CRISIL
An S&P Global Company

Photovoltaic manufacturing and solar energy market

Final Report for Vikram Solar Limited

CRISIL Research

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1 Overview of the Indian macroeconomic landscape

1.1 Review of India's economy

India is the sixth-largest economy in the world, with gross domestic product (GDP) of Rs 135 trillion in fiscal 2021, as per estimates of the National Statistical Office (NSO).

Its GDP shrank 7.3% in fiscal 2021, buffeted by the Covid-19 waves in the first half of the year. With the pandemic having abated, the economy is set to grow 9.2% this fiscal on this low base. It turned positive in the second half of the year, with fourth quarter GDP estimated to have posted a mild 1.6% uptick. However, the fierce second wave in the first quarter of this fiscal challenged the economy. While the lockdowns were localised across the states, the pandemic took a toll on growth recovery curves.

GDP growth for the first quarter of this fiscal came in at 20.1%, a tad better than expectation. Consumer inflation dropped to a lower-than-expected print of 5.3% in August, while industrial growth was quite strong in July as well August 2021. Exports cruised along with global demand, leading to a positive spillover effect on industrial activity. Goods and Services Tax (GST) collections have been healthy and both the Central and state governments are doing well on public investments front.

1.2 Raising the long-term potential

Domestic economic growth hinges on revival in private consumption, lowering of banks' NPAs, improvement in the investment climate, and many more such factors. The central government has taken the following steps in this regard: The steps taken by the Reserve Bank of India ("RBI") in this regard include: (a) post-pandemic policies to revive the economy; (b) monetary policy (RBI's Monetary Policy Committee kept its policy rates and accommodative stance unchanged in its meeting in September 2021); (c) passage of key bills; and (d) Atmanirbhar Bharat Abhiyan. Under Atmanirbhar Bharat Abhiyan, the government has adopted several measures to contain the economic fallout of the pandemic. A relief package of nearly Rs.20.9 trillion has been released, taking into account key sections of the economy such as migrant labourers, small vendors, farmers and micro, small and medium enterprises ("MSMEs"). The scheme focuses on helping India to recover from the Covid-pandemic while making it more self-reliant.

Atmanirbhar Bharat Abhiyan is focused on multiple sectors in the economy, including the renewable energy space and the key schemes introduced herein are as follows:

- Production-linked Incentive ("PLI") scheme 'National Programme on High Efficiency Solar PV Modules', where the financial outlay has been increased from Rs.45 billion to Rs.240 billion (as announced in Union Budget 2022)
- Phase – II of Grid Connected Rooftop Solar Programme for achieving 40 gigawatts ("GW") capacity from rooftop solar by 2022
- Public Procurement (Preference to Make in India) to provide for purchase preference (linked with local content) with respect to the power sector (September 2020, July 2020, March 2020).
- Implementation of the Pradhan Mantri Kisan Urja Suraksha Evem Utthan Mahabhiyan ("PM KUSUM") scheme; Ministry of New and Renewable energy ("MNRE"), in November 2020, scaled up and expanded the PM KUSUM scheme to add 30.8 GW by 2022 with central financial support of Rs.340.35 billion

- Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019
- List of Manufacturers and Models of Solar PV Modules Recommended under the Approved List of Models and Manufacturers ("ALMM") Order periodically
- Scheme of grid connected wind-solar hybrid power projects
- Safeguard duty ("SGD") on solar cells and modules (till July 21)
- Basic customs duty ("BCD") of 25% on solar cells and 40% on modules, respectively, effective April 1, 2022

Amid these reforms, India's economic growth is currently recovering and is expected to pick up, since four drivers – people learning to live with the new normal, flattening of the Covid-19 affliction curve, rollout of vaccinations, and investment-focused government spending – are converging.

2 Renewable market executive summary

2.1 Economic and power market overview in brief

Going forward, conventional sources are expected to witness limited additions of ~29 GW over fiscals 2022-26, limited by a focus on adding clean energy; funding constraints for conventional power plants, especially private ones; and a focus primarily on completion of previously announced projects. On the other hand, renewable capacity additions are likely to increase further to 80-85 GW over the period, largely owing to the environment-driven shift towards renewable generation, government support through favourable policies and a mandate for renewable power offtake, growing participation from centrally owned power generating agencies in addition to existing private entities, and strong funding support from domestic as well as foreign investors and financial institutions

2.2 Overview of the solar energy market – global and India

Global installed solar PV capacity has grown at 29% CAGR over calendar year 2011-20, led by government support to renewables in the form of clean energy penetration mandates, taxation and other incentives, subsidised tariffs set for renewables along with government-led renewable project allocations to drive additions in the segment. It further increased ~22% y-o-y to 710 GW in 2020.

Globally, ~126 GW of solar PV capacity was added in 2020, led by Asia alone which together added ~76 GW or 60.6% of total capacity during the year. In terms of cumulative installed capacity as of December 2020, China is the market leader with a total installed base of ~254 GW.

With increasing investor interest for the segment, the global drive towards clean energy supported by governments, the sustained trend of falling component costs over several years, and increasing private participation, bid tariffs for solar energy have been falling globally. There have been several drivers, mainly regulatory support and creation of policy frameworks to either incentivise solar project installations and /or lower costs for developers. This has been done by providing subsidised capital / infrastructure for setting up projects or providing additional revenue streams post operationalisation to developers.

3 Indian power sector

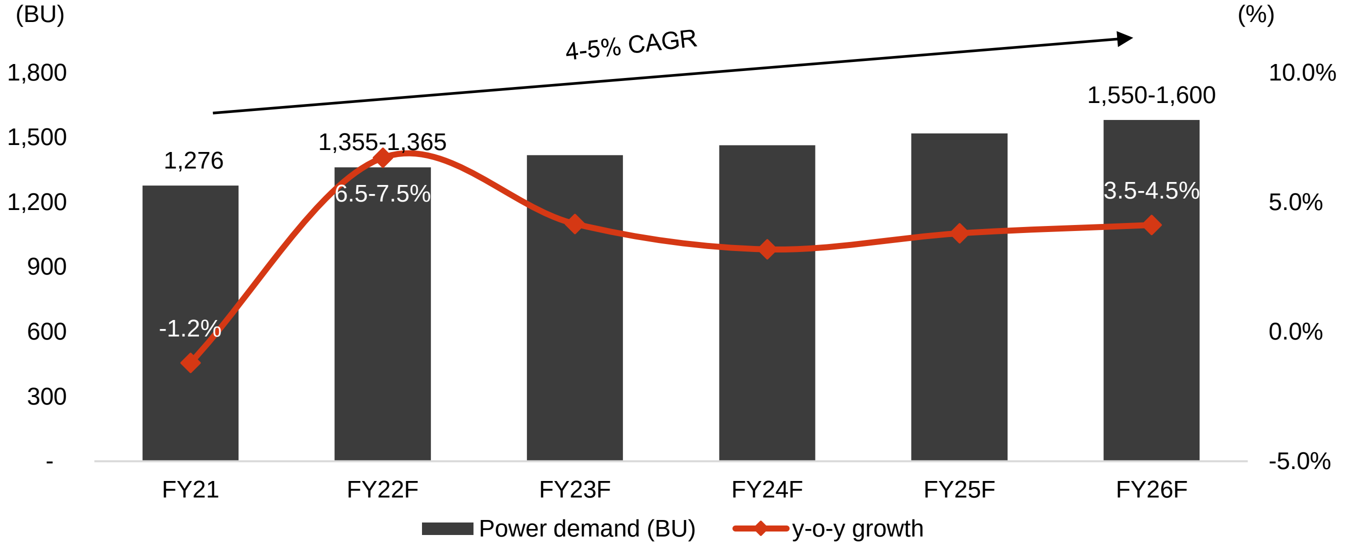
3.1 Domestic power sector vis-a-vis global scenario

The power industry, being a core sector, fulfils the energy requirement of several other industries and has a multiplier effect on the economy by being a key enabler in the functioning of large and small industries. Electricity generation in India is the third highest after China and the US, with 5.8% global share in CY2019. India's electricity generation increased from 1,262 billion units (BU) or terawatt-hours (TWh) in CY2014 to 1,559 BU at 4.3% CAGR, faster than global CAGR of 2.4%, even as China grew the fastest at 5.3% CAGR over the same period.

3.2 Power demand-supply scenario in India

Power demand is expected to register 4-5% CAGR between fiscals 2022 and 2026, supported by economic growth recovery, expansion in reach via strengthening of T&D infrastructure and improved power quality as illustrated below:

Figure 1: Outlook of base power demand



Source: CEA, CRISIL Research

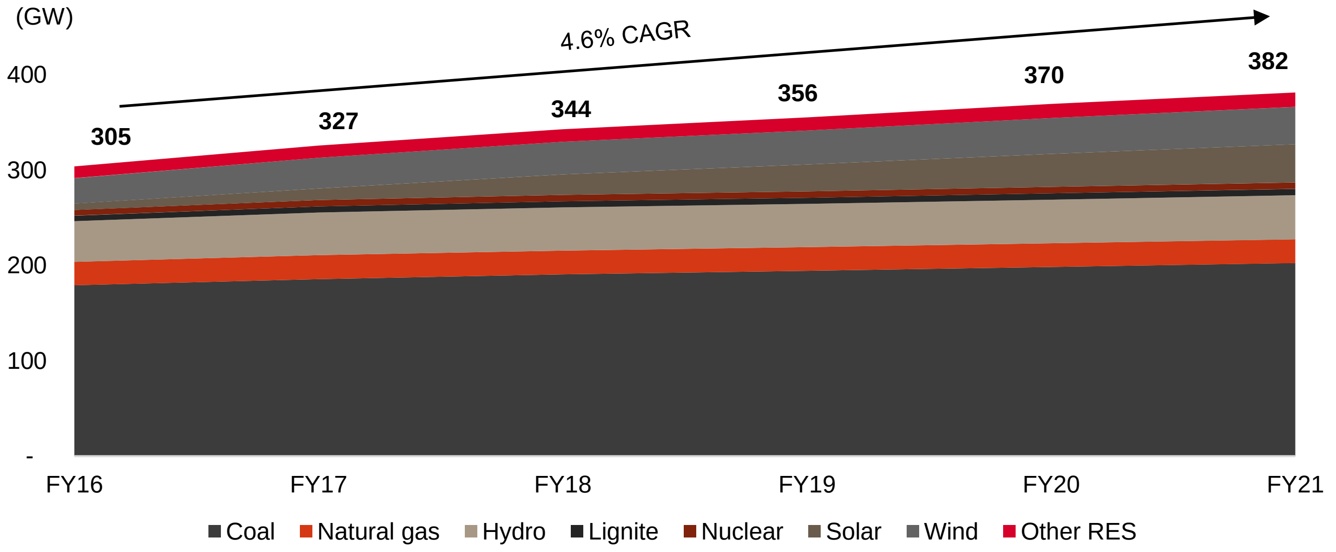
3.2.1 Conventional capacity additions make way for renewable sources

The total installed generation capacity at end-March 2021 was 382 GW, of which ~80 GW was added over fiscals 2017-2021 (net of ~12 GW retirals). Coal- and lignite-based installed power generation capacity has dominated over the years, accounting for 55% as of March 2021.

Renewable capacity (includes solar, wind, small hydro and other renewable sources) has nearly doubled from ~46 GW in fiscal 2016 to ~94 GW in fiscal 2021, with its share in overall installed capacity growing from ~15% to ~25% over the same period. The substantial rise in renewable capacity was led by solar capacity additions to the tune of ~33 GW on the back of strong private participation and competitive tariffs, along with steady government policy support through nodal agencies such as SECI and NTPC.

Major conventional gencos have been moving towards renewable energy capacities to address the uncertainty arising out of imminent phasing out of thermal power generation in the distant future. The graph below represents the breakup of installed power capacity for the periods indicated:

Figure 2: Review of installed power capacity



Source: CEA, CRISIL Research

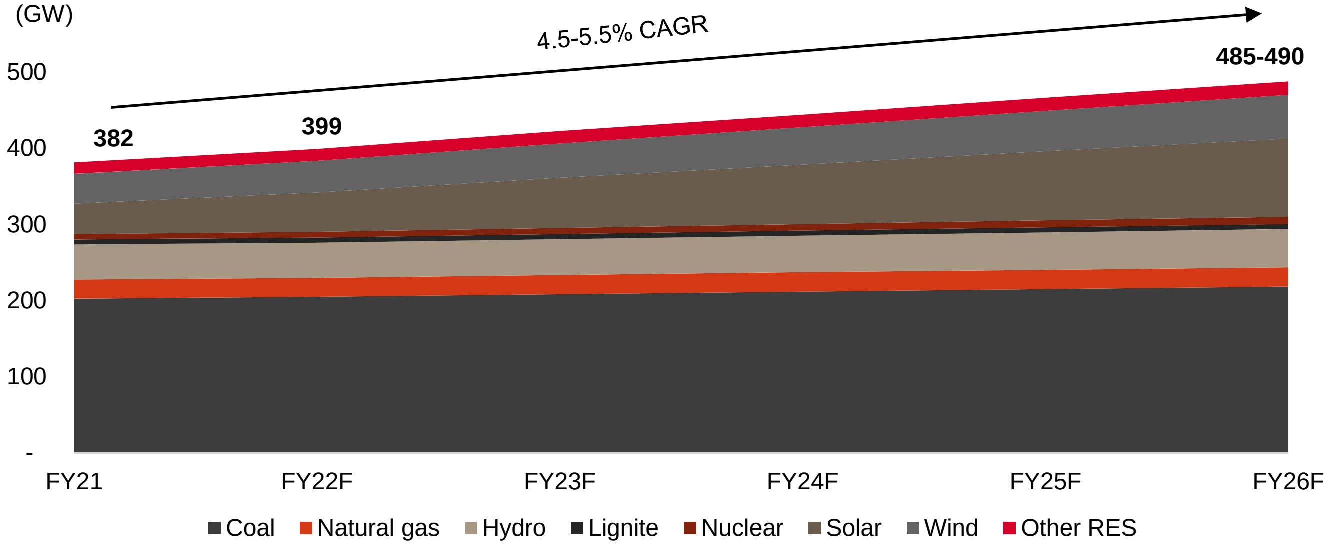
3.2.2 Renewable capacity additions to lead the way over next five years

Conventional capacity additions are expected to moderate further to ~29 GW over fiscals 2022-2026, driven by moderate growth in power demand (barring fiscal 2022 owing to lower base of fiscal 2021), focus on completion of previously announced projects, reduced need for additional capacity due to declining power deficit and delays in a few projects due to funding constraints. Moreover, bankers are also adopting a cautious approach given their high power sector exposure, apart from apprehension in funding conventional power capacities stemming from increased scrutiny of conventional energy investments by global investors.

On the other hand, renewable capacity additions are likely to expand further to ~83 GW over the same period, owing to environment-driven shift towards renewable generation, government support through favourable policies for domestic equipment manufacturing and renewable power offtake, growing participation from central gencos in addition to existing private entities, and strong funding support from domestic as well as foreign investors and financial institutions.

Consequently, the overall installed capacity is expected to reach 485-490 GW by fiscal 2026, largely driven by growth in solar capacity at 20-22% CAGR over fiscals 2022-2026, supported by wind capacity growth at 7-9% CAGR over the period. As a result, the share of solar capacity in overall installed capacity is expected to reach 20-22% by fiscal 2026, out of renewable capacity share of 35-37%, even as the share of conventional capacity is likely to fall from ~75% in fiscal 2021 to 63-65% in fiscal 2026. A graphical representation of the outlook of installed power capacity for from Fiscals 2021 to 2026 is presented below:

Figure 3: Outlook of installed power capacity



Source: CEA, CRISIL Research

3.2.3 Power generation to see healthy growth, renewables' share to rise

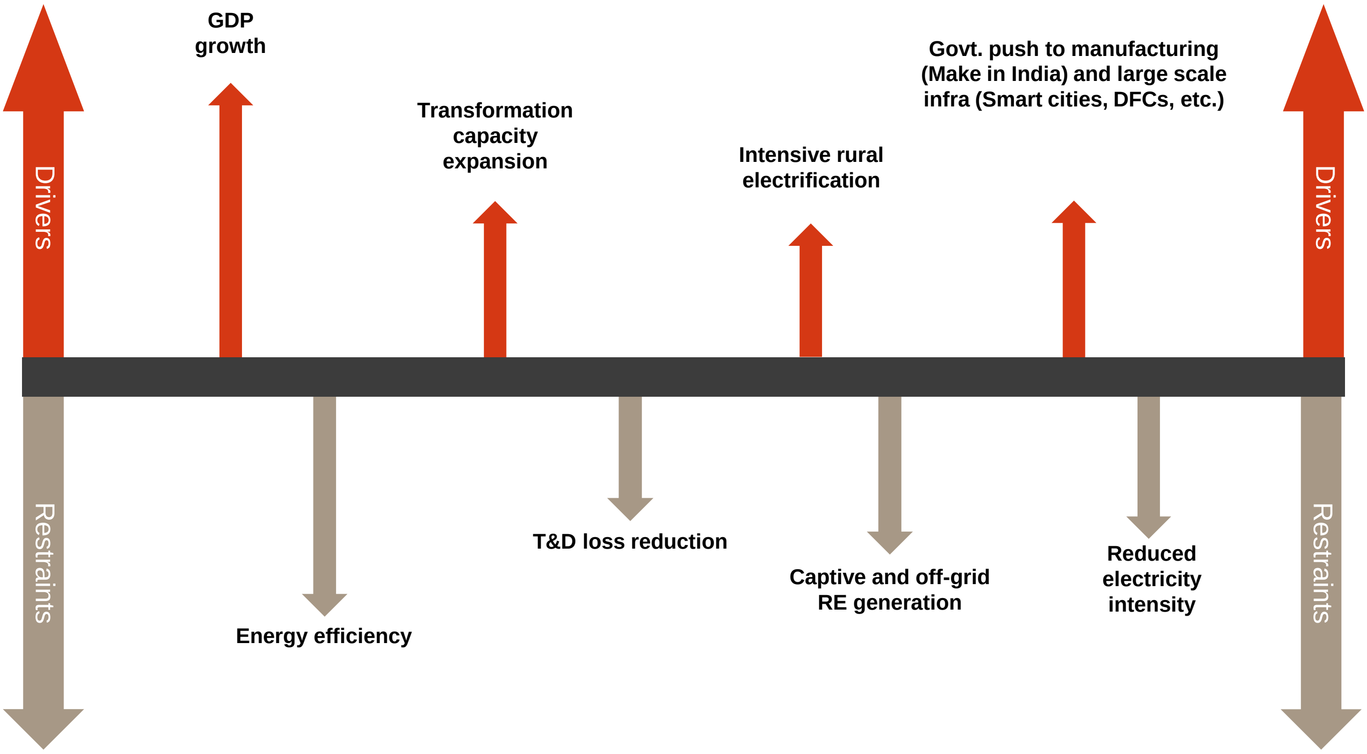
Over the next five years, generation is likely to increase at a healthy 4-5% CAGR in line with power demand, even as the generation mix undergoes a gradual shift.

3.3 Long-term drivers and constraints for demand growth

3.3.1 Economic growth and T&D infrastructure upgrade to drive power demand

CRISIL Research estimates energy requirement to grow at a CAGR of 4-5% over fiscals 2022-2026 on account of following factors.

Figure 4: Factors influencing power demand



Source: CRISIL Research

India's economy is expected to recover slowly post fiscal 2021, with a gradual pickup in industrial growth over the medium term. Trickle-down effect of the Aatmanirbhar Bharat relief package, government spending on infrastructure through the NIP, dedicated freight corridor (DFC) infrastructure, service industry expansion, rapid urbanisation, and increased farm income from agri-related reforms are key macroeconomic factors that will aid a pickup in growth.

Various government initiatives such as Make in India, Smart Cities Mission, DFC, metro rail projects, and railway track electrification, are expected to boost infrastructural development in the country, albeit in the medium-to-long term.

3.3.2 National Hydrogen Energy Mission announced to promote clean alternative fuel

In Union Budget 2021-22, the Central Government announced the National Hydrogen Energy Mission (NHM) envisaging the use of hydrogen as an energy source, leveraging its utility as a clean alternative fuel. The focus of the NHM is to generate hydrogen from renewable energy sources, helping India achieve its emission goals under the Paris Agreement while reducing the country's dependence on fossil fuels. Also, on 17th February 2022 power ministry has unveiled the green hydrogen policy. The key measures outlined under the policy are:

- The waiver of ISTS charges shall be granted for a period of 25 years to the producer of green hydrogen & green ammonia from projects commissioned before 30th June, 2025.
- Banking shall be permitted for 30 days for renewable energy used for making green hydrogen
- Renewable energy used for production shall be counted towards RPO compliance of consuming entity.

- Green hydrogen production facility can be co-located or remotely located & green hydrogen plants will be granted open access for sourcing of renewable energy within 15 days of application.
- MNRE will establish a single window clearance for all approvals required for setting up a manufacturing plant.
- To achieve competitive pricing, MNRE may aggregate the demand from different sector and have consolidated bids conducted for procurement of green hydrogen.

Further to these proposals, there would be a second round to the policy that would be announced shortly.

Further, The Ministry of New and Renewable Energy (MNRE) has been supporting a broad-based Research Development and Demonstration programme on hydrogen energy and fuel. Projects at industrial, academic, and research institutions are being supported to address the challenges of hydrogen production, which has resulted in the development and demonstration of internal combustion engines, two-wheelers, three-wheelers, and minibuses that run on hydrogen fuel. Two hydrogen refuelling stations have been established (one each at the Indian Oil R&D Centre, Faridabad, and the National Institute of Solar Energy, Gurugram). In order to encourage offtake of green hydrogen for energy consumption, the central government is planning to mandate the purchase of green hydrogen for certain industrial segments such as refineries, fertiliser manufacturers, etc, in line with the renewable purchase obligation (RPO) currently applicable for renewable sources such as solar, wind, and hydro.

Major players from the energy industry have also started dabbling in green hydrogen with projects aimed at generating and supplying cost-effective green hydrogen. In July 2021, the MNRE gave its go-ahead to NTPC to develop a 4.75 GW renewable energy park in the Rann of Kutch in Gujarat, which will also generate green hydrogen. NTPC Renewable Energy Ltd (NTPC REL), NTPC's wholly owned subsidiary, invited a domestic tender to set up India's first Green Hydrogen Fuelling Station in Leh, Ladakh, in the same month, as part of its plans to become the largest green hydrogen producer and provider in India, marking a strategic shift towards clean energy for India's largest thermal energy producer. Reliance New Energy Solar (RNESL), a wholly owned subsidiary of Reliance Industries Limited (RIL), a major fossil-fuel producer in India, has partnered with Stiesdal A/S, a Danish company, for licensed manufacturing of low-cost hydrogen electrolysers with the objective of reducing the price of green hydrogen.

Hydrogen produced from renewable energy sources is known as green hydrogen. Green hydrogen can be produced by electrolysis (splitting of water using an electrolyzer powered by renewable electricity such as wind and solar) or through conversion of biomass. Energy can be extracted from hydrogen through combustion or through fuel cells that emit only water as a by-product. Hydrogen provides a means for storage of variable renewable energy to stabilise its output. For long duration storage over several hours, converting excess available energy into hydrogen and utilising it for grid support and other applications is a suitable alternative. Fuel cell electric vehicles (FCEVs) run on hydrogen fuel and have no harmful emissions. BEVs could be suited for the light passenger vehicle segment for shorter driving ranges.

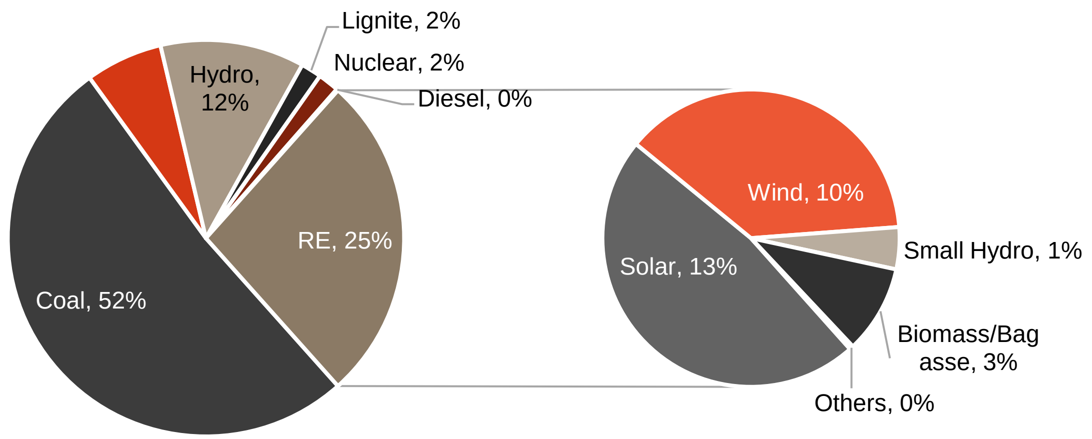
Following the launch of the National Hydrogen Mission by the government, several large private players have announced their plans to enter the segment. Reliance plans to bring down the cost of green hydrogen below $2 per kg within a decade by setting up an electrolyser giga-factory. Similarly, Adani group has set ambitious green hydrogen targets as part of its $70 billion investment plan in renewables, while IOC, one of India's largest fuel retailers, announced plans to manufacture green hydrogen at one of its refineries. As per estimates by the European Commission, 1 million tonne of hydrogen may require 5-10 GW of electrolyser capacity. Further, the International Energy Agency pegs the electricity so required for 1 tonne of hydrogen to be around 50-55 MWh. At a plant load factor of 22-23% (typical of solar power currently in India), this would imply around 25-30 GW of solar power consumption for 1 million tonne of green hydrogen production.

The aim is to develop India into a global hub for manufacturing hydrogen and fuel cell technologies across the value chain. However, considering the cost implications and low requirement, green hydrogen may currently have a limited role in the power sector, considering the segment is still nascent. However, in the long term, renewable energy sources will be very cost-effective. Therefore, RE sources should be used in the most efficient way possible to produce green hydrogen.

3.4 Renewable energy potential by source

The renewable energy capacity in India has logged a CAGR of 15.5% over fiscals 2016-2021, led by various central and state level incentives. The installed renewable energy generation capacity in India stood at ~94 GW as of fiscal 2021, which was ~25% of the total installed generation base in India. The following pie-chart shows the share of renewable energy in installed capacity in Fiscal 2021:

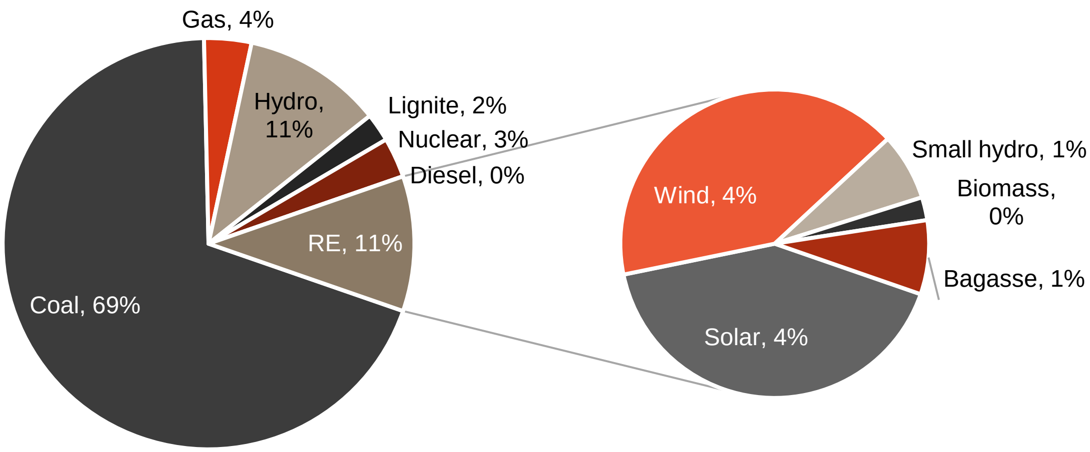
Figure 5: Share of renewable energy in installed capacity as of fiscal 2021



Source: CEA, CRISIL Research

However, total electricity generated from the installed renewable energy capacities (or renewable energy penetration in the grid) still remains low at ~11%, with solar and wind energy garnering the maximum share of ~4% each of the total energy supplied in the country in fiscal 2021. The following pie-chart shows the share of renewable energy in electricity generation in Fiscal 2021:

Figure 6: Share of renewable energy in electricity generation in fiscal 2021



Source: CEA, CRISIL Research

Despite such strong capacity additions, there is a huge potential for RE installations in India. From the table given below, it is evident that there is a huge potential for RE installation in India.

Table 1: Potential for RE installations in India

Technology	Potential	Cumulative capacity as on 31.01.2022
Wind	302 GW (100 m hub height) 696 GW (120 m hub height)	40.10 GW
Solar ground mounted	749 GW	42.4 GW
Solar Rooftop*#	210 GW	6.40 GW
Biomass + bagasse cogeneration	22.5 GW	10.17 GW
Small hydro (up to 25MW)	21.1 GW	4.83 GW
Waste to energy	NA	0.23 GW

Note: *The economically feasible market potential for rooftop solar PV in urban settlements of India; excludes off-grid/captive solar capacities
#Excludes estimates of ~1.0 GW of rooftop capacities for which subsidy is not provided by MNRE
Source: MNRE; NITI Aayog; CRISIL Research

However, among all commercially available renewable energy sources in India, solar energy potential is the highest. As per an assessment done by the National Institute of Solar Energy (NISE) and a report by the MNRE, the top five states with the highest solar PV potential are Rajasthan, Jammu & Kashmir, Maharashtra, Madhya Pradesh and Andhra Pradesh. While the MNRE has considered 3% of wasteland that can be used in a state for the installation of ground-mounted solar PV projects, it has also considered 2-25% of the rooftop space being utilised (1–100 kWp) across various buildings, such as offices, shops, hospital, and government buildings, for setting up rooftop solar PV projects.

4 Global solar energy market

4.1 Global shift in financing and policy to clean energy with a focus on emerging economies

4.1.1 Cause of shift towards renewables in investments and examples of such shifts in goals by global participants

Concern over climate change is at the heart of the energy shift towards renewable energy, with the essence of reducing greenhouse gases (GHG) from use of polluting fossil fuels. Utilisation of more and more renewable energy will be key for decarbonisation as it presents a way to generate power from cleaner sources (lower pollution impact) thus helps curb air pollution and health hazards apart from now even providing access to electricity at affordable rates.

Some of the key drivers for this shift are reducing renewable energy generation costs, favourable policies, improved emphasis on energy security and access, and socioeconomic benefits. Various initiatives such as the Kyoto Protocol, the Paris Agreement, COP 21 RE 100, ISA and subsequent favourable policy interventions have helped the renewable energy segment to flourish. The transition towards renewable energy is a critical part of meeting the goals of the Paris Agreement, which aims to limit the rise of global average temperatures to well below 2 degrees Celsius, and ideally below 1.5 degrees Celsius above pre-industrial levels. Countries which are parties to the Paris Agreement are required to submit their plans for climate action known as nationally determined contributions (NDCs). These NDCs represent the efforts needed to be taken by each country to reduce national emissions.

In line with these targets, various countries have provided a policy impetus to the solar PV industry, apart from other clean energy sources, through various mechanisms such as feed-in tariffs, must-run status, renewable purchase obligations, tax incentives, accelerated depreciation, regulatory framework, subsidies, production linked incentives, etc. This has accelerated the growth of the solar PV industry globally.

With abundant sunlight, untapped potential and declining tariffs, we believe that the solar PV industry will be a leading technology in overall growth of renewable energy going forward.

4.1.2 Key global initiatives towards clean energy

RE100

RE100 is a collaborative, global initiative of influential businesses committed to 100% renewable electricity, working to massively increase demand for, and delivery of, renewable energy. RE100 is led by the Climate Group in partnership with CDP, as part of the We Mean Business coalition.

Various progressive companies are opting for 100% renewable energy and are optimising the benefits of cost reduction and enhanced reputation. By doing so, they are also encouraging the global market to opt for renewable energy and helping reduce emissions.

2020 Progress and Insights Annual Report

As per the RE100, 2020 Progress and Insights Annual Report, corporate demand for renewable power is continuing to grow despite 2020’s challenges. But, it also shows that ambitious companies are being held back by limited availability, regulatory complexities, and the resulting higher costs in some markets. Governments need to do more.

4.1.3 The International Solar Alliance

The International Solar Alliance (ISA) was conceived as a coalition of solar-resource-rich countries (which lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn) to address their special energy needs. The ISA provides a dedicated platform for cooperation among solar-resource-rich countries, through which the global community, including governments, bilateral and multilateral organisations, corporates, industry, and other stakeholders, can contribute to help achieve the common goal of increasing the use and quality of solar energy in meeting the energy needs of prospective ISA member countries in a safe, convenient, affordable, equitable, and sustainable manner.

The ISA, launched by the Government of India and France, aims at mobilising $1,000 billion in funds by 2030. The alliance intends to make joint efforts through various policy measures, such as the international credit enhancement mechanism, which is expected to de-risk investments and reduce the cost of financing for solar projects. ISA member countries will finance solar projects in collaboration with the United Nations, the Green Climate Fund, multilateral development banks, investors, insurers, private financial institutions and other interested stakeholders.

ISA has been conceived as an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies to enhance energy security and sustainable development, and to improve access to energy in developing member countries. The ISA has 122 sun-belt countries that lie between the two tropics as its prospective member countries, and currently boasts a membership of 86 countries globally.

The ISA plays a four-fold role in establishing a global solar market: it is an accelerator, an enabler, an incubator, and a facilitator.

The fourth general assembly of the ISA was concluded recently in October 2021, wherein the assembly reiterated its targets of deploying 1,000 GW of solar capacity and mobilisation of $1,000 billion by 2030. It also launched two new programs – 'Management of solar PV panels and battery usage waste' and 'Solar Hydrogen Program'. The former aims to tackle waste generated from materials used in solar energy generation while the latter aims to enable the use of solar energy to improve affordability of green hydrogen.

4.1.4 COP 26

For nearly three decades, the UN has been bringing together nations for global climate summits called Conference of Parties (COPs). The 2021 United Nations Climate Change Conference, the 26th session (COP 26) to the United Nations Framework Convention for Climate Change (UNFCCC), was held in Glasgow in November 2021 and a draft agreement was circulated with respect to climate change action. The draft agreement calls on countries to phase out coal power and to reduce carbon emissions significantly by next year in order to reach a goal of limiting global warming this century to 1.5 degree Celsius. The draft recognises that limiting global warming to 1.5 degrees Celsius by CY 2100 requires rapid, deep and sustained reductions in global GHG emissions, including reducing global carbon dioxide emissions by 45% by 2030 relative to the 2010 level and to net-zero levels around mid-century. It also expresses alarm and concern that human activities have caused around 1.1 degrees Celsius of global warming to-date and that impacts are already being felt in every region. It also recognises that more finance is needed for developing countries beyond the long-promised $100 billion a year by 2020, which will not be delivered until at least 2022.

The proposal also aims at updating the time frame for revised targets NDCs to next year — much sooner than the requirement of every five years as laid out in the 2015 Paris Climate Accord.

Further, US and China, the world's two largest emitters of carbon dioxide, unveiled a deal to ramp up cooperation tackling climate change, including by cutting methane emissions, phasing out coal consumption and protecting forests. The joint declaration stated China would begin phasing out its coal consumption during 2026-2030 and would cut emissions of methane.

India has also set an ambitious goal at the CoP 26 summit. Addressing the UN's Climate Change Conference in Glasgow, on November 1, India's Prime Minister Narendra Modi announced a 2070 net-zero emissions target, revised the non-fossil based RE target to 500 GW from 450 GW by 2030 and pledged to reduce its carbon intensity by 45% within the decade. Also, the Ministry of Environment has stated that 50% of India's installed power generation capacity will likely be from renewable energy. The previous target of 450 GW renewable energy included 280 GW from solar energy which would mean an installation momentum of 25 GW/annum, equivalent to approximately 35 GW of dc solar capacity annually considering 40% dc overloading, over the next decade. In the near term, the government has set a target of achieving 175 GW of renewable energy by December 2022 in India, with major focus on solar energy (100GW by December 2022) and wind energy (60GW by December 2022). Other RE sources that include small hydro projects, biomass projects and other renewable technologies have to be ramped up to 15 GW by December 2022.

Hence, it is evident global focus on climate change policies has increased, which will likely drive renewable energy growth.

Figure 7: Renewable energy capacity addition target till fiscal 2022

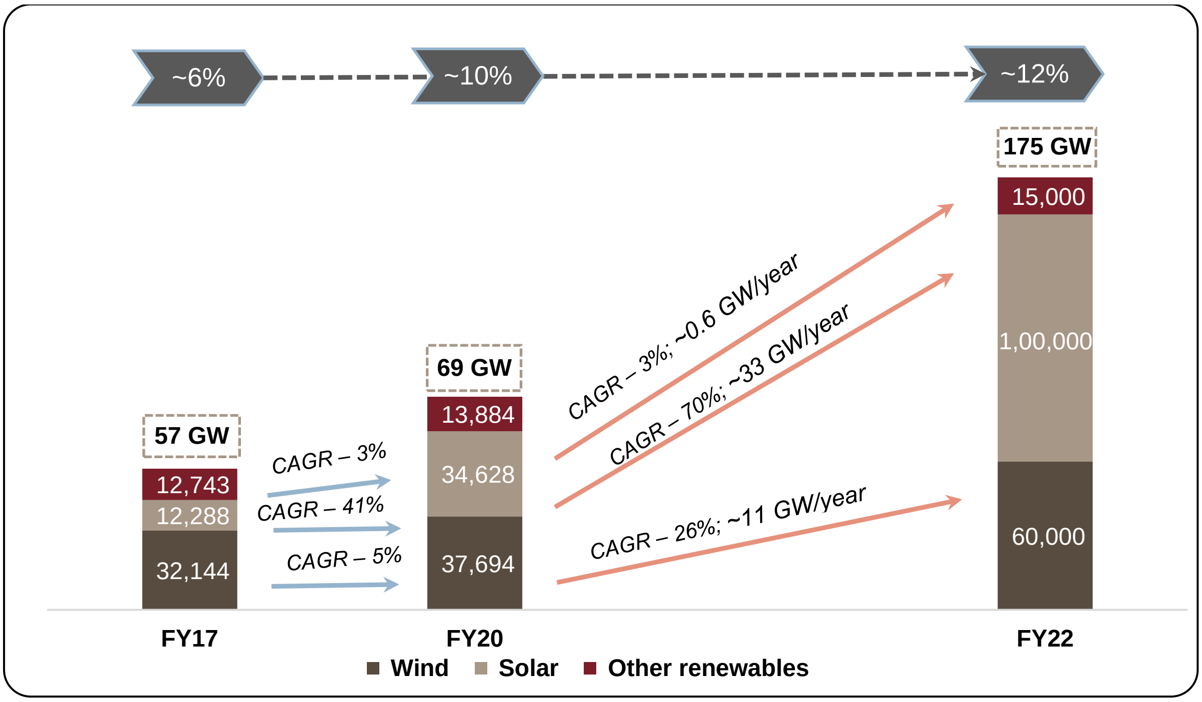
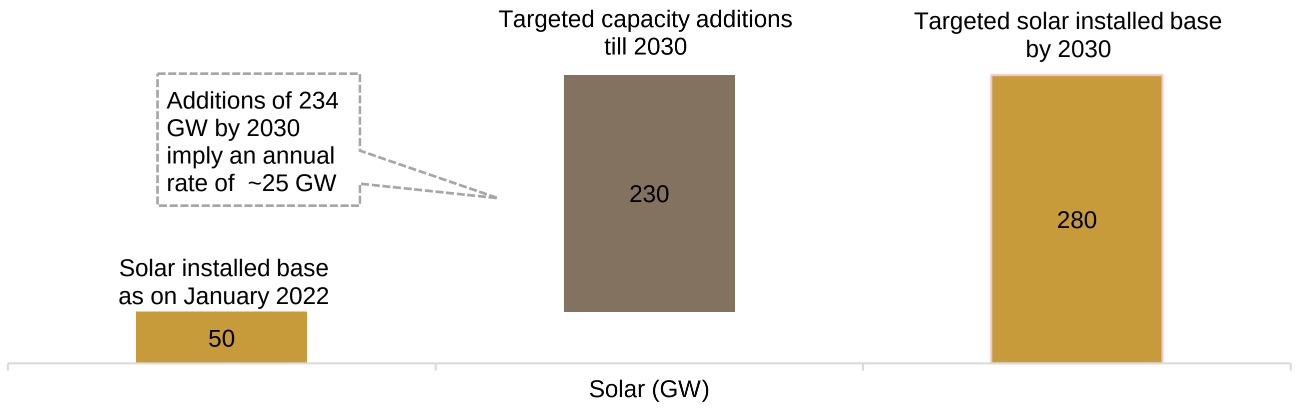


Figure 8: Government had announced a target of 280 GW of solar installed base by 2030



One Sun One World One Grid Initiative (OSOWOG)

Prime Minister Narendra Modi, while delivering his address at the COP 26 summit on 'Accelerating Clean Technology Innovation and Deployment', outlined the vision for an integrated grid enabling transfer of energy generation from solar power on a continuous basis across nations. This has been termed as the One Sun One World One Grid Initiative (OSOWOG), under which the interconnected transmission grids will enable the transfer of clean energy, especially solar energy, across nations and help reduce the carbon footprint from coal-based power generation.

The vision behind the OSOWOG is "the sun never sets" across the globe, which can be leveraged to provide clean energy round the clock. With India at the fulcrum, the regions are envisaged to be divided into two broad zones, viz. the Far East (including Myanmar, Vietnam, Thailand, Lao, Cambodia, etc) and Far West (Middle East and Africa region).

This would require coordinated action and synergising policies over 140 countries across the Far East and Far West regions to build consensus, launch energy policy imperatives and set up a framework for such global cooperation.

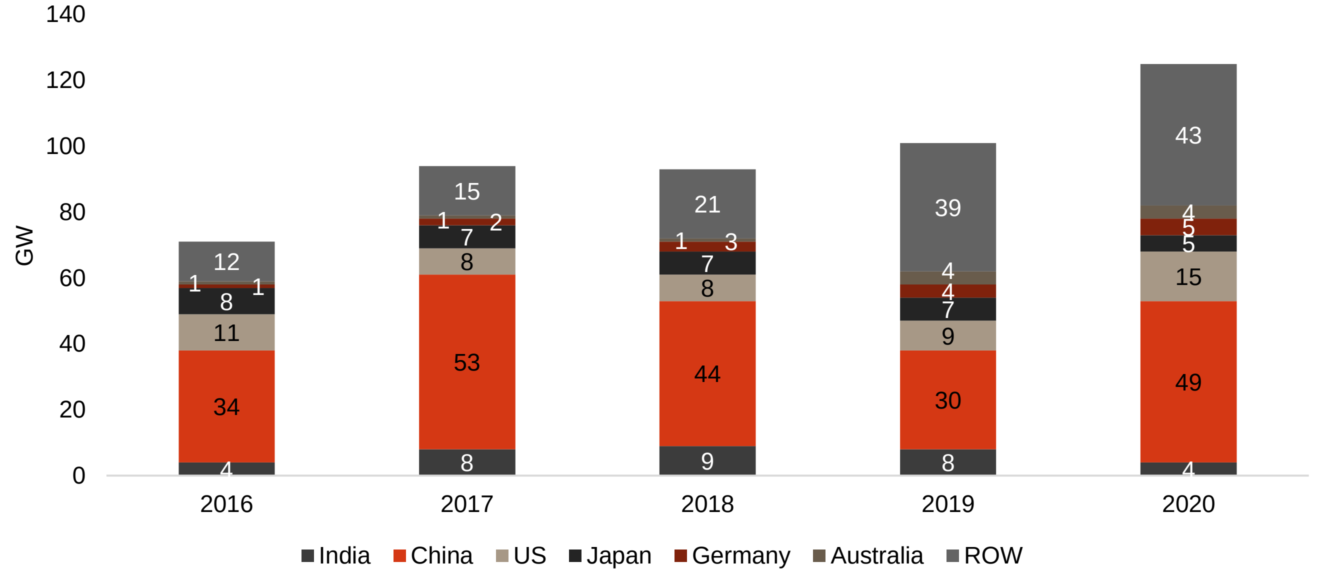
The end objective of this is to develop a global ecosystem of interconnected renewable energy resources that are seamlessly shared for mutual benefits and global sustainability. [Source: MNRE]

4.2 Evolution of the global solar energy market and policy frameworks

4.2.1 Evolution and growth of the global solar energy market

Global installed solar PV capacity increased ~22% on-year to 710 GW in 2020. Globally, ~126 GW of such capacity was added in 2020, led by Asia alone which together added ~76 GW or 60.6% of total capacity added during the year. In terms of cumulative installed capacity as of December 2020, China is the market leader with a total installed base of ~254 GW. The annual solar capacity additions in major economies for the identified periods is produced below:

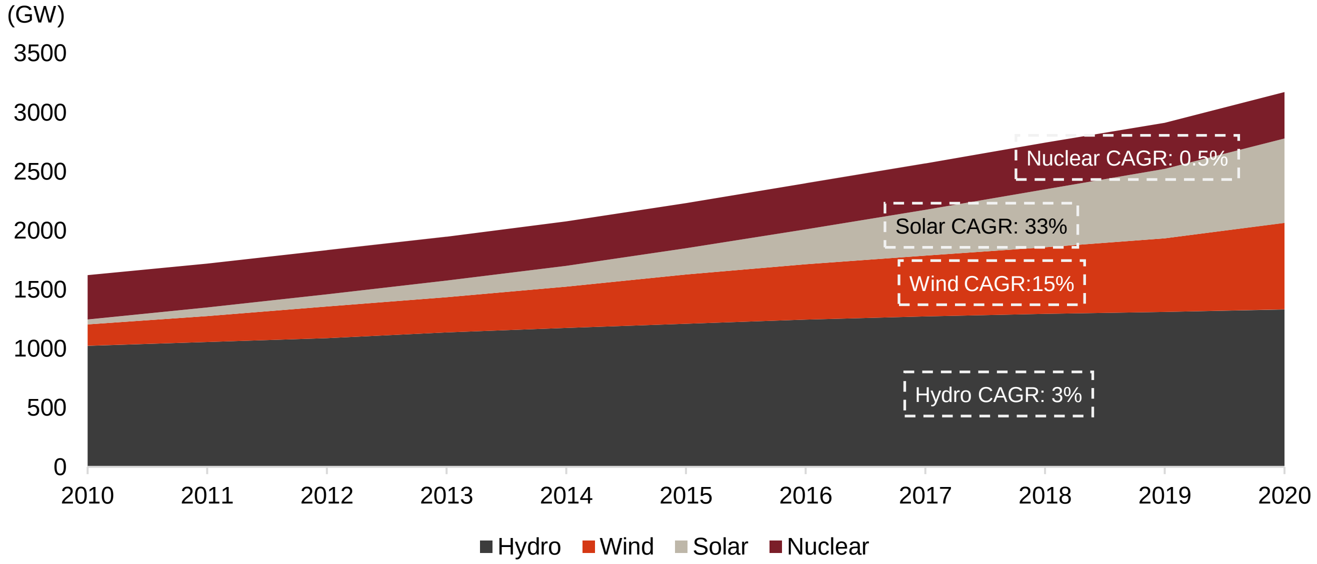
Figure 9: Annual solar capacity additions in major economies



Note: The annual capacity addition numbers pertain to calendar year (January-December)

Source: IRENA Statistics 2021; CRISIL Research

Figure 10: Global cumulative installed PV power capacity grew at a 33% CAGR between 2010 and 2020



Note: Above capacities are in calendar years

Source: IRENA statistics 2021, CRISIL Research

Comparatively, wind energy grew at a 15% CAGR over the same period, with an installed base of 181 GW at the end of calendar year 2010, increasing to 732 GW at the end of calendar year 2020. The table below highlights the solar PV capacity additions and installed base in 2020:

Table 2: Solar PV capacity additions and installed base 2020

Country	Installed capacity (GW)	Capacity additions (GW) in 2020
China	253.8	49.26

Country	Installed capacity (GW)	Capacity additions (GW) in 2020
Japan	68.7	5.47
US	73.8	14.75
Germany	53.8	4.74
India	39.0	4.12
Italy	21.6	0.73
UK	13.5	0.12
Australia	17.3	4.38
France	11.7	0.93
Spain	11.8	2.81

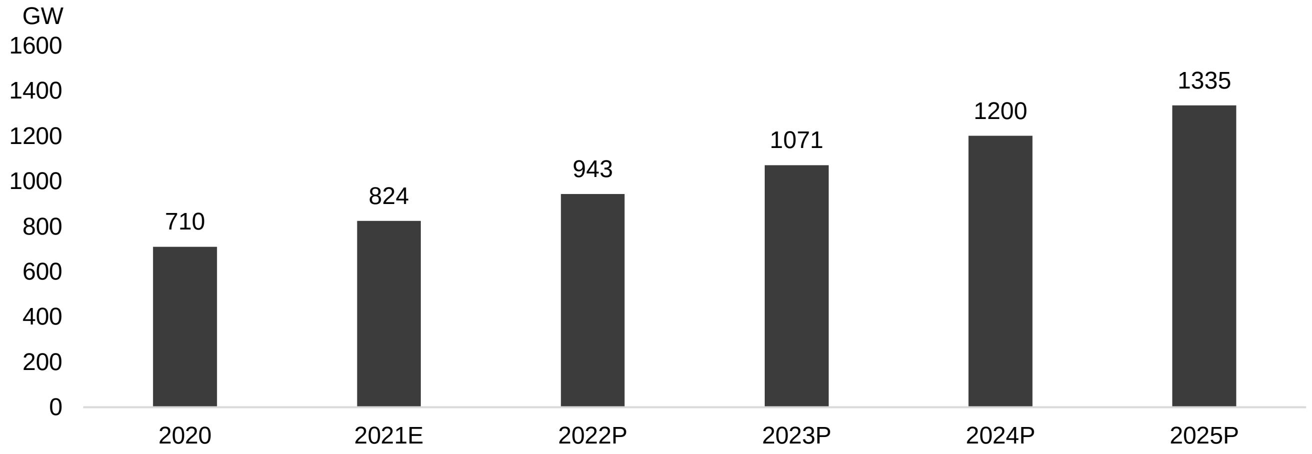
Source: IRENA Statistics August 2021, CRISIL Research

China continues to dominate the solar PV market and account for about 36% of the global installed capacity and key European countries (UK, Germany, France, Spain, Italy) control about 16% of the total solar PV installed capacity as at the end of CY 2020.

4.2.2 Outlook on the global solar energy capacity

Globally, 126 GW of solar PV capacity was added in 2020, taking the installed capacity to 710 GW, a 22% on-year increase. China continued to be the market leader with a total cumulative solar capacity of 254 GW, followed by the US (74 GW) and Japan (69 GW). The bar chart below presents the outlook for global solar PV installed base over calendar years 2021-2025:

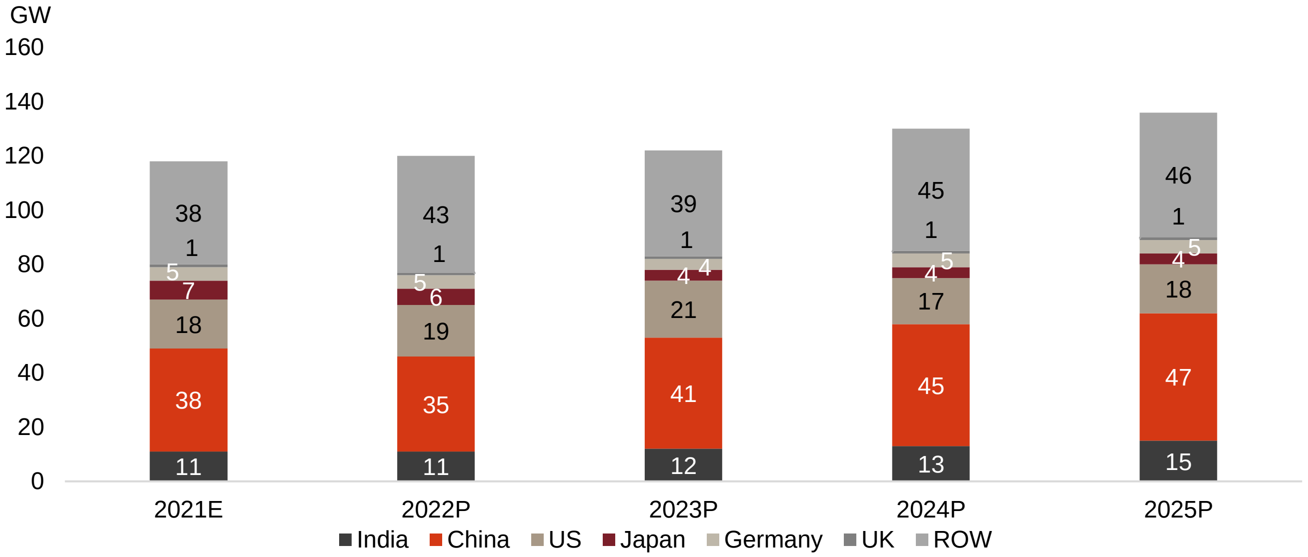
Figure 11: Outlook for global solar PV installed base over calendar years 2021-2025



Note: P: projected

Source:; IEA Renewables 2020, IRENA Statistics August 2021, CRISIL Research

Figure 12: Projected annual solar capacity additions in major solar markets



Note: P: projected

Source: CRISIL Research; IEA Renewables 2020

In calendar year 2020, Covid-19 wreaked havoc on solar manufacturing. Moreover, the pandemic reduced workforce because of lockdown, constrained supply of critical components of PV modules, and made it almost impossible to ship finished products due to the closure, or partial closure of transport routes and ports. Most large projects originally planned for completion in the first half of 2020, along with new projects planned to start in the second half, were affected.

Chinese solar PV capacity addition were 49 GW in 2020, making China the leader in the solar PV market. The total capacity increased 24% on-year to 254 GW. The Chinese government announced the end of the subsidies starting 2021, which led to record installations in 2020. Similarly, in 2019, the Chinese solar market began the process of transforming from a 100% subsidy-driven market to a 100% subsidy-free market by 2021, the first year of its 14th Five-Year Plan (2021-2025).

To achieve this, in June 2018, the Chinese government had issued a statement halting all subsidies for utility-scale solar projects, which restricted capacity additions in the country. Subsequently, in January 2019, the National Development and Reform Commission (NDRC) and National Energy Administration (NEA) announced the removal of quotas for solar projects developed without central subsidies for the next two years. However, there capacity limits for overall project development will remain owing to grid instability in several provinces. Similarly, the central government will impose some control on new solar capacity across provinces.

Overall, we expect capacity additions of ~114 GW in the Chinese market over calendar years 2021-2023, impacted due to a moderate calendar year 2021 and transition to a subsidy free market. Despite that, China will likely remain one of the largest solar markets going forward.

In the US, capacity additions increased to 15 GW in 2020 from 9 GW in 2019. Capacity additions have been driven by tax credits, RPOs and loans and grants provided by government. A sharp decline in input prices has also supported capacity additions. State mandates for renewable electricity have fuelled growth of utility-scale projects, the largest of which are materialising in western US, particularly in California, Arizona and Nevada. States of California, Arizona, North Carolina, New Jersey, and Nevada are leading the country's solar PV installations. We expect capacity additions of ~58 GW over calendar years 2021-2023, driven by extension of tax credits by two years, which were earlier going to end in calendar year 2021. The new US government led by President Biden has proposed to extend the investment tax credit (ITC) in full for 10 years before phasing down the credit value between calendar years 2032 and 2033, though this is yet to be finalised. These tax incentives coupled with state subsidies will be the key US market drivers.

In Germany, capacity additions increased to 4.7 GW in 2020 from 3.9 GW in 2019. Installations were driven by government-led annual auction targets, coupled with independent decentralised and grid connected installations. In the calendar year 2021, capacity additions are estimated to have increased by ~5 GW. Capacity additions are also expected to be sustained at these levels over the next two years, driven by renewable energy auctions and FIT as set by the federal government.

The Indian market faced a temporary slowdown in the second half of fiscal 2020 with capacity additions of only ~4 GW in calendar year 2020, mainly due to several policy issues and pandemic-led restrictions. These included additional taxation in the form of imposition of a safeguard duty, higher GST rate, and other policy issues such as cancellations/renegotiation of PPAs that adversely affected developer sentiments previously. Despite this, India still remains a significant market for solar capacity additions, especially with the government's target of 100 GW by 2022. We expect capacity additions of ~34 GW over calendar years 2021-2023, driven by a healthy pipeline and government targets.

Other markets in Africa, Latin America, Southeast Asia, and the Middle East have also started to grow, further supporting future growth outlook. Key markets include Southeast Asia (countries such as Malaysia, Vietnam, Indonesia, and the Philippines), the Latin American region (Brazil, Venezuela, Chile) and the MENA region (Egypt, United Arab Emirates, Saudi Arabia), which are seeing an increasing focus on renewable energy supported by favourable solar conditions, availability of cheaper land, low labour costs, and supportive tax regimes.

4.2.3 Solar economics

With an increasing investor interest for the segment, global drive towards clean energy, supported by governments internationally, a sustained trend of falling component costs over several years and increasing private participation as the backdrop, bid tariffs for solar energy have been falling globally. Some of the important parameters which drive project economics for a solar project are as follows:

1. Capital costs

Component pricing and project setup costs play a pivotal role in determining tariffs. The rapid fall in module pricing which comprise 50-60% of total project cost (sans land purchase costs) has been instrumental in driving record lows in solar bid tariffs globally.

2. Capital structure

Funding costs and enablers of low-cost debt are some of the key parameters that have been a positive influence post the pandemic in aiding respite in tariffs. Low cost of financing plays a pivotal role in overall cash flows for solar projects as minimal operating costs means most of the cash being consumed in debt servicing, having a significant bearing on net profitability and returns.

3. Utilisation levels

Generation aspects related to location, solar irradiance, connectivity, offtake terms and grid regulations are all important aspects to determining generation levels and consequently revenue from the project and hence, the viable tariffs for the project.

4. Market dynamics

Competitiveness with other fuel sources, a regulatory structure to incentivise clean energy (tax incentives, clean energy penetration mandates, additional taxation etc.) are all important determiners of the tariffs which a market may witness for renewables. Excessive levies in the form of taxation or charges would raise pricing whereas tax holidays, rebates or merchant power market depth would enable lowering of tariffs.

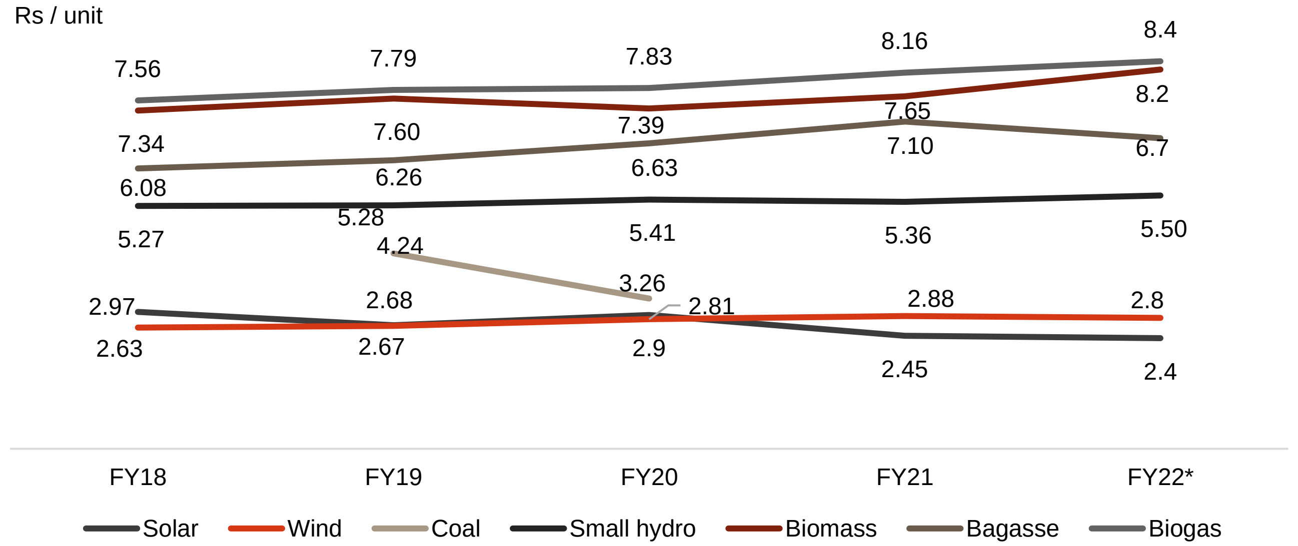
5. Competition

Robust investor sentiment has often been instrumental in pushing supply by enabling low-cost capital, increasing demand for clean energy tenders and driving policy reform. This can be seen in the Indian market, which has seen increasing participation not only from domestic conglomerates but also from several international sovereign and non-sovereign long-term investors.

Price competitiveness of solar versus other fuels

Over the past decade, solar tariffs in the Indian market have emerged to be allocated at the most competitive rates compared with other dominant fuels, essentially due to the drivers related to clean energy and a fall in component costing. A comparison of these is represented below:

Figure 13: Solar versus other fuel tariffs



Note: The weighted-average tariff for biogas, biomass and small-hydro is based on CERC generic tariffs and capacity additions reported by MNRE. Coal tariffs are based on competitive bidding held in FY19 and FY20. Biomass generic tariff is for Biomass Power Projects [other than Rice Straw and Juliflora (plantation) based project] with Water Cooled Condenser and travelling grate boiler. FY22* represents April-January 2022.

Source: CRISIL Research

4.2.4 Cost comparison of solar energy with other sources of electricity

Table 3: Comparison of fuels across key parameters as of December 2021

Type	Project cost	O&M cost (Rs million/MW)	PLFs	Tariffs (Rs/kWh)	Capacity Addition Outlook (GW) FY22-FY26
Coal	Rs 70-80 million/ MW	1.5-2.0	60-%70	3.5-4.5 (varies for domestic and international coal plants)	20-22
Solar	Rs 38-45 million/MW AC	0.4 to 0.7	22-23%	1.99-2.9 (based on recent competitive bidding)	64-66
Wind	Rs 65-75 million/MW AC	0.8 to 1.0	25-35%	2.69-3.4 (based on different bid parameters and regimes)	18-20
Large hydro	Rs 90-100 million/MW	1.5-3.0	50-60%	3.99-5.54 (depending on the state the project is situated in and the capacity of the project)	4-5

Source: CEA, CRISIL Research

5 An overview of the Indian solar energy landscape

5.1 Evolution of solar power in India

The growth story for the Indian solar market has been driven with a view to "establish India as a global leader in solar energy, by creating the policy conditions for solar technology diffusion across the country as quickly as possible" (Source: MNRE). Against this backdrop, the Jawaharlal Nehru National Solar Mission was launched in January 2010 under the National Action Plan on Climate Change. The initial target of installing 20 GW of grid-connected solar power plants by 2022 has since been revised to 100 GW by the end of the scheduled period.

Consequently, sharp growth in the solar power sector was witnessed over Fiscals 2016-2021 which saw capacity additions of approximately 33 GW in the solar power segment, thus growing at 43% CAGR. Solar tariffs have declined continuously over the years. The government has intensified its focus on improving the supportive infrastructure for solar projects, including the construction of solar parks and green energy corridors. Further, allocations under central government schemes have risen to meet the solar power demand from state Discoms willing to meet their revised Renewable Purchase Obligations ("RPO") targets. The National Tariff Policy has revised the solar RPO target to 10.5% by Fiscal 2022. A slew of factors has helped attract more independent power producers ("IPPs") with access to cheaper funds, thus contributing towards growth in the solar market. In the longer term, with renewed targets by India of 500 GW of non-fossil energy base by 2030 taken at the COP 26 summit, clean energy is set to witness a significant policy push.

This has further been aided by falling component prices, especially modules which form 55-60% of project costs typically. Global average solar module prices (multi-crystalline modules) declined to $0.17/watt till December 2020 from $1.78/watt in 2010. An oversupply situation with more manufacturing capacity compared with demand coupled with innovation in manufacturing processes have reduced cost, putting downward pressure on module pricing historically. Global average solar module prices were $0.27/watt as at the end of January, as a result of the COVID-19 pandemic's impact on supply chains and logistics, and the global surge in commodity pricing (poly-silicon and key metals).

The Indian solar energy market is further divided into utility scale and rooftop installations. Utility scale projects are larger size projects (>5 MW), which directly feed energy into the grids for bulk supply of power to distribution utilities, nodal agencies (SECI/ NTPC) or specific large consumers (commercial and industrial). Rooftop installations are typically installed on rooftop premises of buildings owned by various consumers, including residential complexes, office complexes and industrial units.

In Fiscal 2021, solar capacity additions fell 15% to 5,457 MW from 6,447 MW in Fiscal 2020. The lower solar capacity addition was mainly due to restrictions caused by the COVID-19 pandemic in the first half of the year, supply side disruptions, and MNRE's grant of 7.5 months' blanket extension to the commissioning timelines with further provisions for extension available. However between the period of June 2021 and January 2022, solar capacity additions picked up and approximately 9 GW has been added to the sector in the first ten months of Fiscal 2022.

Further, CRISIL Research expects 54-56 GW of utility-scale solar capacity additions over fiscals 2022-26. This will be driven by additions under various central and state allocations, falling bid tariffs and regulatory drivers as outlined previously.

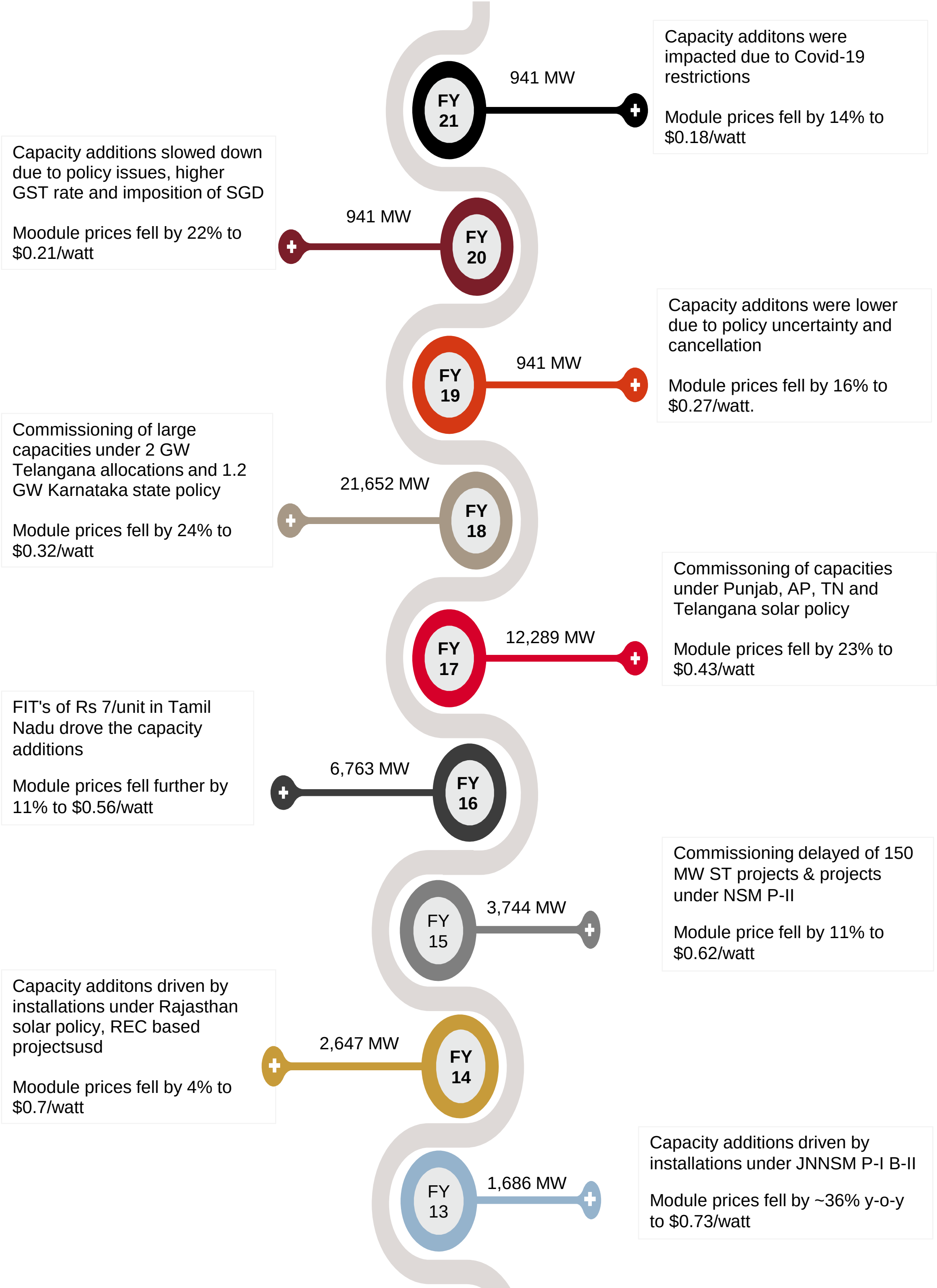
Utility-scale solar projects are awarded to the competent bidders through the process of reverse auctions conducted by the tender-issuing authorities. The rooftop market operates through two key business models, the opex and capex models (discussed in detail below). Variation in regulatory mechanisms, procedural hurdles in implementation of rooftop capacities, lower funding available for the segment, and lack of awareness among end-users are some of the limiting factors constraining growth in the segment.

The commercial and industrial consumer ("C&I") market presents a potential to adopt clean energy, and forms key target segments for domestic Engineering, Procurement and Construction ("EPC") and module makers. C&I users consume approximately 51% of the electricity generated in India, but only a small percentage of the energy procured by them comes from renewable energy sources. This indicates huge untapped potential in the C&I renewable energy market, which has emerged as an important stand-alone business segment in recent years. Even though the present market size is small, specialised developers catering to C&I consumers have emerged, with innovative business models and competitive prices. The C&I segment currently accounts for 70-80% of the country's rooftop solar installations and is making headway in the utility-scale solar space as well through open access and group captive routes.

The Indian market is also expected to witness healthy solar capacity additions, helped by favourable regulatory policies, positive investor sentiment, availability of low-cost funding, increasing participation of the private sector, and infrastructural support from solar parks and dedicated transmission infrastructure.

The solar power evolution between Fiscal 2013 and 2021 was as follows:

Figure 14: Solar power evolution over fiscals 2013-2021



Note: The above module pricing is based on global average values for multi-crystalline modules.

Source: CRISIL Research

5.2 Growth drivers for the solar sector in India

5.2.1 Declining pricing for modules and other system components

Global average solar module prices (multi-crystalline modules), where photovoltaic modules account for 55-60% of the total system cost, declined 73% to $0.47/watt in 2016 (average for January-December) from $1.78/watt in 2010. In fact, prices continued to decline to $0.17/watt until December 2020, due to the wide demand-supply gap in the global solar module manufacturing industry. They are currently at $0.27/watt as at the end of January 2022, impacted in parts by the pandemic impact on supply chain and logistics and the global surge in commodity pricing (poly-silicon and key metals).

Historically, global solar demand has been roughly half of the total module manufacturing capacity. Moreover, innovation in manufacturing processes has reduced the cost, putting downward pressure on module pricing. Declining inverter prices (6-7% of the capital cost), which fell to $0.14/watt by March 2021, helped further reduce system costs.

5.2.2 Fiscal and regulatory incentives

The government has provided several fiscal and regulatory incentives over years to facilitate growth of renewable energy and the solar power sector in particular. We have elaborated on each incentive below:

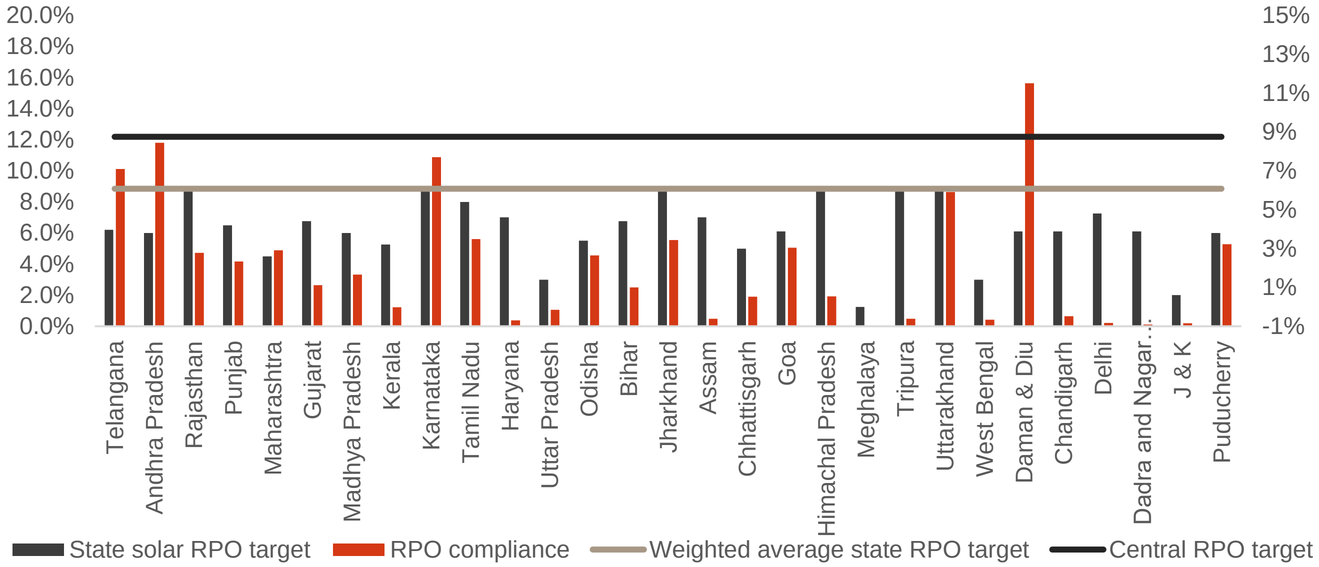
- **Accelerated depreciation (AD):** The government provided an AD of 80% (until fiscal 2017) in the first year of operation; however, in the budget for fiscal 2017, the government halved the AD benefit to 40% for projects getting commissioned after April 2017, i.e., from fiscal 2018. The 40% AD benefit reduces the tariff required by Rs 0.6-0.8/unit (assuming a capital cost of Rs 40 million/MW) for earning a healthy equity internal rate of return (IRR). In fact, several players, particularly in industries such as infrastructure, real estate and construction, effectively used this incentive to offset profit and thereby reduce tax outflow at a company level.
- **Regulatory incentives**: Under the Central government's allocations, the government is providing various incentives for renewable energy projects, such as the 'must-run' status of renewable and deemed generation for projects. Under the must-run status (as per regulation 5.2 (u) of the Grid Code), there is a provision ensuring no back-down of renewable power, except for grid security and stability concerns. However, most state discoms and state load-dispatch centres believe that the must-run status is not absolute, and restrictions must be imposed, considering grid safety conditions and the intermittent nature of renewable energy. Further, in most Central government-level wind and solar allocations, there is also a provision of deemed generation as per the Central government bidding guidelines. Under the deemed-generation concept, the renewable-energy generator is paid for its system availability (based on annual generation on a pro-rata basis), if electricity is not purchased on account of grid issues, i.e., grid unavailability or incompleteness of the transmission line or for any other issue dependent on the offtake.

There are further several incentives for solar players under state solar policies, such as concessional wheeling and banking charges, concessional transmission charges and transmission losses, cross-subsidy surcharges, and reactive charges.

5.2.3 Renewable purchase obligation (RPO)

The renewable purchase obligations are a mechanism by which the electricity regulatory boards ensure that a pre-determined share of overall energy is purchased from renewable sources. The SERCs and CERC, thus, determine renewable purchase targets, which all state distribution utilities as well as captive power and open-access power consumers have to comply with. The estimated state-wise RPO for Fiscal 2021 is as follows:

Figure 15: Estimated state-wise RPO compliance, FY21



Note: The above has been calculated by utilising the total energy quantum as estimated by the utility for purchase and the renewable energy available to the utility vis a vis the RPO targets set by the respective SERC and CERC.

Source: MNRE, Distribution Utility Tariff Orders, CRISIL Research

To promote the installation of solar power systems across various Indian states, the Central government amended the National Tariff Policy (NTP) in fiscal 2016, proposing an increase in the solar RPO target to 10.5% by fiscal 2022. Consequently, several states set RPO targets based on their respective renewable energy potential. However, the MoP issued a revised trajectory in June 2018, as shown in the table below:

Table 4: Long-term RPO trajectory

Long-term RPO trajectory	FY17	FY18	FY19	FY20	FY21	FY22
Non-solar	8.75%	9.50%	10.25%	10.25%	10.25%	10.50%
Solar	2.75%	4.75%	6.75%	7.25%	8.75%	10.50%
Total	**11.50%**	**14.25%**	**17.00%**	**17.50%**	**19.00%**	**21.00%**

Source: MoP, CRISIL Research

The revision has also allowed for inter-replacement of non-solar and solar RPO, in case one falls short. Any backlog would be carried forward.

5.2.4 Infrastructure support from the government

Apart from providing abovementioned incentives, the government has lent significant support to the solar power sector for execution of projects, specifically related to infrastructural requirement.

Solar parks: One of the most notable initiatives by the government has been enabling the setup of solar parks in the country. This is critical, given the land-intensive nature (~5 acre required per MW of solar PV) of solar projects and low average holding (1.16 hectare) per person in India. Under the Solar Park Policy released in September 2014, the government planned to prepare land banks for 20,000 MW of solar projects spread across 25 states. Further, the capacity of the scheme was doubled from 20,000 MW to 40,000 MW on March 21, 2017, to set up at least 50 solar parks by fiscal 2022. Such parks reduce construction/execution risks significantly, as they include a contiguous parcel of land, evacuation infrastructure (HV/EHV substation evacuating to state grid substation), and other ancillary infrastructure and utilities, such as road, water and drainage.

As of December 2021, 52 solar parks with an aggregate capacity of ~38 GW spread across 14 states.

Although the potential of solar energy is high, there exist a few challenges, which are critical to achieving rapid growth in this segment.

Availability of contiguous land parcels – With rapid capacity addition and stiff competition, it becomes imperative for developers to acquire land at competitive costs and in areas with high solar irradiance. The 40 GW solar park scheme is facilitative in this aspect.

Adequacy of evacuation infrastructure – Grid integration of renewables is key to the sector's growth. Instances of delay in readiness of transmission infrastructure at solar parks have caused concern among developers. However, an aggressive roadmap to add an incremental ~100 GW via new schemes and existing available capacity to the grid should be adequate for the expected additions.

Two main schemes for the augmentation of grid capacity to integrate 175 GW of RE and more later are Green Energy Corridor (GEC) and Renewable Energy Zone (REZ). About 11 Renewable Energy Management Centre (REMCs), assigned under GEC Phase-I, are complete, while two additional REMCs added later, situated in Telangana and Andaman and Nicobar, are expected to come online this fiscal. All transmission systems assigned under GEC Phase-II with the CTU are commissioned, while the intrastate element under GEC and both phases of the REZ scheme remain under implementation.

Availability of low-cost financing – Given the capital-intensive nature of the solar power sector, availability of finance – that too at low cost – is critical. On the one hand, the government has undertaken several steps to ensure availability of low-cost finance, while on the other developers are exploring several instruments/sources to raise finance, as elaborated below. This has lent significant support to solar power sector growth.

Some of the steps taken by the government to ensure availability of low-cost finance are as follows:

- *Funding from lending institutions, such as IREDA, PFS and PFC:* Government financial institutions, such as PTC India Financial Services (PFS), PFC/REC and IREDA, finance many solar projects.
- *Green bond/masala bond market:* Green bonds are like any other bond but one which invests the proceeds to support green energy or renewable energy projects. India is the second country after China to have national-level guidelines published by the SEBI for green bonds. Green bonds may be issued by the national government, multilateral organisations (such as ADB, the World Bank or the Export-Import bank of the country), financial institutions and private corporations. Until September 2021, close to $15.3 billion worth of green bonds were issued by various stakeholders to invest in RE projects located in India.

- *Funding from multilateral banks and the International Solar Alliance (ISA):* The government channelises funds available from multilateral banks and financing institutions, such as the World Bank and KfW.

Technological advancements – The solar sector has witnessed continuous technological innovations leading to not only a decline in solar-component pricing (as detailed above), but also improvements in efficiency and / or cost reduction. A few of these have been described below:

- **Dual-axis solar tracking:** To profit from the Sun's continuously changing position through the year, a dual-rotating axis has been developed for PV modules to move from east to west and north to south simultaneously. This allows the solar panel to angle itself so as to maximise the incidence of solar radiation on itself, thus increasing generation.
- **Solar coating:** Solar panels are constantly exposed to natural elements, such as rain and wind. This leads to dust accumulation on the surface of the panel that leads to reduction in efficiency. Multifunctional thin films or coatings combat this by enhancing self-cleaning, anti-reflection, anti-fogging and energy transmittance properties of solar panels.
- **Uninterrupted power supply (UPS) with solar power:** UPS allows electricity-operated objects, such as solar panels, to continue running during an emergency. Solar-charged batteries and battery backups may also be used to store excess solar power for later use.

Green hydrogen

Unlike traditional fossil fuel-based hydrogen, green hydrogen is produced through electrolysis of water, using renewable power such as solar or wind which, after splitting water's two main elements- hydrogen and oxygen- vents oxygen as a by-product into the atmosphere. Use of renewable power contributes to the goal of net-zero emissions.

According to IEA, in 2020, global electrolyser capacity stood at 0.3 GW which mostly used grid electricity to produce hydrogen. However, by 2030, IEA projects global electrolyser capacity to reach 850 GW which if run entirely on solar energy will require close to 3000-3200 GW additionally. This would create additional demand for solar modules globally & an opportunity for domestic solar manufacturers to service this demand through exports.

Further, there is push from the Indian government in terms of targets & policies. The government came out with the National Hydrogen Mission that aims to cut down on carbon emissions and increase the use of renewable sources of energy, while aligning India's efforts with global best practices in technology, policy and regulation.

The Government of India has also allotted Rs 250 million in the Union Budget 2021–22 towards research and development in hydrogen energy and intends to produce three-fourths of its hydrogen from renewable resources by 2050.

On the cost side, IEA analysis finds that the cost of producing hydrogen from renewable electricity could fall 30% by 2030 as a result of the declining cost of renewables and the scaling-up of hydrogen production, further pointing to the increased adoption of green hydrogen manufacturing.

Hence, we believe green hydrogen remains a key growth driver and will contribute meaningfully towards renewable additions. Solar energy installations needed for green hydrogen are expected to be of high order.

5.2.5 Other drivers

Apart from the above key drivers, the following positive factors have also helped in driving the renewable, especially solar, segment in the Indian market:

Traction in the commercial and industrial (C&I) segments – C&I consumers are most favourably placed to take benefit of the lower cost power available from renewable resources, especially solar. With commercial and industrial grid power tariffs averaging around Rs 6-7 per unit (even going as high as Rs 10-12 per unit in certain states), rooftop solar tariffs (RESCO mode) or landed cost of renewable energy under open access at prices of Rs 4-6 per unit compares favourably. Support from state and central policies to the solar rooftop segment (subsidy, metering allowances etc.) and open access charge concessions (lower cross subsidy surcharge, additional surcharge, grid usage charges, ISTS waiver etc.) all help place the economics of utilising direct contracts with renewable generators or setting up captive renewable energy plants favourably by such consumers.

Green term ahead market (GTAM) – The launch of GTAM to promote green energy power trading is aimed at ensuring renewable capacity addition beyond RPO by resource rich states as well as promoting private generators to set up projects outside the competitive bidding framework. In the current environment, with significant RPO targets set by Ministry of Power coupled with low supply in the REC trading market, such a mechanism can incentivise capacity additions beyond the normal tender route by nodal agencies.

Low construction and operational risks – The short gestation period of 12-18 months for solar PV projects compared to 3-5 years for conventional power projects such as coal, nuclear and large hydro are a major positive driver of execution momentum for the segment. This is coupled with low O&M requirements for maintain a solar PV plant, where cleaning of modules and preventive maintenance would be the key activities. This is coupled with ample solar resource, with an estimated 5,000 trillion kWh per year energy incident over India's land area with most parts receiving 4-7 kWh per sq. m per day, and large tracts of land available for setting up solar projects. [Source: MNRE]

5.3 Government policies driving growth of solar sector

5.3.1 Central Public Sector Units (CPSU) scheme

Post the WTO ruling putting an end to domestic content requirement (DCR) after December 14, 2017, even in competitively-bid tenders, DCR was restricted, as per the ruling, to government energy procurement and use only.

Thus, tenders related to energy procurement by CPSUs were exempt under the WTO ruling and could utilise the DCR clause to promote domestic PV module manufacturing demand. Further, the government, in February 2019, extended the scheme to 12 GW from the erstwhile 1 GW, to provide a further impetus to the domestic solar module manufacturing industry.

Implementation of the 1 GW allocated under the CPSU scheme was initially slow, with NTPC forming the chunk of capacity at ~700 MW of a total of ~800 MW commissioned under the scheme. However, as on March 2021, of the 882 MW sanctioned by MNRE under the 1 GW (Tranche I), the entire capacity was commissioned.

Under Tranche II, (programme expanded in February 2019), agencies have issued a cumulative 4.5 GW under the CPSU scheme. While SECI has issued two tenders under the CPSU scheme of 2000 MW and 1500 MW, NTPC has floated a tender of 1 GW. SECI's 2 GW tender (subscribed for only 932 MW) has been auctioned and 922.4

MW has been allocated with a commissioning schedule of 24 months. For SECI's 1.5 GW tender, 1104.8 MW has been allocated with a commissioning schedule of 24 months

Although this is expected to benefit the sector to some extent, execution has remained slow due to restrictions imposed amidst the Covid-19 outbreak. Further, low traction from other CPSUs, except NTPC, and the continued delay in subscription / undersubscription to the CPSU tranche tenders has led to a delay in commissioning momentum. We expect at least 1.5-2 GW overall from this till fiscal 2023, considering the central government's push.

5.3.2 PM-KUSUM

The government has added a DCR clause in this scheme as well due to it being a government-led and subsidised initiative. This, in turn, is expected to drive demand for domestic modules and cells further. The capacities have been allocated to various states in line with the demand received from respective states, the targets listed under the KUSUM program, and the guidelines. However, substantial on-ground progress is yet to start.

In November 2020, MNRE scaled up and amended the PM KUSUM scheme. The scope of the scheme has now been increased by including farmer-owned pasture lands and marshy lands as well. Further, the size of the solar plant has also been reduced so that small farmers can participate, and the completion period has been increased from nine to twelve months. Further, any penalty for shortfall in generation has been removed for ease of implementation by farmers. The component wise revised solar capacity and financial support measures are summarised below:

Table 5: Component-wise revised solar capacity and financial support

Component	Revised target	Solar capacity (GW)	Central financial support (Rs billion)		
			CFA	Service charges	Total
A	10,000 MW	10.0	33	0.25	33.25
B	2 million pumps	9.6	156	3.12	159.12
C	1.5 million pumps	11.2	145.08	2.90	147.98
Total		**30.8**	**334.08**	**6.27**	**340.35**

Source: MNRE, CRISIL Research

5.3.3 Solar Rooftop Phase II (SRISTI)

MNRE has also implemented Phase II of the Residential Solar Rooftop scheme with a target of achieving 40 GW from rooftop solar by 2022. The scheme provides financial incentive for 4 GW of solar rooftop capacity to be set up in the residential segment, coupled with a provision to incentivise distribution companies for incremental achievement over previous years. The use of domestically manufactured solar cells and modules has been mandated for this residential sector as well. This scheme is expected to act as catalyst for adding solar cell and module manufacturing capacity in India.

5.3.4 Jawaharlal Nehru National Solar Mission (JNNSM)

JNNSM, launched as part of India's National Action Plan on Climate Change (NAPCC) in 2010, aims at establishing solar power infrastructure in India. The mission was launched with a target of 20 GW grid-connected solar power generation capacity by 2022. However, the target was increased to 100 GW in June 2015 with a 40

GW target for rooftop solar electricity generation and a 60 GW target for large and medium-scale grid-connected solar projects.

The nodal agencies under this program – NTPC, NVVN and later SECI – have led allocations under several phases and batches as detailed below:

JNNSM Phase I

As detailed before, under JNNSM Phase I, the450 MW was tendered out in two batches - 150 MW (Batch I) and 300 MW (Batch II). In addition, 470 MW was offered under solar thermal technology.

JNNSM Phase II

VGF (capital subsidy) was introduced to lower the capital cost of solar projects and due to limited availability of conventional power from unallocated quota of NTPC plants. MNRE established SECI as the executing agency under Phase II.

5.3.5 Other Government Policies

- **100% FDI single window clearance**: The government has launched the single window clearance on 22nd September 2021 for foreign investors & businesses. The window acts a one-stop solution for all the clearances & approvals. The portal today hosts approval across 18 central departments & 9 states. This is expected to facilitate the growth of foreign investments in India
- **Open access order**: The Draft Electricity (promoting renewable energy through Green Energy Open Access) Rules, 2021, announced by the Ministry of Power in an order dated 16th August, 2021 aims to address the challenges related to different charges levied on the open access consumers thereby improving the certainty of cash flows for new projects to be set-up through this route. This if implemented, is expected to increase the renewable installations in India
- **New wind-solar hybrid policy:** MNRE announced the amendments to guidelines for tariff competitive bidding process for procurement of power from Wind Solar Hybrid Projects in an order dated 23rd July,2021 which are positive for developers driving the growth of the renewable sector.
- **Energy Storage:** As part of India's clean energy push, government is working on Energy Storage Policy for integration of renewable energy with the power system. As stated in order dated 6th October 2021, the policy would broadly focus on regulatory, financial and taxation, demand management and technological aspects in order to speed up the implementation of storage capacity driven by the need to have increased flexibility in Indian power system to absorb the large-scale integration of the renewable energy into the system during the coming years.

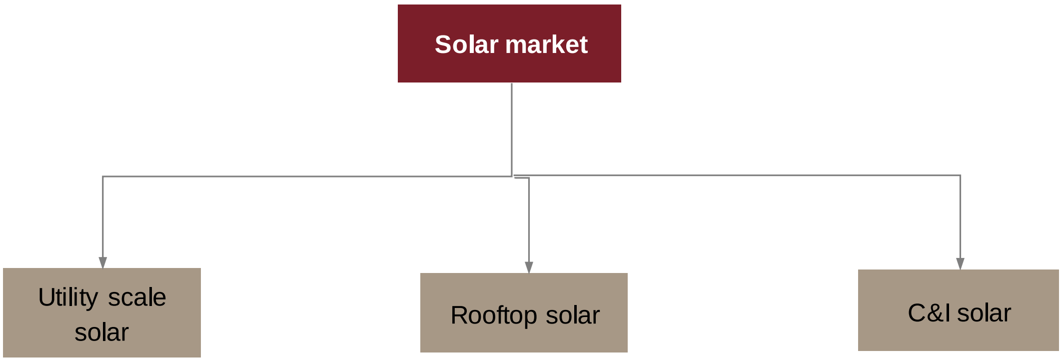
Therefore, these fiscal benefits, tariffs and import duties on foreign imports, ALMM, in addition to various government policies and schemes such as, SRISTI and KUSUM aimed at adoption of residential market segment through solar rooftop, provides us with a favourable regulatory landscape. However, a number of other parameters like technology adoption at metering level, transmission capabilities will remain a monitorable for having full potential of the residential solar rooftop market.

5.4 Overview of the Indian solar energy market

The solar energy market in India broadly comprises the below segments:

- **Utility scale solar -** A utility-scale solar facility is one which generates solar power and feeds it into the grid, supplying a utility/large consumer with energy. Virtually every utility-scale solar facility has a power purchase agreement (PPA) with a utility or large purchaser (SECI / C&I), guaranteeing a market for its energy for a fixed term of time. Typically, the project size of utility-scale project is greater than 5 MW.
- **Rooftop solar -** A rooftop solar is a photovoltaic system that has its electricity-generating solar panels mounted on the rooftop of the premises of a building (residential, commercial complexes, industrial plants, government buildings etc.). Rooftop systems are small, as compared with utility scale solar projects, with capacity typically ranging from 5-20 kW on residential complexes / houses & 100 kW- 1 MW on larger buildings, such as those that are commercial or industrial in nature.
- **Solar capacities set up for the C&I segment** (hereafter referred to as the C&I market) - The C&I solar market caters to the needs of large commercial & industrial establishments. Currently, it has the largest market share in rooftop solar deployment and is becoming increasingly active in the captive and third-party solar PPA segments. A decline in solar power prices under private bilateral contracts as against significant grid power tariffs for C&I consumers has led many of these participants to adopt solar power to meet their power requirements through rooftop solar, captive power or open-access plants. Comprehensive solar rooftop policies, with net and gross metering regulations, exemptions on open access charges for solar power in many states and streamlined utility interconnection processes, have given confidence to the industry and led to rapid deployments in the C&I solar segment.
- **Other key markets:** Other key markets include floating solar, agricultural solar, solar pumps & off-grid.
  - Floating solar system involves installing the solar power plant on the large expanses of water such as land, reservoir, wetlands, lakes etc. It has very large potential across reservoirs & can help save land.
  - Agri-solar brings together agriculture & energy sectors. This collaboration can give much needed boost to sustainable rural development & increase bio-diversity protection.
  - India has been a pioneer in the adoption of solar pumps. The market has a huge potential with the government targets for installations of 2 million solar pumps by 2022 under PM-KUSUM scheme with up to 60% of capital subsidy
  - Off-grid Solar PV Applications Programme is one of the oldest programmes of the MNRE aimed at providing solar PV based applications in areas where grid power is either not available or is unreliable. Applications such as solar home lighting systems, solar street lighting systems, solar power plants, solar pumps, solar lanterns and solar study lamps fall under this programme.

Figure 16: Types of solar markets



	Utility scale solar	Rooftop solar	C&I solar
Potential (GW)	749	210	
Installed capacity(GW)	32	4	10
Government target (GW)	60	40	

Note: The above numbers represent installed capacity as of March 2021 & government targets by Dec 2022. Utility & rooftop solar excludes C&I installed base. Also, there is no separate potential & government target for C&I market.

Source: CRISIL Research

Out of the key segments in solar energy, rooftop and C&I solar market execution is predominantly done via third party EPC contracts. This would mean a significant portion of the capacity addition outlook over fiscals 2022-2026 of 12-13 GW and 15-16 GW in rooftop and C&I segments respectively to be a key market for EPC solution providers. On the private IPP market front, majorly the projects executed under competitive bidding, the outlook of 37-38 GW over fiscals 2022-2026 forms the potential which can be serviced by external EPC providers. However, in this segment the in-house EPC arms set up by the developers themselves can also execute the projects won by their sister concerns.

Further sections describe each of the afore-highlighted solar market segments in detail:

5.4.1 Utility scale solar market

Bidding process for utility scale solar

Utility scale solar projects are awarded to competent bidders through the process of reverse auctions conducted by the tender-issuing authorities.

Reverse auctions serve as a contracting mechanism, where project developers bid for power purchase agreements (PPAs) from a utility, end-customer, or other contracting authority. Once the reverse bidding mode is selected for procurement, the procurer prepares detailed documents (RfS) that includes tendered quantity in power (MW) terms or energy (kWh) terms. Other parameters such as technology to be used, detailed specifications, delivery terms, payment securities, performance requirements, etc., are disclosed by the procurer, as per a formal process. Competent sellers are attracted to and participate in the bid. Once the process is over, the evaluation of presented bids is done by the procurer. Decision based on real-time pricing is done and the seller with the lowest bid price selected. A non-negotiable standard contract is signed with the winning seller, incorporating the bid price offered by that seller. The projects are also scrutinised to ensure that they meet the minimum viability requirements.

The developers bidding for utility-scale solar projects need to follow the guidelines released by MNRE. Further, MNRE continuously makes revisions in the solar competitive bidding guidelines.

Evolution of bid tariffs

Recent cost pressures, such as the safeguard duty imposition, new GST clarification (70% charges at 5%, 30% at 18%), rupee depreciation and the rising cost of debt had caused developers to bid mostly in the Rs 2.7 - 2.9 per unit range over fiscals 2019 and 2020. However, bid tariffs have again fallen to the Rs 2.4-2.5 per unit range towards the end of fiscal 2021 & YTD FY22, driven by lower cost of financing and safeguard duty rate decline. The most recent case has been the SECI 1200 MW ISTS Karnataka Tranche-X auction in February 2022 which witnessed a solar tariff of Rs 2.36 per unit. Previously, in October and November 2020, solar tariffs declined to as low as Rs 1.99-2.0 per unit, driven by lower capital costs, with advancement of technology & decrease in cost of financing available to the projects.

Bid tariffs are also impacted by the nature of the allocations i.e. central vs state. Historically, developers have shown more interest and bid more aggressively in central scheme allocations as compared with state bids.

This is because there are several distinguishing benefits under central schemes such as:

- Lower counter party risk owing to SECI / NTPC / NVVN functioning as intermediary between developers and DISCOMs
- Land provided in solar parks in some schemes (eliminating land acquisition hassles and construction of transmission infrastructure)
- Enhanced payment security mechanisms (security fund, jurisdiction of the tripartite agreement for SECI / NTPC / NVVN).

Increasingly, the share in allocations has begun to be dominated mostly by tenders issued by central agencies instead of the state, as the latter also prefer signing power supply agreements with SECI / NTPC / NVVN directly, instead of procuring renewable energy at higher cost directly from developers.

However, with the standard solar bidding guidelines in place (which provide payment security stipulations, deemed generation clause, etc.) on which state PPAs have been modelled, state solar auctions have also seen as tariffs as competitive as the central allocations. Although, this varies from state to state, as it is dependent on many other factors as well as land prices, grid availability, solar irradiance, etc., specific to the state.

The declining trend in the bid tariffs has led to growth in the solar installations which is detailed in the section below.

Review & outlook of utility-scale solar additions

In fiscal 2021, solar capacity additions fell by 15% to 3,542 MW from 5,728 MW in fiscal 2020. The lower solar capacity addition was mainly due to restrictions caused by the pandemic in the first half of the year, supply-side disruptions and MNRE's grant of a total 7.5 months blanket extension to the commissioning timelines with further provisions for extension available. However, between the period of June 2021 to January 2022, utility scale capacity additions picked up & ~6.87 GW has been added to the sector in 10 months of fiscal 2022. Previously, in fiscal 2020, additional taxation in the form of safeguards and higher GST rates had led to a slowdown in capacity additions.

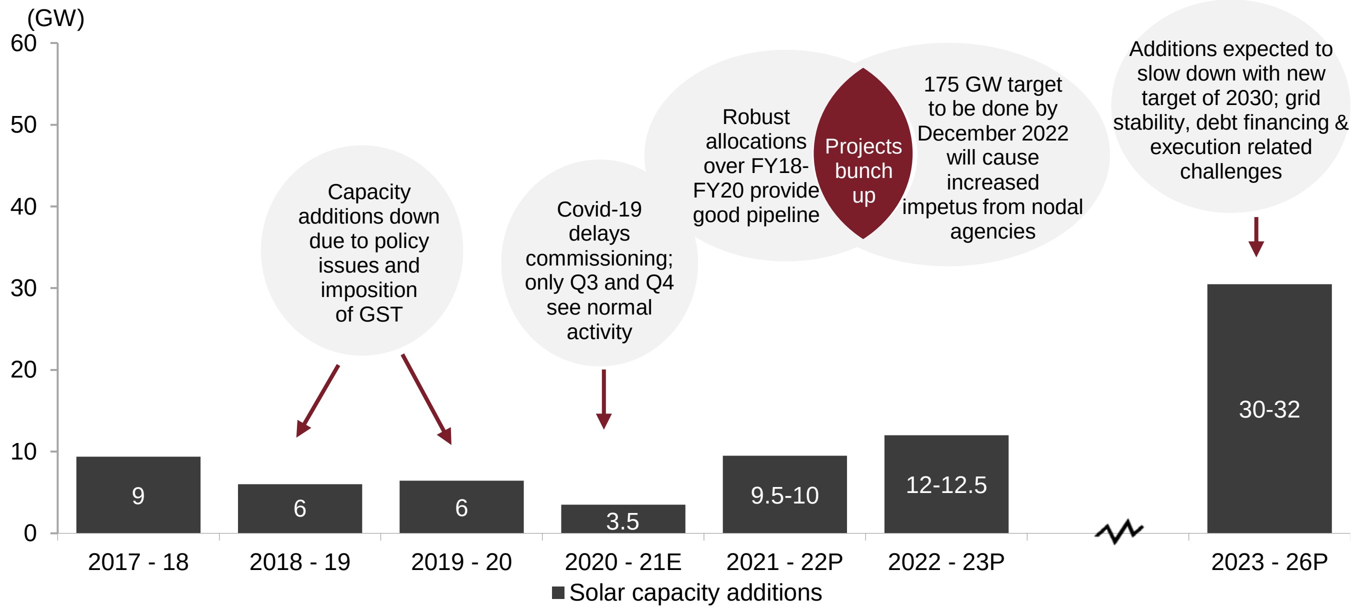
Further, CRISIL Research expects 52-54 GW of utility-scale solar capacity additions over fiscal 2022 to 2026 (refers to fiscal year of April to March). This will be driven by additions under:

- The National Solar Mission (NSM) Phase II Batch IV, V and VI;
- Other schemes launched by SECI (ISTS, floating solar tenders, newer structure tenders, state specific schemes, etc.)
- Capacities tendered by distribution companies in various states to fulfil Renewable Purchase Obligations (RPO);
- Capacities tendered by cash rich public sector undertakings (PSU) such as National Thermal Power Corporation (NTPC), Neyveli Lignite Corporation (NLC), Coal India Limited (CIL), etc.

To arrive at capacity additions, we have considered progress of capacity allocations from the above schemes. For our analysis, we have also factored in the economic feasibility of tariffs, extent of payment security, financial health of state DISCOMs, renewable purchase obligation (RPO) targets as well as execution risks in project implementation.

The share of solar power in total units generated (MUs) is expected to go up from 4.3% as on fiscal 2021 to 10.5-11.5% by 2026, as thermal-based power would continue to be the dominant source of energy.

Figure 17: Utility scale solar capacity additions



Note: The utility scale addition outlook above also includes open-access installations, including from C&I

Source: CRISIL Research

5.4.2 Rooftop Solar Market

Rooftop projects are small-scale solar photo-voltaic (PV) installations on roofs of buildings. Rooftop projects may or may not be connected to the grid.

Rooftop solar business models

OPEX Model

The OPEX or the operating expenses model is a system where the developer owns the solar project, and the consumer only has to pay for the energy generated. This model is also called the Renewable Energy Service Company (RESCO) model.

Rooftops installed under the OPEX or RESCO model require the consumer to enter into a long-term, legally binding agreement for the roof on which the solar system is installed. They must also sign a long-term power purchase agreement (PPA) for the supply of power.

PPAs can be signed for up to 25 years, and the consumer is expected to pay a pre-determined tariff for this duration. Any excess electricity generated may be injected into the grid.

In this model, all capital expenses and risks are entirely borne by the developer. The developer will be the system's owner for its entire lifetime and must provide operation and maintenance services throughout.

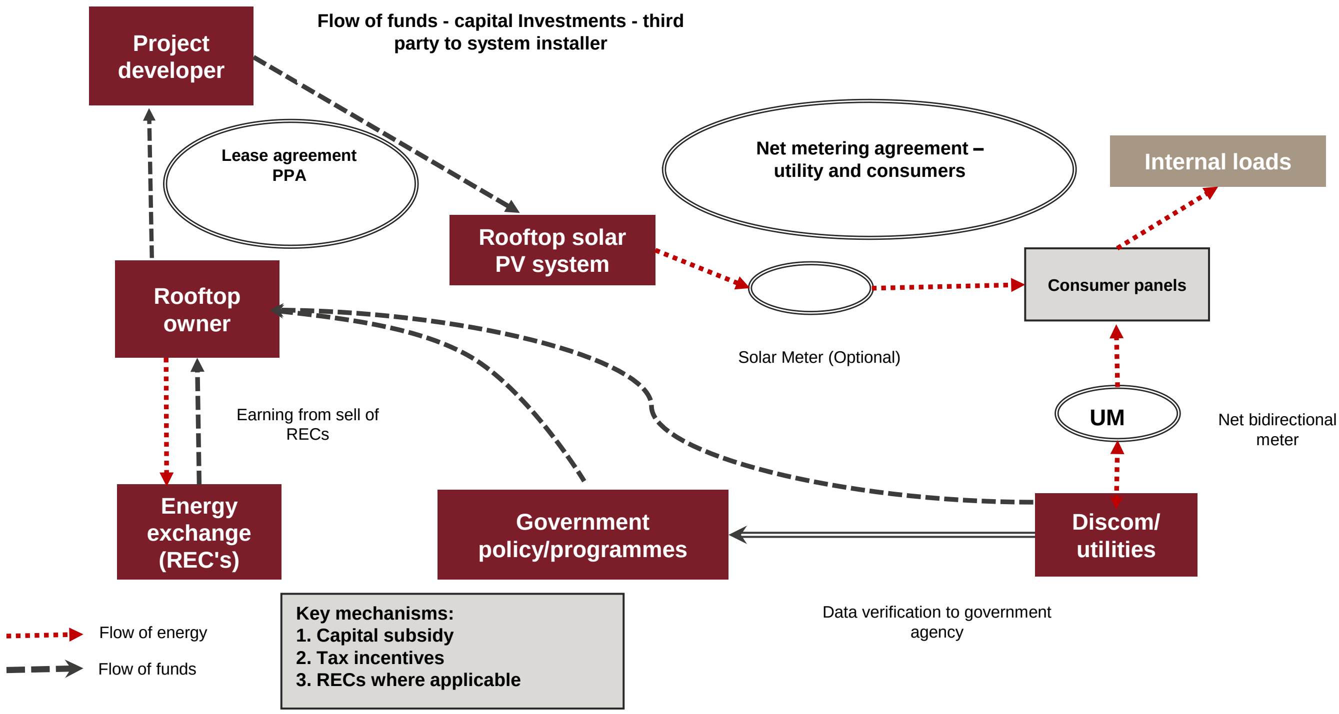
According to rooftop installers, consumers could have to pay a tariff ranging between Rs 3.8 (~$0.051)/kWh and Rs 5 (~$0.068)/kWh for the PPA duration. The tariff varies depending on the state and the policies prevalent at the time.

A major benefit of the OPEX model is going solar without any large upfront investments for the end-consumer. However, not all installers may be willing to undertake smaller projects which individual households or smaller companies may be interested in. OPEX project installers tend to prefer medium to large-sized projects under this model.

Once the PPA expires, the ownership of the rooftop project will be transferred to the customer. However, companies also include a provision for them to buy back the project before the PPA expires. This allows the consumer to transfer the project back to the developer after five years at a pre-determined rate.

Some drawbacks of the OPEX route are the lack of any tax depreciation or GST benefits, and a higher levelised cost of energy (LCOE).

Figure 18: RESCO model depciting flow of funds and flow of energy



Source: CRISIL Research

CAPEX model

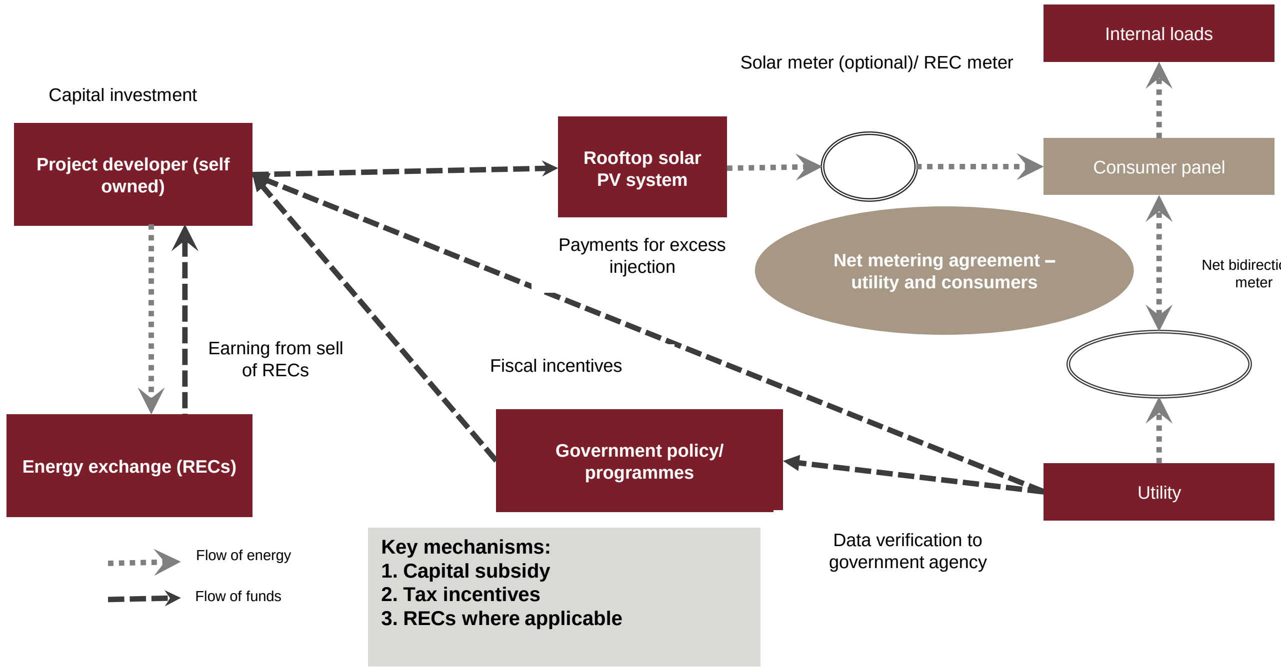
The CAPEX or the capital expenditure model, on the other hand, is a self-funding model where consumers have to bear all the upfront capital expenses incurred in installing a rooftop system. These expenses include funds used to set up, maintain, and operate the project. They also include the cost of the equipment, labour, upgrades, and other material costs.

Consumers taking the CAPEX route can approach vendors or installers to set up the rooftop solar system to reduce their power costs. Any residual power or excess generation can be injected into the grid.

The CAPEX model also allows consumers to enjoy complete ownership of the product. They have control over the type of technology being used and, more importantly, the quality of the components that go into their projects. Consumers and companies can claim GST input and accelerated depreciation benefits & also enjoy a lower LCOE.

The one possible downside to this model is that all the risk involved in owning and operating the rooftop system would have to be borne by the project owner. This includes operations, management, and maintenance.

Figure 19: The CAPEX model depicting flow of energy and funds



Source: CRISIL Research

Review & Outlook on rooftop solar additions

As per the government target of 100 GW of solar by fiscal 2022, 40 GW is proposed to be added under rooftop-based solar systems.

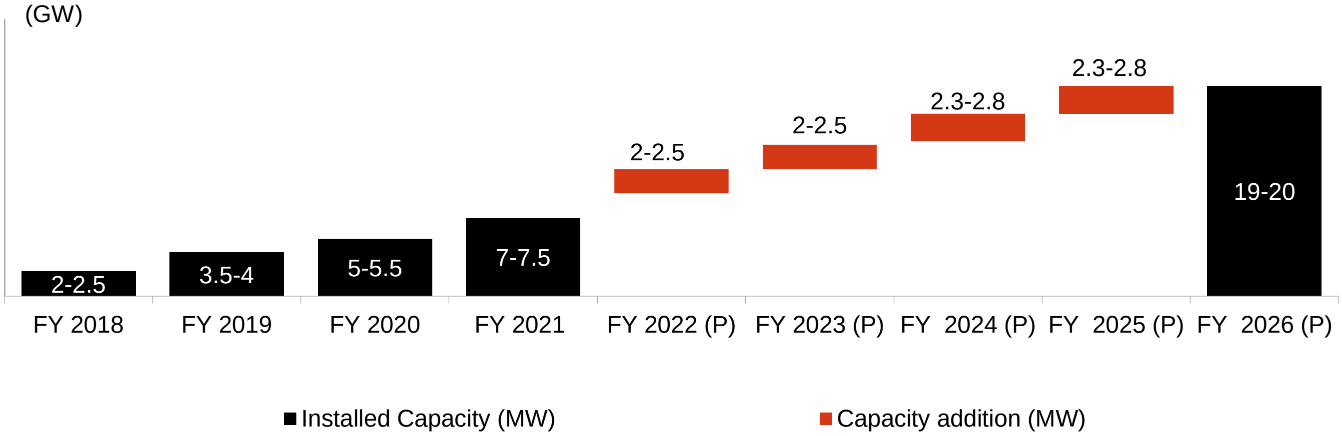
As on January 2022, ~9 GW of rooftop capacity is estimated to be installed. Rooftop capacity additions picked up speed with peak additions of ~1925 MW witnessed in fiscal 2021.

This was driven by a positive change in policy under the Gujarat's Surya Urja Rooftop Yojana targeting rooftop installations for 0.8 million consumers by March 2022. The scheme provided 40% & 20% state subsidy for installations up to 3 KW & 3-10 KW respectively. Additionally, a MSME policy released in September 2019 by the Gujarat government allowed installations of solar rooftop projects in excess of 100% of sanctioned load or contract demand. Under the scheme, MSME's could also sell excess power to state government at Rs 2.25 per unit.

However, recently in a reversal of policy stance, GUVNL withdrew subsidies to small-scale distributed solar projects, which would affect capacity of ~2500 MW & dampen investor sentiment as Gujarat is the leading state for rooftop solar installations.

CRISIL Research expects 11.5-12.5 GW of capacity to be commissioned under the solar rooftop segment over the next five years (2022-2026), mainly led by commissioning of capacities by SECI (up to 1000 MW); capacities allocated by state governments (up to 1500 - 2000 MW), commissioning of capacities by government institutions such as metro, railways and airports (1,000 – 1,500 MW); with the remaining capacity to be added by industrial and commercial consumers under net/gross metering schemes of various states.

Figure 20: Rooftop solar installations and capacity addition estimate



Note: Solar rooftop capacity numbers above include C&I rooftop capacity additions.

Source: CRISIL Research, MNRE

The key roadblocks hindering growth of the rooftop solar segment are:

- **High cost of installations compared with utility scale**: Due to the smaller scale, niche technical design and specifications (due to variations in rooftop area/premise setup) and higher cost of certain components, the cost of solar rooftop installations is typically higher than a large utility scale solar setup. Moreover, a distributed consumer base also lowers affordability of this segment.
- **Funding availability**: Due to the distributed and varied nature of end consumers, credit assessment and funding credibility evaluation of rooftop installations are challenging, especially in the capex-led model. These factors are also key hurdles, especially in the smaller scale residential segment.
- **Weak infrastructure and implementation challenges**: Network capability limitations, coupled with often prolonged approval processes and clearances for rooftop connectivity from power distribution companies, have been a long pending challenge for the sector.
- **Policy divergence and ineffective implementation:** Policy divergence across states and nodal authorities, coupled with hesitation of distribution companies on adoption of the solar rooftop segment (as high paying consumers shift consumption), has also slowed down growth of the segment. Further, although MNRE has entrusted Solar Energy Corporation of India (SECI) with implementation of large-scale, grid-connected rooftop PV projects, with subsidy support from National Clean Energy Fund (NCEF) funds, the release of subsidy has been delayed by more than six months in some cases.

That said, the ministry's approval to allow net-metering up to 500 KW is expected to give a much needed fillip to the sector as it removes the uncertainty for installers and paves the way for future growth. Rooftop solar projects have attracted the interest from players in the entire solar value chain ranging from module manufactures (Tata Power Solar, Vikram Solar, Waaree Energies, etc) to system integrators (Rays Power, Jackson Engineers) and independent power producers (Welspun Solar, Azure Power, Sunedison, Mahindra Solar, etc) owing to falling costs and favourable regulatory policies in a few states (net metering, exemption on electricity duty, wheeling and cross-subsidy charges).

The central government has strongly vouched for rooftop solar, targeting to achieve a whopping 40% of the 100 GW generation capacity under the National Solar Mission (NSM) from this segment by 2022. For instance, the central government is continuing the provision for providing 30% capital subsidy for rooftop projects. The subsidy supports rooftop projects undertaken by residential consumers and public institutions (government hospitals, schools, etc) across various sectors.

However, timely disbursement of the subsidy is necessary to avoid project execution delays and boost investor confidence in the market, with government support critical to boost growth over the long term.

5.4.3 C & I Solar Market

Commercial and industrial (C&I) users consume approximately 51% of the electricity generated in India, but only a small percentage of their energy procurement comes from renewable energy sources. C&I users have emerged as an important standalone business segment in recent years in renewable energy market, indicating their huge untapped potential. Even though the present market size is small, specialised developers catering to C&I consumers have emerged with innovative business models and competitive prices. The C&I segment already accounts for 70-80% of the country's rooftop solar installations and is making headway in the utility-scale solar space as well through open access and group captive routes. The following section describes each of these routes in further detail.

Business models for C&I solar energy assets

Group captive

The group captive model is an arrangement wherein a minimum 26% of the equity is borne by captive consumers and at least 51% of the energy generated is consumed by them. The project is developed for collective usage of one or many corporate buyers. These group captive consumers sign a PPA with the developer, which is responsible for project construction and operations and maintenance (O&M).

Open Access

The open access procurement model under the Electricity Act, 2003 enables heavy users with more than 1 MW connected load to buy cheap power from the open market. The concept enables customers to choose from a number of competitive power companies, rather than being forced to buy power from the local utility monopoly.

Open access can be broadly categorised as intra-state or inter-state. Intra-state open access falls under the State Electricity Regulatory Commission (SERC), whereas inter-state open access can be expensive as it is subject to the regulations and charges of central authorities as well as both the states which have the points of generation and consumption.

Open access can be further classified as:

- Short-term open access for a period of less than a month
- Medium-term open access for a period of three months to three years
- Long-term open access for a period of 12 - 25 years

Further, open access projects have to pay various charges, which vary with location and procurement models. Renewable power plants under a captive or group captive model are generally exempt from many of these charges that vary across each state.

Various charges under the open access mechanism include: (a) transmission charges; (b) wheeling charges; (c) transmission losses; (d) wheeling losses; (e) cross subsidy surcharge; (f) additional surcharge; and (g) banking charges.

In addition to the above, C&I consumers procure power through capex and opex routes described in detail in the rooftop section.

Review & outlook of the C&I solar market

Indian C&I solar sector added ~6 GW over fiscals 2019-21 registering a CAGR of 45% with the total installed capacity as on March 2021 at ~10 GW. The capacity additions picked up in the last quarter of fiscal 2021 in response to easing of pandemic restrictions and increasing power demand. Also, the market has gained momentum over the last few years with consumers keen to reduce their power bills as well as carbon emissions. Increasingly, there is also very strong interest among investors as we continue to see leading independent power producers, private equity funds, and other institutional investors committing huge sums to this market.

Solar power is preferred over other renewable energy sources by C&I consumers due to its ease of implementation, versatility and negligible operating costs. Moreover, solar power prices have declined significantly over the past few years, making it more affordable for C&I consumers. In contrast, state discoms continue to charge C&I consumers very high tariffs compared with residential and public sector consumers to provide subsidies to agricultural and below poverty line consumers. Thus, large industries across all segments and commercial consumers including metro corporations, railways, airports, hotels and multinational corporations can generate substantial savings by meeting their electricity requirements through solar power-based captive, group captive and open access projects.

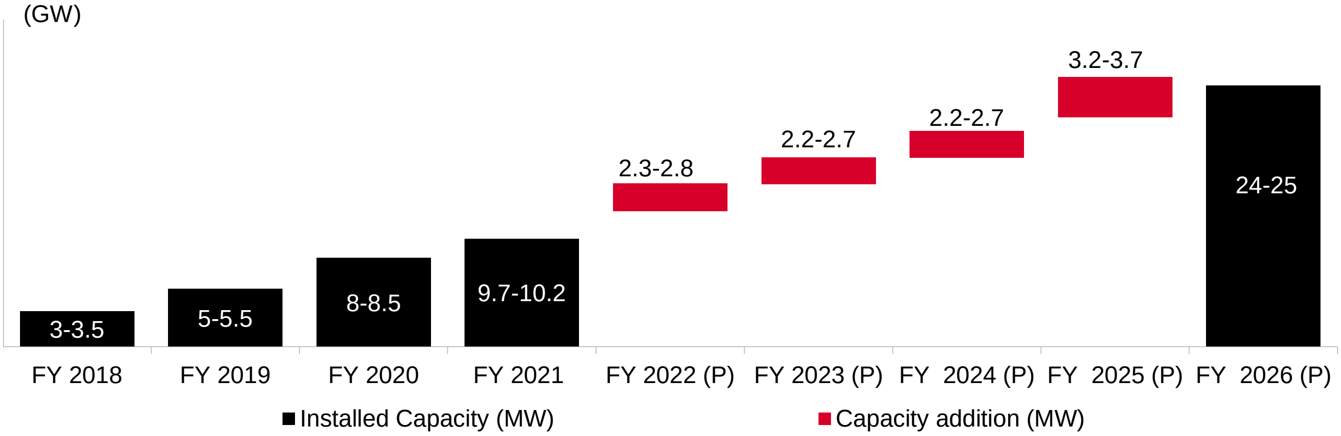
CRISIL Research expects capacity additions of ~14 GW over fiscals 2022-26 driven by rooftop solar and open access installations. We believe distributed domestic generation will be key to meet India's energy and energy security needs. Many factors such as technological innovations, more cost-reflective time-of-day tariffs, smart meters, high-efficiency modules, and battery storage will drive growth of this market.

Additionally, in the recently released Draft Electricity Amendment Act 2020, several progressive measures have been proposed for the solar sector, including the introduction of a pan-India renewable purchase obligation (RPO) with a strict penalty mechanism. Discoms and other large electricity customers are obligated to purchase a specific percentage of their power from solar energy sources under these RPOs. These measures will provide a significant boost to the uptake of rooftop solar in the C&I segment.

However, issues such as financing, regulatory uncertainty and policy divergence across states must be tackled to further speed up solar adoption in this segment.

The C&I market installed capacity and capacity addition estimates are as follows:

Figure 21: C&I market installed capacity and capacity addition estimates

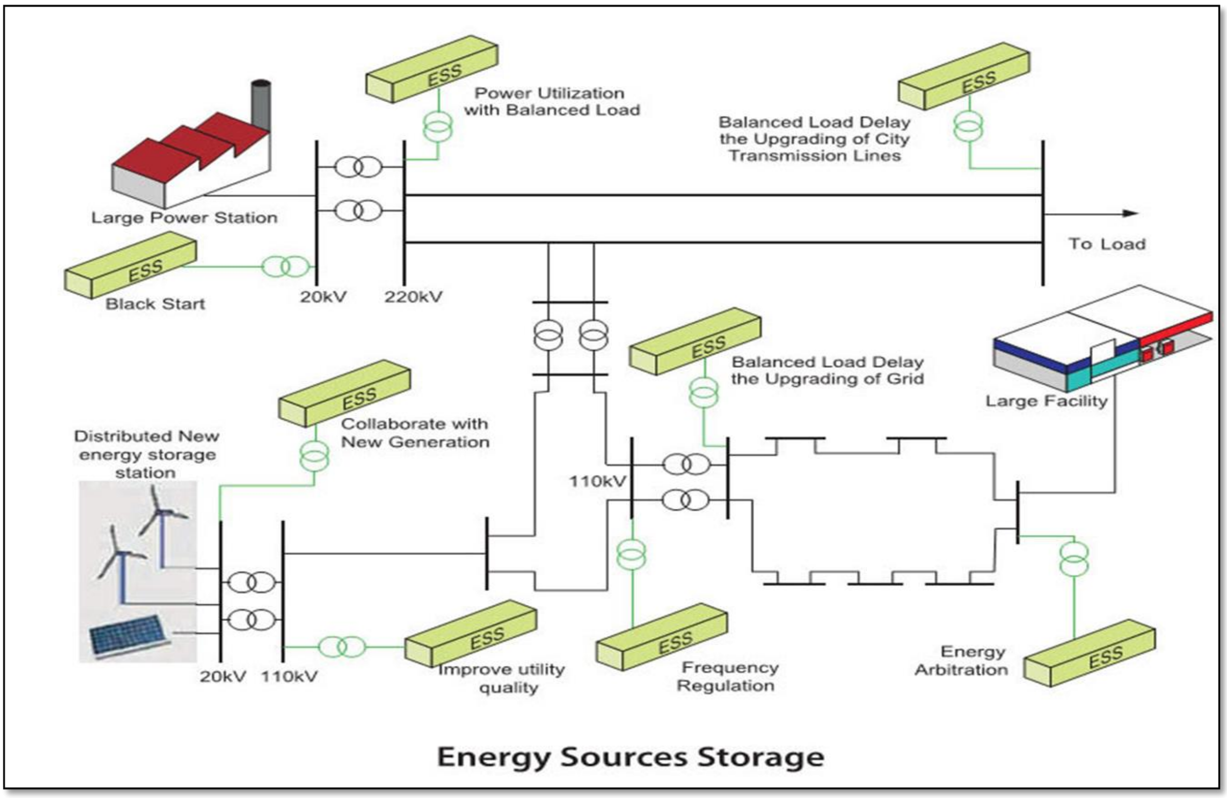


Source: CRISIL Research

5.5 Impact of battery storage on the solar market

Energy storage systems can be deployed at transmission, distribution and consumer ends to serve different needs at different times.

Figure 22: Energy storage system deployment



Source: CRISIL Research

The need for electricity storage stems from the following factors:

- Drives rapid de-carbonisation reducing the need to depend on pollution emitting peak power plants
- Helps to integrate more solar, wind and distributed energy into the grid

- Improves efficiency of the grid by increasing capacity factor of the existing resources
- Saves cost to the society by enabling storage of low-cost energy and retrieving it later when required

Need for battery storage in the solar market

Renewable energy currently accounts for only 4.3% of India's total power generation and is expected to increase to 10.5-11% by 2026. To integrate such a high penetration of renewables into the grid effectively, several measures are being taken, including bringing flexibility in conventional generation, maintaining generation reserves, introduction of ancillary services, etc. Although the concept of energy storage has been around for a long time, its role is now becoming crucial for energy systems. With a rise in intermittent renewables, energy storage is needed to maintain a balance between demand and supply. Rapid innovation and a rise in the global scale of production have helped lower the prices of battery storage systems, with prices gradually falling from 2011 onwards. The prospect of using battery-based storage for grid-scale projects is gaining wider acceptance with rapid progress in battery technologies such as lithium ion. These technologies developed to support to electric vehicles have elicited equal interest from rooftop and utility-scale solution providers on account of rising grid electricity prices and falling costs of modules and batteries.

RE projects, along with battery storage, can ensure steady power supply for a longer duration in both on-grid as well as off-grid applications, helping utilities and consumers to meet energy requirements in an efficient and environment-friendly manner. The International Renewable Energy Agency (IRENA) has also forecast a fall in the price of storage solutions, especially lithium-ion technology. Greater adoption of lithium-ion battery storage, an improvement in battery efficiency and large-scale manufacturing are expected to reduce the lithium-ion battery installation cost to $145-480 per kWh in 2030 from $200-840 per kWh in 2017. With rising adoption of battery storage and maturing technology, newer business models based on storage will evolve and transform the market structure of electricity production and consumption.

5.6 Wind-solar hybrid

Wind-solar hybrid (WSH) is fast becoming the preferred RE option in India. Although the MNRE has not set a generation target for the nascent sector yet, WSH has received strong support from SECI and several state governments.

There are two types of WSH projects – pure-play projects and those with storage.

5.6.1 Outlook on WSH market in India

- CRISIL Research estimates WSH projects to account for 8-10 GW of overall solar capacity of 64-66 GW over the next five years (fiscals 2022 to 2026)
- Of this, ~10 GW is already in the works – either under construction or being tendered
- SECI invited bids for 1.2 GW of WSH capacity in April 2021, under its Tranche IV tender for RE projects
- While the biggest beneficiaries of the WSH policy will be major windy states such as Madhya Pradesh, Karnataka, Gujarat, Tamil Nadu and Andhra Pradesh, under-penetrated windy states such as Maharashtra and Chhattisgarh are also expected to see some traction

6 Solar photovoltaic manufacturing market assessment

6.1 Background to photovoltaic manufacturing

6.1.1 Overview of the solar energy value chain

The solar energy value chain consists of the following 4 phases:

- Manufacturing phase
- Project planning phase
- Implementation phase
- Use phase

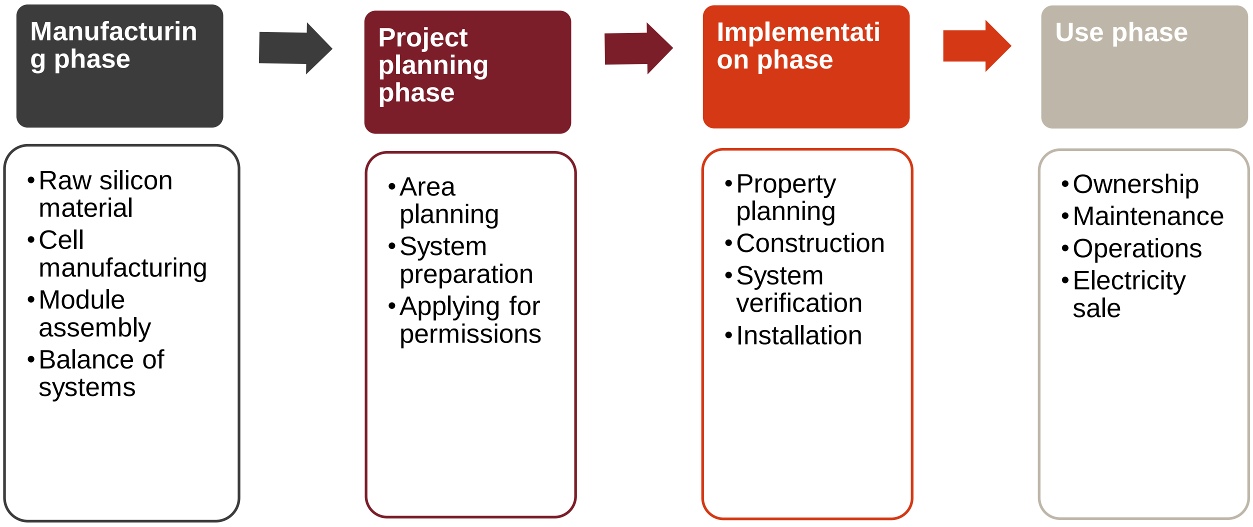
The manufacturing process constitutes the upstream stage of the value chain, while subsequent phases – project planning, implementation, and use – form the downstream stage.

The manufacturing stage comprises different processes required to develop a utility-scale PV solar system.

First, raw silicon must be produced, purified, cut into wafers, doped, cleaned, and coated. The cells hence formed are subsequently assembled into modules and arrays, and combined with other electrical components such as cables, transformers, inverters and other such balance of system components to construct a solar generation system.

Project planning, which is the first process in the downstream stage, involves area planning, system preparation, applying for land approvals, and targeting least cost fund raising for the project. After this begins the implementation phase, which entails the actual construction process, verification and installation of the system. The last phase of the value chain involves operation and maintenance activities as well as different adjustments in the PV solar plant, negotiations with local authorities and communities, and distribution of the energy produced for end-use.

Figure 23: Schematic of c-Si PV module supply chain



Source: CRISIL Research

Crystalline silicon (c-Si) technology is largely deployed in solar PV globally as well as India. The technology is also expected to comprise the largest pie in India's ambitious target of 100 GW solar capacity addition by December 2022.

However, currently, 80-85% of the solar modules need be imported as domestic capacity is inadequate to meet demand. India does not have a manufacturing base for poly-silicon ingots and wafers; hence, players import these components, incurring high cost. Additionally, installed capacity for solar cells in India (~3.2 GW as on December 2021) significantly trails solar module capacities (~13 GW as on December 2021), requiring module players to import the cells from China.

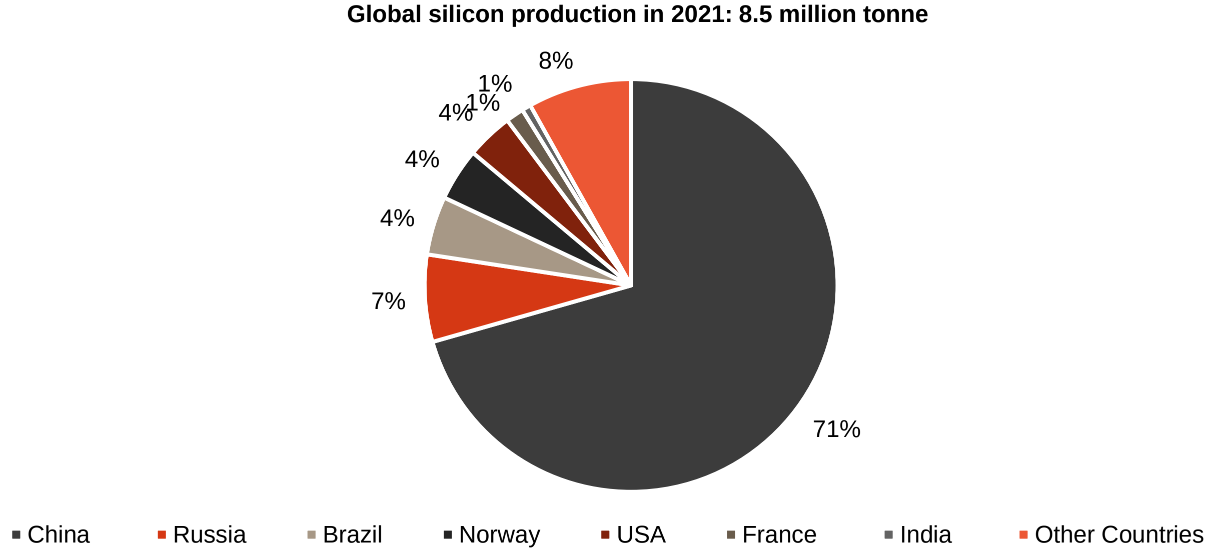
Only a few GW-scale companies are present in India. Many of the smaller companies have capacities in the 100-500 MW range, with very high operational costs.

6.1.2 Overview of key inputs/raw materials and their sources

The primary natural resource utilised in the manufacturing process of solar photovoltaic modules (crystalline technology) is silica, which is then processed further into polysilicon and the successive downstream components.

Polysilicon is essentially a high-purity form of silicon. The leading country for silicon production has been China, where in 2020 more than two-thirds of the global production was located. China is followed by Russia, Brazil, Norway and the US.

Figure 24: Global silicon production-country wise in 2020



Source: USGS, CRISIL Research

Note: Silicon Production figures are estimates for 2021.

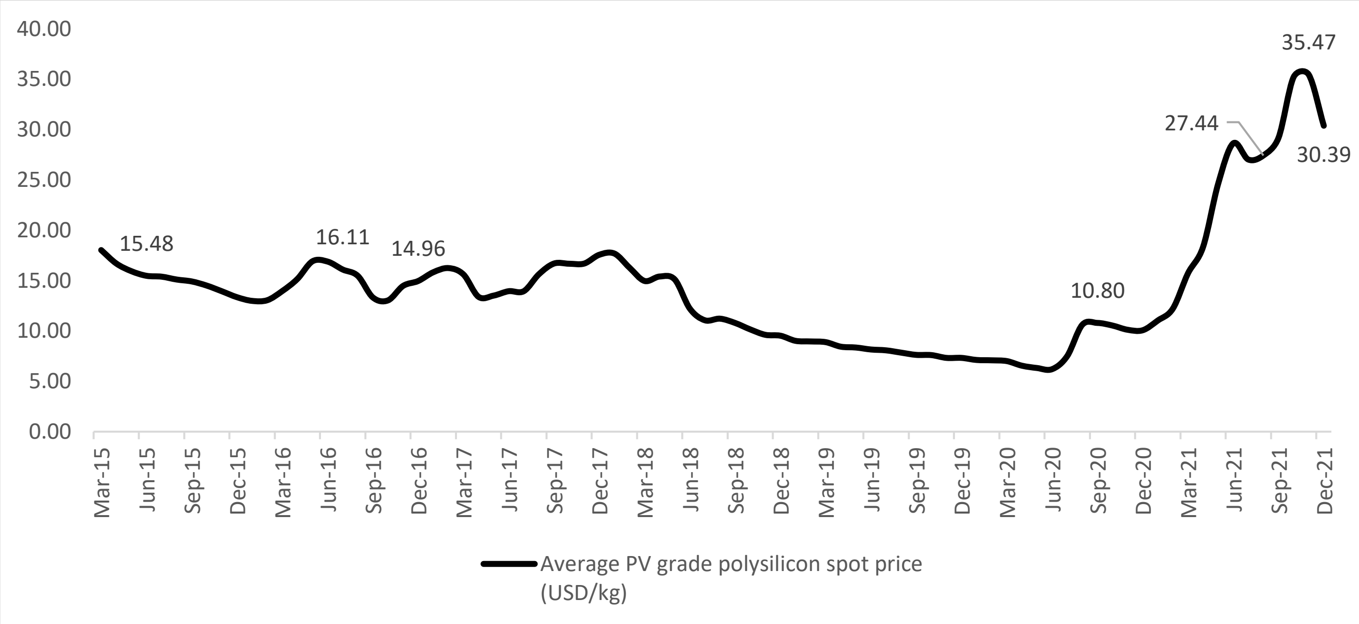
In 2020, of the total global production capacity of 525,000 tonne, China's polysilicon output was 396,000 tonne. Production of silicon, a key component for manufacturing polysilicon declined in 2020 by approximately 5% owing to the COVID-19 pandemic. Pandemic-related uncertainties lowered demand resulting in a decline of polysilicon prices to historical lows, as prices had been falling historically led by a supply glut in the market. The fall in pricing also led several polysilicon players, especially smaller entities, to exit the market or cut back on production. Further, several unexpected events such as fire incidents at manufacturing locations of two key players, flooding in key manufacturing regions, coupled with increased regulatory scrutiny on environmental standards followed by Chinese manufacturers by the domestic government, also hurt supply. This, coupled with a recovery in demand in CY 2021, has put upward pressure on polysilicon pricing currently. After US banned polysilicon manufactured in Xinjiang province of China because of forced labour, players have halted expansion plans and are shifting out of the region.

6.1.3 Component price trends

Price of polysilicon increased sharply over the past 6 months

Solar wafers and cells today require less polysilicon on kg/W basis due to improvements in the manufacturing process over the years. Price of polysilicon declined ~59% over March 2015-March 2020 driven by lower production costs stemming from lower electricity rates and reduction in investment costs needed for the new production facilities that use the Siemens method. It dropped to an all-time low of $6.21/kg in June 2020. However, after March 2021, it increased sharply due to capacity shortage after explosion and floods in key Chinese facilities, increased safety checks, and the shutdown of small manufacturers due to the pandemic. Also, recently the price has increased due to power crunch caused by shortage of coal supply and the government's order curbing silicon production.

Figure 25: Polysilicon price up after five years of decline



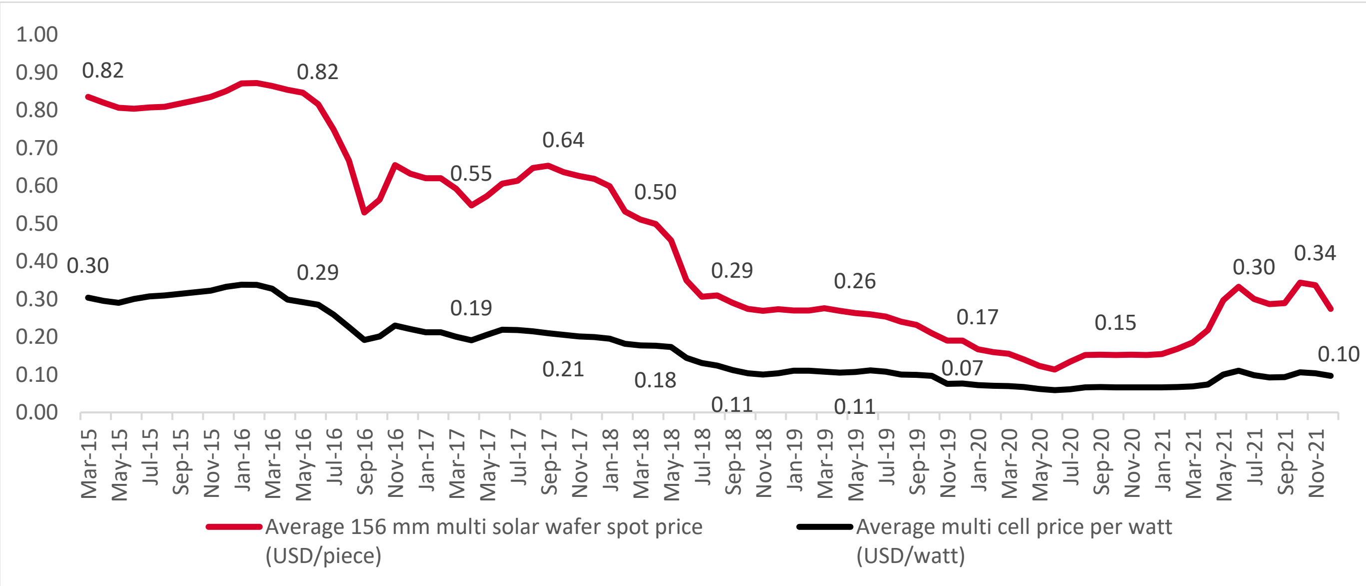
Source: Industry, CRISIL Research

Prices of cells and wafers up in 12 months to May

Technological advancements, economies of scale, slowdown in the Chinese market due to policy changes, and the halt in business activities due to the pandemic pushed up price of silicon wafers (used to make solar PV cells) by ~140% over 12 months to May.

In May, prices of both multi-crystalline and monocrystalline wafers continued to rise due to material shortage and consumption by leading module manufacturers. Insufficient supply of wafers continued to impact the operating rate of cells in May. Due to strained supply of upstream wafers, prices of cells increased, too. Hoarding ahead of the revision in duty rate announced by the Indian government also impacted supply.

Figure 26: Wafer and cell prices have trended down



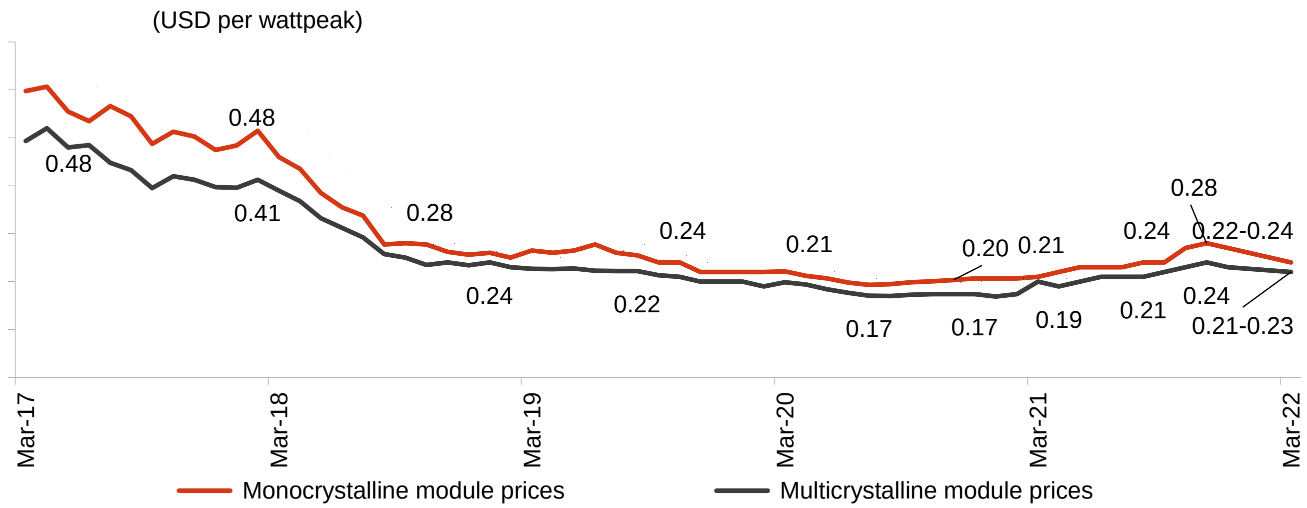
Source: Industry, CRISIL Research

Declining module prices

Global price of solar modules (55-60% of the total cost) declined 73% on average to $0.47/watt in 2016 from $1.78/watt in 2010. In fact, the price continued to decline to $0.22/watt by end-August 2019, owing to the wide demand-supply gap in the global solar module manufacturing industry.

Historically, global demand for solar module has been half of the total module manufacturing capacity. Innovation in the manufacturing processes reduced cost, putting downward pressure on their price. Further, declining inverter prices (6-7% of the capital cost), which fell to $0.14/watt by March 2021, helped further reduce system costs.

Figure 27: Module price declined more than 65% over fiscal 2017-2021



Source: Industry, CRISIL Research

However, a ~135% increase in polysilicon price over March-September this year, due to shortage of capacity and surge in downstream demand, has increased monocrystalline module price to $0.24/watt. Capacity shortage was due to explosion and floods in key Chinese facilities, increased safety checks and closure of small manufacturers during the pandemic.

Also, we forecast China to continue to add solar capacity in the range of 45-50 GW in 2021, at the same level as last year. Global demand is expected to increase due to healthy additions in the Middle East and Africa. However, capacity expansion plans announced by key players, such as Jinko Solar, JA Solar, and GCL-Poly (expected to come online by the end of this fiscal) will put downward pressure on module price going forward.

Hence, we expect module price to stay steady until the end of 2021. Moderation is expected only in the first half of 2022 when polysilicon capacities affected by the pandemic resume, planned greenfield capacities become operational and global commodity prices moderate. Module price is expected to be $0.20-0.22/watt for multi-crystalline and $0.21-0.23/watt for monocrystalline by the end of this fiscal.

6.1.4 Entry barriers and risks for PV manufacturing

Economies of scale

Chinese players have consistently expanded over the past decade to reach an average manufacturing unit size of 10 GW in addition to backward integration until the polysilicon stage. This has boosted their economies of scale and lowered raw material costs as they import from quite lower down in the value chain. In comparison, key players in India are still at an average unit size of ~1-2 GW, with manufacturing starting at the cell stage.

Backward Integration

India does not have a manufacturing base for polysilicon ingots and wafers (key inputs accounting for ~60% of cost in PV cells and panels). Unlike large, backwardly integrated companies (manufacturing polysilicon, ingots, wafers and cells) based in China, Malaysia, Korea or Taiwan, most Indian manufacturers lose out on margins, weakening their pricing power.

Upfront Capital Investment

Integrated manufacturing in the solar energy sector requires a high upfront capital investment to realize economies of scale. Therefore, it is difficult for smaller players with smaller capacities to be price competitive. Indeed, the long-standing supplier relationships and heavy capital investments costs are significant barriers to entry for new entrants into the solar energy sector.

6.2 Global solar PV manufacturing market

The global market for solar PV manufacturing is driven by a shift towards clean energy to reduce carbon emissions, policy support provided by governments in major economies, sharper investor focus on clean energy projects, particularly in solar energy, and reducing cost of solar PV panel manufacturing owing to consistent R&D investments. Sales of solar PV panels for residential or commercial purposes dominate the market. The industry could be classified by technology as thin film, crystalline and others. It can also be classified by end use as residential, commercial and utility scale.

However, the growth of solar PV panel manufacturing had been restricted to some extent by unfair trade and sales practices. For instance, sales of Chinese solar PV panels in North American and European markets at extremely low prices has led to complaints of unfair trade practices. In the US, the erstwhile Trump administration had imposed a 30% one-year tariff on imported solar PV cells in a bid to curb the unfair trade practice. Further, the US Department of Commerce imposed anti-dumping and anti-subsidy duties on Chinese imports. In Europe, the European Commission and major Chinese manufacturers agreed on a minimum price and shipping volume.

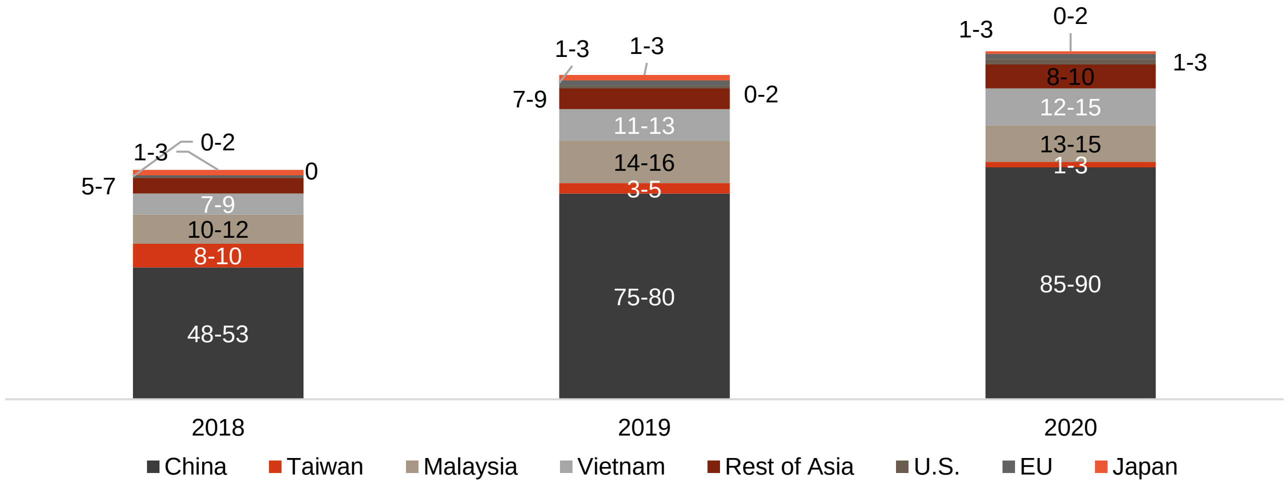
Currently, the PV manufacturing sector is undergoing a number of significant changes aimed at improving the rate of power production from the panels. Players are shifting towards monocrystalline cell technology from the more common multi-crystalline cells and modules and also the industry has made progress towards other high-end technologies such as HJT, TOPCON and n-type, which improve the efficiency and performance of solar panels. The record lab cell efficiency is 26.7% for monocrystalline and 24.4% for multi-crystalline silicon wafer-based technology. The highest lab efficiency in thin film technology is 23.4% for CIGS and 21.0% for CdTe solar cells. The size of wafers used in the panels has increased enabling larger PV module size with power range of +600 W/module.

(Source: Photovoltaics Report by Fraunhofer Institute for Solar Energy Systems, ISE)

The future of the PV modules market greatly depends on technological innovations. As per market consensus, upcoming technologies, such as mono PERC and bifacial modules, are likely to dominate going forward.

The chart below presents country-wise module shipped in the past three years.

Figure 28: Country-wise module shipments



Note: Numbers are estimates based on reports from NREL.

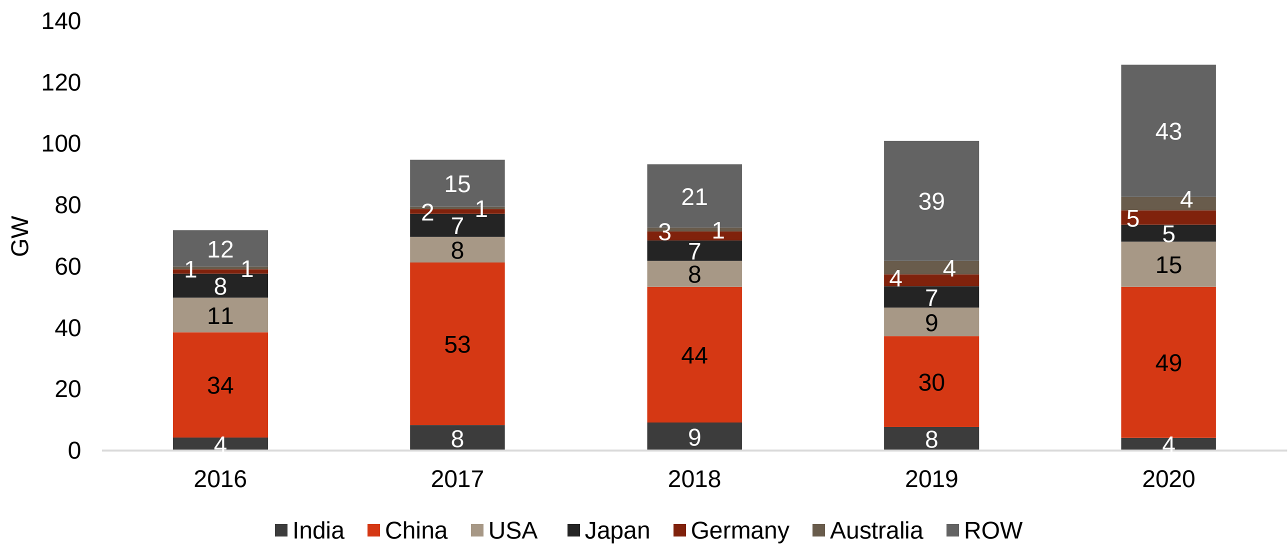
Source: NREL

In 2020, global PV shipments were approximately 132 GW, up 7% from 2019. Of this, 88% were monocrystalline silicon technology, much higher than 35% in 2015, which shows how fast monocrystalline technology is being adopted. China's share in global PV shipments grew from 57% in 2018 to 67% in 2020 while Japan's share declined from 10% to just 1%.

6.2.1 Country-wise consumption

In 2020, global installed solar PV capacity increased ~126 GW or ~22% on-year to 710 GW. The incremental capacity was led by China, the US, Japan, Germany, Australia, and India, which together added ~83 GW or around 66% of total. In terms of cumulative installed capacity as of December 2020, China is the market leader with a total installed base of ~254 GW.

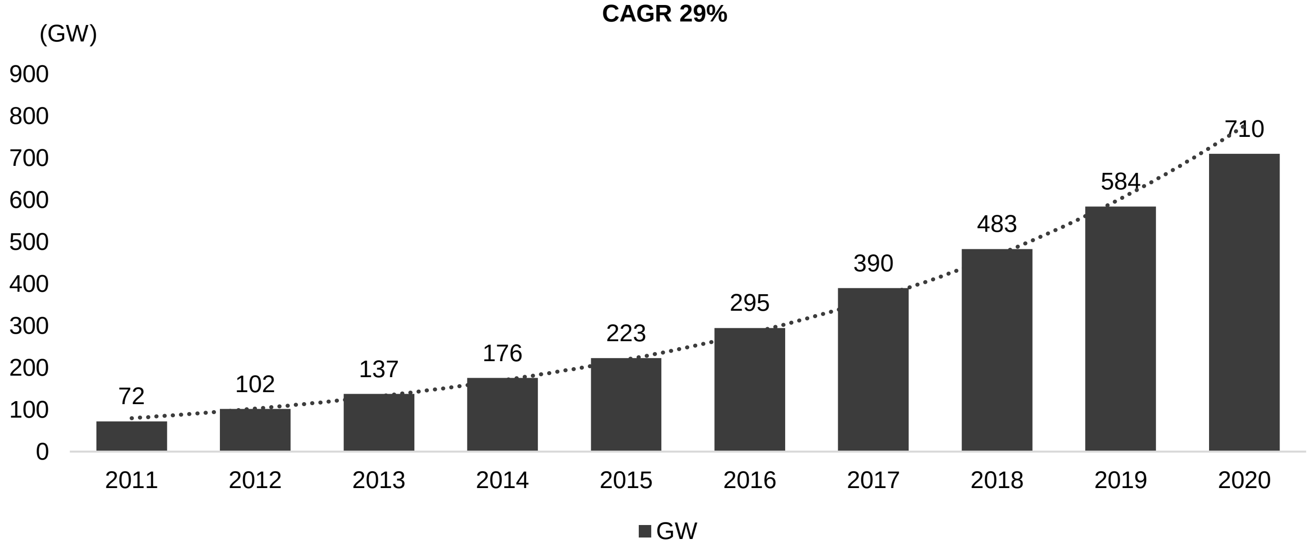
Figure 29: Annual solar capacity additions in major economies



Note: The annual capacity addition numbers pertain to calendar year (Jan-Dec)

Source: IRENA August Statistics 2021; CRISIL Research

Figure 30: Cumulative global installed solar PV power capacity saw 29% CAGR over 2011-2020

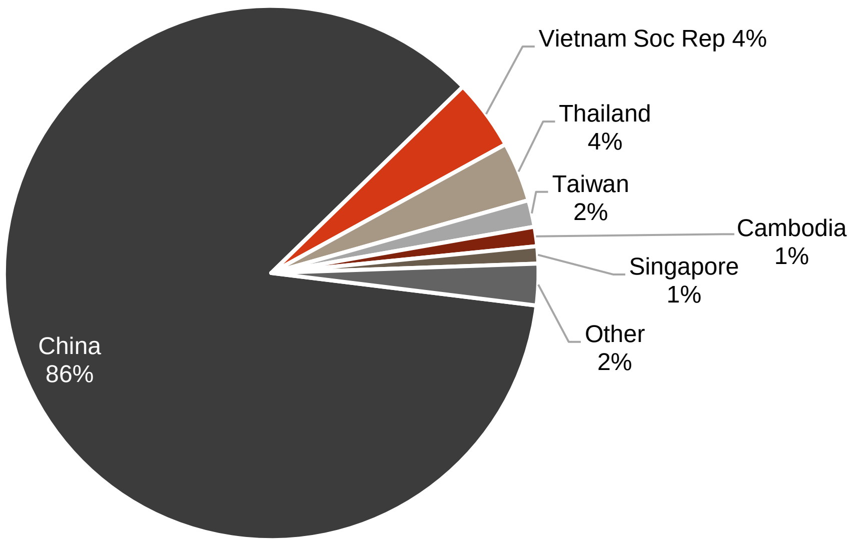


Source: IRENA statistics 2021, CRISIL Research

6.2.2 Country-wise supply to top markets

India

Figure 31: Country-wise module imports by India (2020)

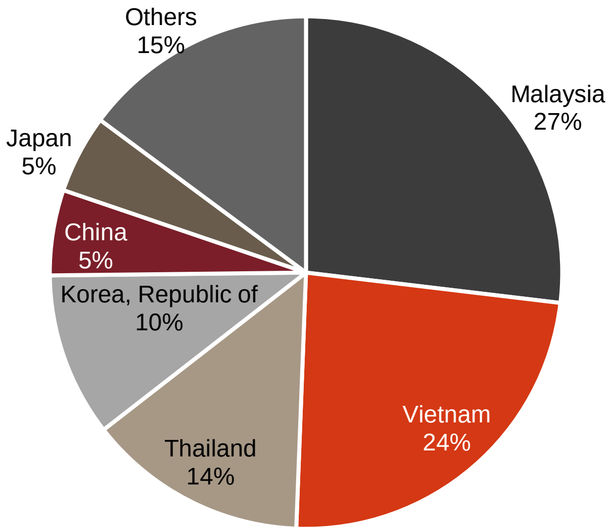


Source: Department of Commerce, CRISIL Research

As seen in the graphic, China continues to dominate India's module imports, followed distantly by Vietnam, Thailand and Taiwan. However, with the imposition of the BCD and government support through PLI, we believe Chinese imports will moderate over the medium to longer term.

The US

Figure 32: Country-wise module imports by the US (2020)



Source: Trade Map, CRISIL Research

In January 2018, the US government implemented Section 201 solar tariffs on imported cells and modules. The trade barriers, comprising multiple layers of tariffs and import quotas, had a material impact in 2018 and early 2019. The 2.5 GW solar cell import cap was enough to support domestic solar module manufacturing, and tariffs on imported modules were high enough to level the playing field.

Import tariffs under Section 201 were effective from February 2018 and are in force till February 2022. The tariff level was set at 30% in the initial year, with a 5% declining rate per year over the four-year tenure of imposition. The tariff imposition did provide an exemption to 2.5 GW of import quantum for PV cells, without any sub-quota for any country. Further, nations eligible under the Generalised System of Preferences (GSP) policy were completely exempted, except for Thailand and Philippines. Bifacial technology-based modules were also exempted.

In October 2020, Section 201 was further amended to:

a) Change the rate of imposition of tariff for the fourth year from 15% to 18%

b) Revoke the exemption for bifacial technology-based modules. However, the revocation of the exemption has been overturned again by the US court of International Trade recently on the ground that it is not as per policy procedures. Further clarity on the impact of this move is awaited.

However, the effectiveness of the trade barriers started to erode in 2019 due to strong demand in the US solar market. Module imports from China were on the rise since January 2019, led by:

- Heightened demand for bifacial solar modules
- The cost-competitiveness of bifacial modules made in China

However, in 2020, import of Chinese PV modules fell precipitously with the removal of bifacial exemption. Malaysia, Vietnam and Thailand were the key exporting regions to the US for these.

Midterm review of the Section 201 imposition also highlighted limited benefit from it. Despite a combination of Section 201 tariffs, anti-dumping and countervailing duties and Section 301 tariffs, also called "the China tariffs", imports have seen a rising trend again.

Having said that, the Section 201 import tariffs on modules from South East Asia have helped narrow the price gap in favour of Indian-make modules and improved their price competitiveness.

Currently, Indian modules priced at $0.33-0.36 per wp cost close to $0.40 -0.41 per wp (factoring additional freight cost of $0.05-0.06 per wp) in the US market.

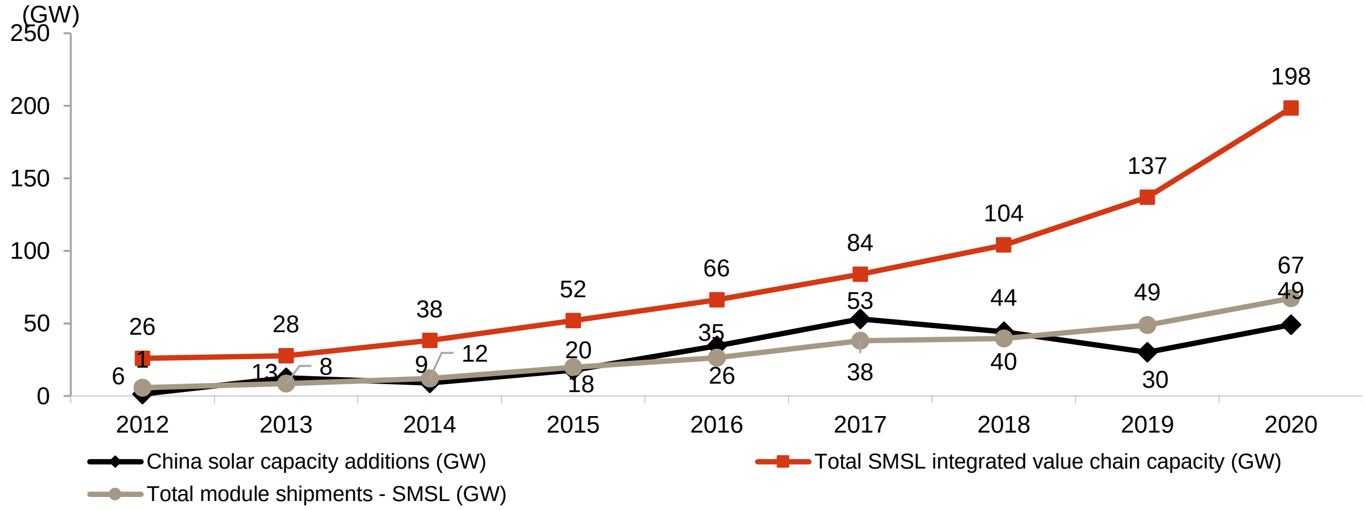
Modules of South East Asian make cost less, but for the import tariffs of 15-18% (a recent court ruling has reversed import tariffs to 15% from 18% earlier). Sans the levy, the cost of Chinese modules for instance would have averaged 0.33-0.35 per wp including freight in CY 2021 YTD (January-November).

Recently on 4th February 2022, Biden administration has extended the Section 201 solar tariffs imposed on the import of modules from China for 4 years. However, the administration increased the import quota for solar cells from 2.5 GW to 5 GW and bifacial modules are exempted from the import tariffs. Additionally, Section 301 tariffs, initiated in CY2019, indirectly raised component costs even for domestic-make modules as products comprising semiconductors produced in China were subject to an additional 25% import duty.

6.3 Chinese solar PV manufacturing sector

China is the largest PV market with installed capacity of 255 GW as of end-2020, which accounts for more than a third of the global capacity. The country dominates in all the sectors of global solar PV production as much of the industry is concentrated there. It accounts for 96% of silicon wafers, 83% of PV cells and 76% of polysilicon production. In 2020, the country added 49GW solar capacity additions.

Figure 33: Growth of key Chinese module makers



Note: Companies considered are JA Solar, Jinko Solar, Trina Solar, Hanwha Q and Canadian Solar, accounting for ~70% of global module capacity.

Source: Company filings, CRISIL Research

6.3.1 Indian solar PV manufacturing market

Historically, imported modules have dominated the Indian solar PV market. This section below explains how the domestic and export markets for Indian modules have evolved and how are they expected to grow in the medium term.

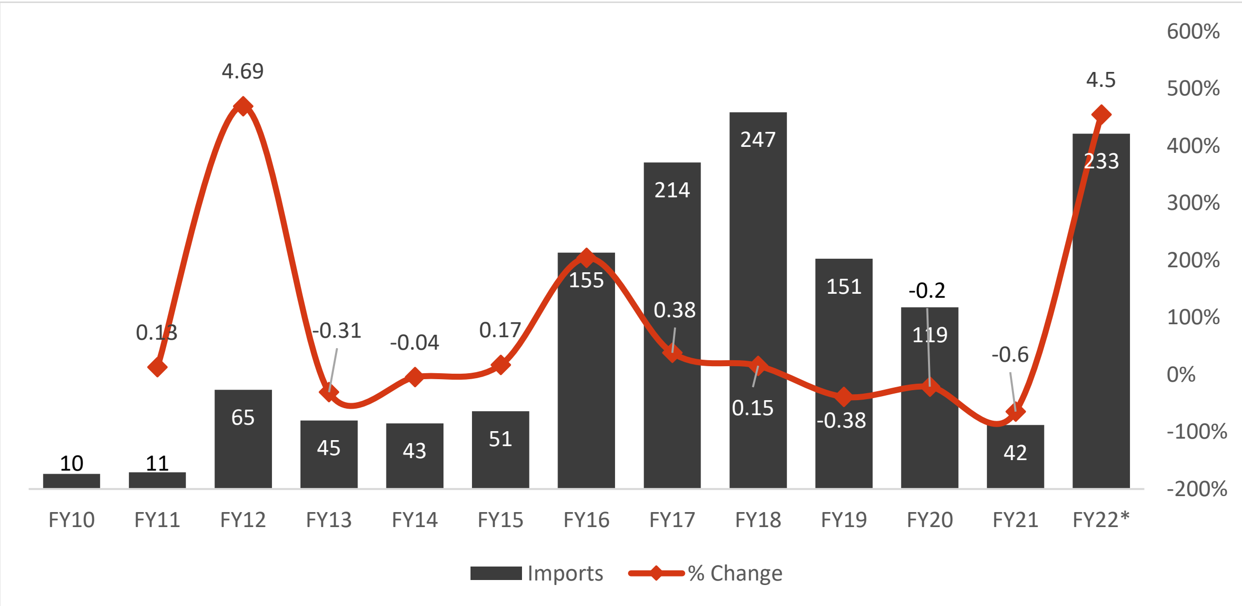
Import dependence of the domestic PV market

During 2000-2010, Indian cell and module manufactures were as competitive as their global counterparts. They exported most of their products as overseas demand was robust. Players such as Moser Baer, Tata BP Solar (now Tata Power Solar), Jupiter Solar Power, and Indo-solar made substantial investments in solar cells and modules manufacturing. However, the Indian market still relied heavily on imported modules that were cheaper and more efficient than domestic modules.

As of December this fiscal, India had ~3.2 GW installed capacity of solar cells and ~13 GW of modules. Even though the country is one of the top 10 solar module producers, it is far behind its bigger competitor China. India imports 80-85% of solar modules as the country has inadequate capacity and technology. In last fiscal, imports declined 65% on-year to Rs 42 billion (from Rs 119 billion the previous fiscal). This was largely because of the pandemic that slowed down project execution, frequent policy changes, and mid-year change in duty rate, which delayed ordering.

The import has surged by 455% in April-December fiscal 2022 compared to fiscal 2021 due to the no-duty window till 1st April 2022. The module import from April-December 2021 has reached Rs 233 billion.

Figure 34: India's solar module imports (Rs billion)

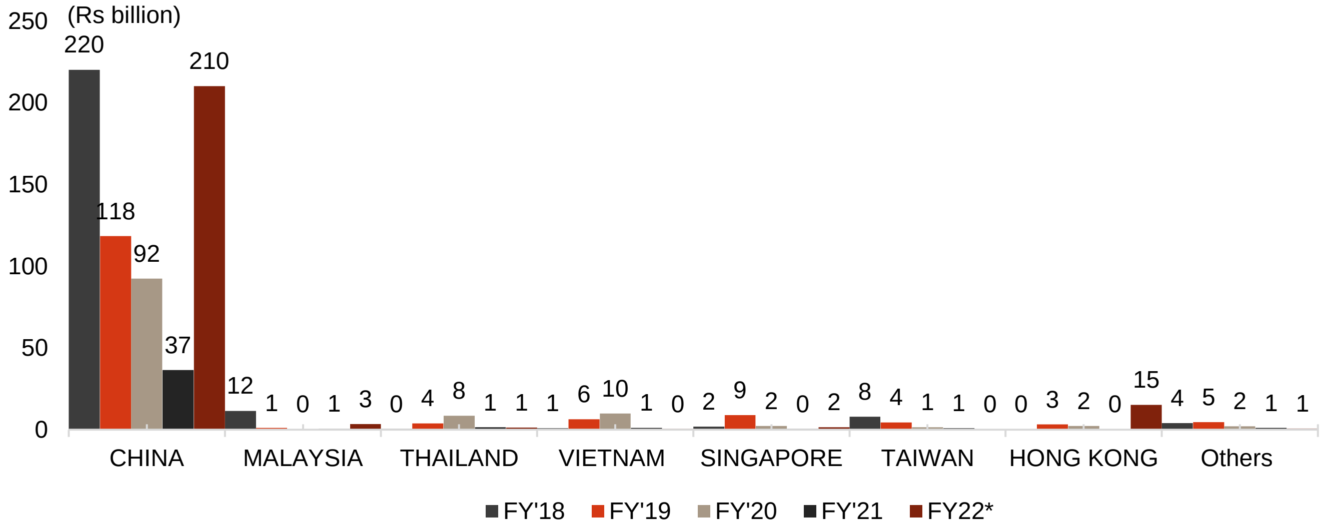


Source: Ministry of Commerce, CRISIL Research

Note: FY22 represents April - December 2021.*

China continues to be the largest module exporter to India, followed by Malaysia. However, the BCD and PLI schemes are expected to improve demand for domestic modules in the future. Until then the country will continue to be dependent on imports to meet most of the domestic demand due to the technological advantage that foreign players enjoy.

Figure 35: Country-wise module imports



Source: The Ministry of Commerce, CRISIL Research

Note: FY22 represents April - December 2021.*

Total demand of 11-13 GW expected for domestic industry over fiscals 2022-2024

CRISIL Research expects 64-66 GW of solar PV capacity additions over fiscals 2022-2026. However, imported modules will continue to hold a significant share of the Indian module market during fiscals 2022-2024. This is because, scaling up of domestic capacities, especially across integrated supply chain until the polysilicon stage, will take time. Also, marginal cost competitiveness will improve with the imposition of BCD and PLI in the current scenario.

CRISIL Research expects Indian module manufacturers to benefit from a domestic demand potential of 9-11 GW over fiscals 2022-2024, mainly stemming from the CPSU scheme, solar rooftop, KUSUM scheme, and in-house solar project development. However, post BCD levy, project developers may tie up with domestic module manufacturers to import cell at 25% duty for local assembly of modules to avoid 40% duty levied on panels and, rather face 25% duty levied on imported cells. With this as a monitorable, demand for domestic modules may increase to 15 GW over the same period.

Export potential is seen at 1.8-2.4 GW. However, export potential could be higher due to the recent US ban on solar panel materials originating from the Xinjiang province & higher global renewable installations driven by the stronger policies and targets under CoP-26, which remain key monitorables. Besides the U.S. ban on import of panel material originating from Xinjiang province, diversifying sourcing policies to consider origin destinations apart from China would be key positive drivers for Indian-make modules. This will be supported by domestic expansion of capacity and newer technology lines being set up to cater to incremental demand. Also, on February 4, 2022, the Biden administration extended the Section 201 tariffs imposed on the import of solar modules from China for four years. This is a positive growth driver for domestic module exports.

As per secondary reports, over the next four to five years, the European Union ("EU") and U.S. regions have a potential of adding up to 35-40 GW and 25-30 GW of solar energy respectively each year while the IEA pegs this at around 20-25 GW each annually. Both regions would be a key driver for export demand from India. Exports will also be further supported by continued demand from Africa, EU and Middle-East.

Government schemes and solar rooftop installations will be key sources of domestic demand. The government in February 2019 extended the CPSU scheme to 12 GW from 1 GW to provide impetus to the domestic solar module manufacturing industry (with a DCR clause). Moreover, the rooftop segment is expected to support demand, as ~4 GW of residential projects under the phase-II of the Solar Rooftop Programme have been mandated to procure domestic modules. Another government scheme, KUSUM, which aims to add 30.8 MW by December 2022, is also expected to drive demand. It is mandatory to procure domestic modules for all the capacity to be set up under the scheme.

To provide support to domestic manufacturing, the MNRE has issued 'Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019' and 'Guidelines for Enlistment under Approved Models & Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration) Order, 2019'. These orders provide for enlisting of models and manufacturers of solar PV cells and modules, after inspection of the manufacturing facilities.

Further, on March 10 last fiscal, the MNRE issued an ALMM list for solar PV modules, i.e. List I - List of Models and Manufacturers for Solar PV Modules. In the office memorandum, it was clarified the ALMM order with respect of List-I (Modules) or List–II (Cells) will be applicable only for projects for which bids were concluded after 30 days of publication of the list. Accordingly, the ALMM order with respect to List-I (Modules) will be applicable on all such bids whose last date of bid submission is on or after April 10 this fiscal. This may further drive the demand for domestic modules with empanelment of only domestic makers as of December 2021. Further, on January 13, 2022, the government of India notified that only the models and manufacturers included in this list will be eligible for use in Government Projects/ Government assisted Projects/ Projects under Government Schemes & Programmes/ Open Access I Net Metering Projects, installed in the country, including Projects set up for sale of electricity to Government under the Guidelines issued by Central Government under section 63 of Electricity Act, 2003 and amendment thereof.

CRISIL Research believes that BCD and PLI together would drive incremental domestic demand. Also, both these would result in domestic modules becoming marginally cost competitive than the imported ones. CRISIL Research, therefore, forecasts demand of 11-13 GW to be met via domestic modules during fiscals 2022-2024.

Export potential of 1.5-2.5 GW over fiscals 2022-24 for domestic manufacturers

In fiscal 2021, exports declined 32% on-year from Rs 15.1 billion a year ago to Rs 5.7 billion. In fiscal 2020, export demand was driven by Indian manufacturers garnering more demand in the US market (after US imposed a tariff on Chinese photovoltaic products). Apart from the US, export demand was driven by European countries, such as Belgium, and African nations.

India's export to the US continued to be strong as it accounted for 82% of the total export share in fiscal 2021. South Africa, the UAE and Belgium accounted for 3%, 1% and 0.4%, respectively.

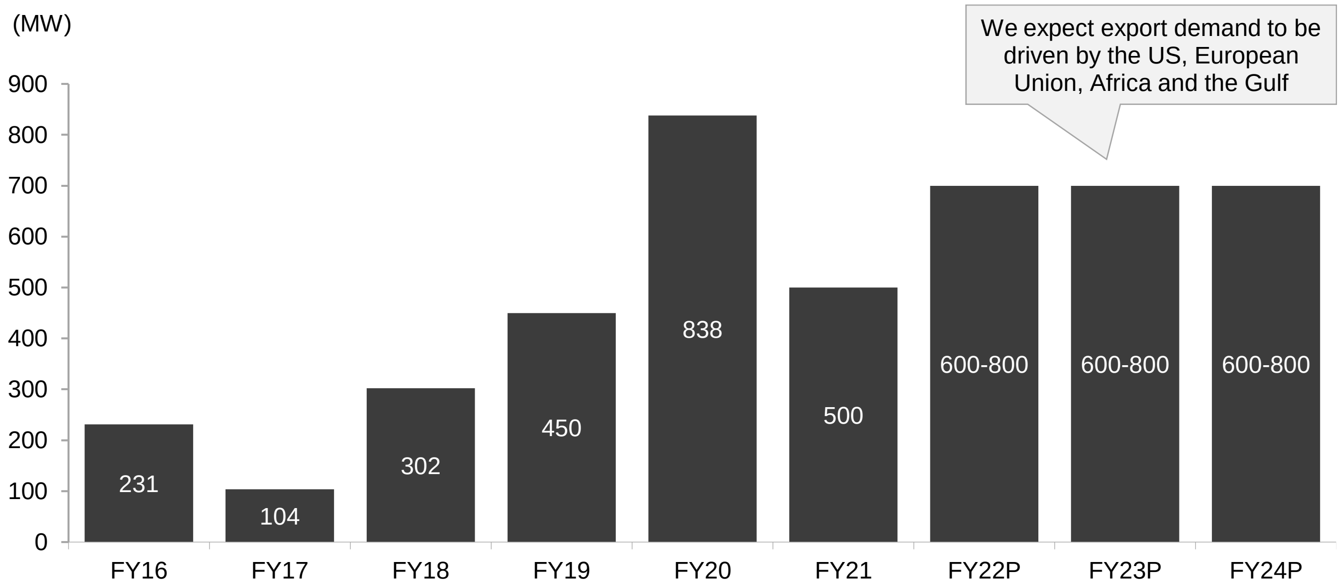
Going forward, the US ban on import of panel material originating from Xinjiang province and diversifying sourcing policies to consider origin destinations apart from China would be key positive drivers for Indian-make modules. This will be supported by domestic expansion of capacity and newer technology lines being set up to cater to incremental demand. Also, on 4th Feb 2022, Biden administration extended the Section 201 tariffs imposed on the import of solar modules from China for 4 years which would be a positive growth driver for domestic module exports.

As per secondary reports, over the next 4-5 years, the EU and US regions have a potential of adding up to 35-40GW and 25-30 GW of solar energy respectively each year while the IEA pegs this at around 20-25 GW each annually. Both the regions would be a key driver for export demand from India Exports will also be further supported by continued demand from Africa, EU & Middle-East.

Further, in light of the rapidly declining module prices, several Chinese firms had withdrawn from the EU MIP arrangement, preferring instead to pay the high duties. But the MIP arrangement has been removed from September 3, 2018, by the EU in interest of the new RE targets set by the Commission. This brings the top China origin players back into competition, which would compromise the market share gained by Indian module makers over the past few years in the region.

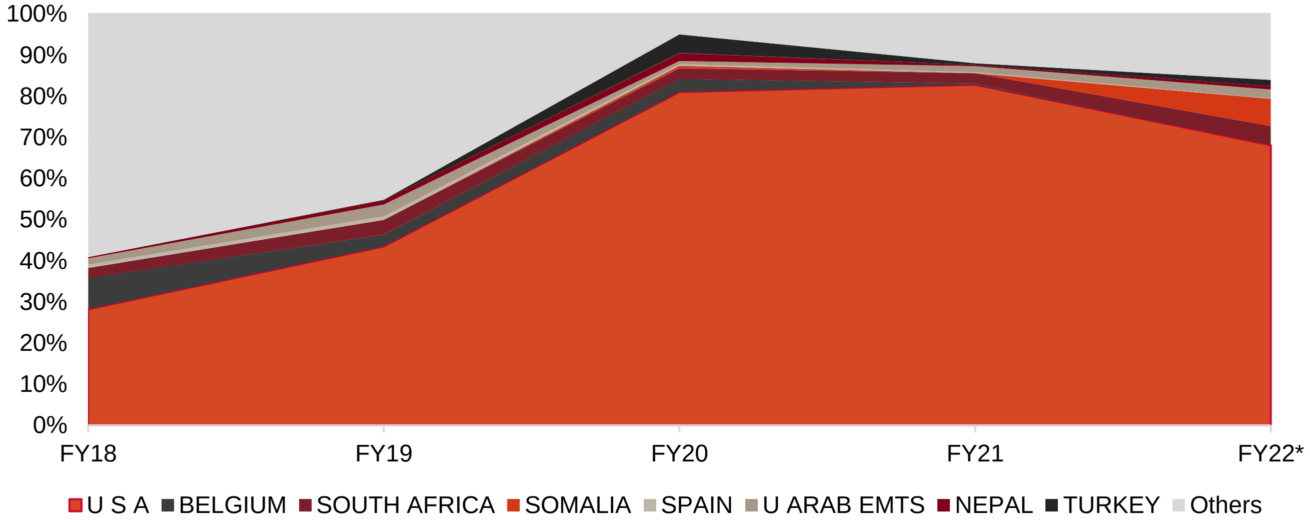
CRISIL Research expects exports to be in the range of 1.5-2.5 GW for domestic-make modules.

Figure 36: Export trend of solar modules



Source: Department of Commerce, CRISIL Research

Figure 37: Key export destination for India manufacturers



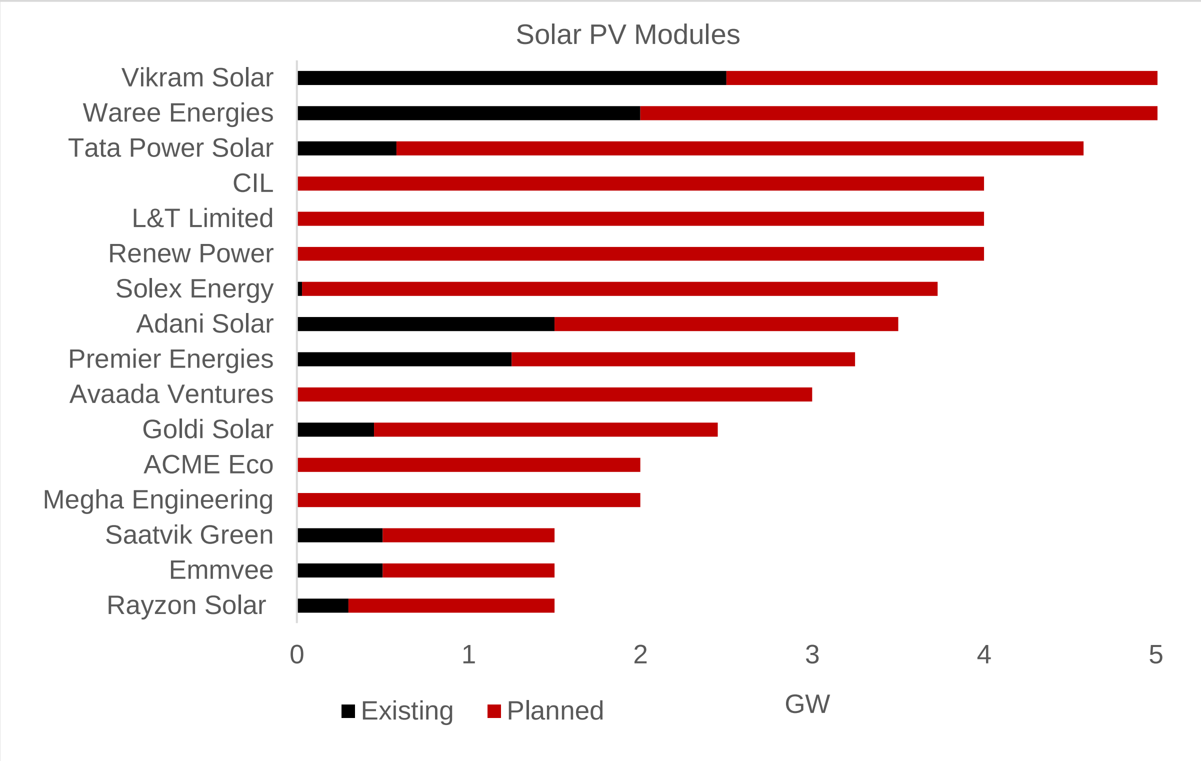
Source: Department of Commerce, CRISIL Research

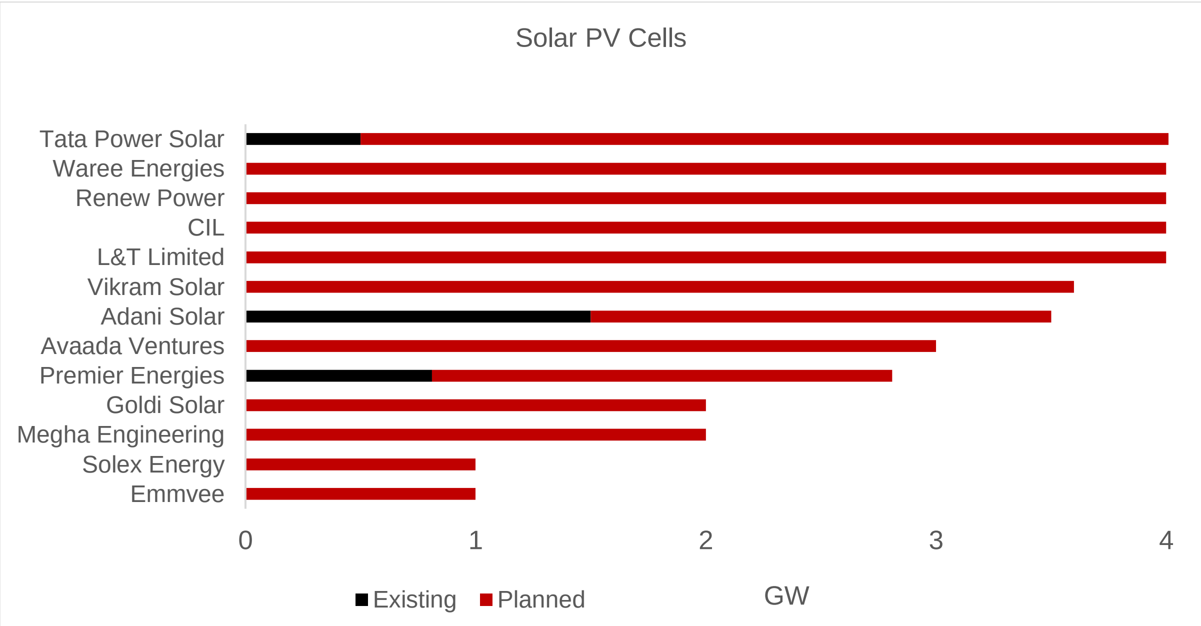
Supply assessment

Robust capacity expansion in domestic cells & modules announced by various players post PLI

To boost domestic production and reduce imports, the central government initiated the PLI scheme with a target of 8-10 GW capacity addition, as well as introduced Basic Custom duty (BCD) on imports. Considering the favourable environment, various Indian solar PV manufacturers have planned for capacity expansion in the segment. As of December 2021, 40-45 GW module and 35-40 GW cell capacity expansion plans have been announced by various players. Also, with announcement in Union Budget 2022 on the enhancement of the outlay under the PLI scheme for high efficiency modules from Rs 45 billion to Rs 240 billion, the segments could see a further boost. This could mean a potential 30-35 GW of integrated cell to module capacities being added by fiscal 2024.

Figure 38: Existing and planned capacity additions in module & cell manufacturing capacity





Note: The planned expansions above are considering the enhancement of PLI to Rs 24,000 crore
Source: Company websites, CRISIL Research

We expect the domestic cells and modules installed base to gain traction with robust expansion plans driven by PLI. We estimate domestic cells and modules capacity to reach ~35-40 GW and ~50-55 GW, respectively, by fiscal 2024.

Demand-supply gap

In the longer term, with renewed targets by India of 500 GW of non-fossil energy base by 2030 taken at the COP 26 summit, clean energy is set to witness a significant policy push. While the fuel-wise target bifurcation of the 500 GW has not been announced yet, considering the emphasis on 280 GW of solar energy as detailed under the previous target of 450 GW by 2030, solar energy is also expected to get special emphasis from the government in achievement of this target. Considering the installed base of ~50 GW as on January 2022 for solar energy, and a target of 280 GW by 2030, a potential 230 GW of solar energy may be driven over the next nine years.

Further, solar projects typically install a higher capacity of modules compared with the rated capacity (known as DC overloading) to improve the generation profile of the project, leading to higher module demand. If such 210-230 GW worth of solar projects are to be achieved and assuming the current practice of approximately 1.4x module capacity installed compared with 1x of solar project rated capacity, approximately 300-320 GW of module demand may potentially arise over the next nine years. Further, assuming a 70-75% utilisation factor for module manufacturing, this would mean a potential requirement of 460 GW of module manufacturing rated capacity to service the abovementioned demand. It would imply that on average, annual demand of modules will be at ~50 GW capacity.

With robust expansion plans announced by key manufacturers supported by PLI, the domestic module capacity is expected to be sufficient to meet demand. However, the preference for domestic module is a key monitorable, with hurdles of lower efficiency, lower preference in terms of technology, and cost disadvantages to be equally overcome.

Figure 39: Estimated supply of cells

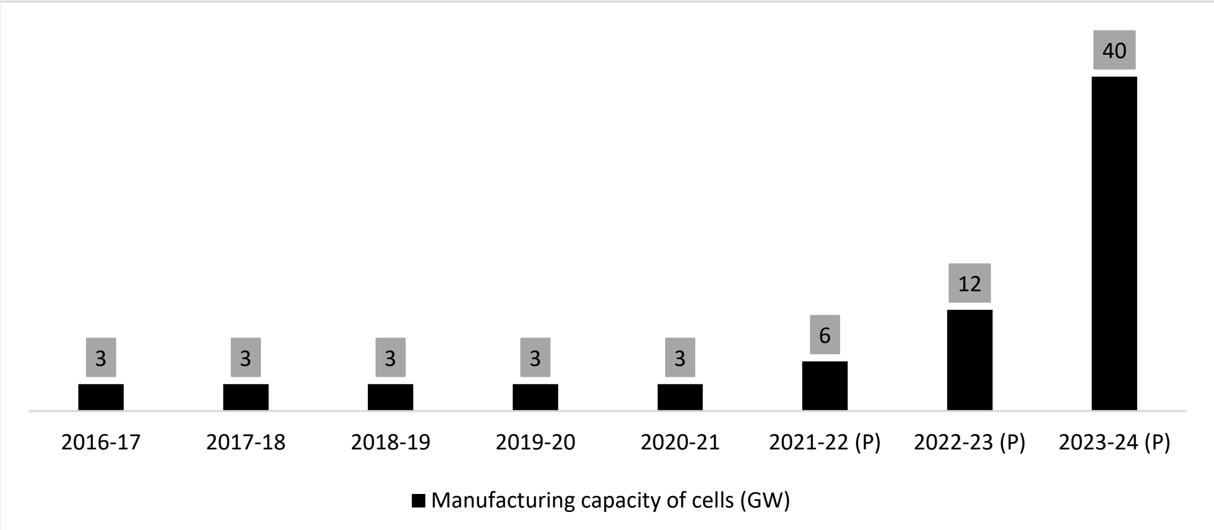
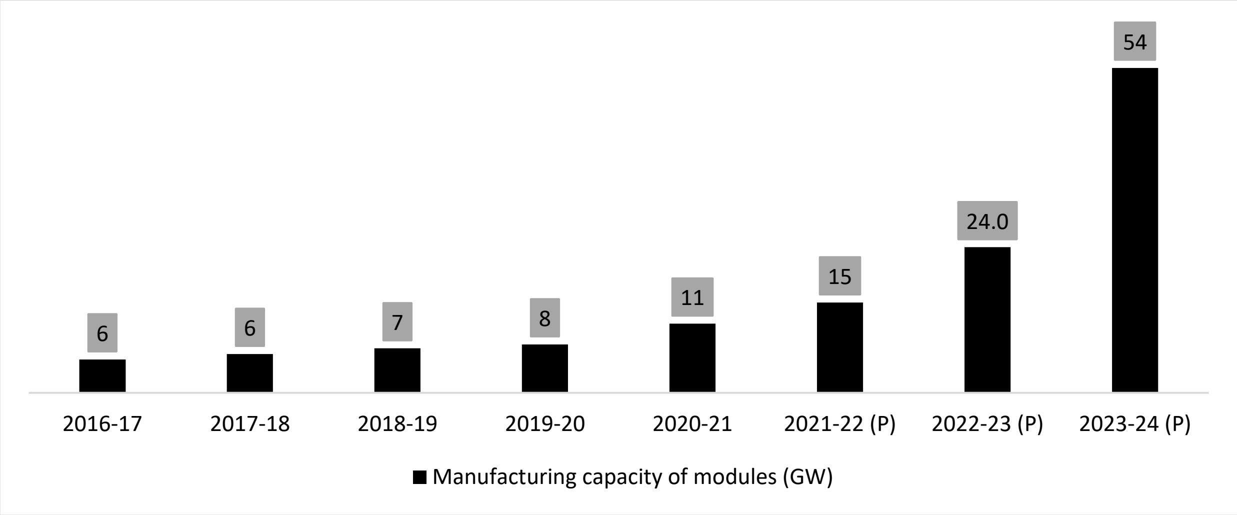
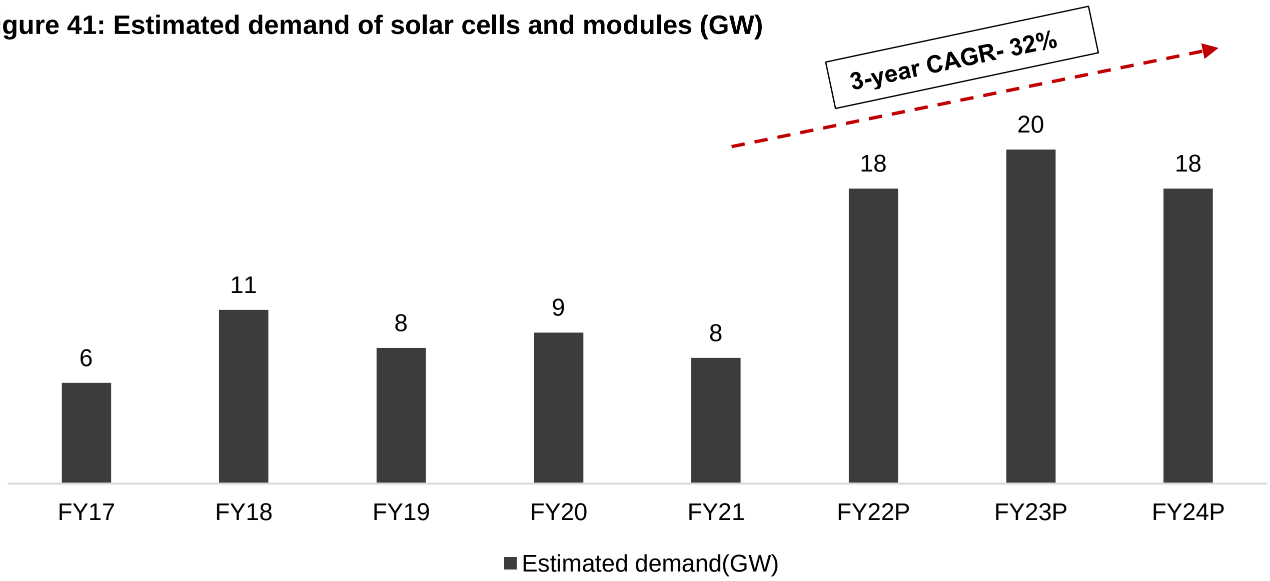


Figure 40: Estimated supply of modules



Note: The manufacturing capacity outlook considers PLI support of Rs 24,000 crore announced recently by the Union Minister of Power.
Source: CRISIL Research

Figure 41: Estimated demand of solar cells and modules (GW)



Note 1: Factors demand based on domestic solar capacity additions and exports for the period. Domestic capacity additions are also adjusted to factor in additional module demand arising from DC side overloading, as is typical of solar projects. This demand can be serviced both from domestic production as well as imports.
Note 2: The demand for cells is estimated to be similar to the estimated demand for modules.
Source: CRISIL Research

From the above figure, considering annual demand of 18-20 GW in FY24, demand is expected to grow at 3-year CAGR of 32% from fiscal 2021 to fiscal 2024.

Provision of basic customs duty (BCD)

The *Atmanirbhar Bharat* initiative has geared up the country towards scaling up domestic manufacturing. Scaling up domestic solar manufacturing would also enable India to export solar cells and modules. This would also provide other countries with an alternative avenue for procuring solar cells and modules. The proposal of MNRE to impose BCD on solar cells and modules (without grandfathering of bid out projects) was agreed to by the Ministry of Finance. Thereafter, in March 2021, MNRE issued office memorandum to impose BCD on solar PV cells and modules at a rate of 25% on solar PV cells and 40% on solar modules with effect from April 1, 2022. The Union Budget 2022 ratified the increased custom duty impositions to provide support to the domestic solar manufacturing industry. The government imposed 25% basic custom duty (BCD) on solar cells & 40% on solar modules from 1st April, 2022. Post a surcharge of 10%, this would take the total taxation to 27.5% and 44% respectively for the imported produce of these two components. Accordingly, the duty levy could result in a maximum gap between imported and domestic module pricing of up to 44% and in cells of up to 27.5%, supporting sustainability of domestic produce.

PLI scheme — National Programme on High Efficiency Solar PV Modules

On November 11, 2020, the government introduced the PLI scheme for 10 key sectors to enhance India's manufacturing capabilities and exports under its *Atmanirbhar Bharat* initiative.

One of the 10 sectors for which PLI was approved is high efficiency solar PV modules, for which MNRE has been designated as the implementing ministry. The financial outlay for the PLI scheme is Rs 45 billion over a five-year period. However, with the announcement by the Union Minister for Power on enhancement of the outlay under the PLI scheme for high-efficiency modules from Rs 45 billion to Rs 240 billion, the segments could see a further boost. This could mean a potential 30-35 GW of integrated cell-to-module capacities being added by fiscal 2024.

Beneficiaries of the PLI scheme are selected through a bidding process. In order to qualify, manufacturers have to set up a plant of minimum 1,000 MW capacity. They also have to fulfil the following minimum performance parameters:

- Minimum module efficiency of 19.50% with temperature coefficient of Pmax better than -0.30% per degree Celsius, or
- Minimum module efficiency of 20% with temperature coefficient of Pmax equal to or better than -0.40% per degree Celsius

The reverse auction under the PLI scheme was held on October 2021. Bidders fulfilling the minimum conditions have been shortlisted under the same.

The preliminary phase of bidding has already been undertaken with the following results:

Table 6: List of bidders under PLI for solar PV manufacturing

No.	Bidder	Bid capacity (MW)	Extent of integration	Marks for bid capacity	Marks for extent of integration	Total marks	PLI amount bid (Rs billion)
1	Adani Infrastructure Pvt Ltd	4,000	Stage-I to IV	50	50	100	36
2	Reliance New Energy Solar Ltd	4,000	Stage-I to IV	50	50	100	19.17
3	Shirdi Sai Electricals Ltd	4,000	Stage-I to IV	50	50	100	18.75

No.	Bidder	Bid capacity (MW)	Extent of integration	Marks for bid capacity	Marks for extent of integration	Total marks	PLI amount bid (Rs billion)
4	FS India Solar Ventures Pvt Ltd	3,009	Stage-I to IV	40	50	90	17.52
5	Coal India Ltd	4,000	Stage-II to IV	50	35	85	13.4
6	Larsen and Toubro Ltd	4,000	Stage-II to IV	50	35	85	13.6
7	Renew Solar (Shakti Four) Pvt Ltd	4,000	Stage-II to IV	50	35	85	19.5
8	Tata Power Solar Systems Ltd	4,000	Stage-III to IV	50	20	70	15
9	Waaree Energies Ltd	4,000	Stage-III to IV	50	20	70	23.4
10	Vikram Solar Ltd	3,600	Stage-III to IV	45	20	65	12.85
11	Avaada Ventures Pvt Ltd	3,000	Stage-III to IV	40	20	60	8.78
12	ACME Eco Clean Energy Pvt Ltd	2,000	Stage-III to IV	30	20	50	6.25
13	Megha Engineering and Infrastructure Ltd	2,000	Stage-III to IV	30	20	50	3.33
14	Premier Energies Ltd	2,000	Stage-III to IV	30	20	50	4.99
15	EMVEE Photovoltaic Power Pvt Ltd	1,000	Stage-III to IV	20	20	40	3.49

Source: IREDA, CRISIL Research

The announcement to enhance the PLI outlay amount from Rs 45 billion to Rs 240 billion would mean the enlistment of the entire above capacity under the PLI scheme, providing a significant boost to capacity additions to the segment.

Modified Special Incentive Package (M-SIPS)

The government offers a financial subsidy of 20% to solar module, cell and wafer manufacturers located in special economic zones (SEZs), and 25% to those in non-SEZs under the Modified Special Incentive Package Scheme (M-SIPS). Launched by the Ministry of Electronics and Information Technology in 2012, the scheme offers subsidies for capital and operating expenditure. Initially, the scheme was open until 26 July 2015 and later extended until December 2018.

The key features of the scheme are:

- Incentives for both new units and expansion of existing units
- Incentives for a period of 5 years from the date of approval of application
- Incentives for 44 categories/verticals across the value chain (including assembly, testing, packaging and accessories, chips, components)
- Minimum investment threshold for each product category/vertical varies from Rs 1 crore for manufacturing of accessories to Rs 5,000 crores for semiconductor wafer fabrication units

The scheme was revised in July 2015 by

- Extending it from July 2015 to December 2018
- Expanding it to 15 new product categories
- Easing the application process.
- Allowing disbursement of incentives on a quarterly basis vs annual basis previously
- Opening it up across the country

Due to these amendments, several manufacturers applied for capex support under the Special Incentive Package Scheme (SIPS) and the Modified Special Incentive Package Scheme (M-SIPS). Adani Solar set up a vertically integrated 1.2 GW solar photovoltaic manufacturing facility under the scheme, along with research and development (R&D) facilities within an electronic manufacturing cluster (EMC) facility in Mundra SEZ.

Finally, the scheme was revised again in January 2017 to expedite the investments in the sector extending the application deadline till December 2018.

Hence, M-SIPS played an important role towards achieving the government's goal of being self-reliant in solar component manufacturing.

Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS)

The Government of India (GOI) has given high priority to electronic hardware manufacturing as it has been a key pillar for both 'Make in India' and 'Digital India' programmes.

The National Policy on Electronics (NPE 2019) aims to position India as a global hub for electronic system design and manufacturing. In line with this vision, the government has introduced the Scheme for Promotion of Manufacturing of Electronic Components & Semiconductors (SPECS).

Notified on April 1, 2020, key incentives and guidelines of the scheme are given below:

- Financial incentive of 25% on capital expenditure for manufacturing of specified components and semiconductors that come under the supply value chain of electronics manufacturing
- Capex for plant, machinery, equipment, associated utilities, and technology including R&D (land & building excluded) will eligible under the scheme
- Incentives for investments in new units and expansion of capacity/modernisation and diversification of existing units
- The tenure would be 3 years for filling applications and 5 years for investments
- The investment threshold will be Rs 5 crore to Rs 1,000 crore

The government's estimated investment outlay under SPECS is Rs 3,252 crore. Further, the government updated the list of goods eligible for SPEC incentives on 30 September 2021 to include solar polysilicon, solar cells and solar wafers.

This move would further support domestic manufacturing of solar components and the Make in India initiative of the government.

Incentives offered by states for manufacturing

Vikram Solar has a facility to manufacture1.3 GW of solar modules in Chennai, Tamil Nadu. Hence, it would be eligible for the incentives offered by the government of Tamil Nadu for electronic hardware manufacturing:

- Special incentives for MSMEs that include capital subsidy, interest subvention, low tension power tariff subsidy, generator subsidy, assistance for obtaining intellectual property and assistance in obtaining certifications
- Capital subsidy up to 30% based on location, investment size, and employment generation
- Subsidy on land lease rate up to 50% for land acquired in government owned industrial parks and private land in C districts
- 50% stamp duty exemption for land purchased / taken on lease in government-owned industrial parks or private land in A, B, and C districts
- Training subsidy of Rs 4,000 (Rs 6,000 for women) per employee per month up to 6 months
- Interest subsidy up to 5% for a period up to 6 years
- Electricity tax exemption for 5 years
- Environmental Protection Infrastructure subsidy: Individual manufacturing units would be eligible for an environment protection infrastructure subsidy of Rs 30 lakh or 25% of capital cost for setting up effluent treatment plants (ETP) and / or hazardous waste treatment storage and disposal facilities (HWTSDF)
- The subsidy for intellectual capital and enhanced quality certification: 50% subsidy on the expenses incurred for patent applications and 50% subsidy on the expenses incurred for quality certifications
- Also, in Union Budget 2022, government announced to replace the existing law governing SEZ's with a new legislation & reforms in custom administration of these zones which will improve the ease of doing business & promote further growth & export

CPSU scheme

Under the National Solar Mission (NSM), the central government is incentivising CPSUs to install solar power under the VGF mechanism. Under Batch V of NSM, it has already allocated ~1 GW. Further, the government has mandated large public sector institutions, such as Indian Railways, defence establishments, Airports Authority of India, and metro corporations, to substitute part of their power consumption with solar power.

Subsequently, MNRE launched CPSU Scheme Phase-II for setting up 12,000 MW grid-connected solar PV power projects by CPSUs/ state PSUs/ government organisations, with VGF support for self-use or use by the government/ government entities, either directly or through discoms. The aim of the scheme is to set up solar PV projects using domestic cells and modules in a WTO-compliant manner to facilitate national energy security and environment sustainability.

Year-wise allocation targeted:

- Fiscal 2020: 4,000 MW
- Fiscal 2021: 4,000 MW
- Fiscal 2022: 4,000 MW

Government support: Although VGF was mentioned as 7 million/ MW in scheme, it was reduced to 5.5 million/ MW in CPSU tender dated 29th January 2021 vide corrigendum dated 14th May 2021; actual VGF is decided through bidding for required VGF.

Mode of allocation: Bidding through SECI on VGF required

Usage of solar power: Self-use or use by other government organisations through discoms

Domestic content requirement: Domestically manufactured solar PV cells and modules

Usage charges:

July 3, 2019	April 13, 2020	May 10, 2021
Rs 3.50/unit	Rs 2.80/unit	Rs 2.45/unit

MNRE subsequently entrusted IREDA with the task of handling the scheme on its behalf, and the responsibility of selecting solar power developers through VGF-based bidding.

PM KUSUM

Vide its notification dated July 22, 2019, MNRE issued guidelines for implementation of the Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) scheme (detailed previously).

Component-A and Component-C will be implemented initially as pilots for 1,000 MW capacity and 0.1 million grid-connected agriculture pumps, respectively, and Component-B will be implemented full-fledged, with total central government support of Rs 190 billion.

Post successful implementation of the pilot projects, these will be scaled up with necessary modifications, based on learnings from the pilot phase, with total central government support of Rs 153.85 billion.

All three components of the scheme aim to add solar capacity of 25,750 MW by 2022, with total central financial support of Rs 344.22 billion.

Subsequently, MNRE, in November 2020, scaled up and expanded the PM KUSUM scheme to 30.8 GW

Solar manufacturing-linked tenders

SECI has issued tenders for setting up ISTS-connected solar PV projects linked with setting up solar manufacturing plants in India on a build-own-operate basis.

SECI will enter into a PPA with successful bidders for purchase of solar power for 25 years. SPDs selected by SECI will be required to set up solar manufacturing capacity over a maximum period of 2-4 years, depending on the capacity. SPDs will be selected through tariff-based competitive bidding followed by e-reverse auction.

Rooftop solar (RTS) projects and domestic content requirement (DCR)

For solar projects proposed to be developed under NSM, DCR was mandated. However, post the WTO ruling, DCR was restricted only to tenders where the government is the procurer. The central government, in December 2015, approved the 'Grid Connected Rooftop and Small Solar Power Plants Programme' to install 4,200 MW of RTS plants in the country by fiscal 2020, of which 2,100 MW was through central financial assistance (CFA) and the balance 2,100 MW was without CFA.

The RTS projects sanctioned under this programme are under implementation by state nodal agencies, SECI, PSUs, and other government agencies.

Subsequently, the central government, in February 2019, approved Phase-II of the Grid Connected Rooftop and Small Solar Power Plants Programme for achieving cumulative capacity of 40 GW RTS plants by December 2022. In Phase-II, it has been decided to implement the programme by making discoms and their local offices nodal points for implementation of the RTS programme. The major components of Phase-II of the programme are as follows:

Component A: CFA* to the residential sector – 4 GW

- CFA @40% for capacity up to 3 kWp
- CFA @20% for capacity beyond 3 kWp and up to 10 kWp
- CFA @20% for GHS/RWA capacity up to 500 kWp (limited to 10 kWp per house and total up to 500 kWp)

Domestic-manufactured modules and solar cells need to be deployed.

* CFA shall be on percentage of benchmark cost of MNRE for the state/ UT, or lowest of the costs discovered in the tenders for that state/ UT in that year, whichever is lower

Implementing agency: discoms

Component B: Incentives to discoms

Through schemes such as CPSU Scheme Phase-II, PM-Kusum and Grid-Connected Rooftop Solar Programme Phase-II, DCR of over 36 GW has been mandated, which will promote domestic manufacturing.

MNRE also clarified that DCR will be applied to all future projects implemented under NSM and to all PPAs that have already been executed, may be executed in the future, or are in the process of finalisation.

Approved list of models and manufacturers

To ensure reliability of solar PV manufacturers, while ensuring consumer interest and assuring larger energy security for the country, in January 2019, MNRE issued an Order for Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirements for Compulsory Registration). The order provides for enlisting of eligible models and manufacturers of solar PV cells and modules, and publishing of the 'Approved List of Models and Manufacturers' (ALMM). Subsequently, on January 13, 2022, the government of India notified that only the models and manufacturers included in this list will be eligible for use in Government Projects/ Government assisted Projects/ Projects under Government Schemes & Programmes/ Open Access I Net Metering Projects, installed in the country, including Projects set up for sale of electricity to Government under the Guidelines issued by Central Government under section 63 of Electricity Act, 2003 and amendment thereof. In March 2021, MNRE issued the ALMM for solar PV modules, i.e., List I – the list of models and manufacturers for solar PV modules, and mandated that the list will be applicable for all bids whose last date of bid submission is on or after April 10, 2021. None of the foreign players are currently accepted as a part of the list. Hence, the absence of any foreign players in the list can aid domestic manufacturers to participate in various government schemes aimed at developing the solar industry in India more aggressively.

There are also state level incentive programs aimed to boost manufacturing of solar equipment. These incentives range from providing land at concessional rate to waiving of state level taxes. For example, Rajasthan allocates land 50% concessional rate in industrial area/ any other area, provides 100% exemption from stamp duty, 10 years exemption from electricity duty, Investment subsidy on SGST to solar energy equipment manufacturers, Employment subsidy as per RIPS; reimbursing of 90% of contribution paid for employees for 7 years.

7 Solar EPC market

Solar EPC (engineering, procurement and construction) contractors are engaged in on-ground execution of solar projects. These companies carry out detailed engineering and design for the plant, execute plans, procure necessary materials, and employ expertise needed to commission the power plant.

With bid tariffs falling rapidly in the Indian solar energy segment along with rising competition driven by higher installations in the market, EPC players have also felt the burden of falling margins, as developers adjust to lower pricing. Despite this, the value for EPC players lies in providing an integrated and customised solution through a consultative approach for setting up solar projects.

7.1 EPC project: turnkey versus balance of plant

Nations, majorly developing ones, have been investing heavily on large infrastructure projects through public as well as private investments. To ensure efficient and timely construction, it is imperative to have an effective model that ensures timely project execution, minimises construction delays and improves transparency. The EPC model is primarily used in construction and O&M of solar plants.

Under the turnkey project structure, the contractor holds full responsibility of design and execution of the works, including EPC. Therefore, the contractor makes the facility ready to be used at the turn of a key. The project must be delivered at a pre-determined time and pre-determined cost, and the contractor must adhere to project specifications. In case of deviations, the contractor is liable to pay monetary compensation.

In the case of the balance of plant (BoP) structure, the entire project is broken into multiple packages with a major chunk contracted through the EPC route and the rest through BoP. For a solar plant, solar modules and inverters constitute the maximum cost and may be contracted singularly, whereas the supporting components and systems (wiring, switches, battery banks, power conditioners, and mounting structures) may be procured from various manufacturers. Additionally, for the BoP project structure, the owner would have to appoint an external consultant or anoint the principal contractor for holistic project management and to act as an interface between subcontractors.

7.2 What is an EPC contract in the solar space?

Project development involves various risks such as construction risks, operational risks, legal risks, financial risks and political risks. EPC contracts are of primary importance, as they help in the bankability of the project by allocation of different risks. EPC contracting helps in the achievement of a coordinated approach among several stakeholders by establishing a single point of responsibility to the owner. In assessing the bankability of an EPC contract, investors and lenders look at a wide range of factors to assess the contract as a whole. The key features of an EPC contract are the following:

- Fixed construction price
- Fixed completion schedule
- Responsibilities and guarantees with respect to project performance and warranties
- Liquidated damages for delay and performance gaps
- Single point of responsibility on the EPC contractor

- Termination and dispute resolution

In terms of contract structuring for turnkey projects, a single contract is prepared, and the contractor owns full responsibility of the risks incidental to the project. In case of BoP projects, contracts may be structured in either of the three ways: (a) procurement and project management services (PMS); (b) procurement only [P stage]; (c) procurement and construction [P + C stage].

a. **One 'wrapped' contract:** The solar panel supplier or the BoP contractor or an external project management consultant acts as a third party and takes full responsibility for coordination and delivery of the works. Such contract typically has lower risk due to aggregation effects.

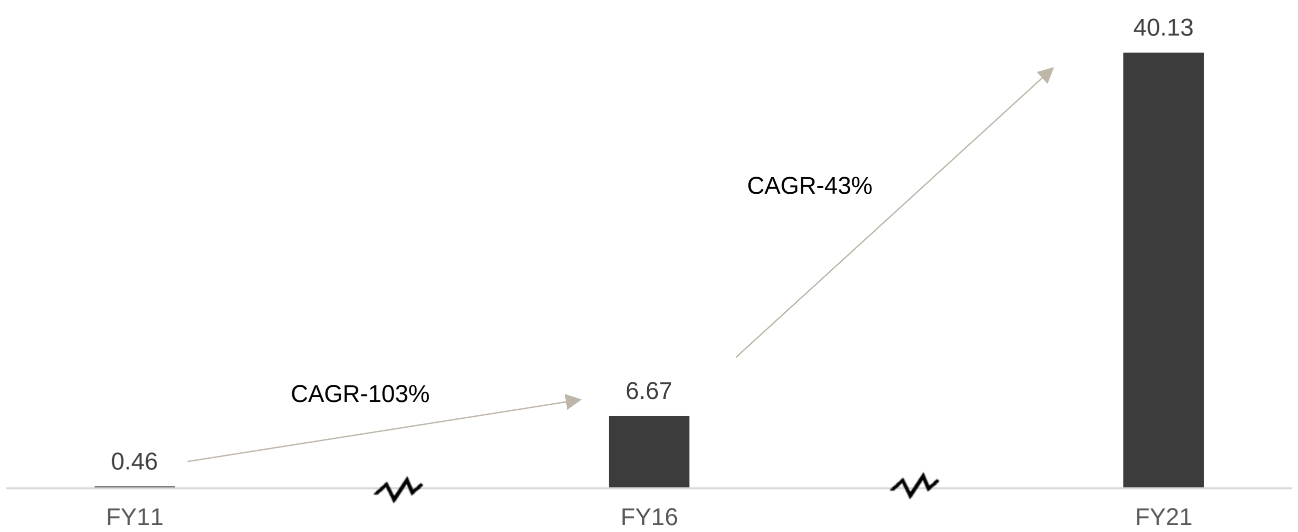
b. **Two or more different contracts (supply only):** Different components for the project are procured from different suppliers. The procurement (P stage) of BoP components is subcontracted. Potential suppliers are contacted and depending on quotations and technical specifications, the works are awarded. The principal contractor is responsible for installation of the different works and delivering the plant in one piece.

c. **Two or more different contracts (supply and installation):** Different components for the projects are procured from different suppliers and installed on site by the respective suppliers. The procurement and construction (P stage and C stage) of BoP components are subcontracted. The principal contractor monitors the works of the subcontractors. In case of non-compliance with performance specifications and /or time to delivery, the subcontractors are liable to pay liquidated damages.

7.3 Growth drivers for the EPC market

The Indian solar market has post rapid growth from the first phase of bidding under JNSSM, starting fiscal 2012, with installed capacity rising from 461 MW to 40,128 MW, as on March 2021. This signifies a CAGR of 63.3%, which has been driven by clean energy goals set by the government.

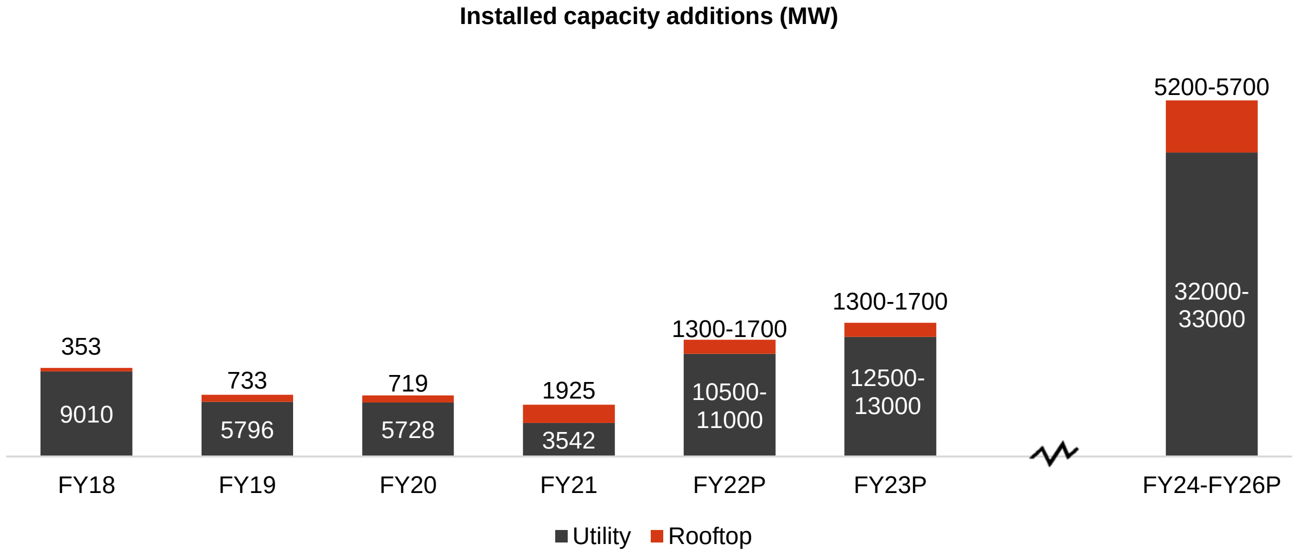
Figure 42: Growth in solar installed base over the past decade (GW)



Source: IRENA, MNRE

India has a target of 500 GW installed renewable capacity by fiscal 2030, of which 280 GW can potentially be contributed by solar, translating to ~25 GW of solar capacity annually equivalent to ~35 GW of dc solar capacity considering 40% dc overloading. But, as per the current pipeline, we can expect to add ~50 GW of solar power capacities (utility and rooftop) between fiscals 2023 and 2026 to the country's base, which is less than what is required annually to achieve the 280 GW target. The additional targets are expected to be met by larger tenders from central and state agencies. These large tenders can set the stage for increase in demand for the EPC business for the entire next decade.

Figure 43: Solar energy capacity additions reviews and outlook



P: Projected

Source: MNRE, CRISIL Research

The divide, however, lies in what will be the source of EPC activities to cater to the increased demand. Developers such as Adani, Renew, Sterling and Wilson, etc have a robust in-house EPC team that can handle large projects with relative ease, while others, such as Engie and Fortum, have opted for third-party EPC.

Out of the key segments in solar energy, rooftop and C&I solar market execution is predominantly done via third party EPC contracts. This would mean a significant portion of the capacity addition outlook over fiscals 2022-2026 of 12-13 GW and 15-16 GW in rooftop and C&I segments respectively to be a key market for EPC solution providers. On the private IPP market front, majorly the projects executed under competitive bidding, the outlook of 37-38 GW over fiscals 2022-2026 forms the potential which can be serviced by external EPC providers. However, in this segment the in-house EPC arms set up by the developers themselves can also execute the projects won by their sister concerns.

7.4 Cost break-up

A utility scale solar power plant is highly capital-intensive project and is susceptible to many price sensitive changes. Solar panels contribute 50-60% of the entire project cost and can be easily influenced by factors that may impact the economics of the power plant.

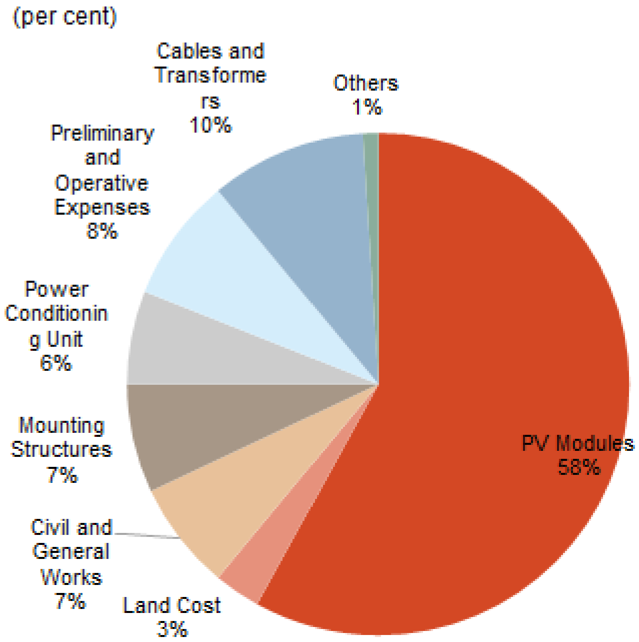
Currently, Indian solar installations are highly import dependent, with 80-85% of panels being imported. Also, any increase in prices of upstream components (polysilicon, glass, etc) can drive the cost of the panel upwards. Capital investment required for a utility installation vary greatly from that of rooftop installations as well, due to the difference in contribution of various components.

A detailed comparison of these costs is as follows:

7.4.1 Utility scale projects

The capital cost for setting up a greenfield solar project in fiscal 2021 ranged between Rs 35-40 million per MW (this estimate does not include land purchase cost).

Figure 44: Cost break-up of a solar utility scale installation



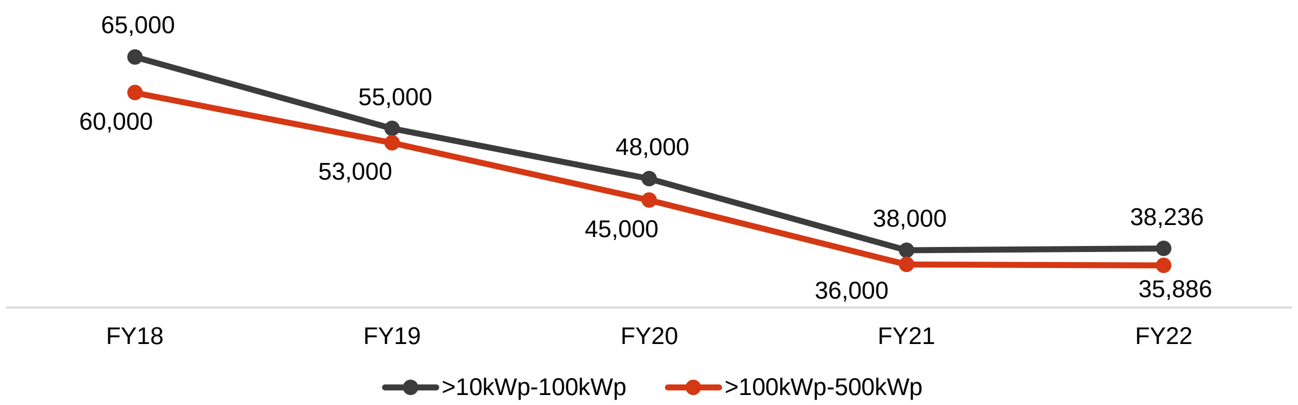
Note: Land purchase cost is not included, as projects have been assumed in this case to be set up in solar parks, where developer pays fees upfront, accounting for land development and allocation charges, while lease rentals are staggered across the life of an asset.

Source: MNRE, CRISIL Research

7.4.2 Rooftop

Compared to utility scale installations, rooftop projects have higher incidence of project cost due to smaller scale and specialised design and technical specifications, which may vary project to project. MNRE ascertains and issues benchmark costs for rooftop installation annually. These price benchmarks serve as a guide for discoms to empanel agencies on a yearly basis for rooftop installations.

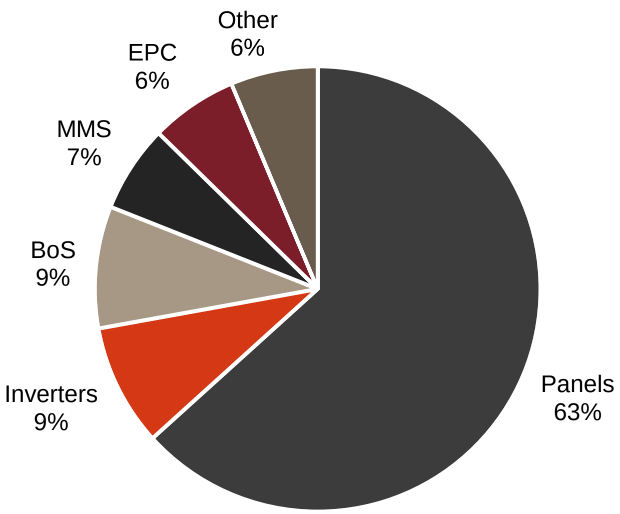
Figure 45: Trend in benchmark pricing for rooftop (Rs per kWp)



Source: MNRE

That said, installation costs have fallen in this segment over the years due to falling component costs, especially modules. The recent increase in fiscal 2022 in project costing incidentally arises from increased base module pricing, taxation levied and post pandemic-related challenges.

Figure 46: Cost break-up for a solar rooftop installation



MMS- Module mounting structure, BoS- Balance of system, EPC- Engineering, procurement and construction

Source: Industry, CRISIL Research

7.5 EPC players

Key EPC players in the market are either subsidiaries of larger conglomerate groups or module makers that have undertaken forward integration to enter the EPC and O&M businesses of the solar segment to leverage additional revenue from a growing operational base.

Table 7: EPC Players in India and their serviced capacity

Name	Domestic EPC Portfolio (GW)	Promoter group	In the market since	Key markets and other aspects
Sterling and Wilson Solar	6.45	Shapoorji Pallonji & Co	2011	India, Middle East, Africa, South East Asia, Europe, US and Australia Company has over 11 GW of EPC portfolio, which comprises 6 GW within India, and the remaining in other markets, in addition to 8 GW of O&M service base
Tata Power Solar System	4.4	Tata Power Company	1989	India Company started with solar PV manufacturing in 1989, having a capacity of 1,100 MW of manufacturing for cell and modules by September 2021 The EPC business started expanding in 2010
L&T-Power, Transmission and Distribution	2.3	Larsen & Toubro	1946*	India and the Middle East The company recently secured a turnkey EPC contract for Sudair Solar PV Project of 1.5 GW capacity in Saudi Arabia The PV-cum-storage project of 22 MWp (DC) and 16 MW / 8 MWh BESS of Andaman was completed in 2020
Mahindra Susten	2.3	Mahindra & Mahindra	2010	India The company has recently forayed into international markets. Its portfolio of 3,937 MW includes 672 MW of international projects
Vikram Solar	1.42	Vikram Group	2006	India The O&M division of company has a project experience of 970 MW. It is also the first company in India to commission a floating solar PV plant of 10 kW. It is among the top 5 EPC players in India by installed base as of 31st December, 2021. It has a module manufacturing facility of 2.5 GW in India Vikram Solar has also commissioned a 140 MW NTPC project. The combined 225 MW (85 MW and 140 MW) capacity project will

Name	Domestic EPC Portfolio (GW)	Promoter group	In the market since	Key markets and other aspects
				be one of the largest solar projects in a single location in Uttar Pradesh. Further, Vikram Solar installed Eastern India's largest single shed solar project with a capacity of 2.15 MW of Keventers. It is also the first to contribute to the solarization of the 'World's 1st Fully Solarized Airport - Cochin International Airport Limited (CIAL)'. Also installed one of the largest 'Carport' Solar Rooftop Installation of 5 MWp at Maruti Udyog Limited, Gurgaon The company has also installed a 10kW floating solar power plant in Rajarhat, Kolkata, as a part of an R&D venture jointly undertaken with Arka Renewable Energy College in Kolkata and New Town Kolkata Development Authority. This project was funded by the MNRE.
BHEL	1.2	Government of India (CPSU with 63.17% stake of GoI)	1964*	India The company has a fully automated solar cell (105 MW/annum) and module (226 MW/annum) manufacturing facility. Additionally, its portfolio of floating SPV projects is the largest in the country, with over 45 MW projects commissioned and ~107 MW under execution
Jakson	0.8	Jakson Group	2012	India, Africa, and other Asian countries are key markets for the company
Belectric India	1.18	RWE Renewables	2007	Germany (HQ), France, UK and India The company has over 500 MW of O&M portfolio as well
Adani Solar	0.25	Adani Group	2017	The company also states a global portfolio of under execution EPC projects of 400 MW as on date. The company also has a module manufacturing capacity of over 3.5 GW

*Year of incorporation has been considered as year of commencing EPC operations is not available

Notes:

1) EPC installed base of the players form**s** ~40% of the current solar installed base, as of January 2022.
2) All the above data points are published/ reported as per company filings and resources as on December 2021, except L&T and BHEL where capacities are available on fiscal 2020 and fiscal 2021 year-end respectively.
3) Capacities for Sterling & Wilson Solar, Tata Power Solar Systems and Mahindra Susten indicate DC side capacities, AC side not available.
4) For some of the above companies capacities executed may include projects for sister concerns.
5) The column titled “In the market since” indicates estimated year of either commencing EPC solutions services or module-making for the solar segment (where players have later forward integrated).

Source: Company Reports, CRISIL Research

Apart from the above, the market also sees participation from several regional / smaller entities, which form part of the unorganised segment. However, with falling bid tariffs and, hence, pressure on costs, the market has been dominated by either the top players or by developers taking the in-house EPC route.

8 Competitive landscape

8.1 Mapping of solar module manufacturers in India

Competitive mapping covers the details of companies, their products and services within a given market to understand competitive intensity. Waaree Energies, Vikram Solar, and Premier Energies are some of the major players in the module manufacturing having installed capacity of between 1-2 GW each as on December 31st, 2021. Adani Solar, Vikram Solar and Premier Energies have added manufacturing capacity after March 2021.

Table 8: Comparative summary of module manufacturers

Parameter	Vikram Solar	Waaree Energies	Adani Mundra Solar	Premier Energies	RenewSys India	Tata Power Solar	Emmvee Photovoltaic	Alpex Solar	Goldi Solar
Number of manufacturing factories	One each in West Bengal and Tamil Nadu	Three in Gujarat	One in Gujarat	Two in Telangana	One each in Karnataka, Andhra Pradesh, and Maharashtra	One in Karnataka	Two in Karnataka	One each in HP and UP	One in Gujarat
Experience in PV module manufacturing	15 years	14 years	4 years	26 years	6 years	30 years	14 years	14 years	10 years
Operational capacity (as of December 31st 2021)	2.5* GW modules	2 GW modules	3.5 GW modules & cells	1.25* GW modules 750* MW cells	750 MW solar PV modules 130 MW solar PV cells	580 MW modules 530 MW cells	500 MW modules	450 MW -modules	500 MW modules
Under-construction capacity	3.6 GW integrated modules & cells	4 GW integrated modules & cells	4 GW integrated polysilicon to modules	2 GW integrated cells & modules	-	4 GW integrated cells & modules	1 GW integrated cells & modules	-	1.2 GW modules (planned)
Market Share as a % of operational modules capacity (as of December 31st 2021)	19%	15%	26%	9%	6%	4%	4%	3%	4%
NABL accredited lab	-	For PV modules	-	-	For encapsulants and backsheets	-	-	-	-
Enlisted capacity as per ALMM list (29th Dec 2021)	2022 MW	2,100 MW#	1,100 MW	482 MW	750 MW	300 MW	500 MW	-	500 MW

Parameter	Vikram Solar	Waaree Energies	Adani Mundra Solar	Premier Energies	RenewSys India	Tata Power Solar	Emmvee Photovoltaic	Alpex Solar	Goldi Solar
Market share as % of total enlisted capacity (as per ALMM)	19%	20%	11%	4.6%	7%	3%	5%	-	5%
Products and services	Integrated Solar energy solutions provider with presence in Solar PV modules, EPC services, and O&M services	Solar PV modules, inverters, batteries, EPC services, rooftop solutions, O&M services, solar home appliances, and solar water pumps	Solar PV cells and modules, EPC services, O&M services	Solar PV cells and modules, EPC services, O&M services, water pumps, power	Solar PV modules and cells, encapsulants, backsheets	Solar PV cells and modules, EPC services, O&M services, and water pumps	Solar PV cells and modules, EPC services, rooftop solutions, O&M services, and solar water heater solutions	Solar PV modules, EPC services, solar water pumps	Solar modules, EPC services, Water pumps
Cumulative Installed capacity in EPC	1,430 MW	600 MW	250 MW	650 MW	NA	7 GW utility scale projects 515 MW rooftop	150 MW	NA	NA
Technology	Mono PERC mono-facial and bifacial, half-cut and full cell modules, poly-Si modules	Mono-crystalline and poly-crystalline PV modules, mono PERC, bifacial, flexible modules, BIPV	Multi-crystalline, mono PERC, and bifacial modules	Poly-crystalline and mono-crystalline Si cells, mono PERC, poly-crystalline PV modules	Mono/multi PERC, bi-facial, half-cut and full cell modules	Mono PERC cells, mono PERC half-cut modules	Mono PERC, poly-crystalline modules, bi-facial modules, half-cut cell modules	Mono-crystalline, poly-crystalline PV modules, bi-facial modules	Mono-crystalline, poly-crystalline PV modules
Distribution network	40 entities	388 franchises pan-India	500 towns^^	NA	NA	NA	NA	NA	NA

Note: # Includes: Waaree Renewables, NA: Not available, *Vikram Solar and Premier Energies added some capacity after March 2021. ^^Data for Adani Mundra is dated October 2019.

Source: Company websites, MNRE ALMM , CRISIL Research

As per CRISIL Research estimates, as of December 31st 2021, the installed manufacturing capacity for PV modules in India was ~13 GW, of which Vikram Solar accounted for ~19% with an installed capacity of 2.5 GW. The installed manufacturing capacity for cells was ~3 GW. While, Vikram Solar currently does not have an operational manufacturing base for PV cells, it envisages expansion into cell production over the medium to long term, thereby enhancing its market share in this segment as well.

As per the PLI scheme released by the government, 'high efficiency' in modules is defined as being greater than 19.5%. Basis the product portfolio, key domestic players such as Vikram Solar, Mundra Solar and Waaree Energies are producing high efficiency modules with efficiency above 19.5%. Further, the PLI scheme will encourage the production of high efficiency solar modules with all domestic module makers likely to produce such products going forward as well.

Technological advancements in the solar industry are fast-paced and any technology can effectively be termed outdated in five years. It becomes important to produce highest quality modules to ensure a healthy bottom line.

In China schemes such as Top Runner have aided in improving the efficiency of cells & modules. Within the scheme, if a manufacturer is unable to meet the standards specified in the program by the set date, penalties, including ban on sales, was imposed. This encouraged production of efficient panels. Compared to China, Indian peers were not as active in spending any significant amounts on R&D affecting their product quality. However, lately with the introduction of PLI scheme encouraging the R&D and efficiency, domestic players are expected to manufacture higher efficiency modules in the Indian market in line with the technological advancement in the module manufacturing space.

Globally, the solar industry is moving towards monocrystalline, passivated emitter and rear cell, or PERC, and bifacial technology, but a significant chunk of the cell lines installed in India are still based on older technologies which remains a key risk factor for the domestic manufacturing industry.

Crystalline silicon (c-Si) technology is largely deployed in solar PV globally as well as in India. [1]According to the Fraunhofer Institute, in 2020, global PV annual production was ~151 GWp. Out of the total production, 80% was mono-crystalline silicon technology compared with only 20-25% as a share in 2015, which shows the current dominance of mono-crystalline as a module technology.

From a cell perspective, while passivated emitter and rear cell (PERC) technology is currently the most prevalently used in new installations, as per secondary reports, the next technological upgrade to PERC is expected to be TOPCON. Parallelly, other technologies like heterojunction technology (HJT) are also expected to gain market share over the next few years.

As per industry reports, PERC/TOPCON cell technology is still expected to remain dominant over the next decade followed by HJT while other high efficiency technologies such as integrated back-contact and tandem technology will form a minor share.

Most of the domestic solar manufacturers which are currently invested or are investing in the PERC technology are progressively moving towards the next generation of technologies like HJT and TOPCON. Ramp up in production as key global and domestic suppliers invest in HJT / TOPCON, will be a key driver to decreasing costs for these emerging cell technologies. This in turn will aid a reduction in LCOE to maintain/enhance competitiveness for solar power as a renewable resource.

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[1] https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

Apart from other technical parameters, module players also seek technical gradings provided by agencies like BloombergNEF, PVEL. As per company filings and releases, Vikram Solar notified its classification as a Tier-1 manufacturer under the BloombergNEF rankings in Q1 CY2014 and has also notified its placement as a top performer by PVEL in its reliability rankings in 2021.

The tier wise classification by BloombergNEF has been developed to classify module makers on the basis of 'bankability'. The term bankability has been defined by BloombergNEF as solar products that, if used in solar projects, would be likely to be offered non-recourse debt financing by banks. Consequently, Tier-I manufacturers are those that have provided modules manufactured in their facilities and under their brand to six different projects that have been financed by non-recourse debt from six different banks over the previous two years. There are other guidelines as well to the Tier-I classification, but the major definition is as aforementioned.

Similarly, the PVEL reliability scorecard recognises manufacturers with positive test results as tested by them under their Product Qualification Program (PQP). It also takes in field data to consider real-world applications. The module brands identified for review undergo several series of tests, where for instance results for 2021 was based on testing across thermal cycling, damp heat test, mechanical stress sequencing, potential induced degradation test (PID), light induced degradation (LID) and light and elevated temperature induced degradation (LETID) tests, PAN performance, backsheet durability sequencing and PQP failures. As per company disclosures, from 2017 to 2021, only 2 Indian manufacturers, Vikram Solar and Adani, have featured in PVEL's module reliability scorecard [Source: Vikram Solar]. Further, Vikram Solar was the first Indian company to feature on the list in 2017 [Source: Vikram Solar].

8.2 Distribution channels for PV modules

Various module manufacturers have established their distributor networks or resorted to the franchise route to reach end-users across categories such as residential, commercial, and industrial consumers. Local contact is very important for these consumers while accepting solar products. With increased awareness, more and more consumers are exhibiting interest in solar installations.

Distribution channel partners help in reaching consumers as well as informing them about the new technologies and their benefits. The end-user generally tends to have very little say in selection due to lack of technical knowledge of complex products such as modules. However, through a known partner, the consumer can be convinced to a large extent, and such networks can be utilised for enhancing consumer reach.

Vikram Solar has a distribution network connecting more than 40 cities, ensuring the availability of solar products and solutions across 600+ locations in India. Also, Vikram Solar is the only manufacturer with capacity greater than 1.5 GW having presence in East and South parts of the country which further facilitates direct access to distributors and their networks, as of December 31, 2021. Waaree Energies has ~350+ unique franchisee network across India. This model provides a different opportunity than merely dealership or distributorship of products. These are exclusively tied-up traders which help in end-to-end product sales as well as after-sales service. They help in ensuring last-mile connectivity and increasing consumer awareness about various offerings among residential and C&I consumers, especially in tier-1 and tier-2 cities.

Adani Solar has retail distribution of its solar panels in seven regions and over 500 cities across the country.

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