, and proactive government initiatives.

8.9.1 China dominates the global solar PV market with ~45% share of total installed solar PV capacity followed by EU and US

In CY23, China's solar power capacity soared by 55% to reach 609.5GW, continuing to dominate the solar PV market, accounting for ~45% of the global installed capacity The total EU solar fleet now amounts to 256.5GW, up ~25% from the 205.6GW in CY22 and controls about ~20% of the total solar PV installed capacity. USA is third in line, accounting for ~11% of the global PV installed capacity while India currently stands at ~5%.



Source(s): International Renewable Energy Agency (IRENA)

8.9.2 Overview of Global Solar PV Manufacturers

In recent years, the global solar manufacturing industry has experienced substantial growth, driven by increasing awareness and demand for renewable energy sources in response to growing environmental concerns. Across the solar PV manufacturing sector, there is a diverse array of companies involved in different stages of the supply chain, spanning from the production of raw materials like silicon ingots and wafers to the assembly of finished solar modules. While China has traditionally held a dominant position as the world's largest solar PV manufacturer with a capacity of 609.5GW as of CY23, other countries including the United States, India, and various European nations have also emerged with significant manufacturing capabilities.

Prominent companies like Jinko Solar, Trina Solar, and Longi Solar from China, along with Canadian Solar based in Canada, exert significant influence in the global PV manufacturing market, operating manufacturing units worldwide. They have established integrated manufacturing facilities, enabling them to maintain control over the entire value chain. Indian players like Waaree Energies have also established themselves in the industry by setting up module manufacturing units but are yet to achieve complete backward integration.

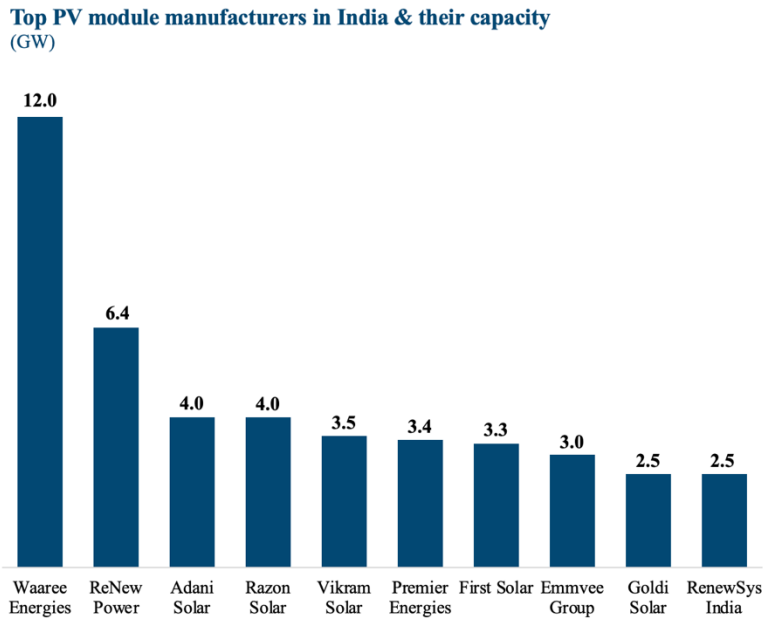
Comparative study of a few major global solar PV manufacturers:

Parameter		Jinko Solar	Trina Solar	Longi Solar	Canadian Solar	Waaree Energies
Number of manufacturing units		14	17	9	26+	4
Location of manufacturing units		• China • Malaysia • Vietnam • USA	• China • Vietnam • Indonesia, • Brazil • Thailand • UAE • USA • Spain	• China • Malaysia • Vietnam	• Canada • China • Brazil • Vietnam • USA • Thailand	• India
Presence in countries & regions		190+	170+	150+	30+	20+
Operational capacity (CY23)	Silicon wafer	75GW	55GW	170GW	21GW	NA*
	Cells	75GW	75GW	80GW	50GW	NA*
	Modules	90GW	95GW	120GW	57GW	12GW
Target capacity (CY24)	Silicon wafers	120GW	60GW	200GW (CY26)	50GW	Modules - 20GW (FY25) - including integrated 6GW ingot-wafer, cell & module manufacturing capacity
	Cells	110GW	105GW	100GW (CY26)	55.7GW	
	Modules	130GW	120GW	150GW (CY26)	61GW	
Key products & services		• Solar PV wafers, cells & modules for C&I, utility & rooftop use • Storage solutions • EPCM services	• Solar PV wafers, cells & modules for C&I, utility & rooftop use • Solar trackers • Storage solutions • EPCM services	• Solar PV wafers, cells & modules for C&I, utility & rooftop use • Storage solutions • EPCM services	• Solar PV wafers, cells & modules for C&I, utility & rooftop use • Inverters • Storage solutions • EPCM services	• Solar PV cells & modules for C&I, utility & rooftop use • Inverters • EPCM services

Note: * NA– Not Applicable
Source(s): Company websites & annual reports

8.9.3 Overview of domestic PV Module manufacturing competition

Over the past few years, India has seen a significant rise in the solar manufacturing sector. Supported by pro-solar government initiatives such as the PLI scheme, the imposition of BCD on solar imports and the rising demand for renewable energy sources, a large number of domestic players have stepped into this sector. Several companies were seen establishing large-scale solar module manufacturing units in India. Some of the top solar module manufacturing companies in India with their module manufacturing capacity are:



Source(s): Company annual report, 1Lattice analysis

8.9.4 Key drivers and challenges to the global PV market

The global PV market, driven by technological innovation and environmental imperatives, is pivotal in the renewable energy revolution. Understanding its key drivers and restraints is essential for navigating its evolution towards a cleaner, more sustainable future:

(a) Key drivers

i) **Rising demand for electricity:** Power consumption in the Asia Pacific and other regions has surged due to robust economic growth, population increase, and a booming manufacturing sector. Industrialization, urbanization, and rising living standards are driving electricity demand. Many countries are expanding existing power plants or installing new ones. This escalating demand presents a significant opportunity for the solar PV market, as solar energy is a clean, renewable and cost-effective solution.

ii) **Prevalence of off-grid areas:** Off-grid areas have limited or no access to grid-connected electricity and rely on photovoltaic sources like solar energy. Over 1B people worldwide live without electricity, with significant off-grid regions. In Sub-Saharan Africa, urban electrification is at 60% and rural at 14%, prompting Sub-Saharan governments to use solar energy to meet power needs in urban and rural areas.

iii) **Rising investment in solar energy:** Stringent global environmental regulations are driving power companies to adopt cleaner energy sources. Solar leads this transition, with significant investments in renewables totalling over US$ 1.7T in CY23. Notably, the U.S. witnessed a 75% increase in solar investment to US$ 25.5B. Record investments were seen in Germany, Poland, and the Netherlands, driven by Europe's energy crisis post Russia's attack on Ukraine. The Indian government has also introduced a Production Linked Incentive (PLI) Scheme, investing INR 24,000 Cr in high-efficiency solar PV cells and modules to enhance domestic manufacturing, reduce import reliance, and foster employment.

iv) **Increasing initiatives/schemes of governments:** Governments worldwide are consistently formulating policies to facilitate easy grid connections for photovoltaic (PV) projects. Nations like China, India, US, Canada, and France are actively advocating for adoption of solar energy. For instance, launched in February 2024, Muft Bijli Yojana is a government scheme that aims to provide free electricity to households in India. Under the scheme, households will be provided with a subsidy to install solar panels on their roofs. The subsidy will cover up to 40% of the cost of the solar panels

v) **Rising demand in the residential sector**: The residential sector stands out as a significant application area and early adopter of PV systems and products. There's notable demand for PV products from homeowners, with a substantial increase in residential solar rooftop installations globally. Increasing

costs of fossil-based energy sources, coupled with the declining costs of solar PV panels, position them as a preferred alternative for homeowners seeking energy-efficient solutions.

vi) **Rising export demand due to the imposition of anti-dumping duty by the US on certain Southeast Asian (SEA) countries:** The US's initiation of imposition of anti-dumping and countervailing duty on imports of certain solar cells and modules from SEA countries which include Cambodia, Malaysia, Thailand and Vietnam post similar impositions on China, has led to the increase in opportunity for Indian exports. This imposition was initiated because SEA which accounted for imports of US$ 12.5B worth of solar products in the US in CY23 was because solar products from these countries were being sold for less than normal value (i.e., dumped) and unfairly subsidized.

vii) **Declining Levelized Cost of Electricity (LOCE) of solar leading to grid parity:** The declining Levelized Cost of Electricity (LCOE) of solar photovoltaic (PV) systems has led to an increase in solar adoption across the globe. This decline is attributed to significant cost reductions over time, driven by economies of scale achieved through industry growth, technological advancements improving solar cell efficiency and manufacturing processes, and supportive policies such as tax incentives and renewable energy targets. Additionally, the decreasing LCOE has also turned the distant dream of grid parity into reality, with solar electricity costs matching or even going lower than those of traditional grid electricity. This has led to, solar PV systems offering reduced payback periods and long-term cost savings, making them appealing investments for consumers, including homeowners, those in commercial zones, remote areas and developing countries.

(b) Challenges

i) **Land use constraints:** Utility-scale solar projects require significant land for power generation, but selecting suitable land can be challenging due to environmental and technical factors. Utilizing land for solar systems can impact natural areas and biodiversity, making deployment difficult in wetlands, agricultural land, water bodies, and forests due to land instability and inaccessibility. Large-scale solar plants must consider factors like land availability, transportation networks, proximity to residential areas, and grid access.

ii) **Dependence on weather conditions:** The reliance of photovoltaic modules on weather patterns presents a notable limitation for the market. Adverse weather events like hailstorms or strong winds can cause damage to the modules, leading to decreased productivity.

iii) **Lack of skilled workforce for PV installation and maintenance:** PV installation demands a diverse range of skilled workers. There's a shortage of trained installers, posing a significant challenge. Consumers seek recognized standards, quality assurance, and skills certification throughout the development phase. Safety concerns, including fatalities during installations, are addressed by various national safety regulations. Despite these measures, consumers often lack awareness of PV products and their benefits, hindering market growth.

Key Challenges and risks faced by Oswal Pumps

Oswal Pumps has backward-integrated manufacturing capabilities which provide significant advantages like better supply chain control and cost efficiencies but there are a few challenges that the company faces which might impact its operational efficiency.

Some of the key challenges faced by the company are-

1. **Fluctuating input costs-** Fluctuations in prices of raw materials like stainless steel, copper, photovoltaic, aluminium, etc. can be highly volatile due to global trade policies and unfavourable economic conditions.
2. **Lower adoption of solar pumps and rooftop solar by the customers-** Solar pumps have high upfront costs compared to grid-connected pumps. It requires investment in pumps, solar panels and controllers and have to bear installation costs, making it less attractive for the customers.
3. **Requirement of high working capital-** As Oswal Pumps continues to produce and supply pumps to the government, it incurs costs upfront, including raw materials, manufacturing, and distribution expenses. Any delay in subsidy payments by the government under the PM-KUSUM scheme can affect the company's liquidity / working capital.

4. **Skilled workforce-** Oswal Pumps, being an EPC player, requires a skilled workforce to maintain high-quality manufacturing standards. The workers require specific technical skills and experience and a shortage of qualified workers can lead to production inefficiencies and potential quality control issues.
5. **Increasing competition-** With more companies expanding their operations with launch of solar pumps and through backward and forward integration, Oswal Pumps might faces heightened competition.

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