Indian Solar Sector: Fostering Growth and Sustainable Development

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INDIAN SOLAR SECTOR: FOSTERING GROWTH AND SUSTAINABLE DEVELOPMENT

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CONTENTS

	Page No.
Executive Summary	1
1. Sustainable Development & Solar Energy	12
2. Solar Energy Scenario: Global and India	20
3. Trade Scenario in Solar Equipment Industry: Global and India	35
4. Investments in the Solar Sector	52
5. Renewable Energy Finance and Financial Institutions	64
6. Challenges and Strategies	77

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LIST OF FIGURES

Figure No.	Title	Page No.
1	Change in Global Surface Temperature Relative to 1951-1980 Average Temperatures	13
2	Global CO_2 Emissions	15
3	Major Energy Sources of Global CO_2 Emissions	16
4	CO_2 Emissions from India	17
5	Major Energy Sources of India's CO_2 Emissions	17
6	Per Capita tCo_2 Emissions	18
7	CO_2 Emissions Based on Income	18
8	Global Renewable Energy Installed Capacity	22
9	Global Solar Energy Installed Capacity	23
10	Major Players in Solar Installed Capacities	24
11	India's Renewable Energy Installed Capacity	24
12	Direct Normal Irradiation of India vis-à-vis World	25
13	India's Solar Energy Installed Capacity	26
14	Solar Energy Share in India's Total Renewable Installed Capacity	26
15	Top 10 States in Solar Installation Capacity	27
16	State Wise Target for 40 GW Roof Top Solar by 2020	31
17	Major Exporters of Solar Equipment	37
18	Major Importers of Solar Equipment	38
19	Global Exports of PV Cells	38
20	Major Exporters of PV Cells	39
21	Major Importers of PV Cells	39
22	India's Trade in Solar Equipment	40
23	Major Export Destinations for India's Solar Equipment	43
24	Major Import Sources for India's Solar Equipment	43
25	India's Trade in Photovoltaic	44
26	Major Exporting Destinations for India's PV Cells	45
27	Major Import Sources for India's PV Cells	45
28	Global: Investments in the Renewable Energy Sector	52
29	Global: Sector-Wise Share in Investments in Renewable Energy	53

Figure No.	Title	Page No.
30	India: Sector-Wise Share in Investments in Renewable Energy	54
31	Global: Investment Received by Development Level of Economies	55
32	Global: Region-Wise Investment Share in Renewable Energy	56
33	Global: Investments in the Renewable Energy by Asset Class	57
34	Global: Total Envisaged Foreign Capex in Solar Electric Power Sector	58
35	Top Source Countries in Global Solar Electric Power	59
36	Top Destination Countries in Global Solar Electric Power	59
37	Total Envisaged Foreign Capex in India's Solar Electric Power Sector	61
38	Top Source Countries in India's Solar Electric Power	61
39	Renewable Energy Finance Flows to the World from Global FIs	65
40	Technology-Wise Share of Renewable Energy Finance by Global FIs	65
41	Top Recipients of Renewable Energy Finances from Global FIs	66
42	Top Recipient Nations in Solar Energy Financing from Major Global FIs	69
43	Share in Finance Flows to Solar Energy by Asset Class	70
44	Renewable Energy Finance Flows to India from Major Global FIs	71
45	Technology-Wise Share of Renewable Energy Finance to India by Major Global FIs	71
46	Share in Finance Flows to Renewable Energy in India by Asset Class	73
47	Major FIs in Solar Energy Finance to India	74
48	Share in Finance Flows to Solar Energy in India by Asset Class	75
49	Component-Wise Breakdown of Solar Tariff	79
50	Sector-wise Commitment of Green Bonds Issued by World Bank	80
51	Yearly Green Bond Issuance	82
52	Currency-wise Issuance of Green Bonds	82
53	Cumulative Installed Floating PV Capacity	88
54	Long-Term RPO Trajectory	92

LIST OF TABLES

Table No.	Title	Page No.
1	Renewable Energy Country Attractiveness Index Scores	21
2	India's Rank in the EY RECAI: Trends	21
3	Global Weighted Average Levelized Cost of Electricity from Utility-Scale Renewable Power Generation Technologies	22
4	State-wise Estimated Solar Energy Potential in the Country	27
5	Leading Domestic Solar Cell Manufacturers in India	35
6	Global Exports of Solar Related Equipment	36
7	India's Exports of Solar Equipment	41
8	India's Imports of Solar Equipment	42
9	India's Competitiveness in Export of Solar Equipment	47
10	India and China: Renewable Energy Investments	53
11	Global: Sector-Wise Investment and Growth	55
12	Global Top Investing Companies in Solar Electric Power by Envisaged Foreign Capex	60
13	Top Investing Companies in Solar Electric Power by Envisaged Foreign Capex	62
14	Major FIs in Renewable Energy Finance	67
15	Share in Finance Flows to Renewable Energy by Asset Class	67
16	Solar Energy Financing by Major Global FIs	68
17	Major FIs in Solar Energy Finance to World	70
18	Major FIs in Renewable Energy Finance to India	72
19	Solar Energy Finance Flows to India from Global FIs	74
20	Leading Solar PV Manufactures and their Production Capacity	77
21	Top 10 Issuers of Green Bonds	81
22	Solar RPO Targets Set by States and Shortfall from MoP Targets	93

LIST OF BOXES

Box No.	Title	Page No.
1	Growth of Solar Energy in Spain: The Barcelona Model	30
2	Success of Solar Rooftop Systems in Gujarat	31
3	Bhadla Solar Park - World's Largest Solar Park	32
4	Production Linked Incentive Scheme (PLI) for Solar Manufacturing	33
5	India Exim Bank and the European Investment Bank (EIB)	69
6	India Exim Bank's Involvement in the Solar Sector	75
7	International Solar Alliance (ISA) and its Role	76
8	ESG Scenario in India	83
9	Floating Solar Farm in Tengeh Reservoir, Singapore	87
10	Case Study- Solar SeaSystems by SwimSol in Maldives	89
11	World and India in COP 26: Recent Developments	96

EXECUTIVE SUMMARY

Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015, provide an equal thrust to the need for the renewable energy in the world. The Goal 7 of SDGs is based on affordable and clean energy. As per the United Nations Development Programme (UNDP), "*Investing in solar, and wind power, improving energy productivity, and ensuring energy for all is vital if we are to achieve SDG 7 by 2030*".

Globally, one of the latest collective actions towards achieving the Goal 7 of the SDGs has been the adoption of international climate agreement at the U.N. Framework Convention on Climate Change (UNFCCC), Conference of the Parties (COP21) in Paris in December 2015 to undertake targeted efforts to counter climate change.

The main goal of COP21 is to "*strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees celsius and to pursue efforts to limit the temperature increase even further to 1.5 degrees celsius above pre-industrial levels*".

Promoting Solar Energy in India

The rising global temperatures put forth various challenges for the economies such as India. India, which is in a developing stage, needs to grow and that too, sustainably. As the sustainability factor is involved, the clean sources of energy like solar become essential. In the case of solar, India is geographically at an advantageous position as it receives almost 300 days of sunlight every year.

India's successful journey in the solar energy started with the Government of India launching National Action Plan for Climate Change (NAPCC) in 2008, with a subsequent launch of National Solar Mission in 2010, under NAPCC.

After garnering strength in the solar energy space, India came out as a leader when it conceived the International Solar Alliance (ISA) with France in 2015. The alliance has 121 member countries

which lie between the two tropics, Cancer and Capricorn, either partly or fully, and given their geographical location, most of them are high sunshine countries.

The first assembly of ISA in 2018 also involved India proposing the concept of '*one sun, one world, one grid'* which will be a transnational grid and will have the potential to supply the electricity to the entire world. As per the Ministry of New and Renewable Energy (MNRE), Government of India, the plan once implemented, could cover almost 140 nations with a common grid.

Emission Trends

A significant chunk of the global population especially the rural developing world still does not have access to the electricity. However, it may also be noted that as per UNDP, energy is the main contributor to the climate change as it contributes to almost 73% of the human-induced greenhouse gases (GHGs). This leaves a large scope for expanding the energy infrastructure, especially in the developing regions, with cleaner technologies such as the solar energy systems.

With respect to the emission trends, globally, the emissions went up from 27,698 $MTCO_2$ in 2000 to 40,389 $MTCO_2$ in 2018, thereby recording an average annual growth rate (AAGR) of 2.9%. The contribution of coal as a source remains the highest with its share being recorded at 37% in 2018.

On per capita basis, the world emitted 4.4 ton CO_2 in 2018 (tCO_2). Qatar registered the highest per capita emission at 31.3 tCO_2 in 2018. China's and India's per capita emission was significantly lower at 6.8 tCO_2 (35^{th} rank), and 1.7 tCO_2 (99^{th} rank), respectively.

The emission trends of India reveal that the share of India in the global emissions has increased from 3.2% in 2000 to 5.7% in 2018. India's emissions increased from 890 $MTCO_2$ in 2000 to 2,307 $MTCO_2$ in 2018, and registered an AAGR of 5.7%, much higher than the world average. The contribution of coal in India's emissions increased from 64.3% in 2000 to 70% in 2018.

Solar Energy Scenario

In the latest EY's Renewable Energy Country Attractiveness Index (RECAI), published in May 2021, India was ranked 3^{rd} based on the investments in the renewable energy space and the deployment opportunities. In fact, under Solar PV, India's rank was the highest. This index ranks the countries based on the investments in the renewable energy space and the deployment opportunities.

It may be noted that between 2010 and 2019, the highest fall in the cost of electricity was registered for energy generated from solar PV, a fall of 82%. The fall was 47% for concentrating solar power (CSP), 38% for onshore wind, and 29% for offshore wind. With respect to the countries, the largest

reduction was noticed for India where costs declined by 85%, to reach US$ 0.045/kWh in 2019 - a value 34% lower than the global weighted average for that year. India was followed by China (US$ 0.054/kWh), and Spain (US$ 0.056/kWh).

With respect to the installed capacity, globally, renewable energy (RE) installed capacity was recorded at 2532.9 GW in 2019, up from 1223.5 GW in 2010, and recorded an AAGR of 8.4%, during this period. The share of solar in this capacity showed a significant jump by increasing from 3.1% in 2010 to over 23% in 2019. This is because the annual growth registered by the solar energy installed capacity during this period was over 35%, with the capacity reaching 584.8 GW in 2019. The top players by installed capacities in 2019 included China, the USA, Japan, Germany, and India.

On the Indian front, the growth has been even more impressive. The RE installed capacity in India increased to 128.2 GW in 2019, from 52.3 GW in 2010, thereby recording an AAGR of 10.6%. As a result, India's share in the global RE installed capacity went up from 4.3% in 2010 to 5.1% in 2019.

The performance was even better for solar where India's installed capacity was recorded at 35.1 GW in 2019, up from just 0.1 GW in 2010, an AAGR of 148%. The share of India in global solar capacity increased from mere 0.2% in 2010 to 6% in 2019. In India's own RE installed capacity, solar's share increased from 0.1% in 2010 to 27.3% in 2019. Some of the top performing Indian states in solar energy include Karnataka, Rajasthan, Tamil Nadu, Telangana, and Andhra Pradesh.

The solar tariffs in India were over ` 12/kWh in 2010. By December 2020, it had hit an all-time low of ` 1.99/kWh. While the low tariffs are a significant game changer in the uptake of solar industry, it may also be noted that these tariffs should be economically feasible. The bidding war or competitive bidding kept the solar tariffs down; however, with the recent increase in module prices which constitute a significant part of the solar projects, the tariffs might not go below the record ` 1.99/kWh level in the near future.

Some of the important schemes which have made India a leader in solar energy include grid connected rooftop solar program, solar park scheme, VGF scheme, among others. In fact, schemes such as solar rooftop have been displaying impressive results in the recent years.

As of August 2021, India had a total solar rooftop installed capacity of 5486.3 MW. Gujarat has been the leader in solar rooftop by contributing to almost one-fourth of this capacity. It may also be noted that smaller states such as Delhi (10th rank) have also been showing impressive performance and have a higher capacity in rooftop solar than states such as Telangana, Punjab, Andhra Pradesh, Kerala, and Madhya Pradesh.

Select Solar Schemes in India

National Solar Mission (NSM)	Bundling Scheme	Grid Connected Rooftop Solar Program	Development of Solar Parks and Ultra Mega Solar Power Projects	Viability Gap Funding (VGF) Scheme
• Initial stages of solar related policies in India - launched in 2010 • Initial target to deploy 20 GW installed capacity by 2022. Revised target is 100 GW by 2022 • Target set for FY 20 and FY 21 has been 30 GW each by MNRE	• Under the first phase of the NSM, option of bundling was provided - solar power could be bundled with the other cheaper power source such as thermal • MNRE, in 2020, proposed a draft policy of round the clock power from renewable energy power projects, complemented with thermal power projects • As per the policy, the power generator must maintain a 51% quota of renewable energy and maintain at least an 80% availability of power, annually	• Program comprises of two phases-I and II • Phase 1- MNRE has been providing a subsidy of up to 30% of benchmark cost for the general category states and up to 70% for the special category ones • Phase II- Program was approved in 2019 with an aim to achieve 40 GW of cumulative installed capacity from rooftop solar projects by 2022	• Scheme launched in 2014 to set up around 20 GW of installed solar power capacity through at least 25 solar parks with each being of a capacity of 500 MW to 1000 MW • Target was revised upwards in 2017 - capacity rising from 20 GW to 40 GW through at least 50 solar parks by FY 22 • Solar parks are developed in collaboration with the state governments, and Solar Energy Corporation of India is the implementation agency for the same	• Under the VGF scheme in the solar sector in India, the grid connected solar power projects of 750 MW, 2000 MW, and 5000 MW have been selected by the MNRE for VGF scheme • SECI was the implementing agency for the same • In 2020, Indian Renewable Energy Development Agency (IREDA) replaced SECI as the implementing agency for VGF, and envisages setting up 12 GW grid-connected solar projects with VGF, under Central PSU scheme phase II

In 2018, India's Directorate General of Trade Remedies (DGTR) imposed a safeguard duty on solar panels imported from China and Malaysia. The DGTR recommended the imposition of 25% safeguard duty on solar panels from these two countries for one year, followed by 20% for the next six months and 15% for another six months. The duty was further extended for a year in July 2020 with the duty being 14.9% from July 30, 2020, to January 29, 2021, and 14.5% from January 30, 2021, to July 29, 2021, for all solar cells and modules imported.

It may be noted that even with the imposition of safeguard duty, 70-80% of solar module imports are still imported from China as their prices remain competitive. The project costs on the other hand increased marginally due to this increase. However, this is set to be compensated as after the expiry of the duty, there is a nine-month duty free period, and only post that period, basic customs duty will come into picture. The expiry of safeguard duty on solar module imports could negatively impact the Indian manufacturers but could be a positive change for the developers.

Trade Scenario

The global exports of solar related equipment (total 14 HS 6-digit codes) were recorded at US$ 155.2 billion in 2019, up from US$ 152.3 billion in 2010. The AAGR recorded during this period was 17%. The top exporters (China, Germany, and USA) and top importers (USA, China, and Germany) were largely the same in 2019.

The global exports of photovoltaic (PV) (HS 854140) however fell from US$ 73.2 billion in 2010 to US$ 56.5 billion in 2019, an AAGR of (-) 2.2%. While the top exporters were China, Malaysia, and Japan, the top importers included the USA, China, and Hong Kong in 2019. Additionally, as compared to 2010, some of the gainers in 2019, with respect to export shares were China, Malaysia, and Vietnam. On the import front, countries such as Germany and Italy saw a significant drop in their shares in the global imports of PV.

Trade Scenario for Solar Industry

As per Institute for Energy Economics and Financial Analysis (IEEFA), India's domestic PV module manufacturing capacity is around 15 GW. Additionally, the capacity utilization is around 40-45%, and as a result, the operational capacity is around 7 GW. India faces tough competition from China not just in the production of PV modules but also in the production of other raw materials such as wafers, cells, and poly silicon. This leads to India depending on imports from China for installing solar capacities. Some of the leading domestic solar cell manufacturers include Adani Solar, Tata Power Solar, Jupiter Solar, Indosolar, among others.

In solar equipment, while India had a marginal trade surplus of US$ 0.3 billion in 2010, it registered a trade deficit of (-) US$ 2.4 billion in 2019. India's exports of the same were recorded at US$ 1.3 billion in 2019 with 65% of the share coming from static converters, followed by PV (share of 15.2%).

Imports on the other hand were recorded at US$ 4.2 billion in 2019. Interestingly, PV's share in the imports was almost 60%, followed by static converters at 27%.

Given the dependency of India in PV, it may be noted that India's imports of the same, increased from US$ 0.3 billion in 2010 to US$ 2.5 billion in 2019. The trade balance for India, during the same period, changed from of a surplus of US$ 0.3 billion in 2010 to a deficit of (-) US$ 2.2 billion in 2019. The top import sources for PV by India included China, Vietnam, and Thailand, with China alone contributing to almost 74% of these imports.

The export competitiveness analysis through Revealed Comparative Advantage (RCA) reveals that India was not competitive in the exports of solar PV in 2019; however, in the exports of other solar related equipment such as static converters, and mirrors of base metals, India exhibited competitiveness in 2019.

Investments

The world has seen massive investments in the renewable energy space, during the last few years. These investments were and are still essential to cater to the negative externalities created by the climate change.

As per 'Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance', the global investments in the renewable energy sector increased from US$ 238.5 billion in 2010 to US$ 301.8 billion in 2019, thereby growing at an average rate of 3.5%.

India received US$ 9.3 billion of investments in 2019, up from US$ 6.7 billion in 2010, and registered an AAGR of almost 11%, much higher than the world. India's share in the global investments also increased from 2.8% in 2010 to 3.1% in 2019.

Further, the sectoral analysis shows that globally, 47.3% of the RE investments went to the wind sector in 2019, followed by solar at 46.7%. Globally, in the last decade, investments to the solar energy grew by an average of 6.3% annually, while for wind it was 5%. In India's case, however, almost 70% of total RE investment went to the solar sector, followed by 23% to wind in 2019.

By the development level of economies, it is interesting to note that while pre-2014, most RE investment went to the developed nations, in the post-2014 period, most RE investments went to developing economies. China has been a big gainer with its share increasing from 18% in 2010 to 30% in 2019. Europe, on the other hand, lost its share from 47% in 2010 to 19% in 2019.

Further, as per fDi markets database of the Financial Times which tracks the investments announced and provides an estimation of the envisaged investments, the global envisaged foreign capital expenditure in the solar electric power sector increased from US$ 9.4 billion in 2010 to US$ 35.9

billion in 2019, an AAGR of 25%. The number of projects associated with these investments also increased from 70 in 2010 to 241 in 2019. While the top source countries by capex during this period were Spain, the USA, and Germany, the top destinations were the USA, the UK, and India.

In India's case, as per fDi markets, the envisaged foreign capex to solar electric power sector increased from US$ 0.9 billion in 2010 to US$ 1.1 billion in 2019. During this period, the top source countries for investment in India by capex were the USA, China, and Spain.

Renewable Energy Finance and Financial Institutions (FIs)

Select MDBs / FIs considered in this study for analysis include: The World Bank Group (WBG), UNDP, Japan Bank for International Cooperation (JBIC), Overseas Private Investment Corporation (OPIC), BNDES, China Exim Bank (CEXIM), Export Import Bank of Korea (KEXIM), European Bank for Reconstruction and Development (EBRD), Agence française de développement (AFD), ADB, amongst others.

As per International Renewable Energy Agency (IRENA), the total RE finances by the MDBs / FIs to the globe were recorded at US$ 3 billion in 2003 and stood at an all-time high in 2017 at US$ 29.1 billion, recording an AAGR of almost 44%, during this period. On the technological front, hydropower was the largest recipient with 40% of the finances, followed by wind energy (19.5%), multiple renewables[1] (15%), and solar energy (14.4%). During the period 2003-17, Brazil (19%), India (5%), and Pakistan (4%) were the top recipients of these finances. Some of the major MDB/ FIs involved during this period were BNDES (18%), C-EXIM (16%), and EIB (14%). Globally, almost 75% of the investment was through loans and only 5% was through grants.

Particularly, in global solar energy sector, the finance flows increased from US$ 0.06 billion in 2003 to US$ 3.8 billion in 2017, an AAGR of 54%. The top recipients of these finances included India (10%), Morocco (9%), and Chile (7%). Further, the top FIs that made the investments include WBG, OPIC, and EIB. WBG alone had a one-third contribution to this. While 51% of the flows were through loans, 41% were through other official flows (non-export credit). Grants constituted 6%.

In the Indian RE finance scenario, the flows increased from US$ 10.1 million in 2003 to US$ 692.3 million in 2017, which is a jump of almost 70 times. Most of these finances went to multiple renewables (34%), solar (31%), and renewable hydropower (26%). WBG was the largest contributor with a share of over 28%, followed by KfW Development Bank, and ADB at 13.7%, and 13.5%, respectively. 54% of the finances were through loans, and another 41% came through other official flows (non-export credit).

[1] The multiple renewables refer to commitments that target more than one renewable energy technology. These could be equity investments, green bonds, investment funds, multiple project commitments, projects that combine technologies (e.g., hybrid minigrids) and any other commitment that cannot be clearly categorised under one single technology.

Finally, under solar energy in India, the global finances increased from just US$ 0.06 million in 2003 to US$ 300 million in 2017. The WBG contributed to 30% of the finances, followed by another 23% coming from OPIC and 22% coming from CIF. ADB also contributed 16% of these finances. Loan as an asset class had the largest share at 50%, followed by other official flows (non-export credit) at 46%, and grants at 3%.

It may be noted that ISA is also playing an increasingly important role in the global uptake of the solar energy. The Solar Risk Mitigation Initiative (SRMI) was launched in 2018 by the World Bank and the Agence Francaise de Développement (AFD), in support of the ISA, for affordable financing. For the implementation of its programme of 'Scaling Solar E-mobility & Storage', the ISA has also launched two studies.

Challenges and Strategies

The renewable energy sector, and solar energy, in particular, has increasingly received government support in India, in the last few years. Sustainable development through solar energy is viable by safeguarding access to affordable, reliable, and advanced energy for the population. However, there exists a host of challenges in India which need to be addressed, so that India is able to achieve its ambitious targets in solar energy.

Enhancing finance

It may be noted that more than 70% of the renewable energy projects in India use debt to finance their needs. While the cost of the debt is in the range of 3-6% in the developed world, it could range from 10-15% for the developing nations. Further, financing costs constitute the largest share in the tariffs of India's solar energy. Also, while the banks prefer extending short term facilities to other power projects, solar power projects cash flows necessitate the requirement of a long-term financing. These factors demand the need for finding solutions to address the finance challenge in solar energy.

The first solution could be encouraging private funds through limited public funds. As per the Fiscal Monitor October 2020 database of International Monetary Fund, India's general government fiscal balance was estimated at (-) 13.1% of GDP in 2020 and was recorded at (-) 8.2% of GDP in 2019. With limited fiscal space, private capital needs to be encouraged with measures such as pilot projects support, and risk mitigation instruments such as hedging, guarantees etc.

Green bond is another area which can be worked upon. During 2007-19, green bond issuance in INR amounted to US$ 2.1 billion equivalent, which is just 0.3% of the total issuances. As a result, green bonds should be promoted through improved coordination amongst the issuers, capital markets, policy makers, and the investors.

Further, off grid financing which has a huge potential should be increasingly catered to through innovative solutions like results-based financing (RBF). RBF refers to incentive structures in which payments are made to companies, or directly to customers after the delivery or installation of a given quota of an output (for example, kilowatts installed). India can explore the scope of this by starting this as a pilot project for certain geographies.

Finally, institutional investment cannot be undermined. According to the Climate Policy Initiative, India needs an additional US$ 450 billion to achieve its 40% renewable energy share target by 2030. Challenges such as off-taker risk need to be addressed through appropriate solutions like transparent payment security mechanism to invite more investment.

Promoting Floating Solar Power

Floating Solar is one of the new age innovations in the field of solar energy which has been gaining momentum in the recent years. Countries such as India which have a high population density, and land acquisition being difficult, floating solar power could be one of the needed innovative solutions.

As per the World Bank, as of mid-September 2018, the global floating solar capacity reached almost 1.1 GWp, with most of the growth coming during 2015 to 2018.

To achieve a growth in floating solar power, India may like to come with clear-cut policies with respect to the regulation of the floating Solar PV systems, given that some cities could be ecologically sensitive. Further, initial support from the Governments may be required in the R&D of this technology.

In future, India could also explore the possibilities of marine PV installations. While challenges such as high waves and high speed winds exist in that, the increased R&D into the areas of new designs and technologies could help India in becoming a leader in this, given its significant coastline, and river basin.

Addressing the Land Issue

To set up 1 MW of solar power plant, there is a requirement of 4 acres with the crystalline technology and 4.5-5 acres with the thin-film technology. This would mean that land acquisition plays a significant role in solar energy in India.

Various challenges exist in the land acquisition in India. For instance, as land is a state subject, in a project with Interstate Transmission System (ISTS), each state could take its own time in granting the approvals which further delays the project. Further, the restrictions also exist as per the land ceiling acts of different states.

In such a case, digitization of land records could probably be one of the most important solutions for the solar industry to take a further leap in India. Due to the lack of digitization, at times it takes months to find the rightful owners of the land. While the GOI did launch 'The Digital India Land Record Modernization Programme (DILRMP)' in 2008, the implementation needs to be strengthened. Further, the updating of records is as important as digitizing them in the first place.

The land pooling solution should also be explored increasingly. Under this, more than the required land is purchased or acquired for the project, and after the project is complete, a fraction of the land is given back to the owners. States such as Haryana, and Andhra Pradesh (for its new capital) are already using this concept to attract investments.

Integrating Solar Power with Electric Vehicles (EVs)

India has endorsed the EV30@30 campaign launched by the Clean Energy Ministerial in June 2017, which aims to reach a 30% market share for EVs in all modes except two-wheelers by 2030.

While EVs emit fewer GHG emissions than the internal combustion engine (ICE) vehicles even when fossil fuel-based power is used to charge them, the emissions due to EVs can vary across countries, depending on the grid supply mix. This becomes important for India because the power mix of India to charge the EVs is mostly coal based.

As a result, India needs to focus on decarbonization on both the fronts- transportation, by switching to EVs, and charging of EVs from renewable sources of energy such as solar.

Strategy for RPO Compliance

Under the Electricity Act 2003, and the National Tariff Policy 2006, RPO is a mechanism by which the obligated entities are obliged to purchase certain percentage of electricity from Renewable Energy sources, as a percentage of the total consumption of electricity.

In 2018, the Ministry of Power mandated that 21% of all power purchased by a power distribution company during FY 22 will have to be generated from renewable sources and out of this, 10.5% needs to be from solar alone. The RPO mandate was 17% in FY 19, with the solar RPO being 6.75%.

As per the RPO portal, the targets set by the States' regulatory commissions reveal that their RPO targets are mostly falling short for FY 22, especially in the solar power which has a target of 10.5% RPO set by the Ministry of Power (MoP), Government of India.

To achieve the near future targets, the MoP, MNRE, State Electricity Regulatory Authorities, State Governments, Discoms, and the recently set up RPO Compliance Cell may work together, in not just setting realistic targets, but also making sure that the mandates are complied with.

Learning from the Successful Models

While India works on the internal challenges of the solar market, it is equally important to have an outward approach and learn from some of the successful global models.

First could be the learning from German government's energy research policy which has been in place since 1977. The Energy Research Programme is the main element setting out the principles and priorities of the funding policy. The German Government adopted the 7th energy research program called 'Innovation for the Energy Transition' in 2018 which is providing around €6.4 billion during 2018-22, for research, development, demonstration and testing of forward-looking technologies and concepts. This is a growth of 45% from the preceding programme during 2013-17. Given that India's R&D expenditure is low, replicating this model could be of benefit to India. It can be in the form of scaling up the funding for the existing institutes as well as setting up new research institutes under the aegis of MNRE or SECI.

Another successful model is Climate Fund program of BNDES which was established in 2009. The cumulative funding from the Ministry of Environment of Brazil to this program crossed Brazil Real 1 billion in 2020. While the GOI established National Adaptation Fund for Climate Change (NAFCC) in FY 16, it needs to scale up its funding and utilization. In FY 20, only ` 40 crore of the ` 100 crore allocation was utilized.

Finally, JBIC established 'Global Action for Reconciling Economic Growth and Environmental Preservation' (GREEN) in 2010 to support projects which can positively impact the global environment. Taking a cue, Indian FIs could start a separate business segment similar to JBIC's GREEN, specifically to focus on renewable energy projects. These programs could also target other countries such as the ones in Africa which have a huge potential in solar energy growth.

Conclusion

Given the recently released Intergovernmental Panel on Climate Change (IPCC) sixth assessment report, climate change has become a threat now more than ever. In such circumstances, it is even more important to work towards the Goal 7 (clean and affordable energy) of the Sustainable Development Goals-2030. This paper has made an effort to explore areas such as access to the finance, land availability, floating solar power systems, among others, towards greater access and promotion of solar energy in India.

It may be noted that India also has placed an ambitious goal in the solar energy sector towards installing a capacity of 100 GW by 2022. This is achievable considering the country's estimated solar potential of almost 750 GW. India's goal and strategies should be to maximize this potential in the long run. The implementation of listed strategies will not only help India in achieving its target but would also provide the country with a chance to become self-sufficient in the solar PV technologies, and even export globally.

CHAPTER

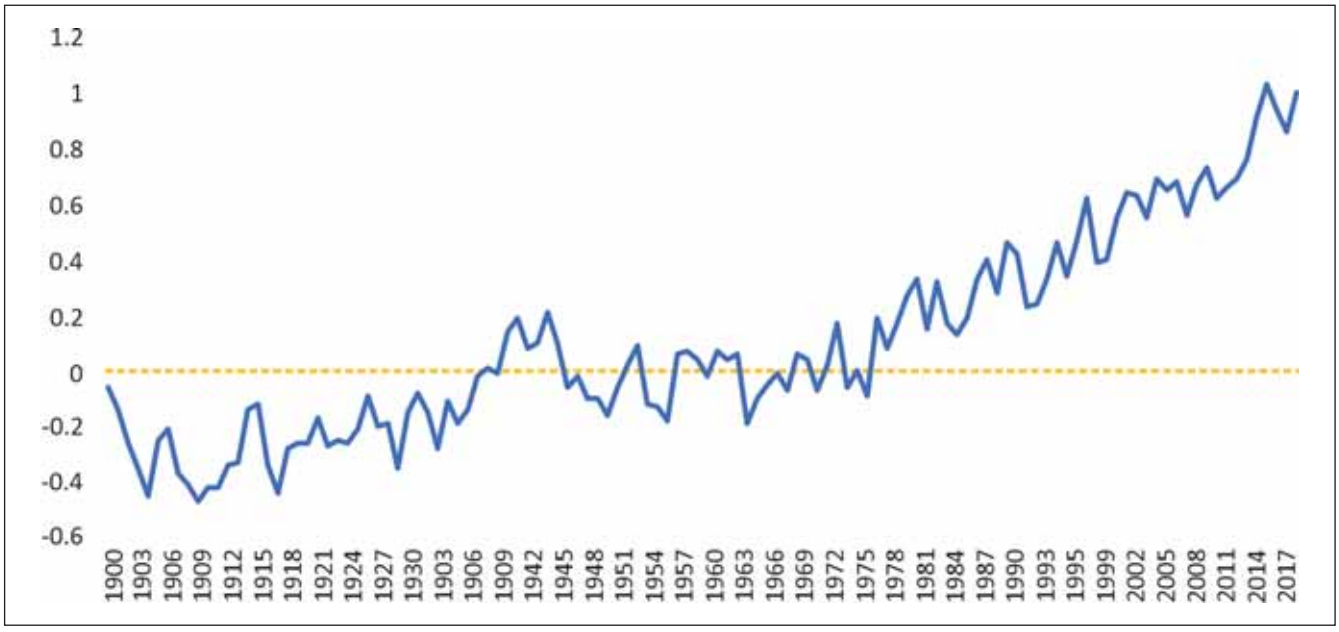
SUSTAINABLE DEVELOPMENT & SOLAR ENERGY

While the world continues to move on the path of growth and employment generation to pull the vulnerable populace across the globe out of poverty, it is equally vital to understand the negative consequences of environmental degradation and carbon emissions which have led to climate change. The adverse impacts like frequent droughts, rising levels of the sea, and increased greenhouse gas (GHG) emissions are the reasons against which the world is increasingly taking steps to mitigate these risks and their causes. It has also been observed that in the last few years, the economic growth and the increase in carbon emissions have moved parallelly. The governments across the world are aware and are increasingly calling for international collective actions.

It may be noted that the Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015, provide an equal thrust to the need for the renewable energy in the world. The Goal 7 of SDGs is based on affordable and clean energy. As per the United Nations Development Programme (UNDP), "*Investing in solar, and wind power, improving energy productivity, and ensuring energy for all is vital if we are to achieve SDG 7 by 2030.*"

One of the latest collective actions has been the adoption of international climate agreement at the U.N. Framework Convention on Climate Change (UNFCCC), Conference of the Parties (COP21) in Paris in December 2015 to undertake targeted efforts to counter climate change. The primary goal of the COP21 Agreement is to "*strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees celsius and to pursue efforts to limit the temperature increase even further to 1.5 degrees celsius above pre-industrial levels.*"

Figure 1: Change in Global Surface Temperature Relative to 1951-1980 Average Temperatures (°C)



Source: Data accessed from NASA

The COP 21 further specified, "*to reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.*"

Under Article 4 of the COP 21, the countries pledge, "*to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty.*"

Promoting Solar Energy in India

Given the aforesaid challenges and the issues therein, it is but crucial to take due measures to facilitate aspects which would promote solar energy. It is even more important to note that in developing and emerging nations like India, the contribution of combustion of fossil fuels in the carbon emissions has been increasing. This, in a way, compels economies to achieve the dual objective of economic growth (significantly dependent on energy), and low carbon emissions.

In such a scenario, it becomes necessary for the nations, especially the developing ones, to look for viable alternatives to the conventional forms of energy which largely include coal, and oil and gas. Further, the supply dynamics of these resources make them price volatile and at times, can lead to supply shocks. A situation such as this is naturally bound to impact developing nations like India more than the developed ones.

The solution to the aforesaid challenges lies in the new age renewable energy systems such as the solar energy. In the last few years, with the increasing awareness on the ill-effects of climate change as well as the rising concerns for the energy security, the global community has shown more eagerness than ever to move towards facilitating cleaner energy sources such as solar.

One of the biggest benefits of the solar energy is that it is literally inexhaustible and one of the cleanest forms of energy. In countries like India, almost 300 days of sunlight is there which naturally puts India at an advantageous position to move to the solar energy systems.

While the solar energy world is full of potential and opportunities, especially for the developing world, it is vital to note that having the access to sunlight and being able to harness energy from it, are two different things. There is a division in accessing the solar energy where developing countries and LDCs are not able to achieve the desired amount of green energy growth even with more solar resources than the developed ones which might have much higher installed capacities to produce solar energy with lower solar resources.

India being one of the pioneers in solar energy space understood this and came out as a leader when it conceived the International Solar Alliance (ISA) with France in 2015. The alliance has 121 member countries which lie between the two tropics, Cancer and Capricorn, either partly or fully, and given their geographical location, most of them are high sunshine countries.

During the first assembly of ISA in 2018, India also proposed '*one sun, one world, one grid*' which will be a transnational grid and will have the potential to supply the electricity to the entire world. As per the Ministry of New and Renewable Energy (MNRE), Government of India, the plan once implemented, could cover almost 140 nations with a common grid.

Solar Energy Facilitating SDG

The climate change in the world cannot be separated from the activities in the energy sector, with the latter significantly impacting the former. While the energy demands kept increasing as the years passed, the methods to produce it were also not quite sustainable. There is not a one-point solution to the unsustainable methods of energy generation, and therefore, sustainability in energy generation requires global stakeholders to come together in addressing this challenge.

It may be observed that the solar energy in this space could be one of the major contributors when it comes to sustainability. As per the UNDP, energy is by far the main contributor to the climate change as it contributes to 73% of the human-caused greenhouse gases. Further, a huge chunk of population in the rural areas of the developing regions does not have access to the electricity. As a result, expanding infrastructure and upgrading to technologies like solar can help in providing a clean and more efficient energy to the world.

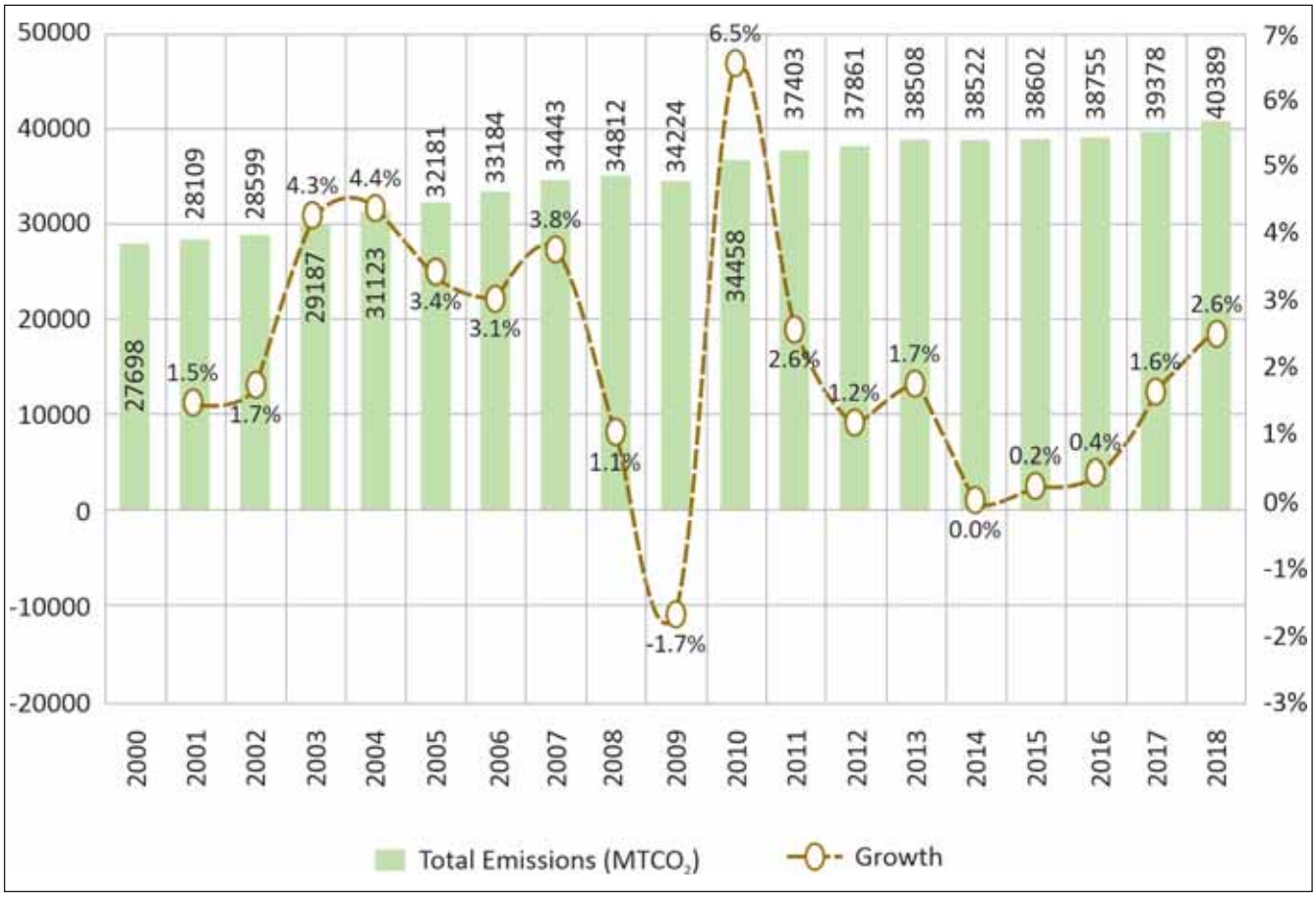
Trends in CO_2 Emissions: Global

The global CO_2 emissions were recorded at 40,389 metric tons ($MTCO_2$) in 2018, up from 27,698 $MTCO_2$ at the start of this century in 2000. During this period, the emissions have increased at an average annual growth rate (AAGR) of 2.9%, or at a compounded annual growth rate of 2.2%.

With respect to the components of these emissions, coal registered the highest AAGR of 2.9% during 2000 to 2018. Further, natural gas recorded an AAGR of 2.5% and oil grew at just 1%, during this period.

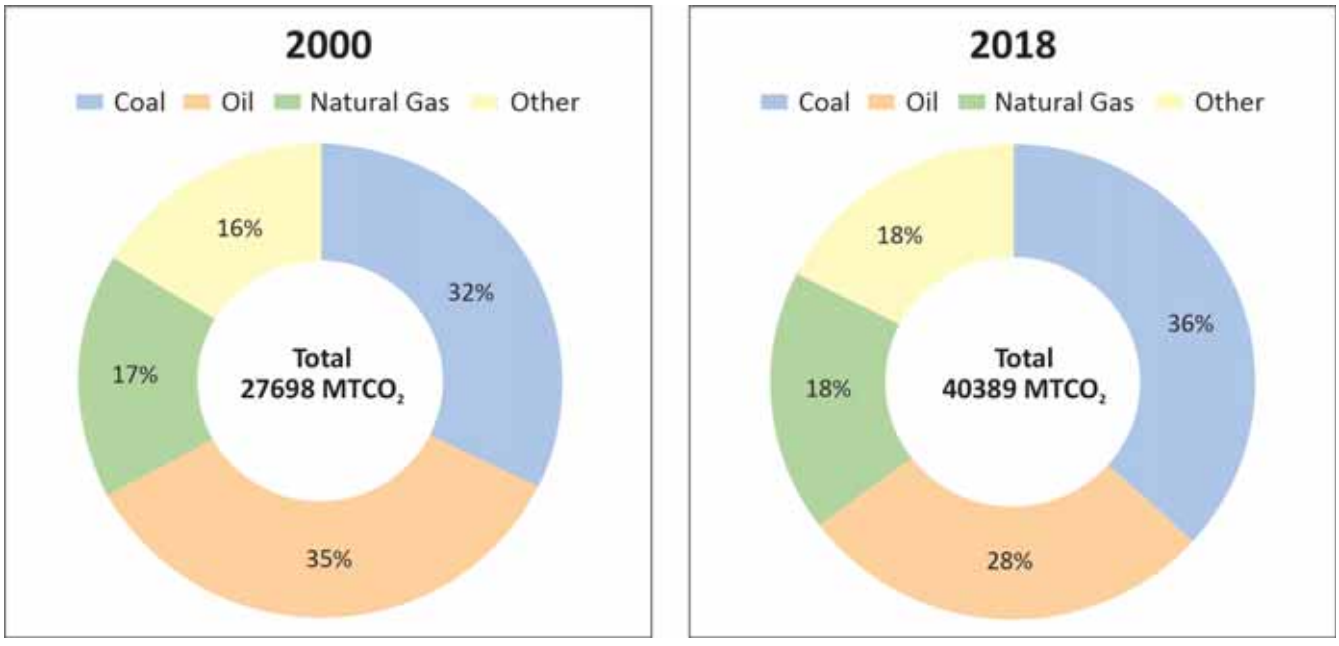
Coal energy is considered to be one of the biggest reasons of the increased carbon emissions and has been one of the most commercial forms of generating electricity traditionally, across the globe. The contribution of coal to the global CO_2 emissions has increased from 32.3% (8937 $MTCO_2$) in 2000 to almost 37% (14766 $MTCO_2$) in 2018. The contribution was as high as 39% in 2012 and has since then, decreased.

Figure 2: Global CO_2 Emissions



Source: International Energy Agency; India Exim Bank Research

Figure 3: Major Energy Sources of Global CO_2 Emissions



Source: International Energy Agency; India Exim Bank Research

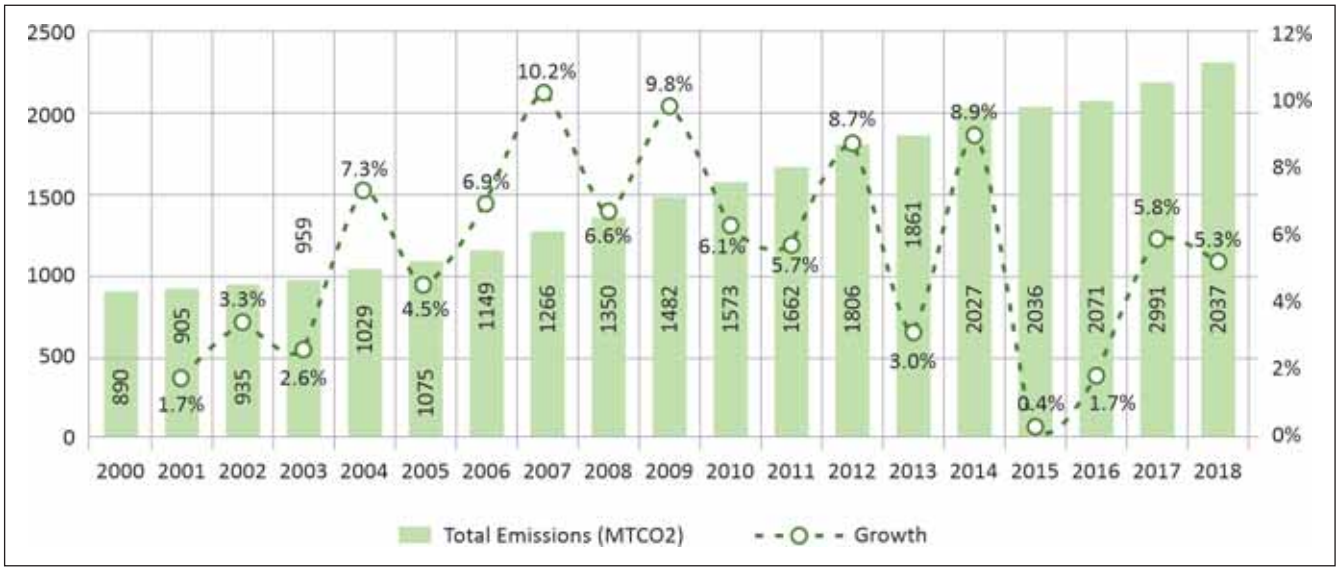
Trends in CO_2 Emissions: India

The CO_2 emissions from India were registered at 2,307 metric tons ($MTCO_2$) in 2018, up from 890 $MTCO_2$ in 2000. During this period, the emissions from India (as a developing economy) have increased at an AAGR of 5.5%, much higher than the world average (including from developed, developing, and less developed economies) of 2.1%, during the same period. India, being a developing country, has limited access to financial and technological resources when compared to developed economies. A worrying fact for India is that the share of India in the global emissions which was recorded at 3.2% in 2000, has increased almost every year since then and reached 5.7% in 2018. Nevertheless, as per the World Bank, in 2016, India's per capita $MTCO_2$ was significantly less at 1.8 than the world's, which was recorded at 4.6.

With respect to the components of these emissions, coal registered the highest AAGR of 6.9% during 2000 to 2018. In fact, in four of the nineteen years considered, it recorded a double-digit growth. Further, emissions from natural gas recorded an AAGR of 4.4% and oil emissions grew at 4.7%, during this period.

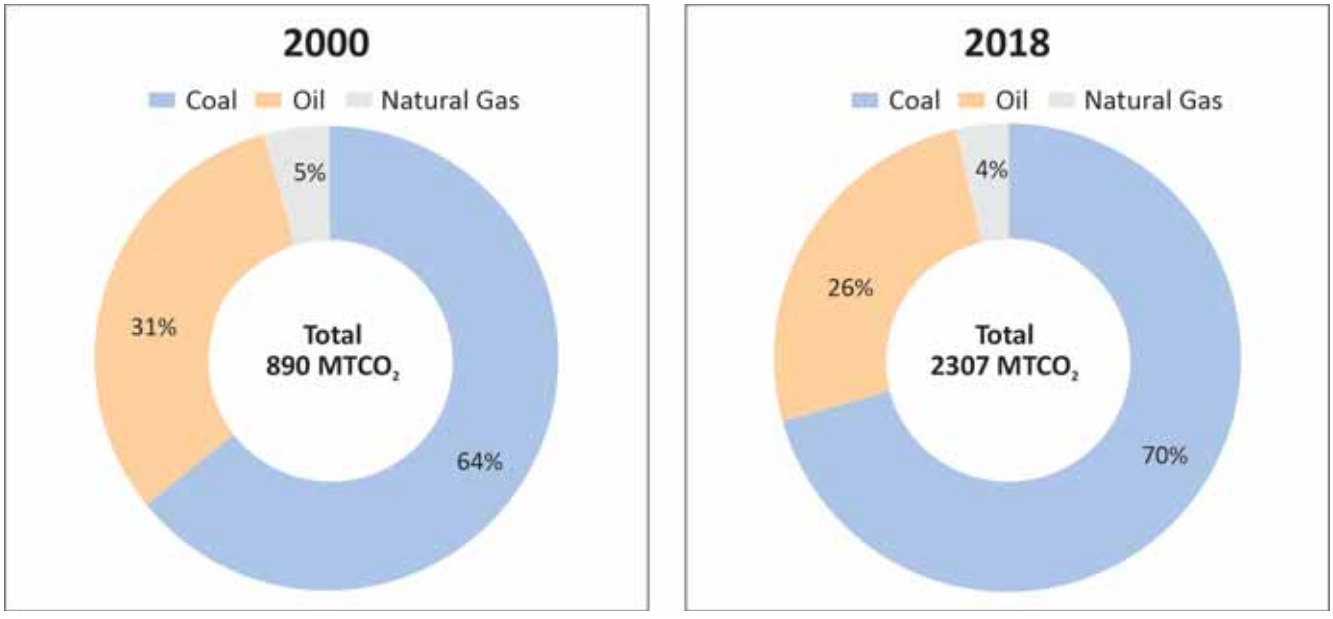
Albeit, in the recent years, the rise of the renewable energy systems has been significant, majority of India's electricity need is still dependent on coal energy. As a result, its share in the India's CO_2 emissions is still the highest and has rather increased in the last two decades. The contribution of coal to India's CO_2 emissions has increased from 64.3% in 2000 to over 70% in 2018. The contribution reached as high as 73.3% in 2014.

Figure 4: CO_2 Emissions from India



Source: International Energy Agency; India Exim Bank Research

Figure 5: Major Energy Sources of India's CO_2 Emissions

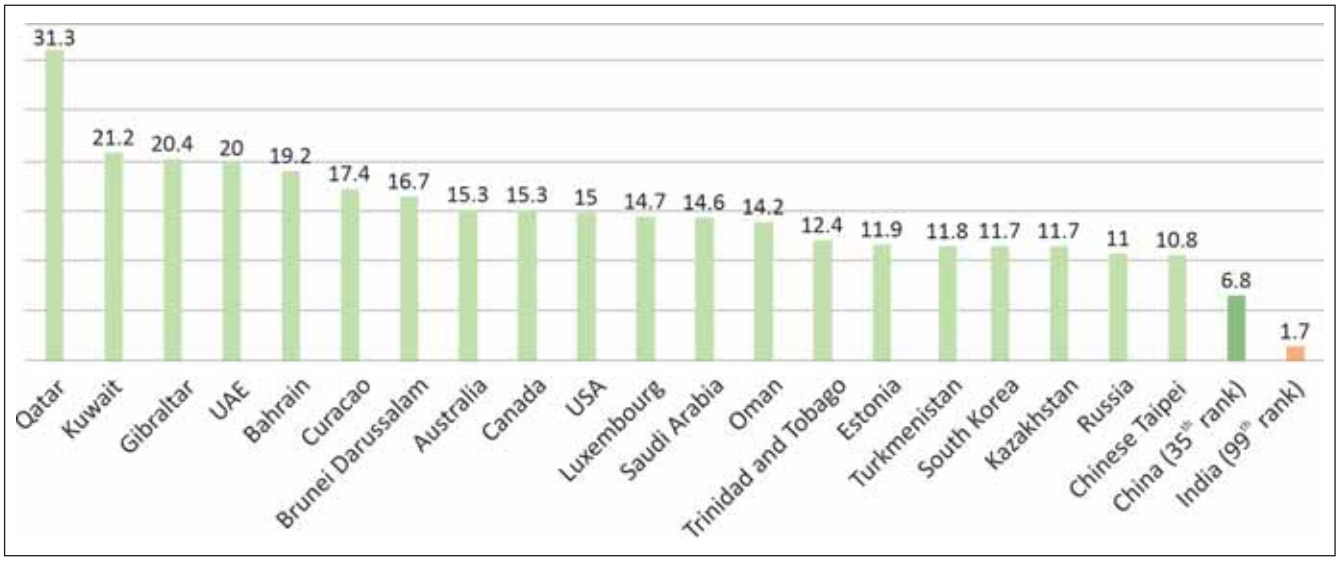


Source: International Energy Agency; India Exim Bank Research

CO_2 Emissions per Capita

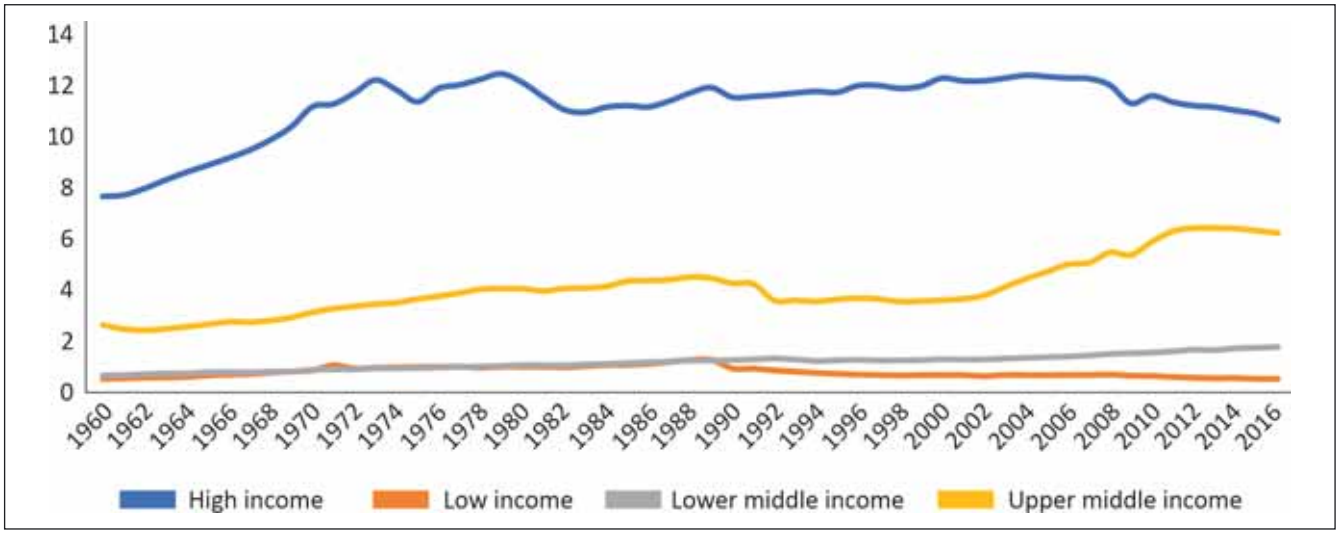
Further, it is also important to assess the carbon emissions on per capita basis. A high population country is bound to have total carbon emissions on the higher side, but it may not reflect the true situation if the per capita emission is low. It may be noted that the world emitted around 4.4 ton CO_2 (tCo_2) per person in 2018. India's per capita emission was way lower at 1.7 tCo_2. The highest per capita emissions were registered for Qatar at 31.3 tCo_2 in 2018.

Figure 6: Per Capita tCo_2 Emissions: 2018



Source: International Energy Agency; India Exim Bank Research

Figure 7: CO_2 Emissions (Metric Tons per Capita): Based on Income



Source: World Bank; India Exim Bank Research

Purpose of the Study

The Study takes a note of the trend in the global carbon emissions, especially in the context of India. These emissions have been on the rise in the last few decades. With its rising energy needs to progress towards growth and its significant dependence on the coal-based form of energy, India is required to look for alternative forms of energy such as solar.

The Paper attempts to investigate current solar energy scenario in India as well as its potential. Further, it also evaluates investments in this sector and the various schemes introduced by the Government to promote the use of this energy.

It will also delve deep into the trade opportunities of photovoltaic cells (PV) which are primary component in the setting up of a solar plant. Finally, the Study attempts to recommend select strategies and programmes which can be undertaken to promote solar industry, when it comes to fulfilling the energy demands of India.

This Study has attempted to cover a diverse range of elements such as the financial institutions, investments, new systems of solar power, land availability issues, MSMEs in solar energy, among others. These elements seek to work towards not just the Goal 7 of the SDGs, the scope of which includes clean and affordable energy, but also indirectly contribute towards achieving the other sustainable development goals.

CHAPTER

2

SOLAR ENERGY SCENARIO: GLOBAL AND INDIA

The previous chapter focused on understanding the trend in the global carbon emissions and as a result, the need for solar energy as one of the solutions to mitigate the climate change. This chapter would focus on the solar energy scenario in the world and particularly, India and how it has evolved in the last few years.

Renewable Energy Attractiveness

Ernst & Young (EY), has been publishing the Renewable Energy Country Attractiveness Index (RECAI) since 2003 wherein it ranks the countries based on the investments in the renewable energy space and the deployment opportunities.

As per the RECAI published in May 2020, India ranks 7th with an overall RECAI score of 58.6, behind the US, China, France, Australia, Germany, and the UK. However, what is interesting to note is that India's score in the solar PV is 54.7, highest amongst all the nations in this list published by EY. This score in the solar PV technology displays the investment friendly climate with respect to the solar technology in India where it beats the score of major giants like China.

Further, it may be noted that India, in the last five years, was ranked within the top 5 countries ranked under RECAI by EY, except in the May 2020 edition of the report, when it was ranked 7th.

Table 1: Renewable Energy Country Attractiveness Index Scores: May 2020

Rank	Country	RECAI score	Solar PV
1	USA	65.8	52.2
2	China	62.4	54.0
3	France	60.8	48.0
4	Australia	60.7	51.2
5	Germany	59.5	47.2
6	UK	59.0	40.0
7	India	58.6	54.7
8	Denmark	55.0	39.7
9	Netherlands	54.9	41.8
10	Japan	54.8	39.9
11	Spain	53.5	44.1
12	Ireland	52.7	40.4
13	Chile	51.9	41.4
14	Israel	51.3	47.9
15	Canada	51.2	38.5
16	Brazil	50.7	44.1
17	South Korea	50.7	44.1
18	Argentina	50.4	45.6
19	Italy	50.4	41.3
20	Belgium	50.3	36.0

Source: Ernst & Young

Table 2: India's Rank in the EY RECAI: Trends

Month	Oct 2016	May 2017	Oct 2017	May 2018	Oct 2018	May 2019	Oct 2019	May 2020	Oct 2020	May 2021
Rank	3	2	2	4	2	4	3	7	4	3

Source: Ernst & Young

It may be noted that between 2010 and 2019, the highest fall in the cost of electricity was registered for energy generated from solar PV, a fall of 82%. The fall was 47% for concentrating solar power (CSP), 38% for onshore wind, and 29% for offshore wind.

Table 3: Global Weighted Average Levelized Cost of Electricity from Utility-Scale Renewable Power Generation Technologies, 2010 and 2019 (in US$/kWh)

Energy Source	2010	2019	Decline
Fossil Fuel	0.076	0.066	-13.2%
Geothermal	0.049	0.073	49.0%
Hydro	0.037	0.047	27.0%
Solar PV	0.378	0.068	-82.0%
Concentrating Solar Power	0.346	0.182	-47.4%
Offshore Wind	0.161	0.115	-28.6%
Onshore Wind	0.086	0.053	-38.4%

Source: IRENA

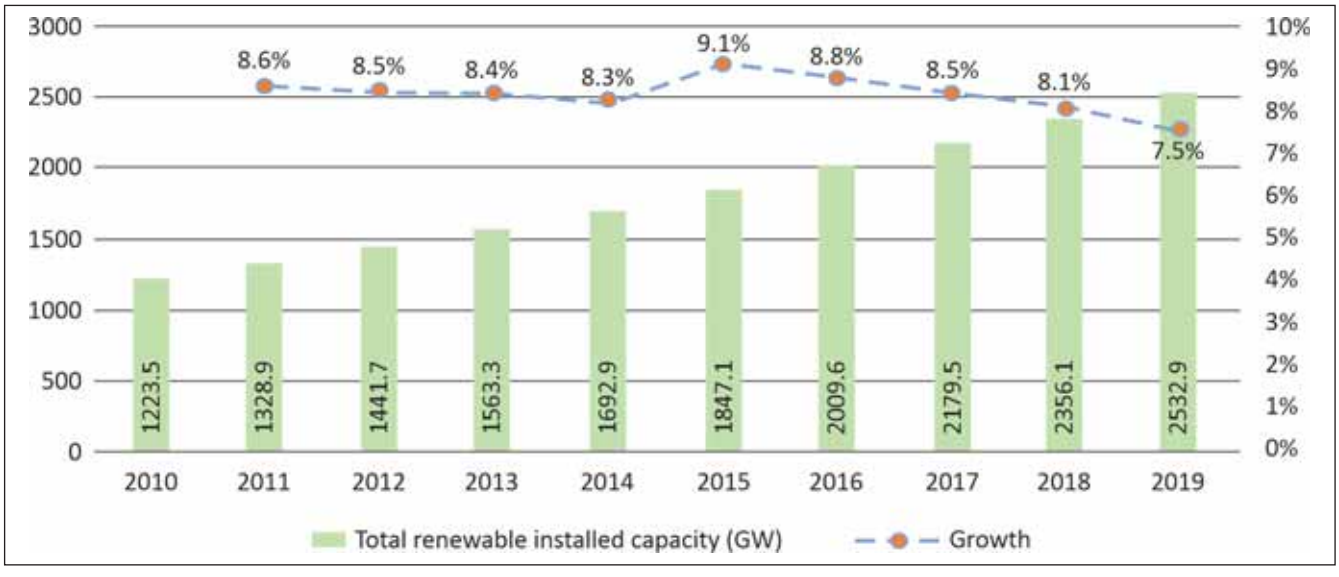
With respect to the countries, the largest reduction was noticed for India where costs declined by 85%, to reach US$ 0.045/kWh in 2019 - a value 34% lower than the global weighted average for that year. India was followed by China (US$ 0.054/kWh), and Spain (US$ 0.056/kWh).

Global Scenario

With the increasing consciousness of climate change and the resultant technological advancements, the usage of renewable energy as a fuel, especially solar energy, has increased exponentially in the last couple of decades.

The total renewable energy installed capacity in the world was recorded at 2532.9 GW in 2019, up from 1223.5 GW in 2010, registering an average annual growth rate of 8.4% during this period, which led to the capacity growing by more than twice in the last decade.

Figure 8: Global Renewable Energy Installed Capacity

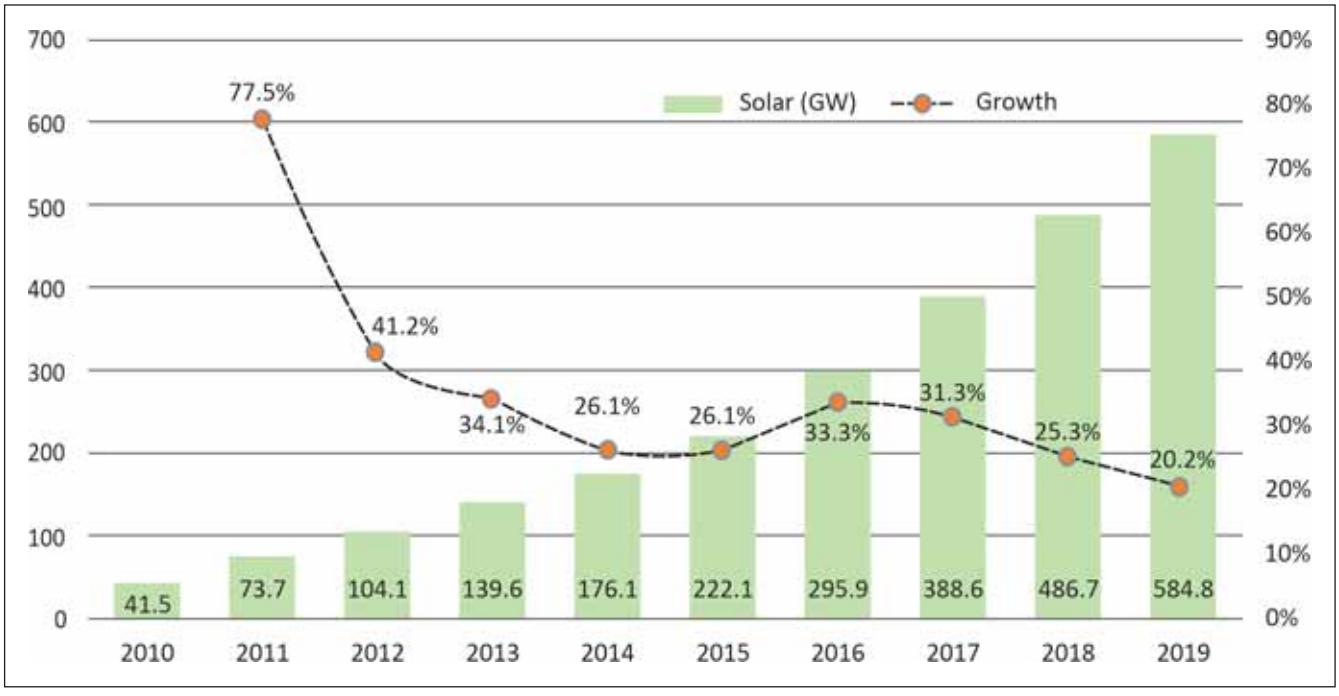


Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

It is important to note that the share of solar energy in the total installed capacity of the renewable energy has grown by almost 20%, from 3.1% in 2010 to 23.1% in 2019. This is reflected from the fact that the solar installed capacity has increased from 41.5 GW in 2010 to 584.8 GW in 2019, thereby recording an AAGR of 35%, during this period. It may be noted that almost 99% of the solar installed capacity is from solar PV and only 1% is attributed to concentrated solar power.

Solar electricity generation due to this capacity reached 562 TWh in 2018, up from 33.8 TWh in 2010, which is almost 17 times more, and thus, recorded an AAGR of 43.4%, during this period.

Figure 9: Global Solar Energy Installed Capacity

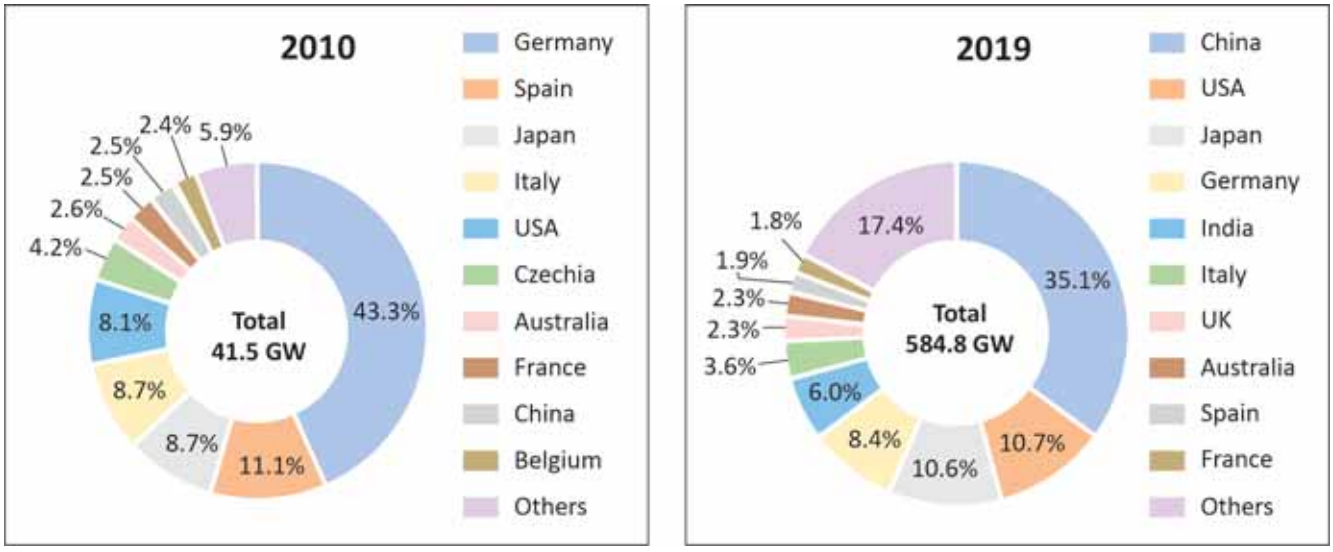


Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

With respect to various nations having installed solar capacities, it may be noted that the top ten countries globally contributed to 82.7% of the total solar installed capacity in the world in 2019. While this share, per se, is definitely a huge concentration and reflects the division amongst countries with respect to making use of their solar resources, it is important to observe that the top ten nations in 2010 contributed to over 94% of the total solar installed capacity. Therefore, though there is a need for other countries to increasingly utilize their solar resources, the concentration of the capacities has declined in the last decade. This also shows a huge opportunity for further expansion, while not limiting the concentration in a few countries only.

In the context of the shares of different countries in the installed capacity of solar, it may be noted that some of the major gainers in 2019 vis-à-vis 2010, have been China (increase of 32.7%), India (5.8%), the USA (2.5%), Japan (1.9%), and the UK (2.1%). Some of the losers have been Germany (decrease of 35%), Italy (5.1%), and Spain (9.2%).

Figure 10: Major Players in Solar Installed Capacities

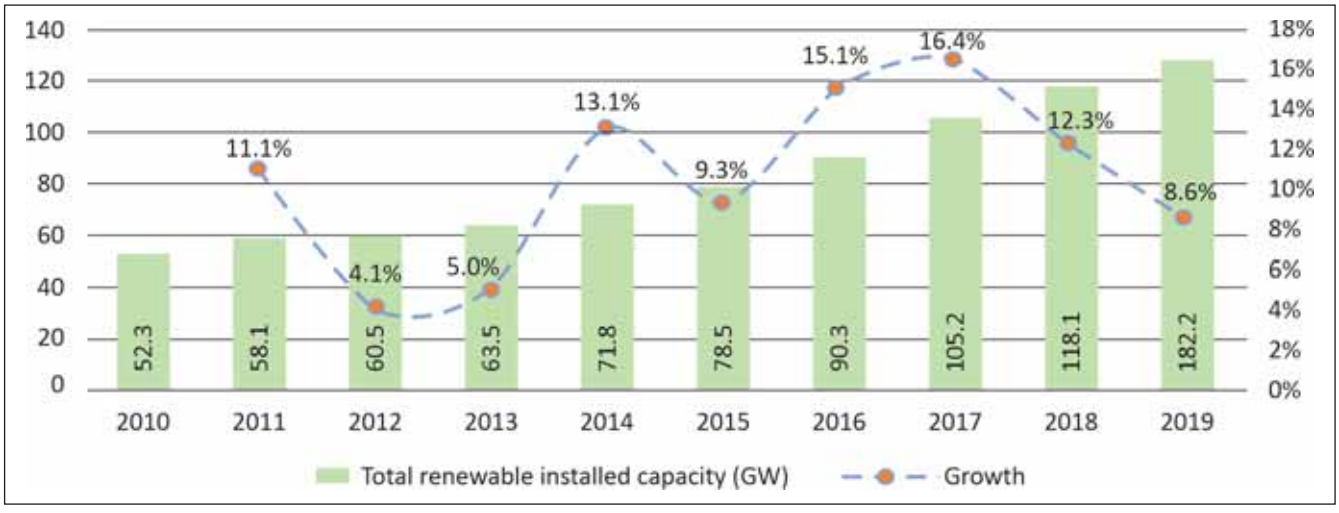


Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

Indian Scenario

Within the last decade, the total renewable energy installed capacity in India has increased by almost 2.5 times, with the capacity being registered at 128.2 GW in 2019, up from 52.3 GW in 2010, recording an AAGR of 10.6%, during this period. It may be noted that India's share in the global installed capacity of renewable energy has increased from 4.3% in 2010 to 5.1% in 2019.

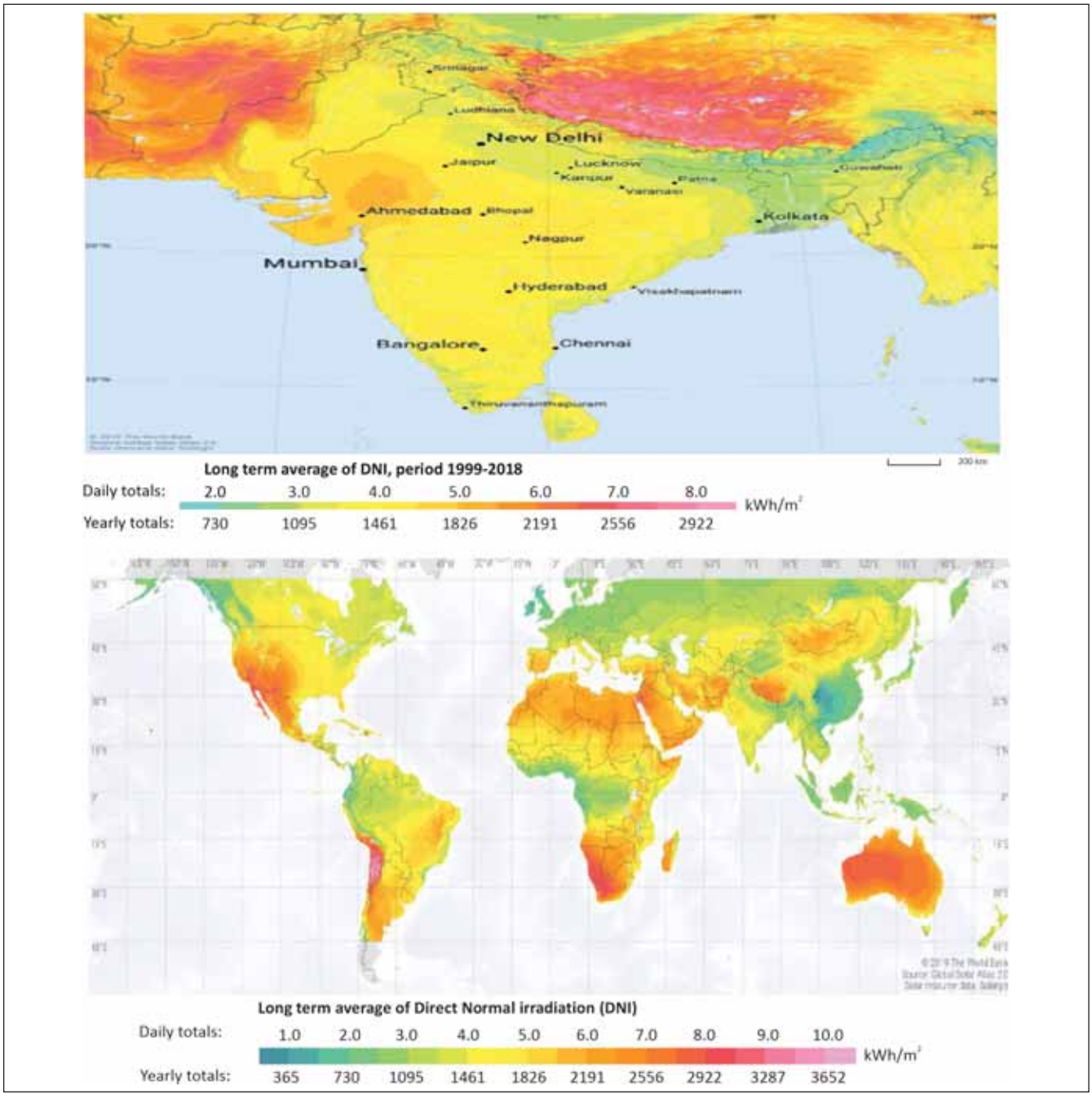
Figure 11: India's Renewable Energy Installed Capacity



Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

With respect to the solar energy, India has one of the highest Direct Normal Irradiance (DNI) which is dependent on various factors such as the earth-sun movement, geographical location, tilt of Earth rotational axis etc. DNI is the solar radiation per unit of area that comes perpendicularly from the direction of the sun at its current position.

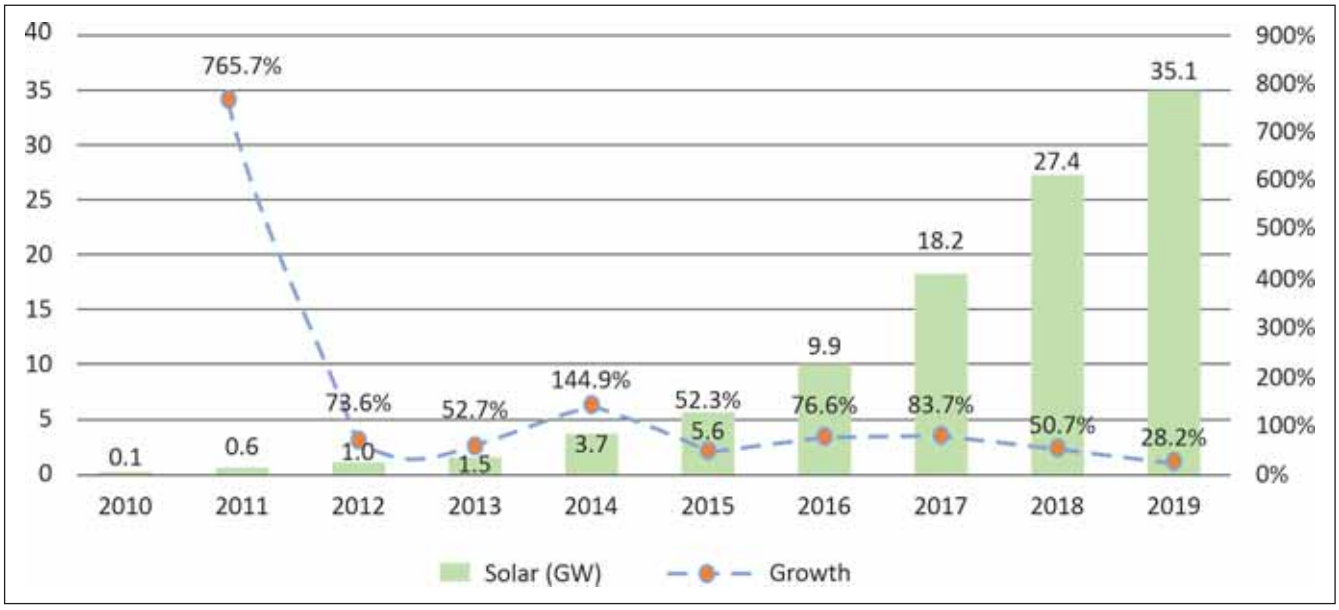
Figure 12: Direct Normal Irradiation of India vis-à-vis World



Source: Accessed from Global Solar Atlas, World Bank Group

Due to the advantageous position that India has with respect to the solar energy, the installed capacity has certainly gained momentum in India in this space. The installed capacity of solar energy in India was recorded at 35.1 GW in 2019, up from just 0.1 GW in 2010, registering an AAGR of almost 148%, during this period. India's share in the global solar capacity has also increased from mere 0.2% in 2010 to 6% in 2019. According to the Central Electricity Authority (CEA), Government of India, as on 30th June 2021, the installed solar power capacity was at 42.3 GW.

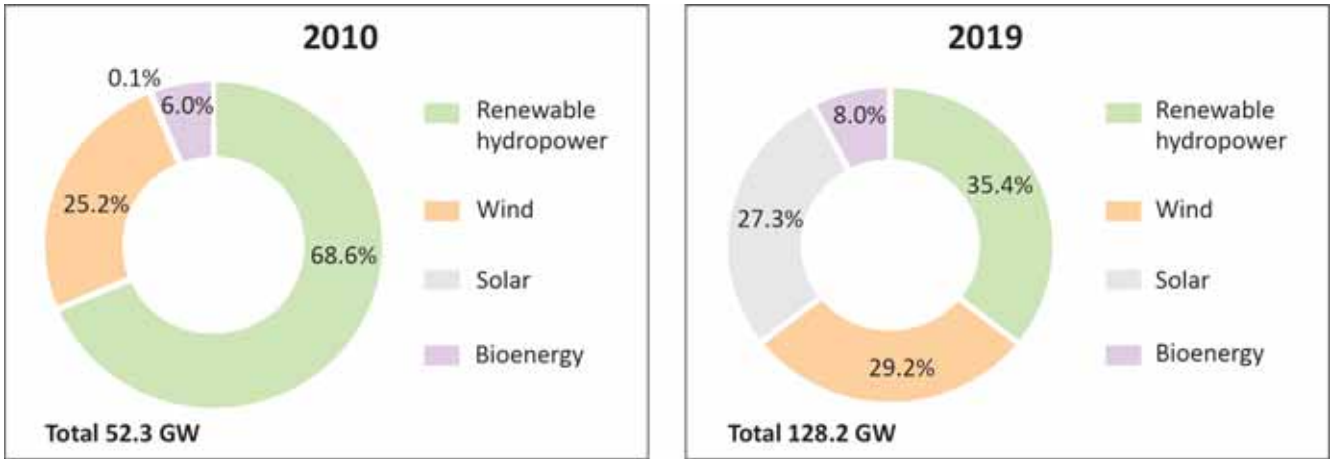
Figure 13: India's Solar Energy Installed Capacity



Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

Further, it may be noted that the fast growth of solar energy installed capacity in India has helped it to increase its share in the India's total renewable energy installed capacity. The share of solar installed capacity in total renewable capacity was just 0.1% in 2010 and increased significantly to 27.3% in 2019.

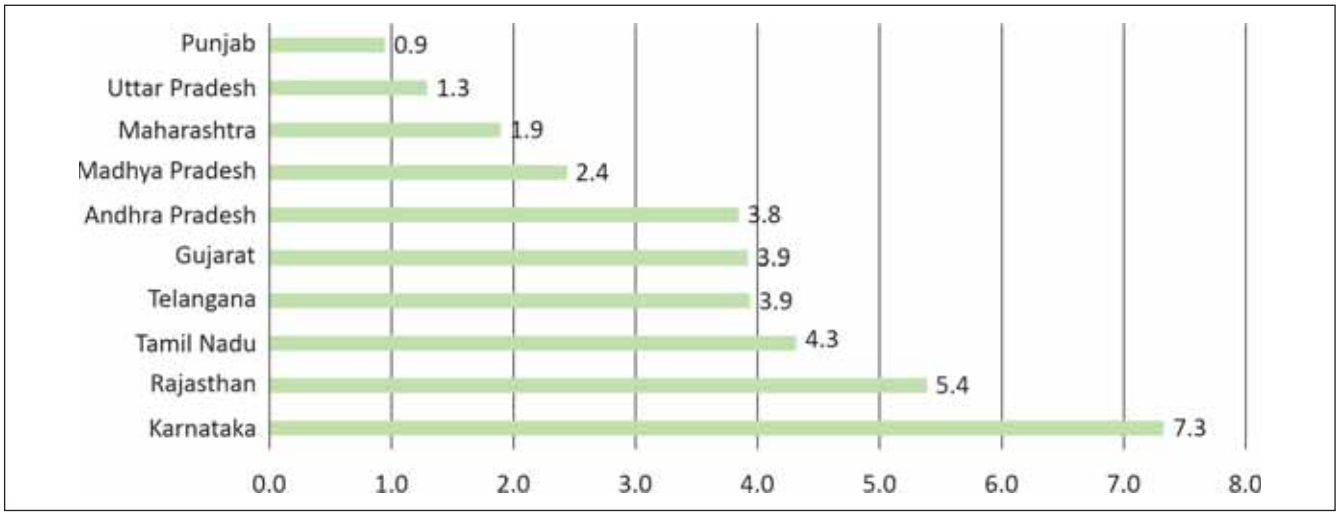
Figure 14: Solar Energy Share in India's Total Renewable Installed Capacity



Source: International Renewable Energy Agency (IRENA); India Exim Bank Research

As on 31st December 2020, the highest installed capacity in India was in the State of Karnataka at 7.3 GW, comprising of almost one-fifth of the total installed capacity in India. This was followed by Rajasthan at 5.4 GW and Tamil Nadu at 4.3 GW. It may be noted that the top five states contribute to almost 66% of the total installed capacity in India and therefore, a significant diversification is required, with respect to installing of new capacities.

Figure 15: Top 10 States in Solar Installation Capacity (As on 31.12.20): In GW



Source: Ministry of New and Renewable Energy, Government of India

Further, by potential, it may be observed that India has almost 750 GWp of solar capacity potential, with the highest potential being with Rajasthan at 142.3 GWp, followed by J&K at 111.1 GWp.

Table 4: State-wise Estimated Solar Energy Potential in the Country (As on 31 Dec 2020)

State/UT	Estimated Solar Energy Potential (GWp)
Andhra Pradesh	38.4
Arunachal Pradesh	8.7
Assam	13.8
Bihar	11.2
Chhattisgarh	18.3
Delhi	2.1
Goa	0.9
Gujarat	35.8
Haryana	4.6
Himachal Pradesh	33.8
Jammu and Kashmir	111.1
Jharkhand	18.2
Karnataka	24.7
Kerala	6.1
Madhya Pradesh	61.7
Maharashtra	64.3
Manipur	10.6

State/UT	Estimated Solar Energy Potential (GWp)
Meghalaya	5.9
Mizoram	9.1
Nagaland	7.3
Odisha	25.8
Punjab	2.8
Rajasthan	142.3
Sikkim	4.9
Tamil Nadu	17.7
Telangana	20.4
Tripura	2.1
Uttar Pradesh	22.8
Uttarakhand	16.8
West Bengal	6.3
UTs	0.8
Total	**749.0**

Source: National Institute of Solar Energy

Select Solar Schemes in India

The solar energy momentum gained by India in the last decade correlates directly with the missions and policies introduced by the Government of India as well as various state governments. The growth in the installed capacity during this time has been tremendous and eventually, solar power is being a tough competitor to the other forms of electricity in India.

The Jawaharlal Nehru National Solar Mission (JNNSM), or the National Solar Mission (NSM)

With the rising concerns around the climate change across the globe, including India, the Government of India came up with the National Action Plan on Climate Change (NAPCC) in 2008. The plan consisted of eight core missions, out of which, one of the most important was the National Solar Mission.

The National Solar Mission is the core of the solar related policies in India and was launched in 2010 with an aim to promote the use of solar energy in India and establish it as a global leader in this space. While the initial target was to deploy 20 GW installed capacity of solar power by 2022, the target was revised to 100 GW by 2022 with the extraordinary performance and interest of India's solar sector.

The phase 1 of the NSM was during 2010-13 where the target for the grid connected PV was 1000 MW and the target for the off grid solar applications was 200 MW. The phase 1 of this mission consisted of three stages, namely, migration scheme; NSM Phase 1 Batch I; and NSM Phase 1 Batch II.

The migration scheme was introduced to give a kickstart to the NSM and allowed the speedy completion of the then projects which were at an advanced stage of implementation in various states. Capacity amounting to 84 MW through 16 projects was approved under this scheme.

As per the Ministry of New and Renewable Energy (MNRE), in the batch I and II of the NSM phase 1, the reverse bidding process was used to allot the solar power projects which meant that the bidders who bid lower won the projects. The batch I consisted of 150 MW of Solar Photovoltaic (SPV) and 470 MW of Solar Thermal (ST) technologies in 2010. And the batch II comprised of 350 MW of SPV technology in 2011.

With respect to Phase II of NSM, the target is set for a cumulative solar capacity of 100 GW by 2022. This phase involved a combination of various schemes such as bundling, generation-based incentive, and viability gap funding. The target set for FY 20 and FY 21 has been 30 GW each by MNRE.

Bundling Scheme

Under the first phase of the NSM, to incentivize the solar power projects, an option of bundling was provided wherein the solar power could be bundled with the other cheaper power source such as the thermal power. This bundled power could then be sold to the state distribution facilities at a price regulated by the Central Electricity Regulatory Commission (CERC). This could bridge the gap between the average cost of power and the sale price of power.

Over the period, the renewable energy sector, especially the solar, has become less risky and its tariffs have fallen (currently between ` 2.50-2.87 per kilowatt hour). However, a continuous supply of renewable power is challenging. There are issues of intermittency and low-capacity utilization of the transmission lines. As a result, the MNRE recently proposed a draft policy of round the clock power from renewable energy power projects, complemented with thermal power projects.

The policy is based on the concept of reverse bundling, where in, thermal power, which is of higher cost, can be bundled with the low-cost renewable power in order to cater to the round the clock power supply to the DISCOMs. As per the policy, the power generator must maintain a 51% quota of renewable energy and maintain at least an 80% availability of power, annually.

Box 1: Growth of Solar Energy in Spain: The Barcelona Model

Barcelona, one of the major cities of Spain, receives close to 2800 hours of sunshine every year and has an ideal climate for harnessing the solar energy for the buildings sector. Realizing this potential, in 1999, the city council of Barcelona passed the Solar Thermal Ordinance (STO). As per the STO, it was mandatory for all new buildings, renovated buildings, and new use (both private and public) to supply at least 60% of running hot water with solar energy.

The STO was implanted into two stages. During 2000 to 2006, the regulations only applied to buildings using more than 0.8 MW per day for hot water production and after 2006, this exemption was eliminated, and the regulations were applied universally.

With the successful implementation of STO, solar energy became the major source of renewable energy for Barcelona in 2008, accounting for 52% of total renewable energy production. The city was also able to achieve its target of installing 88,015 m^2 of solar thermal panels by 2010.

This Barcelona model was followed by over 70 municipalities in Spain and in 2006 the principles of the Barcelona STO were adopted in legislation at the national level.

It may be noted that in the last two decades, during 2000 to 2020, the AAGR in the installed capacity of solar in Spain was recorded at almost 70%, increasing from 10 MW in 2000 to 14,089 MW in 2020. While the solar installed capacity was growing at double or even triple digit rates for most of the years during 2000 to 2012, it slowed down since 2013. In fact, the AAGR during 2013 to 2018 was less than 1%.

The reason for the same was that in 2013, the Government of Spain cut subsidies for renewable energy to tackle a EUR 28 billion debt, known as a tariff deficit, built up by years of regulation which kept prices below costs. The reforms also included a 'sun tax' which charged Spanish homes fitted with solar panels with an additional tax of 7% to remain connected to Spain's electricity grid should the solar panels not produce enough energy. This meant that the average family home with three solar panels fitted to their home had to pay around EUR 70 each month to remain connected to the grid whether or not they use the electricity it generates.

Recently, in 2018, the sun tax was repealed. This was reflected in the growth of installed capacity in 2019 and 2020. The growth was recorded at 59.6% in 2019 and 24.9% in 2020.

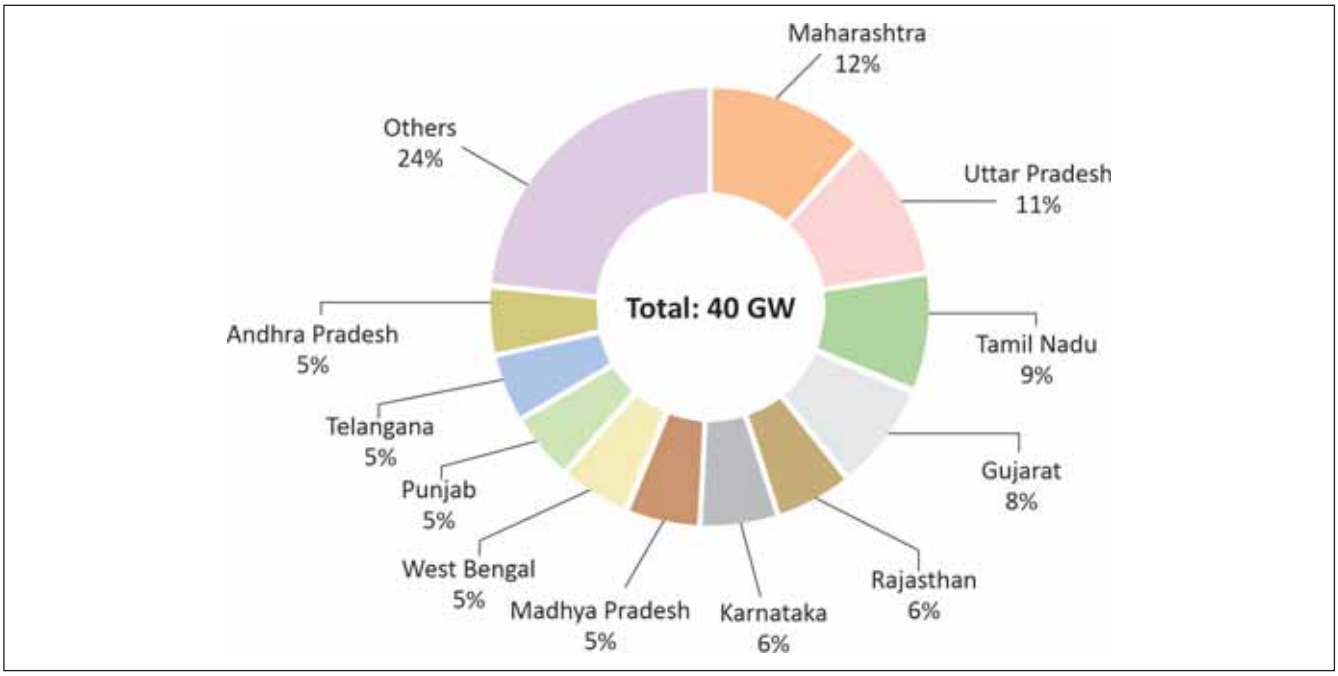
Source: Centre for Clean Air Policy; India Exim Bank Research

Grid Connected Rooftop Solar Program

The grid connected rooftop solar program comprises of two phases-I and II. Under the phase I of this program, the MNRE has been providing a subsidy of up to 30% of benchmark cost for the general category states and up to 70% for the special category ones which primarily comprise of the states and UTs such as Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Lakshadweep, Andaman & Nicobar Islands, and the North-Eastern states including the state of Sikkim. The purpose

to provide this subsidy is for the installation of grid connected solar rooftop plants in residential and institutional buildings for the projects which are sanctioned under this program. As on 31st December 2019, around 1889.3 MW of capacity was installed under phase I of this program.

Figure 16: State Wise Target for 40 GW Roof Top Solar by 2020



Source: MNRE; India Exim Bank Research

Box 2: Success of Solar Rooftop Systems in Gujarat

Gujarat has the highest number of solar rooftop installations in India with almost 1356.9 MW of capacity, as on August 31, 2021. This is almost one-fourth of the total solar rooftop installed capacity of India which was 5486.3 MW.

Gujarat has in place a scheme called 'Surya Gujarat' to encourage the installation of solar rooftop systems. As per this scheme, 40% subsidy is provided for up to 3 KW of solar rooftop installation projects. Further, a subsidy of 20% is there for the projects between 3-10 KW.

The scheme also allows the domestic users to sell the surplus electricity after the consumption to the state grid.

The phase II of this program was approved in 2019 with an aim to achieve 40 GW of cumulative installed capacity from rooftop solar projects by 2022. The total central financial support in order to implement this phase is ` 11,814 crore and the same will be implemented through DISCOMs. For the residential rooftop systems, this phase will provide a central financial assistance (CFA) of 40% for the rooftop systems up to 3 kW and for 3-10 kW, the CFA will be 20%. According to MNRE, as on 31st December 2019, an aggregate capacity of 410.96 MW has been allocated for 49 DISCOMs/ Electricity Departments in the residential sector.

Development of Solar Parks and Ultra Mega Solar Power Projects

The Government of India came up with the scheme for development of solar parks and ultra-mega solar power projects in 2014 to set up around 20 GW of installed solar power capacity through at least 25 solar parks with each being of a capacity of 500 MW to 1000 MW. The target was revised upwards in 2017 with the capacity rising from 20 GW to 40 GW through at least 50 solar parks by FY 22.

The objective behind the implementation of this scheme is that solar power projects in isolation and being scattered could attract higher costs of the projects which would ultimately impact the per MW cost of project. Some of the factors that could contribute to a higher project cost are site development, deriving separate transmission line to the nearest sub-station, and creating other infrastructure. However, when set up under a solar park, a solar project's cost reduces significantly.

Box 3: Bhadla Solar Park - World's Largest Solar Park

In 2020, Bhadla Solar Park in Rajasthan became the world's largest solar park with the final phase of 300 MW installation being completed in this park. The Park has 2250 MW of solar projects commissioned, which is more than previous largest of 2050 MW Pavagada solar park in Karnataka.

The Park is spread across more than 14000 acres and was completed in four phases. Multiple agencies were involved in the completion of the same. These include Rajasthan Solar Park Development Company Limited (RSPDCL), Saurya Urja Company (JV of Rajasthan Government and IL&FS Energy Development Company), and Adani Renewable Energy Park Rajasthan (JV of Rajasthan Government and Adani Renewable Energy Park).

This solar park size is expected to be overtaken by NTPC's 4750 MW solar power park at Rann of Kutch in Khavada, Gujarat in the coming years.

Source: Mercom

With respect to the incentives provided under this scheme, it may be noted that the MNRE provides a central financial assistance (CFA) for the preparation of detailed projects of up to ` 25 lakh per solar park. Further, a CFA of ` 20 lakh per MW or 30% of the project cost, whichever is lower, is provided as well.

The solar parks are developed in collaboration with the state governments, and Solar Energy Corporation of India is the implementation agency for the same. As on 31st December 2019, 39 solar parks have been approved with an aggregate capacity of 22,879 MW.

Box 4: Production Linked Incentive Scheme (PLI) for Solar Manufacturing

The Government of India, in 2020, approved the implementation of a PLI Scheme 'National Programme on High-Efficiency Solar PV (Photo Voltic) Modules' for achieving manufacturing capacity of Giga Watt (GW) scale in high-efficiency solar PV modules with an outlay of ` 4,500 crore.

The disbursement of the PLI will be for five years, post the commissioning of solar PV manufacturing plants, on sales of high-efficiency solar PV modules. Manufacturers will be rewarded for higher efficiencies of solar PV modules and for sourcing their material from the domestic market. Thus, the PLI amount will increase with increased module efficiency and increased local value addition.

Some of the other objectives include bringing cutting edge technology to India for high-efficiency module manufacturing, promoting setting up of integrated plants for better quality control and competitiveness, developing an ecosystem for sourcing of local material, and generating employment and technological self-sufficiency.

Further, IREDA recently also announced the list of solar companies which have qualified under the PLI scheme. The companies selected include Jindal India Solar Energy Limited (PLI of ₹1390 crore for a capacity of 4 GW), Shirdi Sai Electricals Limited (PLI of ₹1875 crore for a capacity of 4 GW), and Reliance New Energy Solar Limited (PLI of ₹1190 crore for a capacity of 2.5 GW).

It may be noted that the Government of India also gave an in-principle approval to sanction ₹19,000 crore more under the PLI scheme, taking the total of PLI scheme for solar cells to modules to ₹24,000 crore.

Source: Saur Energy International; India Exim Bank Research

Viability Gap Funding (VGF) Scheme

In India or anywhere in the world, there could be instances where the projects to be executed in any field, might not be financially viable but they are still executed because they are socially justified. That is where the need for a scheme like VGF arises as the gestation period could be long and the user charges cannot be increased exorbitantly.

Under the VGF scheme in the solar sector in India, the grid connected solar power projects of 750 MW, 2000 MW, and 5000 MW have been selected by the MNRE for VGF scheme and the SECI was the implementing agency for the same. In 2020, Indian Renewable Energy Development Agency (IREDA), replaced SECI as the implementing agency for VGF, and envisages setting up 12 GW grid-connected solar projects with VGF, under Central PSU scheme phase II. A VGF is provided to cover the cost difference between domestic and imported solar cells and modules.

The VGF scheme for 750 MW solar power plants provides for setting up of large-scale ground-mounted PV projects. Projects totalling of 680 MW have been commissioned under this. The total VGF disbursement by the SECI in the calendar year 2019 was ` 131.88 cr.

For the 2000 MW VGF scheme, out of the total scheme allocation of ` 2100 cr, the bidding has been executed for ` 1515 crore worth of projects. As on 31st December 2019, the total capacity awarded was 2155 MW and the total VGF disbursement by SECI in 2019 was ` 356.62 cr.

The 5000 MW VGF scheme was launched in FY 16 with a target to implement at least 1250 MW in each year for the next four years. The total capacity awarded as on 31st December 2019 was 3420 MW under this scheme and the total VGF disbursement in 2019 was ` 155.58 cr.

Conclusion

Analysis here shows that the global solar installed capacity in the last ten years recorded an AAGR of 35%, while on the other hand, the Indian solar installed capacity registered an average annual growth of 148%, during the same period - which was almost 4.2 times.

This impressive growth also got reflected in EY's RECAI Report in May 2020, where under the solar segment, India was at the top of the list. This growth is largely due to the acknowledgement by the Government of the potential of solar energy in the country and the various efforts and schemes like the national solar mission, bundling scheme, grid connected rooftop solar program, solar parks development, viability gap funding, amongst others.

CHAPTER

3

TRADE SCENARIO IN SOLAR EQUIPMENT INDUSTRY: GLOBAL AND INDIA

India has a domestic PV module manufacturing capacity of around 15 GW. However, India faces tough competition from China not just in the production of PV modules but also in the production of other raw materials such as wafers, cells, and poly silicon. Further, the capacity utilization of domestic production of PV modules is just 40-45%, and the operational capacity is around 7 GW[2]. As a result, India is mostly dependent on the imports of PV modules for installing the solar capacities.

Table 5: Leading Domestic Solar Cell Manufacturers in India

Company	Production Capacity (MW)
Adani Solar	1500
Indosolar	450
Jupiter Solar	450
Tata Power Solar	300
Websol Energy System	280
RenewSys	130
BHEL	105

Source: Adapted from IEEFA and JMK Research, January 2021

As discussed, India has come a long way with respect to the solar energy capacity installed in the country. However, while the generation of solar power is one aspect, the solar cells and associated equipment required to generate power is an important constituent to cater to. This chapter specifically analyses the trade scenario in this space.

[2] Institute for Energy Economics and Financial Analysis (IEEFA)

It may be noted that the items considered in this chapter for the trade analysis consist of the PV cells (photovoltaic cells[3]) and related goods. While the PV cells are specifically used in the solar energy, other items considered are of multiple use.

Global Trade

The global solar related equipment (14 HS 6-digit codes[4] mentioned in the table) exports were registered at US$ 155.1 billion in 2019, marginally up from US$ 152.3 billion in 2010, thereby registering an AAGR of 0.3%, during this period. The highest AAGR was registered by HS 711590[5] at 17%, during 2010 to 2019.

Table 6: Global Exports of Solar Related Equipment (US$ Billion)

Product code	Product label	2010	2019	Share in 2019	AAGR: 2010 to 2019
850440	Static converters	44.3	60.1	38.8%	3.6%
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	73.2	56.5	36.4%	-2.2%
900190	Lenses, prisms, mirrors and other optical elements, of any material, unmounted	7.8	9.6	6.2%	2.7%
841989	Machinery, plant or laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, sterilising, pasteurising, steaming, evaporating etc.	6.9	8.3	5.4%	2.3%
841990	Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature, and of non-electric instantaneous and storage water heaters, n.e.s.	5.6	6.4	4.1%	1.7%
711590	Articles of precious metal or of metal clad with precious metal, n.e.s.	3.0	2.8	1.8%	17.0%
900290	Lenses, prisms, mirrors and other optical elements, mounted, of any material, being parts of or fittings for instruments or apparatus	1.9	2.8	1.8%	4.9%
700992	Glass mirrors, framed	1.0	2.0	1.3%	8.4%
841919	Instantaneous or storage water heaters, non-electric	1.8	1.8	1.2%	0.3%

[3] HS 854140: photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels and light-emitting diodes

[4] New Renewable Energy in India: Harnessing the Potential, OP No. 143, India Exim Bank

[5] Articles of precious metal or of metal clad with precious metal, n.e.s.

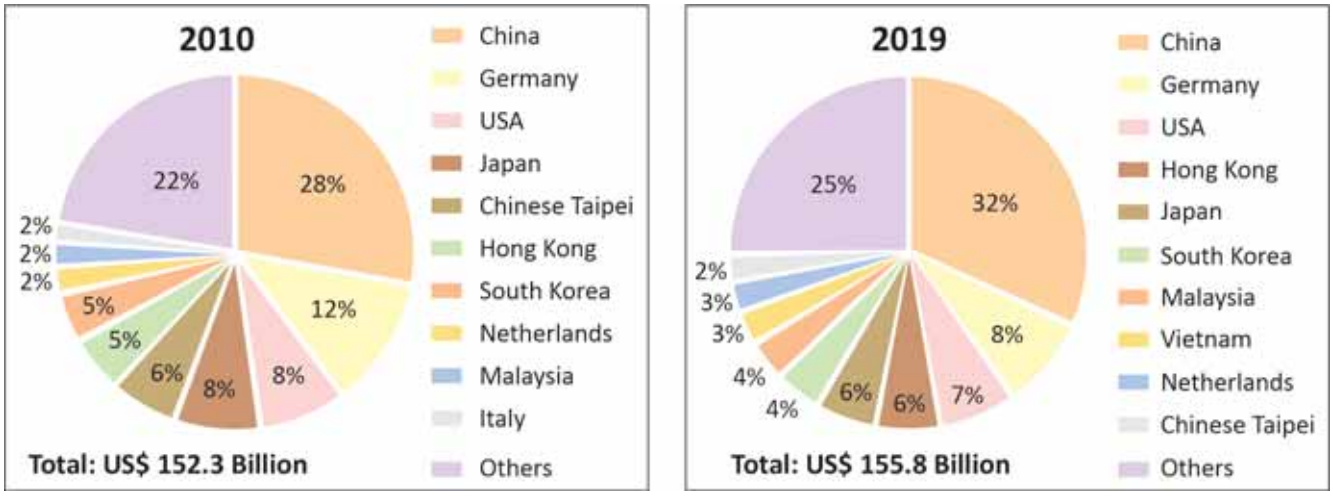
Product code	Product label	2010	2019	Share in 2019	AAGR: 2010 to 2019
850239	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	4.2	1.8	1.2%	-7.3%
732290	Air heaters and hot-air distributors	1.1	1.1	0.7%	1.4%
700991	Glass mirrors, unframed	0.8	1.1	0.7%	3.2%
900580	Monoculars, astronomical and other optical telescopes and other astronomical instruments	0.5	0.5	0.4%	2.8%
830630	Photograph, picture or similar frames, of base metal; mirrors of base metal	0.4	0.3	0.2%	-3.0%
Total		**152.3**	**155.1**	**100.0%**	**0.3%**

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

The major exporters of the solar related equipment in 2019 were China (31.8%), Germany (8.3%), the USA (7%), Hong Kong (5.9%), and Japan (5.9%). It may be noted that China's share has increased by almost 4 percentage points in the last decade.

Further, while the top ten exporters had a combined share of almost 78% in 2010, the same in 2019 was at around 75%, signifying that the concentration of the exports has reduced marginally, i.e., diversification of the exporter community.

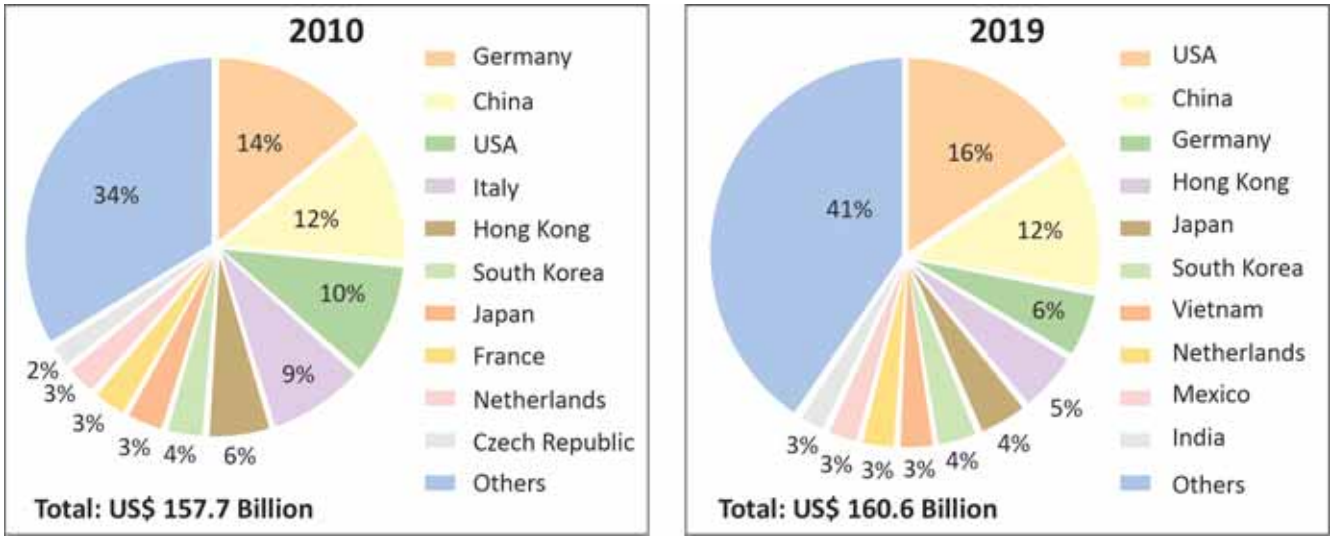
Figure 17: Major Exporters of Solar Equipment



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Additionally, with respect to the major importers, the top importers in 2019 were the USA (15.6%), China (12.1%), Germany (5.7%), Hong Kong (5.5%), and Japan (4.5%). The share of India which was just 0.8% in 2010, increased to 2.6% in 2019, clearly signifying the growth of the solar energy in the country, in the last decade.

Figure 18: Major Importers of Solar Equipment



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Trade in Photovoltaic

Particularly, for the photovoltaic cells[6], the global exports were recorded at US$ 73.2 billion in 2010. The same fell to US$ 56.5 billion by 2019. As a result, the AAGR recorded for this category of solar equipment, which is rather the most vital, was (-) 2.2%, during 2010 to 2019.

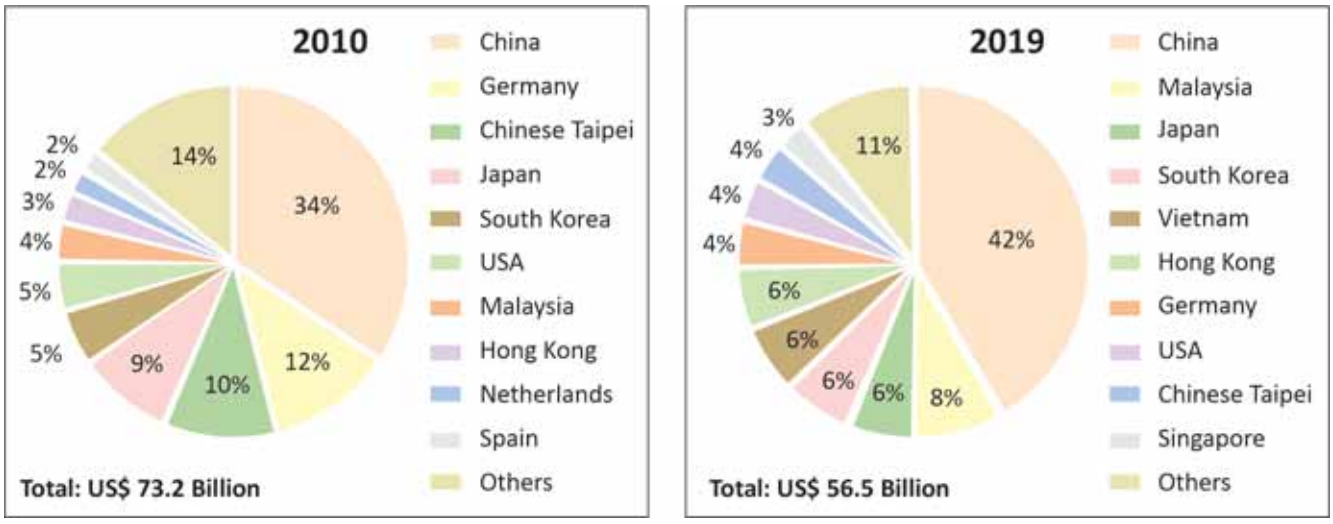
It may be noted that the share of China's exports of PV cells in the world exports which was around 34.4% in 2010 has increased by more than seven percentage points to reach 41.8% in 2019. A similar case is noticed for Malaysia which was the second largest global exporter of PV cells in 2019 with a share of 8.3% but had a share of only 3.6% in 2010. An impressive performance is noticed for Vietnam which had zero contribution to world PV exports in 2010 but had a share of 6.2% in 2019.

Figure 19: Global Exports of PV Cells (HS 854140)

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

[6] HS 854140

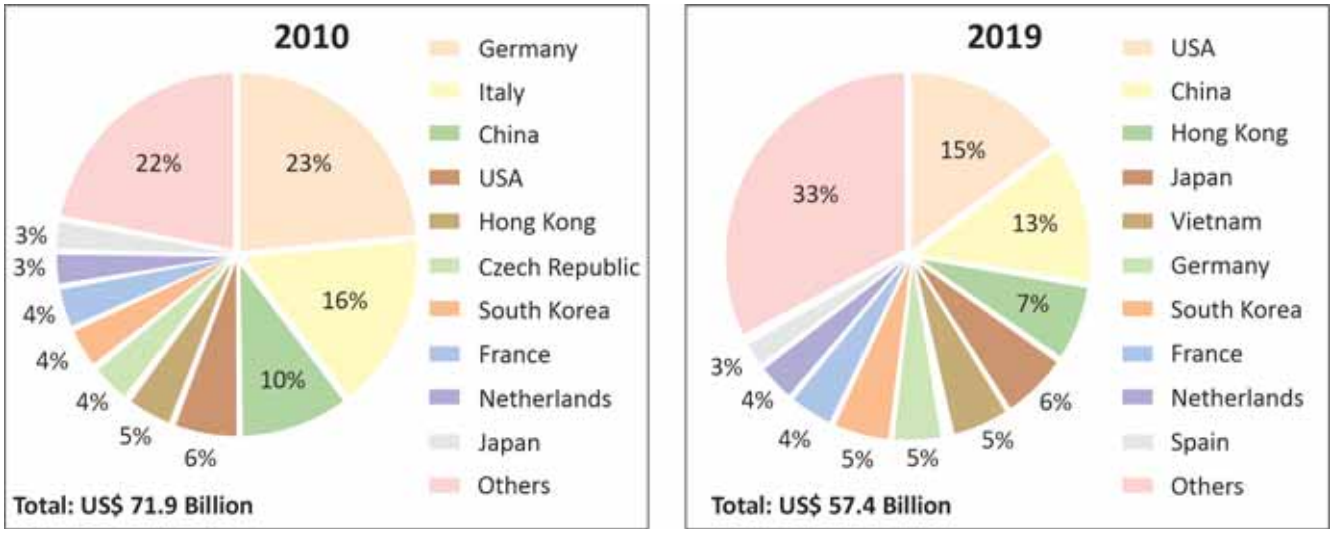
Figure 20: Major Exporters of PV Cells



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

With respect to the major importers of the PV cells, USA was the largest importer of the same with a share of 14.8% in 2019, up from 6.1% in 2010. Germany, which used to be the largest importer with a share of 23.5% in 2010, saw its share reducing to 5.3% in 2019. Italy's share was also in double digit in 2010 and got reduced to just 1% in 2019. India showed a tremendous improvement in its share of global PV imports from just 0.4% in 2010 to 4.3% in 2019. An even better performance was displayed by Vietnam (share increased from 0.1% to 5.4% between 2010 and 2019).

Figure 21: Major Importers of PV Cells

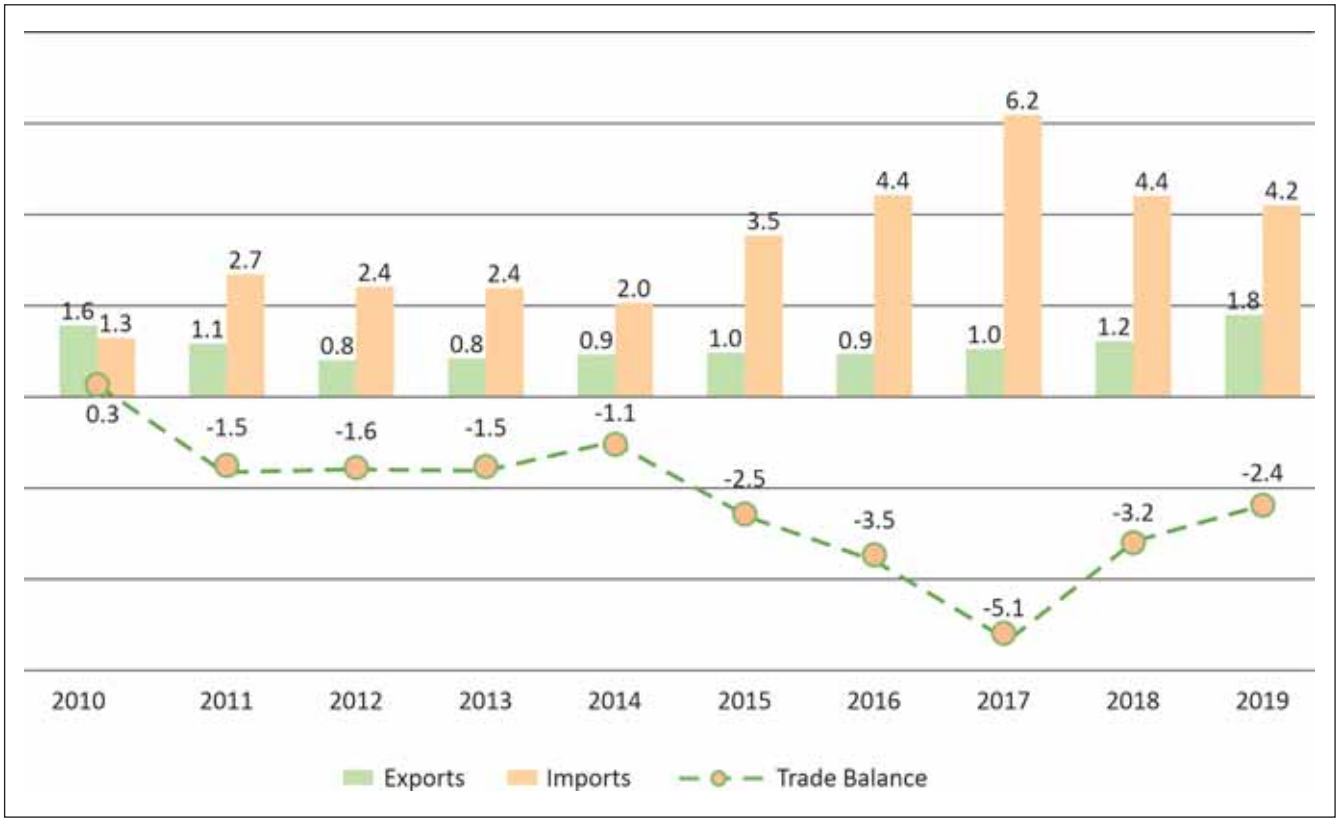


Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

India's Trade

India's solar energy demands have expanded exponentially in the last decade, which in turn exhibited demand for the solar related equipment. However, unfortunately, with limited domestic manufacturing capacities, India has been importing more than it exports.

Figure 22: India's Trade in Solar Equipment (US$ Billion)



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

India's exports of solar equipment in 2019 were US$ 1.8 billion, marginally above the level of 2010, when the exports were US$ 1.6 billion. The AAGR recorded for the same during 2010 to 2019 was 4.3%. On the other hand, the AAGR for imports was recorded at almost 21% during 2010 to 2019, with imports reaching US$ 4.2 billion in 2019. As a result, the trade deficit for India widened to US$ 2.4 billion in 2019, from a surplus of US$ 0.3 billion in 2010.

Within India's exports of solar equipment industry, the exports of static converters grabbed the highest share of over 65% with a double digit AAGR being recorded for its exports, during 2010 to 2019. On the other hand, with respect to the imports, the PV cells imports commanded the highest share in the imports of solar equipment with a share of around 60% in 2019.

Table 7: India's Exports of Solar Equipment (US$ Billion)

Product code	Product label	2010	2019	Share in 2019	AAGR: 2010 to 2019
850440	Static converters	354.3	1186.0	65.1%	16.5%
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	585.7	277.2	15.2%	6.6%
841989	Machinery, plant or laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, sterilising, pasteurising, steaming, evaporating etc.	472.9	181.1	9.9%	-6.1%
841990	Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature, and of non-electric instantaneous and storage water heaters, n.e.s.	109.2	93.5	5.1%	1.3%
700992	Glass mirrors, framed	1.7	32.2	1.8%	47.8%
850239	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	8.5	20.2	1.1%	13.3%
841919	Instantaneous or storage water heaters, non-electric	7.3	11.2	0.6%	48.0%
900290	Lenses, prisms, mirrors and other optical elements, mounted, of any material, being parts of or fittings for instruments or apparatus	2.7	7.0	0.4%	23.7%
830630	Photograph, picture or similar frames, of base metal; mirrors of base metal	1.4	5.8	0.3%	35.9%
900190	Lenses, prisms, mirrors and other optical elements, of any material, unmounted	2.7	4.6	0.3%	9.4%
700991	Glass mirrors, unframed	0.7	2.0	0.1%	56.5%
711590	Articles of precious metal or of metal clad with precious metal, n.e.s.	4.3	0.5	0.0%	30.1%
900580	Monoculars, astronomical and other optical telescopes and other astronomical instruments	0.5	0.5	0.0%	71.2%
732290	Air heaters and hot-air distributors	1.1	0.4	0.0%	-6.8%
Total		**1553.1**	**1822.2**	**100.0%**	**4.3%**

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

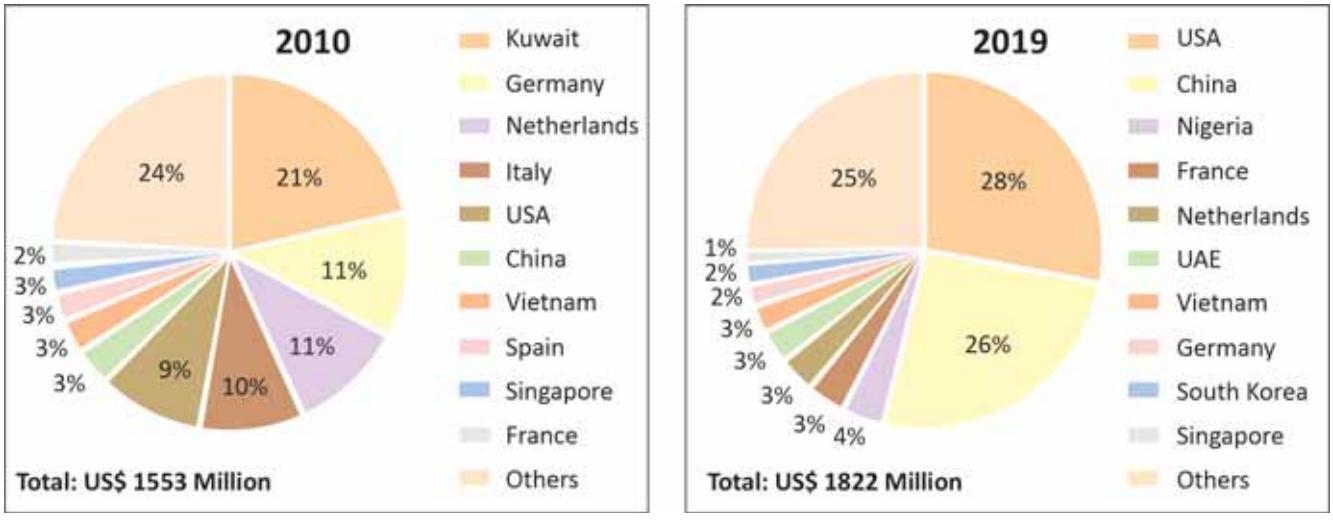
Table 8: India's Imports of Solar Equipment (US$ Billion)

Product code	Product label	2010	2019	Share in 2019	AAGR: 2010 to 2019
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	298.9	2458.6	59.1%	57.6%
850440	Static converters	515.9	1111.0	26.7%	10.4%
841989	Machinery, plant or laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, sterilising, pasteurising, steaming, evaporating etc.	160.5	288.2	6.9%	11.7%
841990	Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature, and of non-electric instantaneous and storage water heaters, n.e.s.	140.8	143.9	3.5%	1.7%
850239	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	120.4	89.6	2.2%	73.6%
700991	Glass mirrors, unframed	5.9	19.9	0.5%	23.9%
900290	Lenses, prisms, mirrors and other optical elements, mounted, of any material, being parts of or fittings for instruments or apparatus	9.4	15.1	0.4%	14.5%
900190	Lenses, prisms, mirrors and other optical elements, of any material, unmounted	19.3	8.6	0.2%	5.1%
711590	Articles of precious metal or of metal clad with precious metal, n.e.s.	3.1	7.0	0.2%	53.3%
700992	Glass mirrors, framed	1.9	4.7	0.1%	12.7%
841919	Instantaneous or storage water heaters, non-electric (excluding instantaneous gas water heaters ...	5.0	4.5	0.1%	14.4%
900580	Monoculars, astronomical and other optical telescopes and other astronomical instruments	9.3	3.5	0.1%	84.5%
830630	Photograph, picture or similar frames, of base metal; mirrors of base metal	1.6	2.5	0.1%	8.9%
732290	Air heaters and hot-air distributors	0.5	0.6	0.0%	12.6%
Total		**1292.6**	**4157.7**	**100.0%**	**20.6%**

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

With respect to the major export destinations of the solar equipment from India, in 2019, the USA was the largest export destination with a share of 28%, followed by China with a share of 25.7%. It may be noted that the share of both these nations was in single digits, a decade ago. On the other hand, Germany and the Netherlands had a double-digit share in 2010 and were reduced to single digits in 2019. Countries such as Kuwait (top exporting destination in 2010) and Italy which were a part of top ten export destinations for India's solar equipment in 2010, were not a part of the list in 2019.

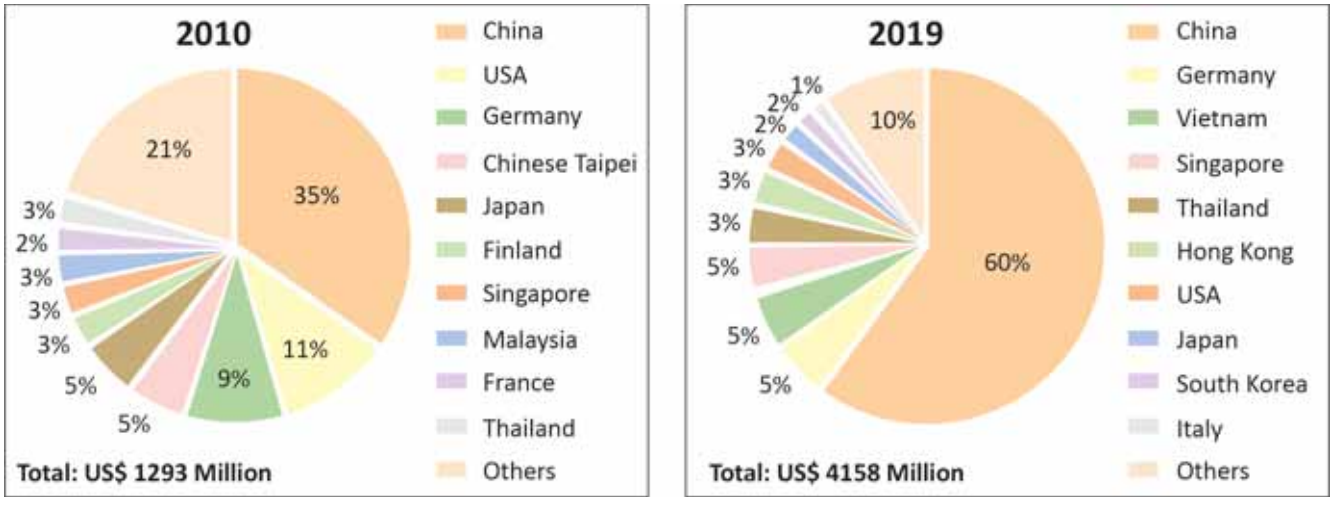
Figure 23: Major Export Destinations for India's Solar Equipment



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Further, with respect to the import sources for India's solar equipment, 60% of India's import demands were met from China in 2019 and all other import sources had a share in single-digit. It may be noted that China's share in the import sources of India was 34.7% in 2010.

Figure 24: Major Import Sources for India's Solar Equipment



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Trade in Photovoltaic

As discussed previously, India's demand for the renewable energy, especially the solar energy, has increased exponentially in the last decade. One of the main components for the solar energy to become functional is the solar PV cells which India has usually imported in the last decade. As a result, India's imports during 2010 to 2019 increased from US$ 298.9 million to US$ 2458.6 million, registering an AAGR of 57.6%, with imports reaching as high as US$ 4538 million in 2017. On the other hand, the exports recorded an AAGR of 6.6%, during 2010 to 2019, decreasing from US$ 585.7 million in 2010 to US$ 277.2 million in 2019. As a result, from a surplus of US$ 287 billion in 2010, India's trade in PV turned into deficit, in the subsequent years.

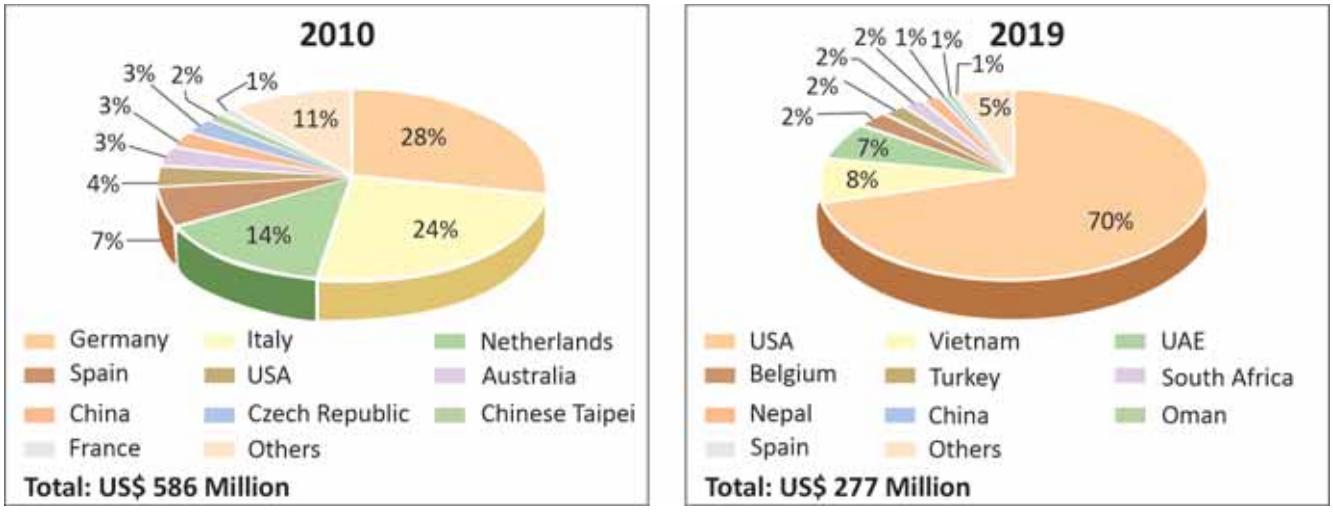
Further, specifically regarding PV cells, the USA which had a share of over 70% in India's exports in 2019, had a share of just 3.6% in 2010. A similar growth is also seen for Vietnam which had almost a nil share in 2010 but was the second largest export destination in 2019. Germany, which was the largest export destination in 2010 had a share of just 0.1% in 2019.

Figure 25: India's Trade in Photovoltaic (US$ Million)

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

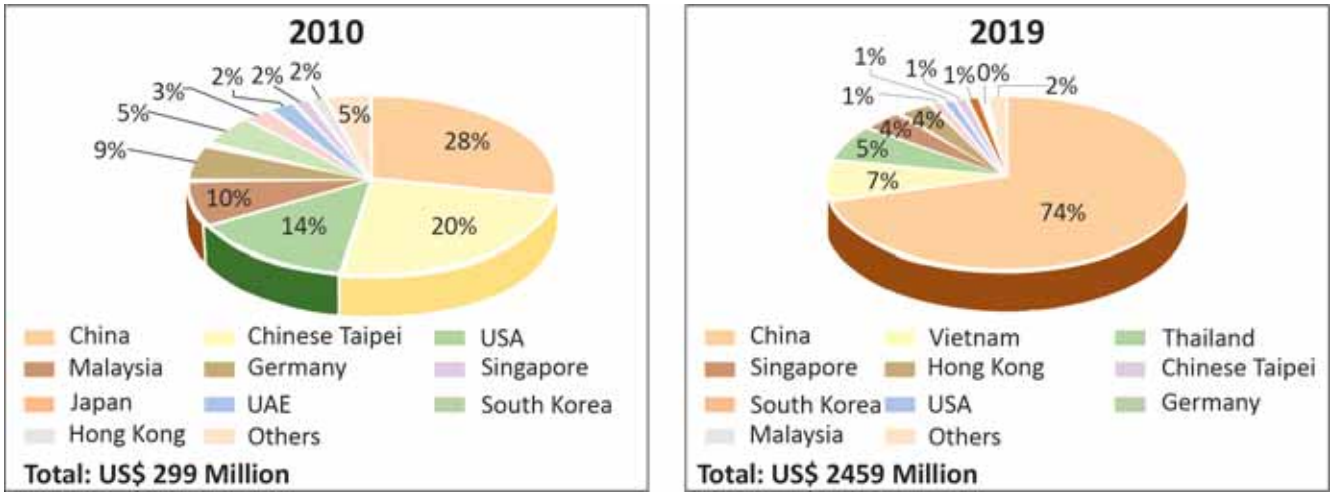
On the import side, a clear dominance can be seen of China with India fulfilling almost three-fourth of its PV cell imports from the country. Its share was 28% in 2010 and went as high as 86.4% in 2017. The share of Malaysia which was over 10% in 2010 and was 6% until 2017, got reduced to under 1% in 2019.

Figure 26: Major Exporting Destinations for India's PV Cells



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Figure 27: Major Import Sources for India's PV Cells



Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

In fact, it is to be noted that India's photovoltaic cells imports from China registered a higher AAGR of 90% during the period 2010 to 2019 against the 57.6% average annual growth in total import of photovoltaic cells by India, during the same period. It is observed that solar panels imported from China cost less, about US$ 0.16 - US$ 0.20 per watt, compared to domestic modules (US$ 0.25-US$ 0.28 per watt) or those imported from South Korea (US$ 0.22- US$ 0.24).

Safeguard Duty on Solar PVs

In 2018, India's Directorate General of Trade Remedies (DGTR) imposed a safeguard duty on solar panels imported from China and Malaysia. The DGTR recommended the imposition of 25% safeguard duty on solar panels from these two countries for one year, followed by 20% for the next six months and 15% for another six months.

Further, as per the DGTR, the share of indigenously made solar cells and panels, which constituted about 10% of Indian solar projects in 2014-15, had fallen even further in the subsequent years, which was one of the reasons to impose this duty.

With respect to the import trends from these two nations, it is observed that the imports of PV cells from Malaysia were over US$ 275 million in 2017 and it was the second largest import source of PV cells for India. In the subsequent years of 2018 and 2019, the imports from Malaysia declined to US$ 40.1 million and US$ 14.4 million, respectively. As a result, Malaysia's share also declined from 6.1% in 2017 to 1.4% and 0.6% in 2018 and 2019, respectively. The imports from China declined from US$ 3.9 billion in 2017 to US$ 2.3 billion in 2018 and further to US$ 1.8 billion in 2019.

It may be noted that the duty was further extended for a year in July 2020 with the duty being 14.9% from July 30, 2020, to January 29, 2021, and 14.5% from January 30, 2021, to July 29, 2021, for all solar cells and modules imported. As per the notification, the duties will not apply on any developing country except for China, Thailand, and Vietnam.

India's Competitiveness in Export of Solar Equipment

This section undertakes an analysis with the objective of identifying items under solar equipment industry, where domestic capacities can be strengthened and the markets which they can target.

The analysis is made through revealed comparative indices which are used to identify categories of exports, in which an economy has a comparative advantage by way of comparison of the country's trade scenario with the world scenario. The basic assumption underlying the concept of revealed comparative advantage is that trade profile reflects the inter-country differences in terms of relative costs as well as non-price aspects. As per Balassa's (1965) measure, index for country i, commodity j is,

$$RCA_{ij} = (x_{ij}/X_{it}) / (x_{wj}/X_{wt})$$

Where,

x_{ij}: exports of commodity j from country 'i'

X_{it}: total exports from country 'i'

x_{wj}: total exports of commodity 'j' from world

X_{wt}: total exports from world

The RCA index ranges from 0 to infinity, with 1 as the break-even point. That is, an RCA value of less than 1 means that the product has no export comparative advantage, while a value above 1 indicates that the product has a comparative advantage.

Although, useful in examining whether a country has a comparative advantage in specific products, it has its limitations in reflecting the extent of comparative advantage. In order to overcome this limitation, the Normalized Revealed Comparative Advantage (NRCA) index is used. NRCA index reveals the extent of comparative advantage that a country has in an item more precisely and consistently than other alternative RCA indices. NRCA can be defined in the following manner:

$$NRCA_{ij} = (RCA_{ij} - 1)/ (RCA_{ij} + 1)$$

NRCA ranges from -1 to 1 with 0 as the breakeven point. That is, an NRCA value of less than 0 means that the product has no export comparative advantage, while a value above 0 indicates that the product has a comparative advantage. The extent of comparative advantage/disadvantage can be gauged from the proximity of the NRCA values to the extreme data points, viz. +1 and -1.

Table 9: India's Competitiveness in Export of Solar Equipment

Product code	Product label	Normalized Revealed Comparative Advantage (NRCA)			2019		
		2010	2015	2019	Major Global Exporters (Share)	Major Global Importers (Share)	Top Export Destinations for India (Share)
850440	Static converters	-0.292	-0.238	0.065	China (30.6), Germany (9.9), Hong Kong (7.7), USA (6.9), Japan (4)	USA (16.4), China (11.5), Germany (6.9), Hong Kong (6.2), Mexico (4.1)	China (38.3), USA (22.6), France (4.9), Netherlands (4.9), Germany (2.0)
854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules or made up into panels; light emitting diodes	-0.292	-0.734	-0.558	China (41.7), Malaysia (8.3), Japan (6.2), South Korea (6.2), Vietnam (6.2)	USA (14.7), China (12.5), Hong Kong (7.0), Japan (6.2), Vietnam (5.4)	USA (70.4), Vietnam (7.6), UAE (6.9), Belgium (2.5), Turkey (2.2)

Product code	Product label	Normalized Revealed Comparative Advantage (NRCA)			2019		
		2010	2015	2019	Major Global Exporters (Share)	Major Global Importers (Share)	Top Export Destinations for India (Share)
841989	Machinery, plant or laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature such as heating, cooking, roasting, sterilising, pasteurising, steaming, evaporating etc.	0.647	0.0003	0.112	Germany (23.4), China (11.3), USA (8.2), South Korea (7.5), Italy (7.1)	China (9.9), USA (9.6), Russia (8.9), Kazakhstan (5.2), South Korea (3.9)	Nigeria (18.8), South Korea (7.6), Oman (6.0), Saudi Arabia (5.9), China (4.5)
841990	Parts of machinery, plant and laboratory equipment, whether or not electrically heated, for the treatment of materials by a process involving a change of temperature, and of non-electric instantaneous and storage water heaters, n.e.s.	0.147	0.090	-0.086	China (14.3), USA (12.3), Germany (11.3), Italy (6.6), Sweden (4.4)	USA (15.2), China (6.0), Germany (5.8), Japan (4.7), Canada (4.2)	Nigeria (16.7), USA (13.9), Saudi Arabia (5.8), China (4.2), Switzerland (3.6)
700992	Glass mirrors, framed	-0.780	-0.213	-0.025	China (67.7), Germany (3.8), Vietnam (3.1), Poland (2.9), USA (2.4)	USA (29.7), UK (7.2), France (5.2), Germany (5.1), Canada (4.4)	USA (65.2), UK (7.6), France (6.5), Netherlands (2.5), Australia (2.2)

Product code	Product label	Normalized Revealed Comparative Advantage (NRCA)			2019		
		2010	2015	2019	Major Global Exporters (Share)	Major Global Importers (Share)	Top Export Destinations for India (Share)
850239	Generating sets (excluding wind-powered and powered by spark-ignition internal combustion piston engine)	-0.757	-0.435	-0.214	USA (20.6), Germany (8.5), Israel (8.2), China (6.6), Hong Kong (6.6)	Vietnam (11.6), Malaysia (8.9), Brazil (7.9), Thailand (7.6), Indonesia (5.9)	Australia (45.0), Nepal (8.7), Nigeria (8.6), USA (8.4), Indonesia (5.7)
841919	Instantaneous or storage water heaters, non-electric	-0.569	0.049	-0.478	Mexico (24.2), Germany (11.6), USA (9.3), China (9.1), France (6.0)	USA (25.2), Germany (12.8), Canada (8.9), Switzerland (4.1), Austria (3.9)	Nigeria (45.6), Australia (30.7), Nepal (4.2), Germany (3.6), Kenya (3.4)
900290	Lenses, prisms, mirrors and other optical elements, mounted, of any material, being parts of or fittings for instruments or apparatus	-0.827	-0.826	-0.748	China (16.6), Germany (14.1), Japan (9.2), USA (8.5), Singapore (7.8)	China (27.4), South Korea (13.0), Vietnam (10.4), USA (6.8), Chinese Taipei (5.4)	France (18.2), USA (12.6), Bulgaria (7.0), Indonesia (4.0), Norway (3.9)
830630	Photograph, picture or similar frames, of base metal; mirrors of base metal	-0.572	-0.254	0.116	China (47.9), Germany (11.6), Hong Kong (4.8), Netherlands (3.3), USA (3.2)	USA (27.6), Germany (9.7), UK (9.2), France (4.5), Netherlands (3.3)	USA (54.4), UK (11.9), Netherlands (4.9), Spain (4.4), France (3.1)

Product code	Product label	Normalized Revealed Comparative Advantage (NRCA)			2019		
		2010	2015	2019	Major Global Exporters (Share)	Major Global Importers (Share)	Top Export Destinations for India (Share)
900190	Lenses, prisms, mirrors and other optical elements, of any material, unmounted	-0.953	-0.944	-0.946	China (21.5), South Korea (15.3), USA (13.9), Japan (13.8), Hong Kong (7.0)	China (31.5), Japan (9.3), Hong Kong (7.1), Germany (7.0), USA (6.5)	South Korea (23.7), UK (23.1), France (12.1), USA (9.7), Germany (5.4)
700991	Glass mirrors, unframed	-0.895	-0.914	-0.801	China (53.9), Belgium (5.9), Czech Republic (4.1), Germany (4.0), Italy (3.7)	USA (11.9), Germany (7.3), UK (5.3), France (4.6), Poland (3.6)	Qatar (24.5), USA (17.5), UAE (15.7), Nepal (11.3), Sri Lanka (4.6)
711590	Articles of precious metal or of metal clad with precious metal, n.e.s.	-0.819	-0.982	-0.978	Canada (24.9), USA (15.8), China (13.2), Japan (12.4), Germany (9.5)	USA (50.6), China (10.3), Malaysia (10.2), Singapore (5.6), Thailand (3.1)	Saudi Arabia (49.0), Germany (37.1), Egypt (3.9), Nepal (3.5), UK (1.7)

Product code	Product label	Normalized Revealed Comparative Advantage (NRCA)			2019		
		2010	2015	2019	Major Global Exporters (Share)	Major Global Importers (Share)	Top Export Destinations for India (Share)
900580	Monoculars, astronomical and other optical telescopes and other astronomical instruments	-0.864	-0.741	-0.905	China (25.3), USA (13.3), Switzerland (10.9), UK (6.8), Germany (6.5)	USA (20.5), Germany (12.3), UK (6.1), Norway (5.9), South Korea (4.8)	Israel (36.0), USA (22.7), China (6.2), Indonesia (4.3), UK (4.1)
732290	Air heaters and hot-air distributors	-0.863	-0.910	-0.971	Mexico (26.5), USA (24.9), Canada (8.3), Netherlands (7.7), Italy (6.1)	USA (40.4), Canada (21.8), Russia (3.8), Germany (3.2), Poland (2.7)	USA (19.7), Nigeria (15.0), Bangladesh (13.1), Egypt (12.9), Indonesia (10.5)
Solar Equipment: Total		-0.178	-0.423	-0.193	China (31.7), Germany (8.3), USA (7.0), Hong Kong (5.8), Japan (5.5)	USA (15.5), China (12.1), Germany (5.8), Hong Kong (5.5), Japan (4.5)	USA (28.0), China (25.7), Nigeria (3.8), France (3.5), Netherlands (3.3)

Source: Data accessed from ITC Trade Map, December 2020; India Exim Bank Research

Conclusion

India is currently utilizing only 40-45% of its domestic production capability of PV modules. Given the limited production, India meets its needs of solar PV, mostly through imports. India was in a surplus in the trade of solar PV in 2010, however, with the turn of the decade there has been a trade deficit throughout and is in fact, now dependent on China for almost 75% of its import requirements. The analysis hence reveals that India was not competitive in the exports of solar PV in 2019; however, in the exports of other solar related equipment such as static converters, and mirrors of base metals, India exhibited competitiveness in 2019.

CHAPTER

4

INVESTMENTS IN THE SOLAR SECTOR

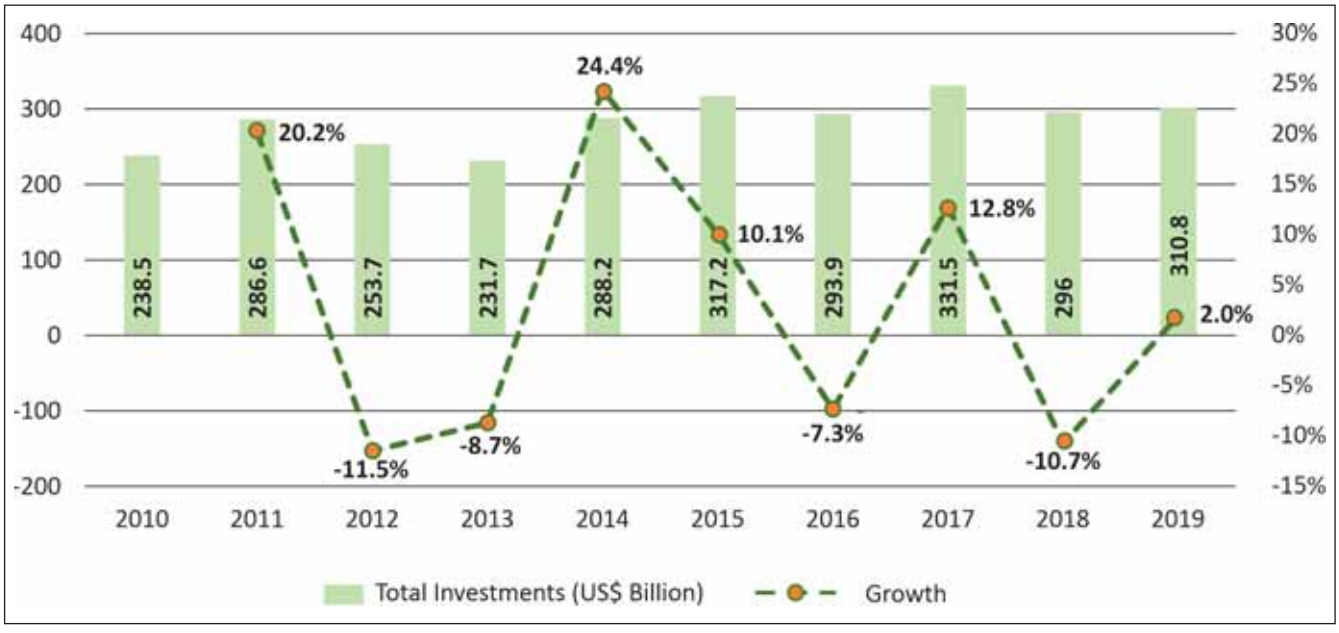
The renewable energy space had a positive impact on health, energy access, environmental protection, while mitigating the risks associated with the climate change. All these benefits came with millions of jobs that were generated in this process. The externalities, as mentioned, could not have happened without the massive investments that were made in this area.

This chapter particularly assesses the investment trends in the renewable sector, especially solar, globally and in India.

Investments in Renewable Energy

The total global investments in the renewable energy were recorded at US$ 301.8 billion in 2019, up from US$ 238.5 billion in 2010, thereby recording an AAGR of 3.5%, during this period.

Figure 28: Global: Investments in the Renewable Energy Sector



Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

Particularly, with respect to India, the total investments received in the renewable energy space increased from US$ 6.7 billion in 2010 to US$ 9.3 billion in 2019. The investment flow to India registered an AAGR of almost 11%, much higher than the global average. Further, India's share in the global renewable energy investments increased from 2.8% in 2010 to 3.1% in 2019.

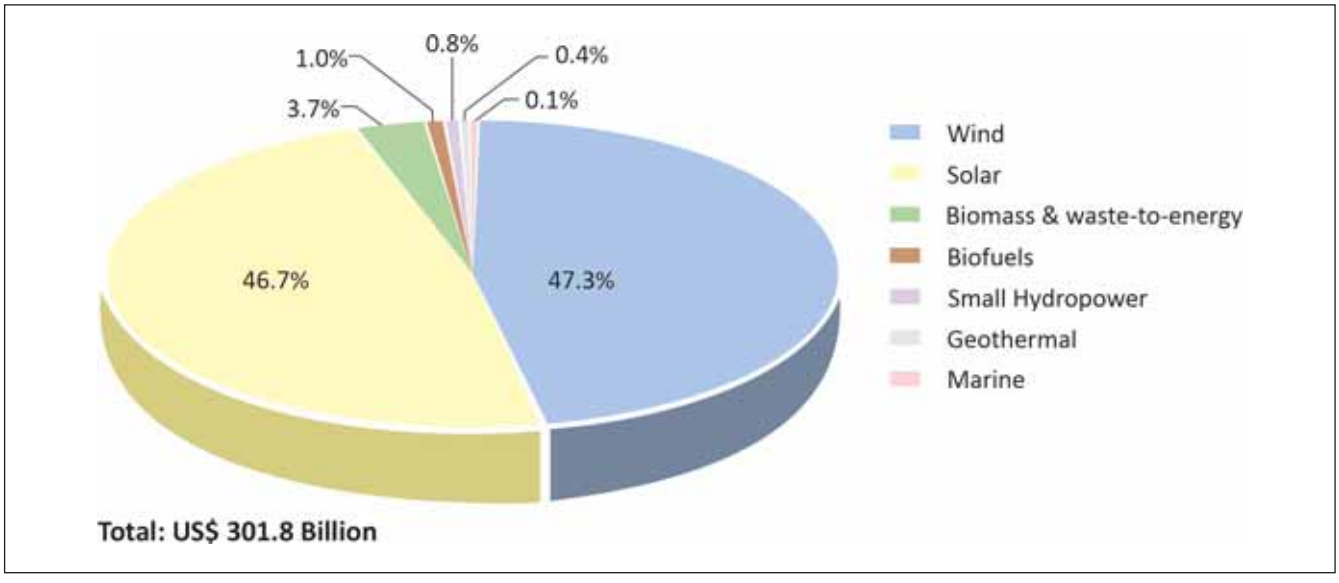
On the other hand, in the case of China, the total investments in the renewable energy increased from US$ 36.9 billion in 2010 to US$ 83.4 billion in 2019, after reaching as high as US$ 143 billion in 2017. The AAGR registered during this period for renewable energy investments into China was 13%.

Table 10: India and China: Renewable Energy Investments (US$ Billion)

Year	India	Growth: India	China	Growth: China
2010	6.7	-	36.9	-
2011	12.1	61.0%	39.3	6.5%
2012	6.8	-46.0%	54.8	39.4%
2013	4.7	-25.4%	61.7	12.6%
2014	6.1	48.0%	85.0	37.8%
2015	7.6	8.1%	119.3	40.4%
2016	12.5	56.3%	103.5	-13.2%
2017	13.3	9.6%	143.0	38.2%
2018	10.8	-15.3%	91.1	-36.3%
2019	9.3	-3.4%	83.4	-8.5%

Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

Figure 29: Global: Sector-Wise Share in Investments in Renewable Energy: 2019

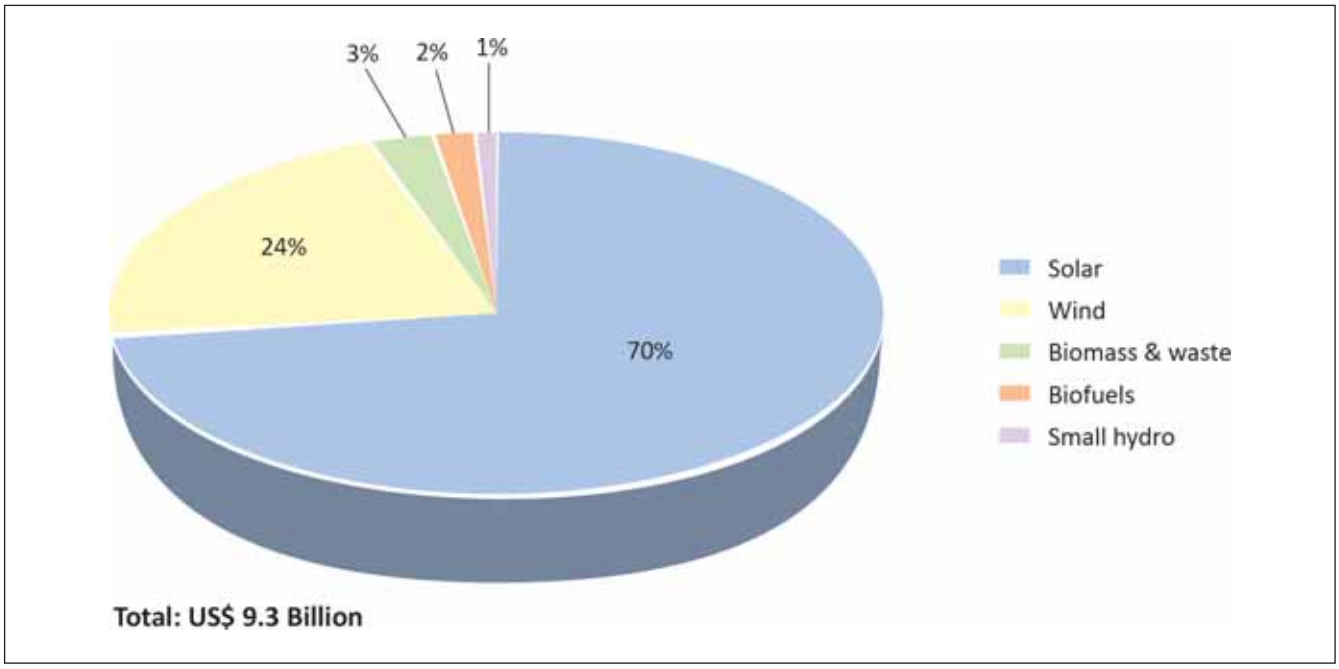


Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

A glance at the sector-wise investment shows that, globally, the highest investment in 2019 went to the wind sector at 47.3%. This was followed by solar at 46.7%. It may be noted that the share of wind was at 41% in 2010, while that for solar was 42.8%. It may also be observed that the share of solar was over 50% in six out of the last ten years, during 2010 to 2019.

With respect to the Indian scenario, in 2019, over 70% of the renewable energy investment went to the solar sector. This was followed by wind energy which had a share of 23% in 2019. In the case of China, almost 66% went to the wind energy in 2019, followed by solar at 30.8%.

Figure 30: India: Sector-Wise Share in Investments in Renewable Energy: 2019



Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

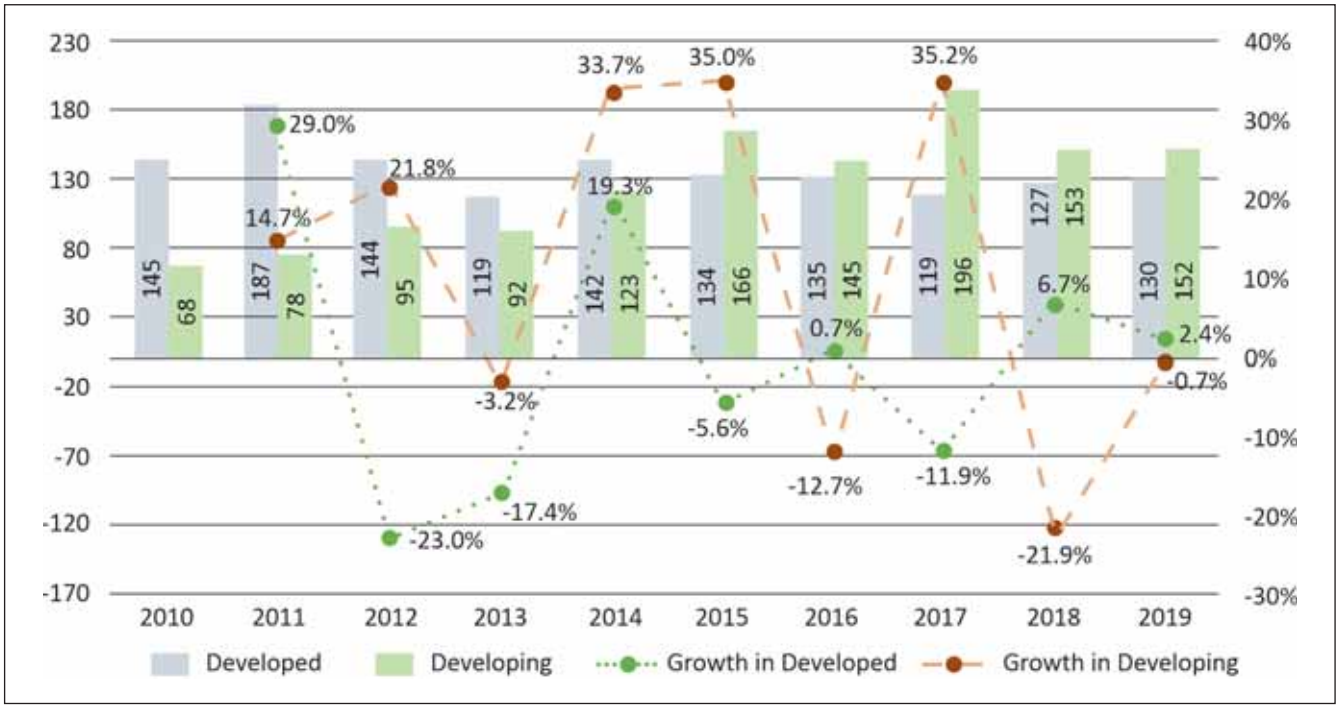
In the last decade, amongst its peers in the renewable energy, solar energy registered the highest growth with respect to receiving new investments. Investments to the solar energy grew by an average of 6.3% annually, during 2010 to 2019. It was followed by wind energy which registered an AAGR of 5% in receiving new investments, during the last decade.

Table 11: Global: Sector-Wise Investment (US$ Billion) and Growth during 2010-19

Year	Total Investments	Solar	Wind	Biomass & waste-to-energy	Biofuels	Small Hydropower	Geothermal	Marine
2010	238.5	102.0	97.8	17.3	10.1	8.2	2.8	0.3
2011	286.6	160.1	83.3	20.9	10.5	7.7	3.8	0.3
2012	253.7	144.0	78.3	15.4	7.7	6.3	1.7	0.3
2013	231.7	120.4	83.3	14.6	5.1	5.7	2.4	0.2
2014	288.2	147.8	111.1	13.1	5.5	7.4	2.9	0.4
2015	317.2	176.6	119.7	10.4	3.6	4.2	2.5	0.2
2016	293.9	145.9	123.5	15.2	2.1	4.3	2.7	0.2
2017	331.5	180.8	133.4	7.4	3.3	4	2.4	0.2
2018	296	143.5	132.7	11.5	3.3	2.3	2.5	0.2
2019	301.8	141.0	142.7	11.2	3	2.5	1.2	0.2
AAGR (2010-19)	**3.5%**	**6.3%**	**5.0%**	**0.7%**	**-8.5%**	**-9.5%**	**-2.5%**	**1.9%**

Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

Figure 31: Global: Investment Received by Development Level of Economies (US$ Billion)

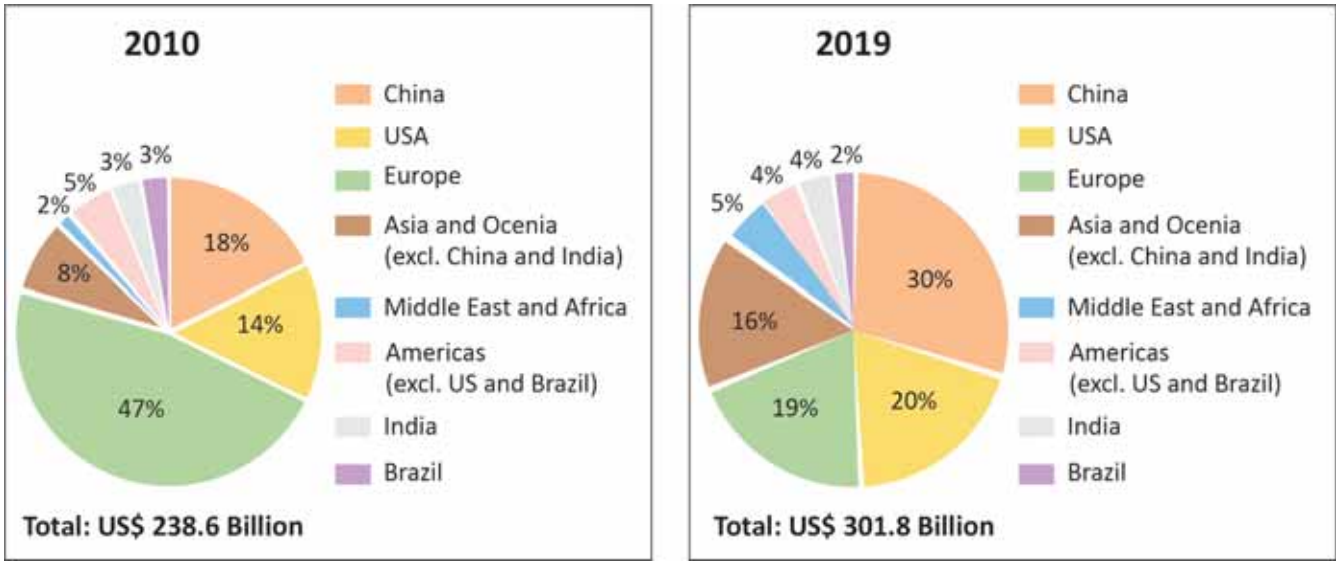


Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

Additionally, while assessing the investment levels by the development level of economies, it is observed that most investment in the renewable energy sector was going into the developed countries until 2014. The scenario changed later, and in 2019, the developing countries accounted for majority of the new investment in the renewable energy sector.

With respect to the geographies receiving the investments in the renewable energy, it may be noted that the share of the geographies has gone through a significant transformation. The share of China in the investment received has increased from 18% in 2010 to 30% in 2019. The shares of the USA, and Asia and Oceania (excl. China and India), increased by 5% and 8.2%, respectively, in 2019 vis-à-vis 2010. The share of Europe however fell from 47% in 2010 to 19% in 2019 in renewable energy investments received.

Figure 32: Global: Region-Wise Investment Share in Renewable Energy: 2010 vis-à-vis 2019



Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

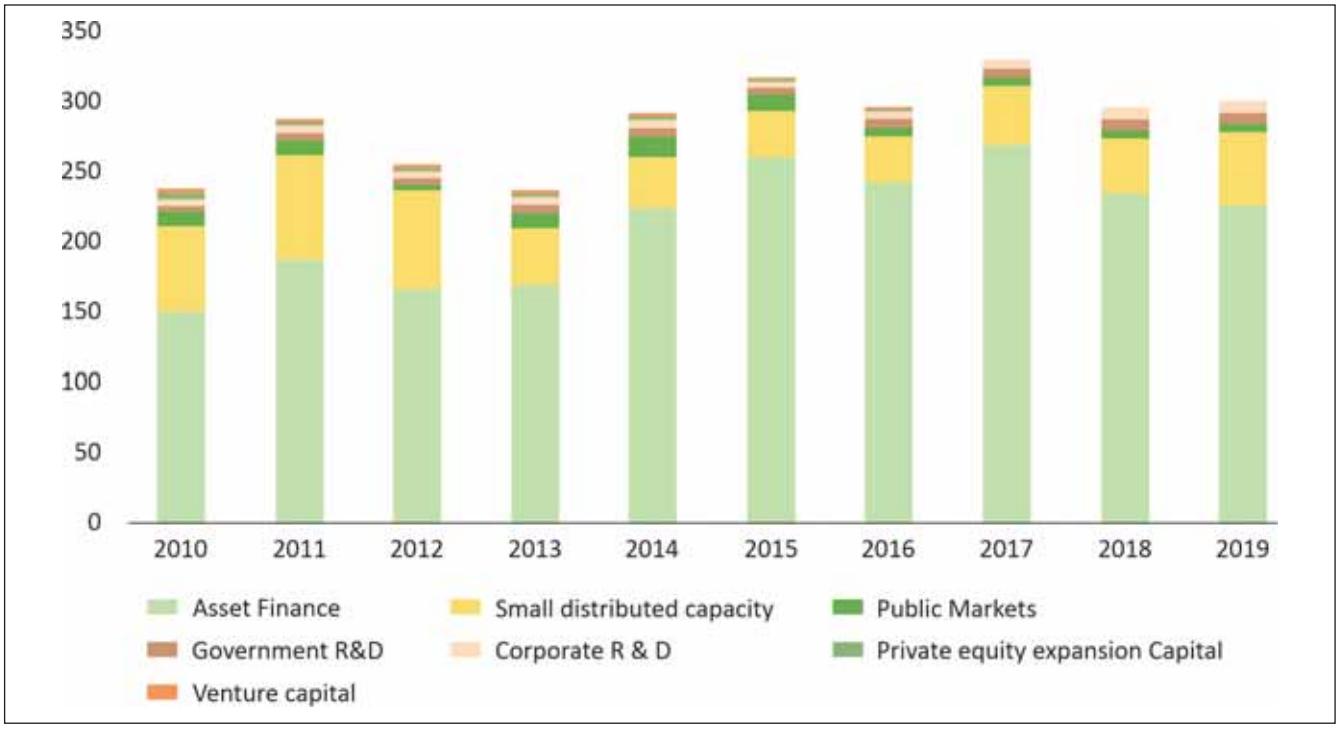
In the context of investments in the renewable energy by asset class, it is noted that most of the investment has gone into the asset finance[7] and small distributed capacity[8], with the latter being the distant second. It may be observed that the investments into asset finance and small distributed capacity registered AAGRs of only 5.7% and 1.2%, respectively, during the last decade. This is due to the reason that the cost of capital associated with the solar and wind energy has fallen significantly in the last few years, precisely indicating that more new capacity could be added with the same amount of expenditure.

[7] All money invested in renewable energy generation projects (excluding large hydro), whether from internal company balance sheets, from loans, or from equity capital. This excludes refinancing

[8] Annual investment in small-scale and residential projects such as rooftop solar is estimated. These figures are based on annual installation data, provided by industry associations and REN21

The public markets[9] investment registered an impressive AAGR of 9% during 2010 to 2019. Further, while the government R&D investment increased from US$ 4.9 billion in 2010 to US$ 5.7 billion in 2019, registering an AAGR of just 2%, the corporate R&D investment recorded an AAGR of over 9.5%.

Figure 33: Global: Investments in the Renewable Energy by Asset Class (US$ Billion)



Source: Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance; India Exim Bank Research

Foreign Capital Expenditure in the Solar Energy

The 'Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance' database referred above gives a picture of the overall renewable energy sector investments. To complement the analysis, the study further analyses the fDi markets database of the Financial Times by tracking cross-border investment in a new physical project or expansion of an existing investment creating new jobs and capital investment. It may be noted that joint ventures are only included where they lead to a new physical operation[10]. However, to the extent that this database tracks investments announced, it is likely that the data may be an over estimation, given that not all announcements fructify into actual investments. Notwithstanding, the data, from fDi Markets, does throw up a strong indicative assessment of how a country is perceived as an investment destination by foreign investors.

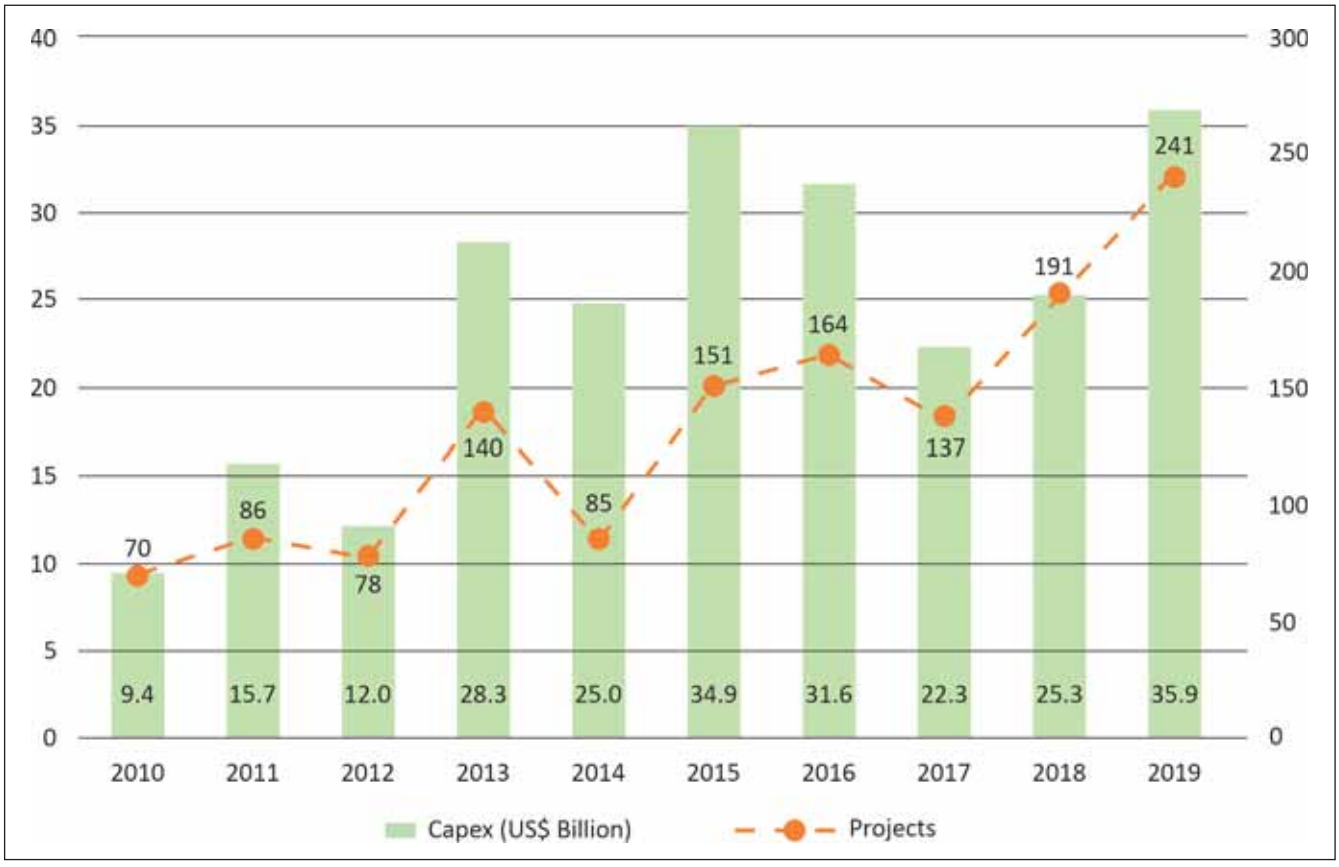
[9] All money invested in the equity of specialist publicly quoted companies developing renewable energy technology and clean power generation

[10] The data on capital investment is based on the total investment the company is making at the time of the project announcement or opening. As companies can raise capital locally, phase their investment over a period of time, and can channel their investment through different countries for tax efficiency, the data could be different to the official data on FDI flows

Global Capex in the Solar Electric Power

As per the fDi markets, the global envisaged foreign capex in the solar electric power increased from US$ 9.4 billion in 2010 to US$ 35.9 billion in 2019, registering an AAGR of almost 25% during this period. The highest growths in the global envisaged foreign capex in the last decade was in 2013 (135.6%), 2011 (66.8%), and 2019 (42.1%). The total number projects associated with this envisaged capex were recorded at 241 in 2019. The average envisaged foreign capex has increased from US$ 134.1 million in 2010 to US$ 149.1 million in 2019. A total of over 68000 jobs are estimated to have been created in the last decade through envisaged capex in the global solar electric power sector. The envisaged capex of US$ 35.9 billion in 2019 came through 124 companies, the highest in the last decade.

Figure 34: Global: Total Envisaged Foreign Capex in Solar Electric Power Sector



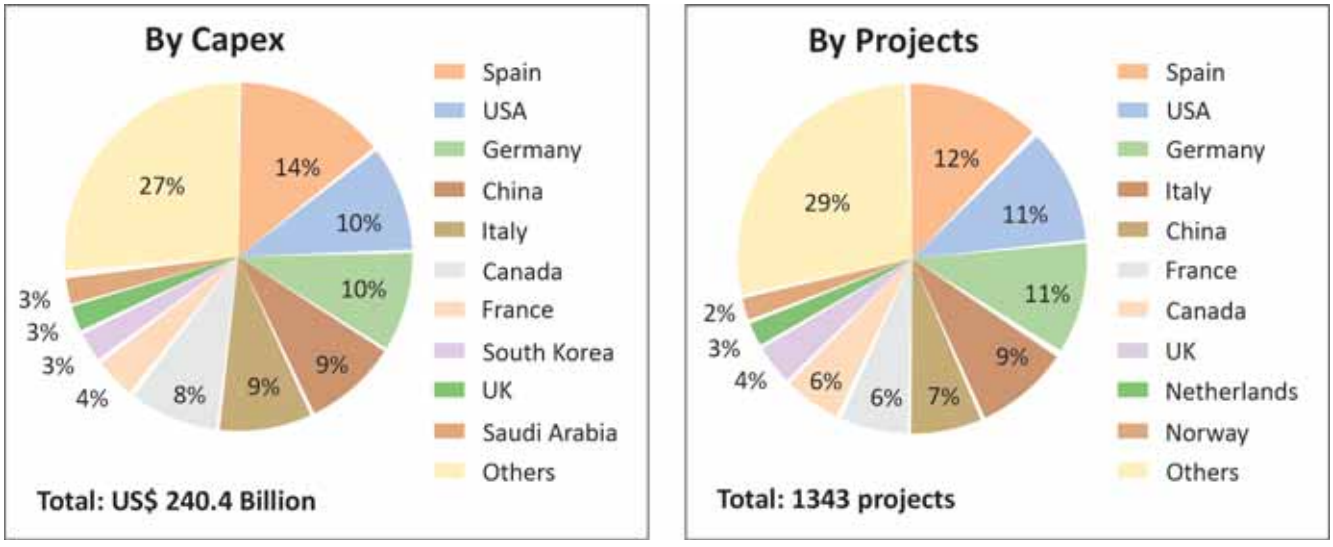
Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

In the context of the source countries, during the last decade, it may be noted that the highest envisaged foreign capex came from Spain with a share of 14.2%, followed by the USA at 10.5%, and Germany at 9.6%. The top five source nations accounted for almost 52% of the envisaged capex.

With respect to the source countries by 'number of projects' in the last decade, the top five nations accounted for 50% of the total number of projects.

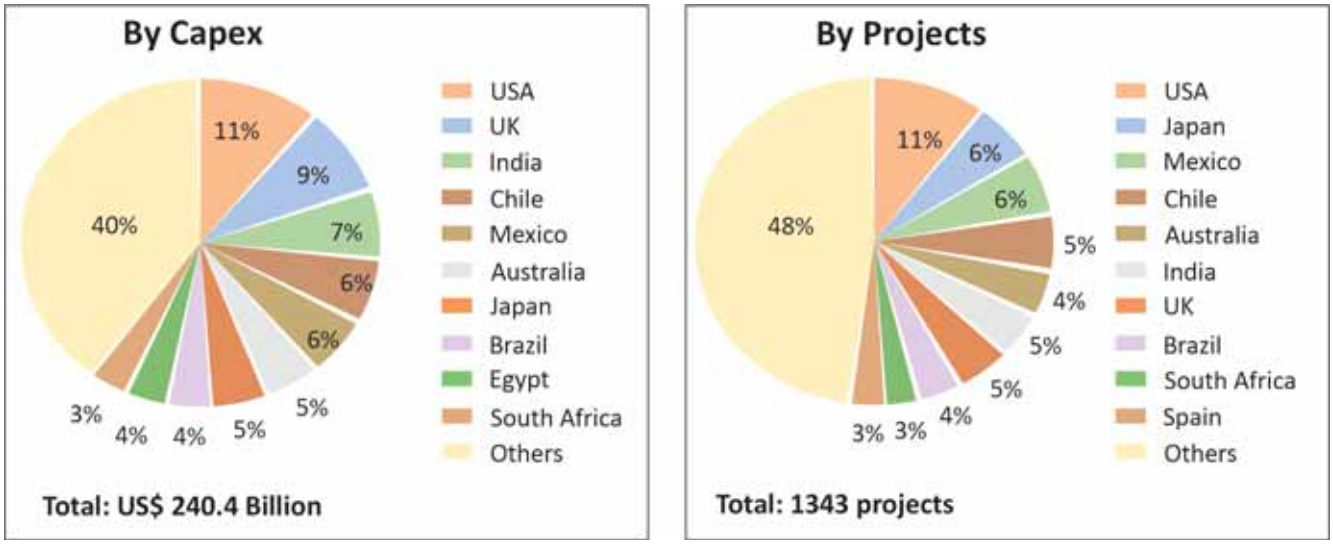
On the lines of the source countries, the USA is also a major destination for the global solar electric power projects, which in fact, tops the list by accounting for over 11% of the envisaged capex and almost 11% of projects. By capex, the USA was followed by the UK with a share of almost 9%, and India with a share of 6.7%. However, by the number of projects, the second top destination was Japan with a share of 6% with 80 projects in the last decade.

Figure 35: Top Source Countries in Global Solar Electric Power (2010-19)



Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

Figure 36: Top Destination Countries in Global Solar Electric Power (2010-19)



Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

A total of 555 companies were associated with the 1343 foreign envisaged projects, in the global solar electric power, during the last decade. The top investing company by foreign envisaged capex in this space was Canadian Solar Inc with a capex of almost US$ 10 billion. This was followed by Enel Green Power at US$ 7.7 billion, and SunEdison at US$ 5 billion.

Table 12: Global Top Investing Companies in Solar Electric Power by Envisaged Foreign Capex (2010-19)

Investing company	Capex (US$ Billion)	Share in Capex
Canadian Solar Inc (CSI)	9.8	4.1%
Enel Green Power	7.7	3.2%
SunEdison	5.0	2.1%
SkyPower FAS Energy	5.0	2.1%
ACWA Power International	4.4	1.8%
Scatec Solar	4.1	1.7%
OPDE	4.1	1.7%
SkyPower	4.0	1.7%
Terra Sola	3.5	1.5%
Abengoa	3.4	1.4%
Abengoa Solar Chile	3.3	1.4%
Fotowatio Renewable Ventures (FRV)	2.8	1.2%
Building Energy	2.8	1.1%
Shanghai Electric	2.7	1.1%
DP Energy	2.5	1.0%
ib vogt	2.5	1.0%
Solatio	2.4	1.0%
Chint Group	2.2	0.9%
Solarpack	2.2	0.9%
SolarReserve	2.1	0.9%
Others	163.9	68.2%
Total	**240.4**	**100.0%**

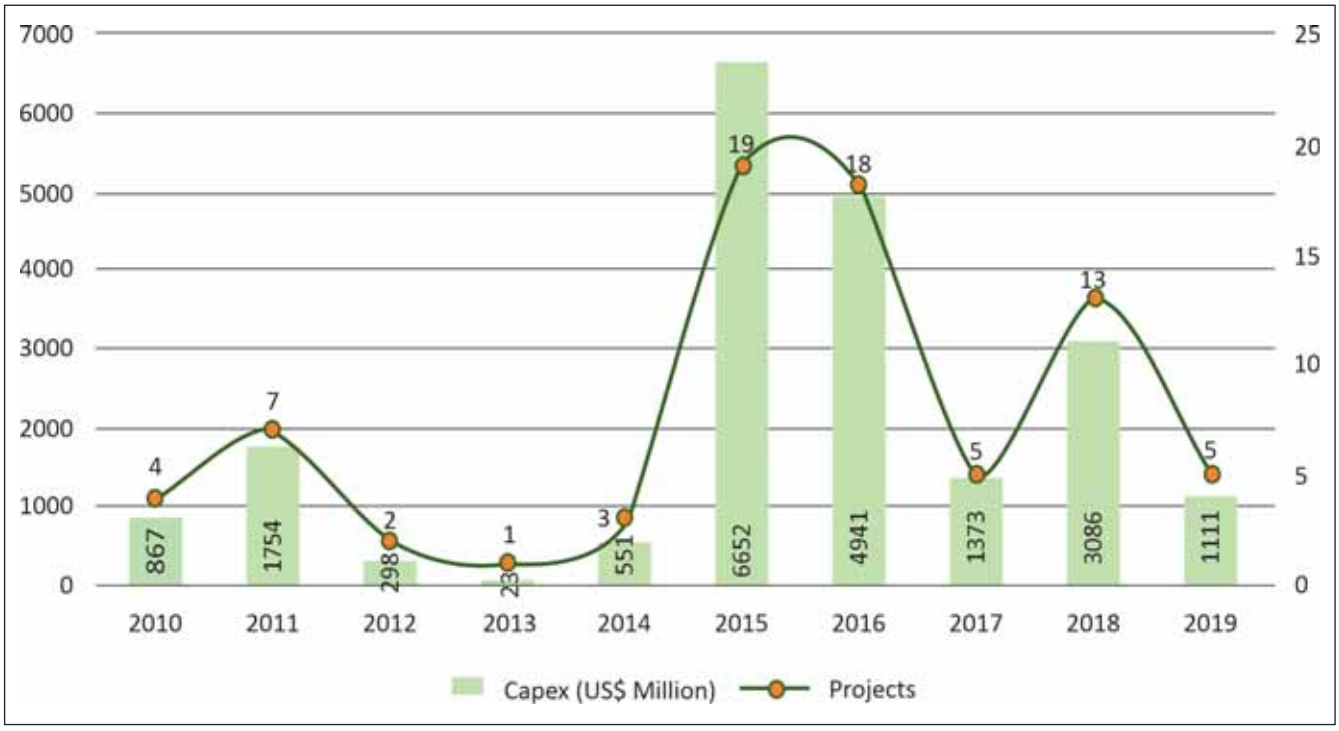
Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

Foreign Capex in India's Solar Electric Power

As per the fDi markets, the envisaged foreign capex in India's solar electric power sector increased from US$ 866.5 million in 2010 through 4 projects, (one each from the USA, Germany, Belgium, and France) to US$ 1111.3 million in 2019 through 5 projects. The average envisaged foreign capex has increased from US$ 216.6 million in 2010 to US$ 222.3 million in 2019, with the same reaching as high as US$ 350.1 million in 2015.

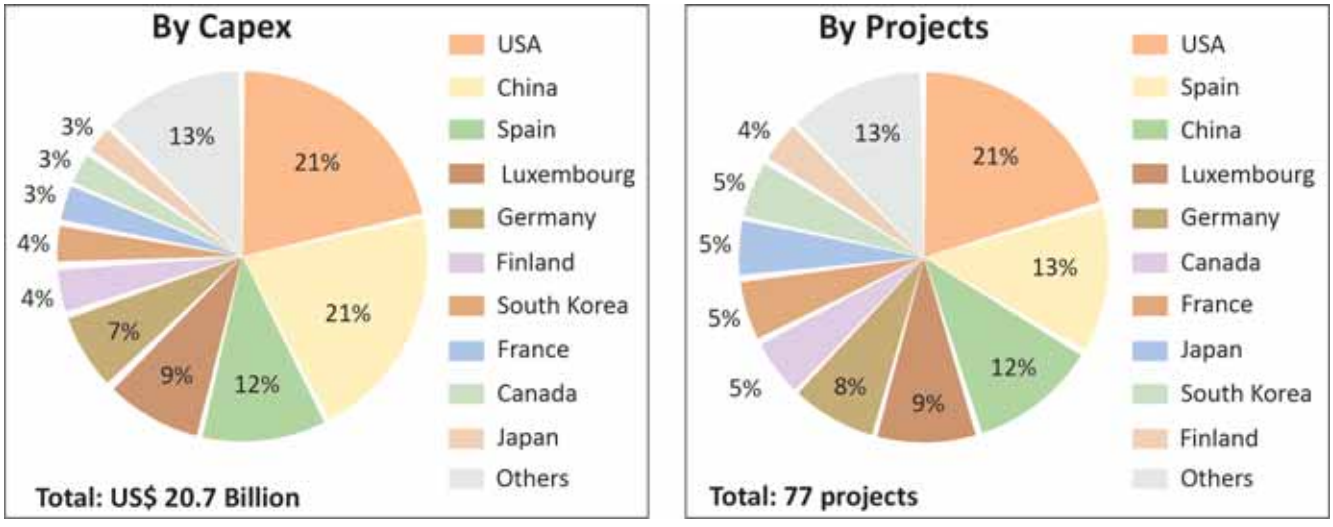
A total of over 1730 jobs are estimated to have been created in the last decade through envisaged capex in the India's solar electric power sector. The total envisaged capex of US$ 20.7 billion in the last decade came through 49 companies.

Figure 37: Total Envisaged Foreign Capex in India's Solar Electric Power Sector



Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

Figure 38: Top Source Countries in India's Solar Electric Power (2010-19)



Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

The top source countries with respect to the envisaged foreign capex during the last decade in the Indian solar electric power sector included the USA (21.2%), China (20.8%), and Spain (11.8%). The top five source countries accounted for over 70% of the envisaged foreign capex. With respect to the source countries by number of projects in the last decade, the top five nations accounted for over 62% of the projects.

With respect to the companies, it may be noted that a total of 49 companies are associated with the total US$ 20.7 billion of foreign envisaged capex in India's solar electric power sector, during 2010-19. The top investing companies during this period was SunEdison, followed by Chint Group and Solarpack.

Table 13: Top Investing Companies in Solar Electric Power by Envisaged Foreign Capex: 2010-19

Investing company	Capex (US$ Million)	Share in Capex
SunEdison	2053.8	9.9%
Chint Group	2000	9.7%
Solarpack	1647	8.0%
Eden Renewables India	1098	5.3%
Fortum	823.5	4.0%
T-Solar	637.2	3.1%
Asia Pacific Generation	600	2.9%
Statkraft BLP Solar Solutions	549	2.7%
Hareon Solar Technology	549	2.7%
Juwi India Renewable Energies	549	2.7%
Others	10147.8	49.1%
Total	**20654.3**	**100.0%**

Source: Data accessed from fDi markets, Financial Times; India Exim Bank Research

Foreign Capex from India to Other Countries

Analysis shows that the envisaged foreign capex from India to the world during 2010-19 was US$ 2.2 billion through 11 projects, with US$ 196.1 million being the average envisaged foreign capex.

Out of the US$ 2.2 billion, US$ 1.4 billion was aimed for Australia through 6 projects, four of which were through Adani Green Energy in 2016 and two were through Sterling and Wilson in 2017. The other countries where investments were envisaged included Yemen (Shapoorji Pallonji Infrastructure Capital in 2014), Egypt (Shapoorji Pallonji Infrastructure Capital in 2015), Spain (Electrotherm in 2011), Germany (Moser Baer Clean Energy[11] in 2011), and UAE (Cleanmax Solar in 2017).

Conclusion

To conclude, the investment analysis shows that the global investments in the renewable energy space into India grew at faster pace than the renewable energy investments to the world, during the last decade. As a result, India's share in the global renewable energy investments increased from 2.8% in 2010 to 3.1% in 2019. Investments into China, however, grew even faster than that of India.

[11] The company, in 2019, was directed by NCLT to go under liquidation

The analysis also revealed that while the solar had a share of 46.7% in the total renewable energy investments received in the world in 2019, the share of solar in India was almost 70%, signifying the potential of the sector.

Another vital point to note is that while the first half of the last decade saw developed regions receiving more investments into renewable energy, in the latter half, developing regions had a higher share.

Specifically, with respect to the solar electric power sector, in the global foreign capex, the USA was the largest recipient, followed by the UK and India. In India's solar electric power sector, the USA and China were the largest investors.

CHAPTER

RENEWABLE ENERGY FINANCE AND FINANCIAL INSTITUTIONS

The growth of solar energy over the years has been a result of several factors, which inter alia, includes government support, institutional financing, private investment, and most importantly, the consumer participation.

While all stakeholders have played their roles in making solar energy model a success, not just in India but across the globe, a major role has been played by the various financial institutions in supporting renewable energy projects globally. To assess it, this chapter evaluates the renewable energy finance flows, particularly to the solar sector, by various financial institutions, for both global and Indian markets. The data has been sourced from IRENA for the timeline 2003 to 2017, which is giving project-wise data.

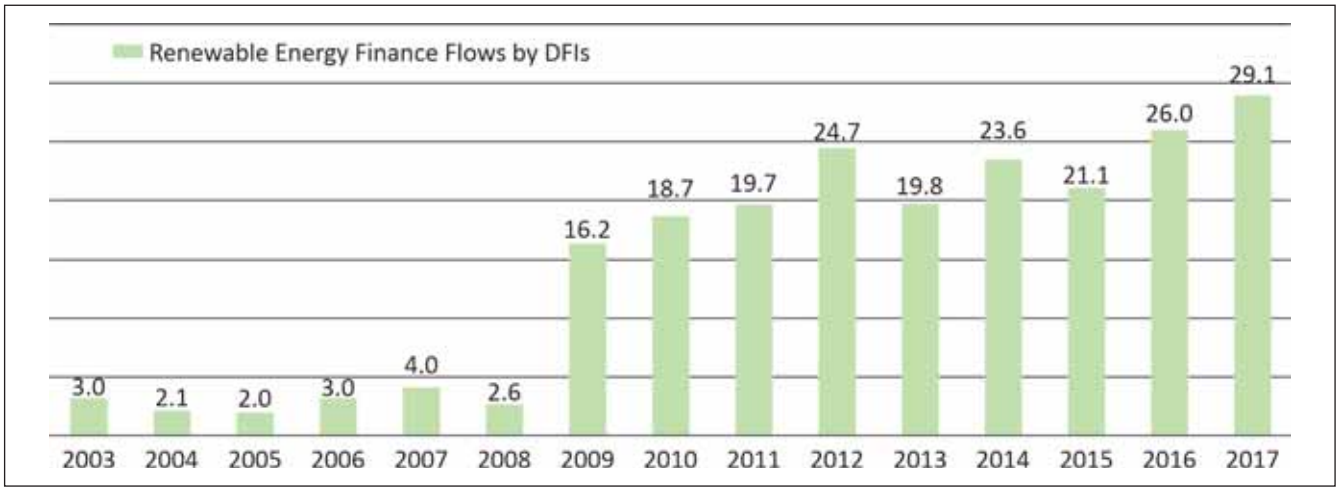
Select MDBs / FIs considered here for analysis include World Bank Group (WBG), UNDP, Japan Bank for International Cooperation (JBIC), Overseas Private Investment Corporation (OPIC), BNDES, China Exim Bank (CEXIM), Export Import Bank of Korea (KEXIM), European Bank for Reconstruction and Development (EBRD), Agence française de développement (AFD), ADB, amongst others.

MDBs / FIs' Finances to the World

Overall Renewable Energy Sector

The total renewable energy finances by the MDBs / FIs to the globe were recorded at US$ 3 billion in 2003 and stood at an all-time high in 2017 at US$ 29.1 billion, recording an AAGR of almost 44%, during this period.

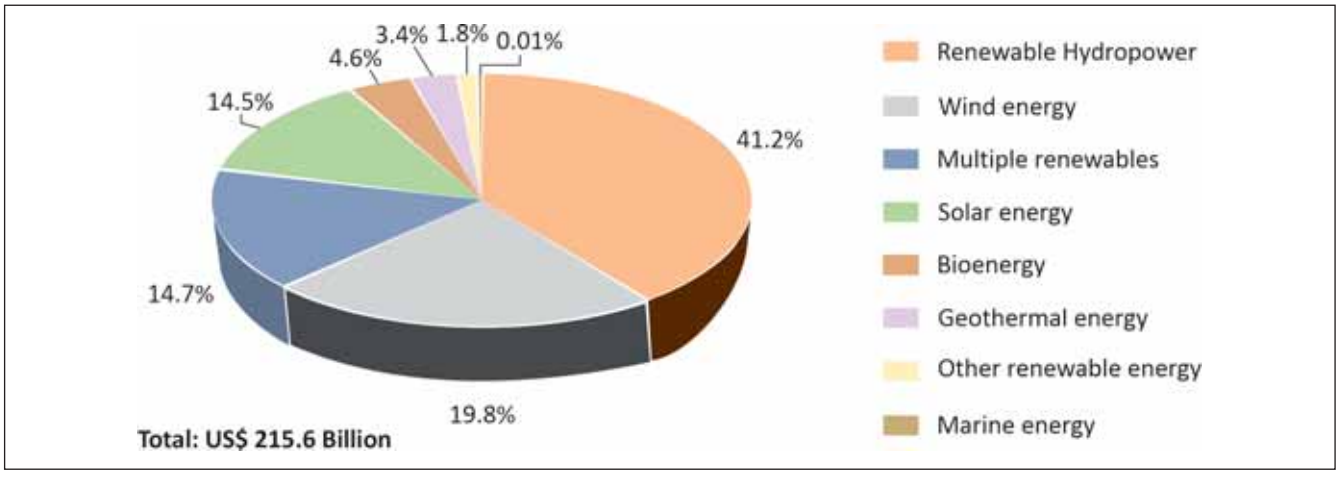
Figure 39: Renewable Energy Finance Flows to the World from Global FIs (US$ Billion)



Source: IRENA; India Exim Bank Research

With respect to the technologies which has been receiving the finances during 2003-2017, renewable hydropower topped the chart with over 40% of the share. This was followed by projects in wind energy (19.5%), multiple renewables[12] (15%), and solar energy (14.4%).

Figure 40: Technology-Wise Share of Renewable Energy Finance by Global FIs (2003-17)



Source: IRENA; India Exim Bank Research

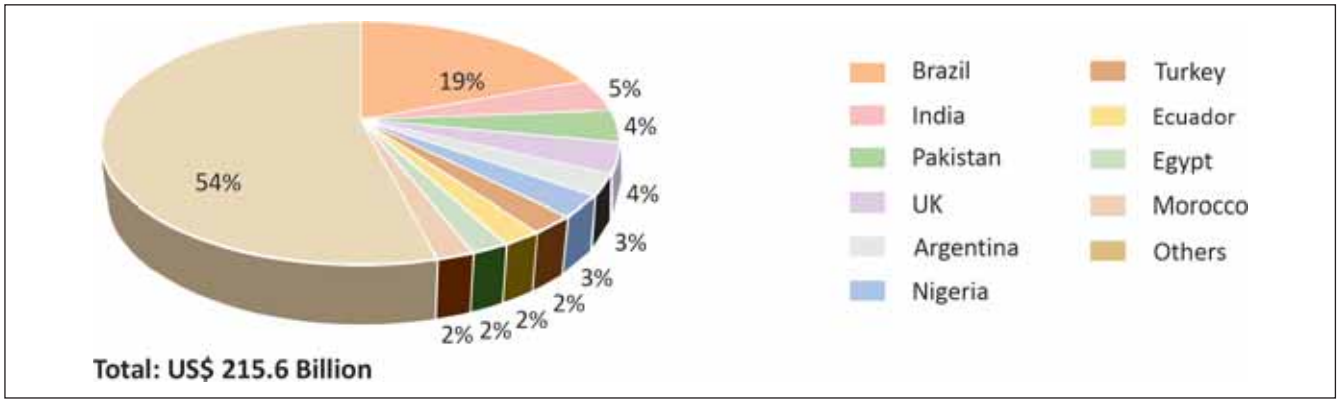
It may be observed that the list of countries receiving the finances from various MDBs / FIs during 2003-17 is quite diversified. Institutions such as the World Bank Group have been quite active with respect to financing the renewable energy systems across the world. For instance, in Peru, as per the World Bank Annual Report of 2020, between 2011 and 2017, about 143,000 people gained new electricity connections, which include nearly 12,000 solar power systems for households in remote areas.

[12] The multiple renewables refer to commitments that target more than one renewable energy technology. These could be equity investments, green bonds, investment funds, multiple project commitments, projects that combine technologies (e.g., hybrid minigrids) and any other commitment that cannot be clearly categorised under one single technology.

The top five recipients accounted for almost 35% of these finances. Brazil was the largest recipient (19.3%), with India being a distant second at 4.5%. The share of Brazil was merely 0.24% in 2003; however, since 2009, it has been able to maintain a double-digit share every year till 2017, except in 2016, when the share was 7.6%. In fact, in 2016, India was the highest recipient of renewable energy finances from global MDBs / FIs.

The case of Brazil is however interesting. The high share of finances in Brazil for renewable energy have largely been driven by BNDES. Out of US$ 41.8 billion finances by global MDBs / FIs to Brazil, during 2003 to 2017, almost 95% were through BNDES. The BNDES, contributing to the National Policy on Climate Change of Brazil and goals related to Paris agreement, also recently launched two new subprograms. The first of them, under the Climate Fund scope, focuses on the acquisition of machines and equipment with higher levels of energy efficiency or which contribute to the reduction of greenhouse gas emissions. The second, under the BNDES Finame (financing of machinery and equipment) scope, finances solar and wind energy generation systems, as well as solar collectors and heaters. Both are open to individuals and micro and small-sized businesses[13].

Figure 41: Top Recipients of Renewable Energy Finances from Global FIs: 2003-17



Source: IRENA; India Exim Bank Research

Further, unlike the recipient nations, the MDBs / FIs have been quite concentrated. In the period analysed of 2003 to 2017 for the renewable energy finances, the top five MDBs / FIs accounted for over 63% of the share, with two of the five institutions being from China (Exim bank of China and China Development Bank). The highest share in the analyzed period was of Brazilian Development Bank (BNDES) at 18.4%. China Development Bank has been actively involved in regions of LAC such as Argentina, Chile, Ecuador, and Peru and South Asian regions such as Pakistan. In fact, under the China Pakistan Economic Corridor (CPEC), China Development Bank and Exim Bank of China are also financing the phase 2 and 3 of Quaid-e-Azam Solar Park (one of the world's largest) in Pakistan.

KfW, which is the German state-owned investment and development bank, had almost 17% of its finances in renewable energy dedicated to India, during 2003-17. Recently, in 2017, KfW also signed an agreement with the State Bank of India for EUR 150 million. The goal of this first of the two planned credit lines is the expansion and conversion of India's power supply towards more

[13] BNDES Annual Report 2018

renewable energy sources by refinancing sub-loans to install solar power systems. The two credit lines will make it possible to invest up to EUR 400 million in solar power systems. This, in turn, can supply at least 400 MW of power[14].

Table 14: Major FIs in Renewable Energy Finance: 2003-17

Financial Institution	Amount (US$ Billion)	Share in Total Renewable Finance Flows
Brazilian Development Bank (BNDES)	39.6	18.4%
Exim Bank of China (C-EXIM)	33.7	15.7%
European Investment Bank (EIB)	29.2	13.6%
World Bank Group (WBG)	23.7	11.0%
China Development Bank (CDB)	10.9	5.1%
KfW Development Bank	8.7	4.0%
Overseas Private Investment Corporation (OPIC)	7.1	3.3%
Asian Development Bank (ADB)	5.5	2.6%
Inter-American Development Bank (IADB)	5.5	2.5%
Agence Française de Développement (AFD)	5.5	2.5%
Others	46.2	21.4%
Total	**215.6**	**100%**

Source: IRENA; India Exim Bank Research

With respect to the type of flows to the renewable energy sector during 2003-17, it is observed that over three-fourth of it was loans. This was followed by 'Other Official Flows (Non-Export Credit)' at 16.2%.

Table 15: Share in Finance Flows to Renewable Energy by Asset Class: 2003-17

Type of Asset Class	Share
Loan	75.3%
Other Official Flows (Non-Export Credit)	16.2%
Grant	5.1%
Equity Investment	2.5%
Guarantee	0.5%
Insurance	0.2%
Credit line	0.1%
Private Development Finance	0.02%
Concessional loan	0.02%
Bond	0.02%

Source: IRENA; India Exim Bank Research

[14] Press Release from 2017-12-06 / Group, KfW Development Bank

Solar Energy Sector

The finance flows to the solar energy sector in the fifteen-year period analyzed (2003-17) have been quite erratic with the amount increasing from US$ 59 million in 2003 to US$ 3796.5 million in 2017, an increase of over 60 times. In the last ten years, that is, during 2008 to 2017, the AAGR recorded in the finance received was almost 54%. A sudden spike was noted in 2016 as the World Bank financed a host of projects (180 projects in 62 countries), to the tune of over US$ 8 billion. Over 30% of this US$ 8 billion finance flow was to Colombia, Turkey, and India.

Table 16: Solar Energy Financing by Major Global FIs: 2003-17

Year	Amount (US$ million)	Growth
2003	59.0	–
2004	14.7	-75.1%
2005	245.3	1571.5%
2006	51.9	-78.8%
2007	23.5	-54.7%
2008	337.1	1334.6%
2009	746.1	121.3%
2010	1654.8	121.8%
2011	1769.5	6.9%
2012	3215.5	81.7%
2013	2178.1	-32.3%
2014	3399.9	56.1%
2015	3566.5	4.9%
2016	10189.4	185.7%
2017	3796.5	-62.7%

Source: IRENA; India Exim Bank Research

Unlike the overall renewable energy sector, India is at the top of the list when it comes to the solar energy financing by various FIs across the globe. The share of India amongst all the countries which were the recipient of solar energy finances by the FIs was 9.5%, during 2003 to 2017. The share of India went as high as over 14% in 2011 and 13.7% in 2016. During the fifteen-year period, India was followed by Morocco at 9.1%, and Chile at 7.2%.

Egypt, which has a share of 5% in the global solar energy financing has received a significant financing support from AFD, which is the French Development Agency. In 2014, AFD allocated a EUR 40 million sovereign loan to finance the construction of the first photovoltaic power plant connected to Egypt's grid. Recently, in 2020, AFD and Egyptian Government signed a new Development Program Financing (DPF) agreement for the development of Egypt's Electricity sector. AFD DPF is part of a multi-donor support program jointly with the African Development Bank (AfDB) and the Japan International Cooperation Agency (JICA), for an estimated total financing of EUR 1 billion[15].

[15] Agreement on the Development of the Electricity Sector in Egypt, AFD

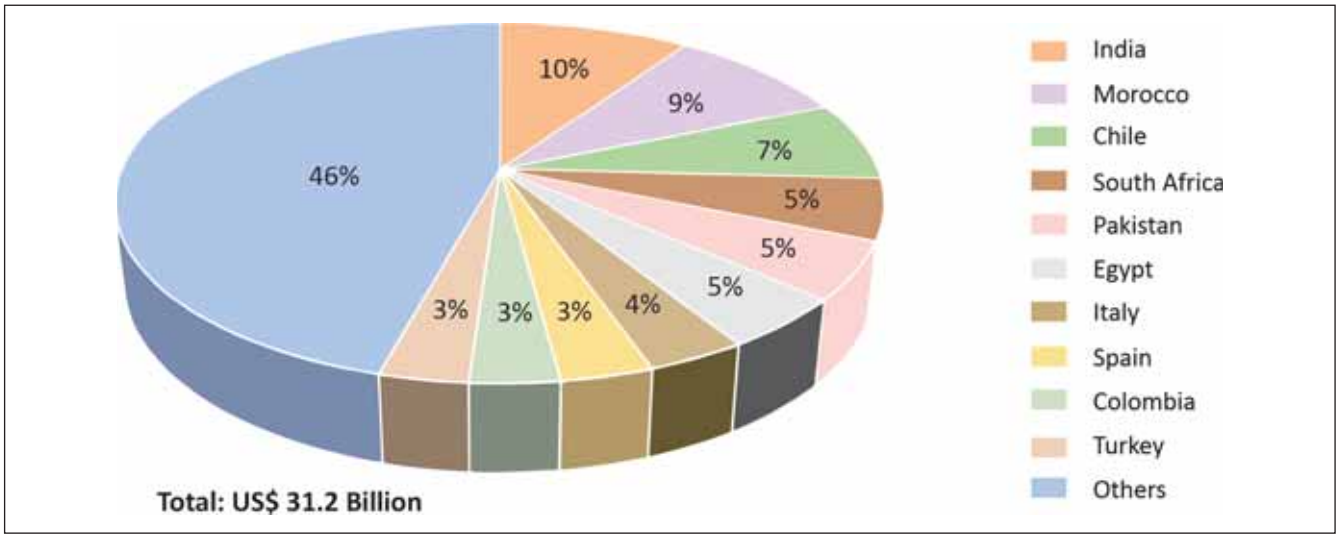
Box 5: India Exim Bank and the European Investment Bank (EIB)

The Export-Import Bank of India signed an agreement for a long-term loan of Euro 150 million equivalent with tenure up to 15 years with the EIB in December 2008. The purpose of the EIB loan was to support projects that contribute to climate change mitigation and to increase the EU presence in India through FDI, transfer of technology or know-how from Europe. The borrowings under this Facility were on-lent for import of equipment for projects including renewable energy projects (e.g., wind, solar), energy efficiency enhancement (e.g., fuel switching, plant modernization, etc.) as well as projects that reduced greenhouse gases emission and clean environment. The Bank received allocations from the EIB for 18 proposals aggregating EUR 150 million (US$ 205 million). Amount drawn under the EIB line aggregated EUR 136 million (US$ 181 million) in three tranches.

India Exim Bank signed another agreement for a long-term loan of Euro 150 million equivalent with tenure of up to 20 years with the EIB in March 2013, which was the second credit line extended by the EIB to India Exim Bank. The borrowings under this facility enabled the Bank to on-lend for electricity / heat generation projects, notably wind, solar photovoltaic, concentrated solar power, hydropower, geothermal, biomass, and efficient cogeneration.

The list of MDBs / FIs which put India to the top of the recipient chart include the World Bank Group, OPIC, CIF, and ADB. In regions such as Morocco and other regions of Africa, AfDB has been actively involved. The AfDB is the leading financial partner of the Noor Ouarzazate complex, the world's largest solar power station extending over 3,000 hectares of desert in Morocco. The AfDB is also rolling out a second giant electricity-generation project, in the Sahel stretch. The Desert-to-Power (D2P) project, when complete, will turn the Sahel into one of the largest solar-power-generating areas in the world. The US$ 20 billion program aims to produce 10 GW of electricity by 2025, providing 250 million people with power, of whom at least 90 million will be connected to the electricity grid for the first time.

Figure 42: Top Recipient Nations in Solar Energy Financing from Major Global FIs: 2003-17



Source: IRENA; India Exim Bank Research

The top five financers/investors contributed to almost two-thirds of the total global solar finances during 2003 to 2017, with almost one-third of the total finances coming from the World Bank alone, clearly signifying the importance the World Bank has accorded to promoting solar energy around the world.

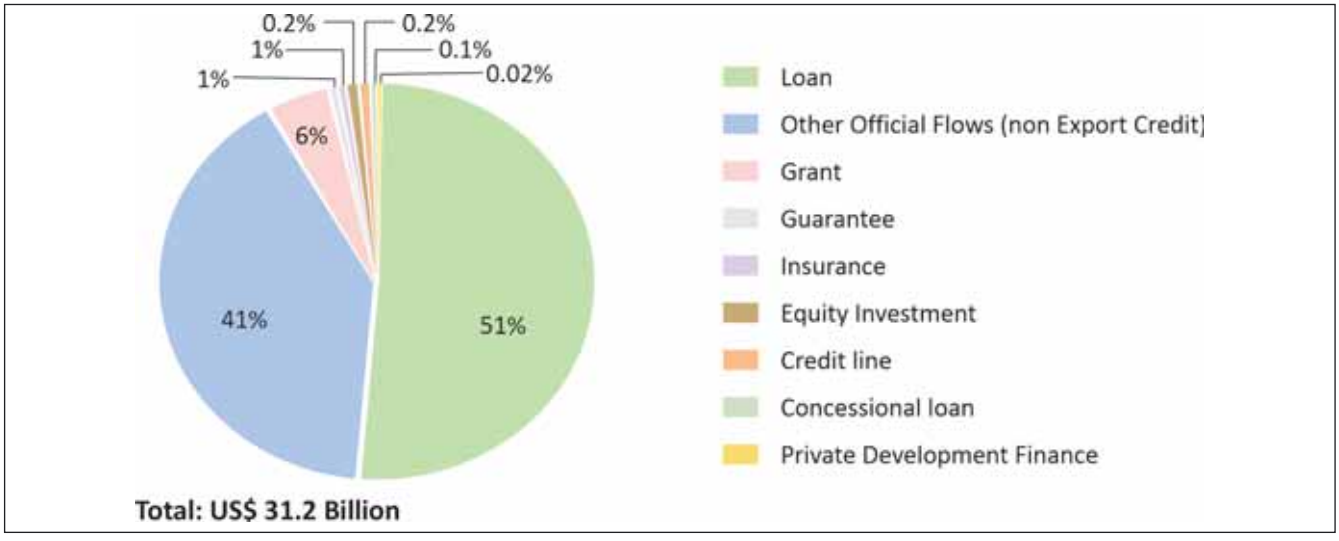
Table 17: Major FIs in Solar Energy Finance to World: 2003-17

Financial Institution	Amount (US$ Billion)	Share in Total Solar Finance Flows
World Bank Group (WBG)	10.4	33.3%
Overseas Private Investment Corporation (OPIC)	3.6	11.4%
European Investment Bank (EIB)	3.0	9.7%
China Development Bank (CDB)	2.6	8.3%
Climate Investment Fund (CIF)	1.3	4.1%
Asian Development Bank (ADB)	1.2	4.0%
Exim Bank of China (C-EXIM)	1.2	3.9%
Agence Française de Développement (AFD)	1.2	3.7%
KfW Development Bank	1.1	3.4%
African Development Bank (AfDB)	0.8	2.7%
Others	4.8	15.5%
Total	**31.2**	**100%**

Source: IRENA; India Exim Bank Research

Further, over 90% of these flows to the solar energy sector came through loans (51.3%) and 'Other Official Flows (non-Export Credit)' (40.4%), during 2003 to 2017. Additionally, grants constituted almost 6% of these flows to the solar sector.

Figure 43: Share in Finance Flows to Solar Energy by Asset Class: 2003-17



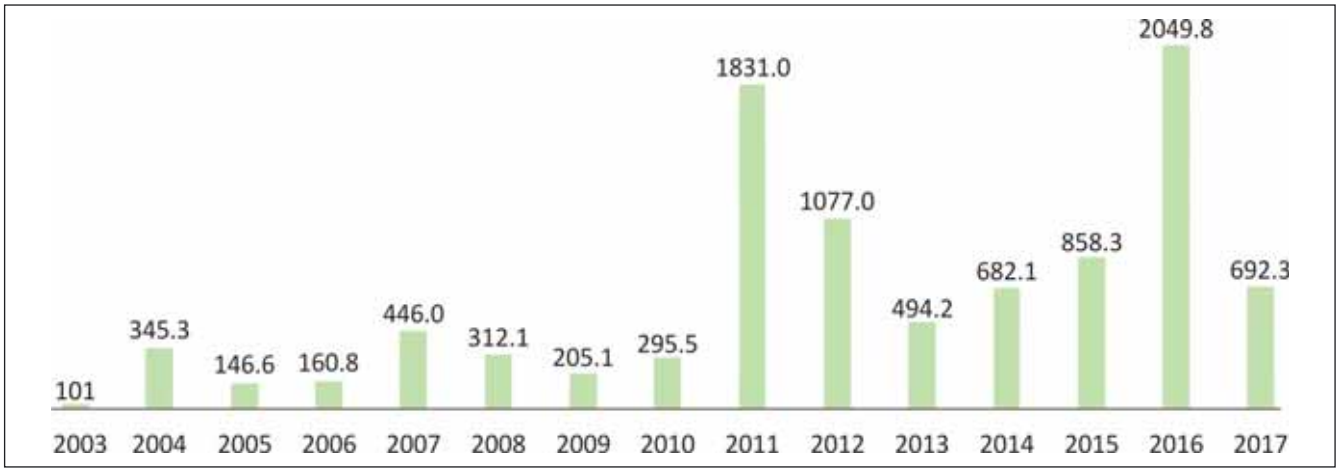
Source: IRENA; India Exim Bank Research

Major Global FIs' Finances to India

Overall Renewable Energy Sector

The renewable energy finance flows to India from the global FIs reached US$ 692.3 million in 2017, up from US$ 10.1 million in 2003, an increase of almost 70 times in the last fifteen years. The finances reached an all-time high in 2016 when they were recorded at over US$ 2 billion.

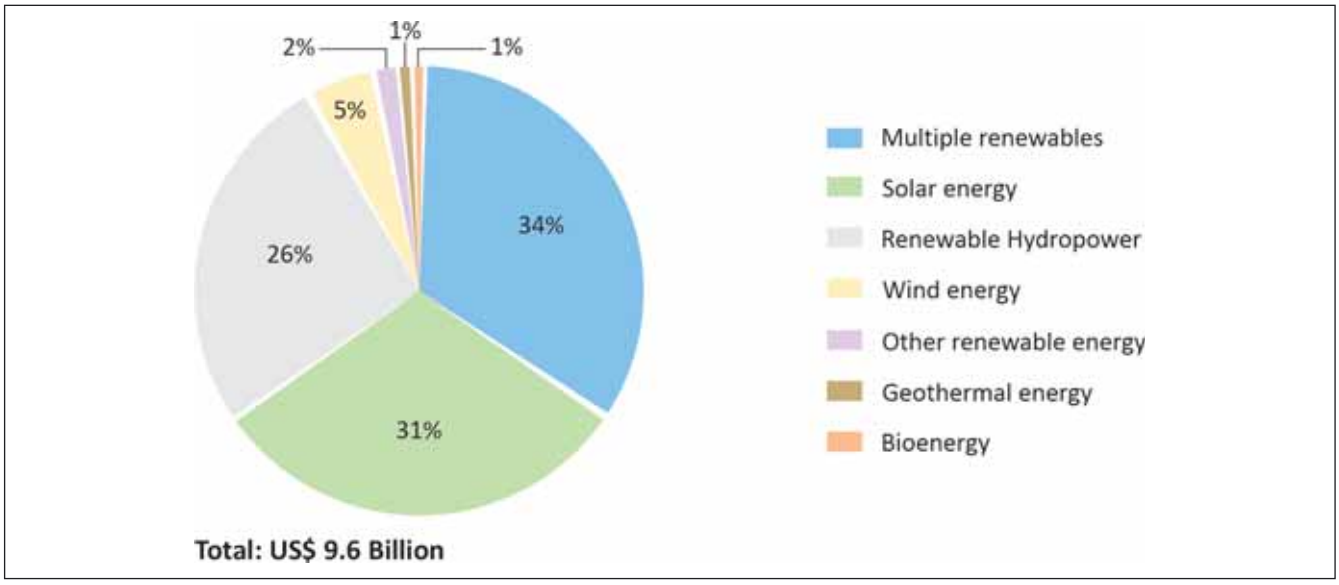
Figure 44: Renewable Energy Finance Flows to India from Major Global FIs (US$ Million)



Source: IRENA; India Exim Bank Research

In the context of the projects which received these finances from various agencies, it may be noted that during the analyzed period of 2003 to 2017, the highest share went to the multiple renewable projects (34.4%). This was closely followed by the solar energy projects which accounted for another 31%. Renewable hydropower was the third highest with a share of over 26%.

Figure 45: Technology-Wise Share of Renewable Energy Finance to India by Major Global FIs (2003-17)



Source: IRENA; India Exim Bank Research

In fact, until 2008, renewable hydropower used to account for majority of the finances received. Solar energy, which was hardly in the picture, with respect to the finance flows until 2008, saw its share gradually increasing from 0.9% in 2007 to 7.5% in 2008 and further to an impressive 42.8% in 2017.

Table 18: Major FIs in Renewable Energy Finance to India: 2003-17

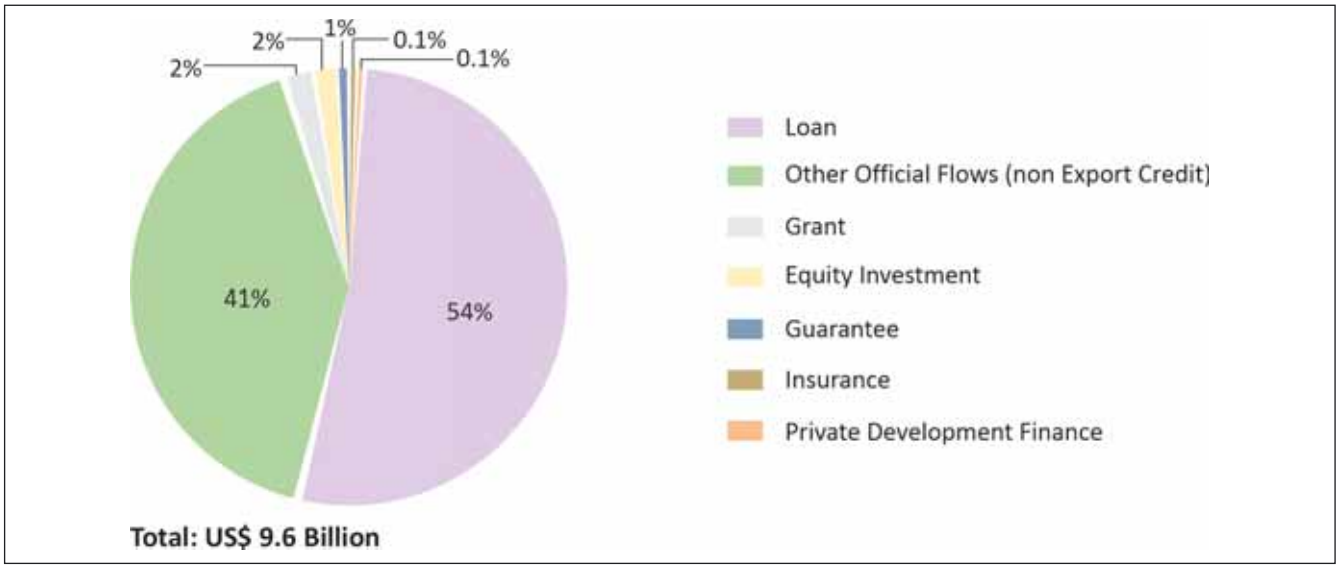
Financial Institution	Amount (US$ Million)	Share in Total Renewable Finance Flows
World Bank Group (WBG)	2707.2	28.2%
KfW Development Bank	1320.2	13.7%
Asian Development Bank (ADB)	1300.7	13.5%
Overseas Private Investment Corporation (OPIC)	756.4	7.9%
Climate Investment Fund (CIF)	748.7	7.8%
Japan International Cooperation Agency (JICA)	569.0	5.9%
European Investment Bank (EIB)	550.5	5.7%
FMO Entrepreneurial Development Bank	321.1	3.3%
Agence Française de Développement (AFD)	320.0	3.3%
Nordic Investment Bank (NIB)	92.7	1.0%
United Nations Development Programme (UNDP)	0.1	0.001%
Others	414.2	4.3%
Total	**9606.1**	**100%**

Source: IRENA; India Exim Bank Research

As far as the financial institutions are concerned, the top five institutions contributed to over 70% of the FIs finance flows to India, during 2003 to 2017, with the World Bank Group leading the way at 28.2% share. KfW Development Bank, and Asian Development Bank were other major financial institutions which significantly contributed to these flows. Recently, ADB also signed an agreement to invest US$ 15 million in INR equivalent in Avaada Energy Private Limited (AEPL) to help the company to scale up photovoltaic solar energy generation capacity in India. The investment is going to come from ADB's Ordinary Capital Resources and from Leading Asia's Private Infrastructure Fund (LEAP), each of which will invest US$ 7.5 million. LEAP was established in 2016 by the JICA to finance high quality and sustainable private sector infrastructure projects.

Further, similar to the global picture, majority of the finance flows came through the loans and 'Other Official Flows (non-Export Credit)'. Approximately 95% was contributed by these two classes in the fifteen-year period of 2003 to 2017, with the loans accounting for almost 54% and the rest by other official flows. Grants contributed to just over 2% of the total flows during this period to India in the renewable energy sector.

Figure 46: Share in Finance Flows to Renewable Energy in India by Asset Class: 2003-17



Source: IRENA; India Exim Bank Research

Solar Energy Sector

The solar energy sector in India has been one of the most successful segments in Indian renewable energy space, involving various reasons such as the high solar irradiance, and friendly government policies. While the finance flows to solar energy in India by global FIs were recorded at just US$ 0.06 million in 2004, the amount was almost US$ 300 million in 2017.

On the investors' front, World Bank Group, similar to the overall renewable energy finances, was also the top investor for solar energy in India with a share of over 30%, during 2003 to 2017. It was followed by OPIC (23%), CIF (22%), and ADB (16.1%). Overall, the top five institutions comprise over 96% of the share, signifying a huge concentration.

In 2016, the World Bank Group also signed an agreement with the International Solar Alliance (ISA), to collaborate on increasing solar energy use around the world, with the goal of mobilizing US$ 1 trillion in investments by 2030. The World Bank Group also announced to provide more than US$ 1 billion to support India's ambitious initiatives to expand solar through investments in solar generation. The World Bank-supported projects under preparation include solar rooftop technology, infrastructure for solar parks, bringing innovative solar and hybrid technologies to market, and transmission lines for solar-rich states.

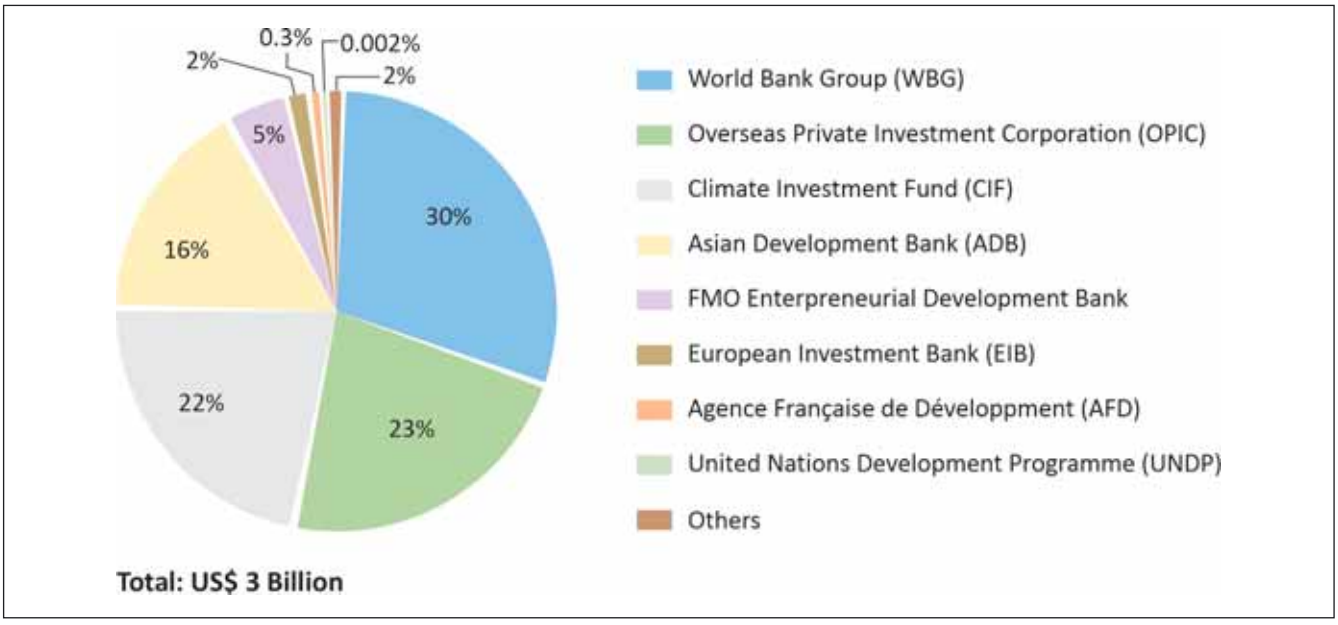
In 2016, ReNew Power, an Indian company, signed an agreement with OPIC to receive debt financing of up to US$ 250 million. The funds are expected to help in the construction of 400 MW of new solar power projects in India.

Table 19: Solar Energy Finance Flows to India from Global FIs

Year	Amount (US$ million)	Growth
2004	0.06	–
2005	0.01	-75.9%
2006	0.04	217.2%
2007	0.3	570.6%
2008	2.7	854.2%
2009	15.4	465.0%
2010	40.2	160.4%
2011	249.2	520.3%
2012	376.4	51.0%
2013	229.5	-39.0%
2014	195.5	-14.8%
2015	180.4	-7.7%
2016	1396.0	673.7%
2017	296.4	-78.8%

Source: IRENA; India Exim Bank Research

Figure 47: Major FIs in Solar Energy Finance to India: 2003-17



Source: IRENA; India Exim Bank Research

Box 6: India Exim Bank's Involvement in the Solar Sector

In the last decade, India Exim Bank has made significant efforts towards facilitating renewable energy in India as well as in other nations. On the advisory front, India Exim Bank in 2020 released a study 'Self-Reliant India: Approach and Strategic Sectors to Focus', as part of GOI's Atmanirbhar Bharat campaign. The Bank in this study highlighted the challenges in the domestic manufacturing capacity of silicon wafers and ingots.

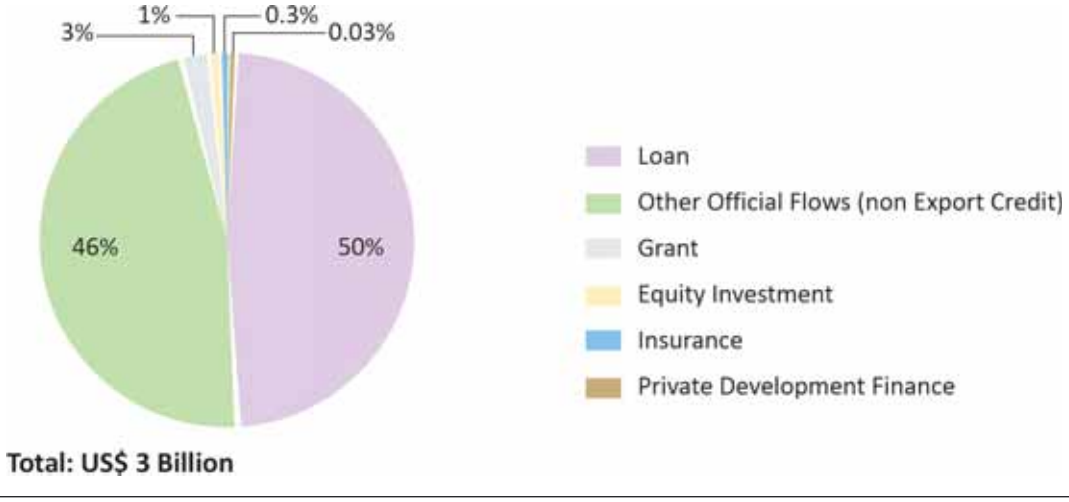
In the past also, Exim Bank had undertaken a study titled 'International Solar Alliance: Nurturing Possibilities'. Besides, Exim Bank was a part of the Advisory Council during the formative years of the ISA.

With respect to financing solar projects in India, India Exim Bank has financed several solar projects in India for solar power generation and manufacture of solar panels through import financing program. Select companies include Bhagerie Industries; Essel; Intelizon Energy; Marikal Solar Parks; New Era Enviro Ventures; Roha Dyechem.

Besides, India Exim Bank has supported installation of solar water pumping systems in Uganda, and hybrid solar power plant in Maldives. The Bank has also supported Indian companies by way of Bank Guarantees. For instance, Sterling and Wilson was supported by India Exim Bank through guarantees aggregating US$ 11.83 million for executing the design, engineering, procurement, and construction contract of a 50 MW (AC) photovoltaic solar electricity generating project at Benban, Egypt valued at US$ 48.75 million.

Further, the Bank has extended Lines of Credit (LOCs) to countries such as Congo (US$ 83.11 million for installation of 3 solar projects); Sierra Leone (US$ 20 million through EBID to enhance their access to alternative and cheaper sources of electricity); Mozambique (US$ 13 million for solar photo voltaic module manufacturing plant); among others. In 2020, the Bank also extended a LOC of US$ 35.8 billion to Suriname for rural electrification through solar DG hybrid PV systems, which would cater to 50 remote villages.

Figure 48: Share in Finance Flows to Solar Energy in India by Asset Class: 2003-17



Source: IRENA; India Exim Bank Research

Box 7: International Solar Alliance (ISA) and its Role

The ISA was launched in 2015, jointly by India and France at the 21st session of the United Nations Climate Change Conference of the Parties (COP-21) in Paris. It is an alliance of 121 countries which are solar rich in resources and lie either completely or partly between the Tropic of Cancer and the Tropic of Capricorn.

It was formed to promote the solar energy in 121 member countries of the alliance and mobilise US$ 1 trillion investment for the solar energy deployment at affordable costs. Majority of these 121 nations have signed the ISA's Framework Agreement and deposited their instruments of ratification.

The ISA has various programmes in place, namely, Scaling Solar Application for Agricultural Use; Affordable Finance at Scale; Scaling Solar Mini-grids; Scaling Solar Rooftop; Scaling Solar E-mobility & Storage; ISA Solar Park; and Solarizing Heating and Cooling Systems.

With respect to affordable financing, the Solar Risk Mitigation Initiative (SRMI) was launched in 2018 by the World Bank and the Agence Francaise de Développement (AFD), in support of the ISA. This aims at development of bankable solar programs in developing countries leveraging private sector investments. ADB has also approved a Technical Assistance program of US$ 2 million for ISA member countries in South Asia, and the program will be utilized for supporting solar project preparations.

ISA has also launched two studies for the implementation of its programme of 'Scaling Solar E-mobility & Storage'. The two studies include, a) assessment of the Member countries' capacities and needs on solar electric mobility and storage, and b) benchmarking of the existing technologies and projects on solar e-mobility, solar powered charging infrastructure and storage systems.

Source: ISA

Even with respect to the categories of the finance flows, a huge concentration can be observed. Loans (49.4%), and 'Other Official Flows (non-Export Credit)' (46.4%) together account for almost 96% of the finance flows to India in the solar energy sector by Global FIs, during 2003 to 2017. It may be noted that until 2008, all money from these FIs into solar energy financing was through grants.

Conclusion

The top recipients of renewable energy finance by global financial institutions during 2003 to 2017 include countries such as Brazil, India, and Pakistan. The top investors have been BNDES, China Exim Bank, EIB, the World Bank Group, among others. However, particularly with respect to the solar energy finances, India stands at the top with almost 10% share in the world. Almost one-third of the finances in solar energy were through the World Bank Group. The top MDBs / FIs supporting India's solar energy installations have been the World Bank Group, OPIC, Climate investment fund, and ADB.

CHAPTER

6

CHALLENGES AND STRATEGIES

The principal purpose for adopting solar energy in India is to further the economy, trade, and industry, while expanding energy security, and alleviating climate change. Sustainable development through solar is viable by safeguarding access to affordable, reliable, and advanced energy for the population.

India in the last decade or so has experienced robust government support in promoting the solar sector in particular, and renewable energy in general. Given the potential of solar sector in India, it can generate significant jobs in the coming years in the country, should it start producing for India and for the world.

It is a fact that India's domestic manufacturing capacity of solar cells has not been up to the market demand yet. While the capacity is lower, the utilization also hangs between 40%-45%. But it is important to assess the reasons as to why India has mostly been dependent on imports of solar cells, especially from China.

Table 20: Leading Solar PV Manufactures and their Production Capacity as of December 2020

China	
Longi	30 GW
Jinko	25 GW
Trina	21.5 GW
JA Solar	15 GW
Canadian Solar	14 GW
Risen	12.6 GW
Hanwah	10.7 GW
Suntech	10 GW
India	
Waaree	2 GW
Adani	1.5 GW

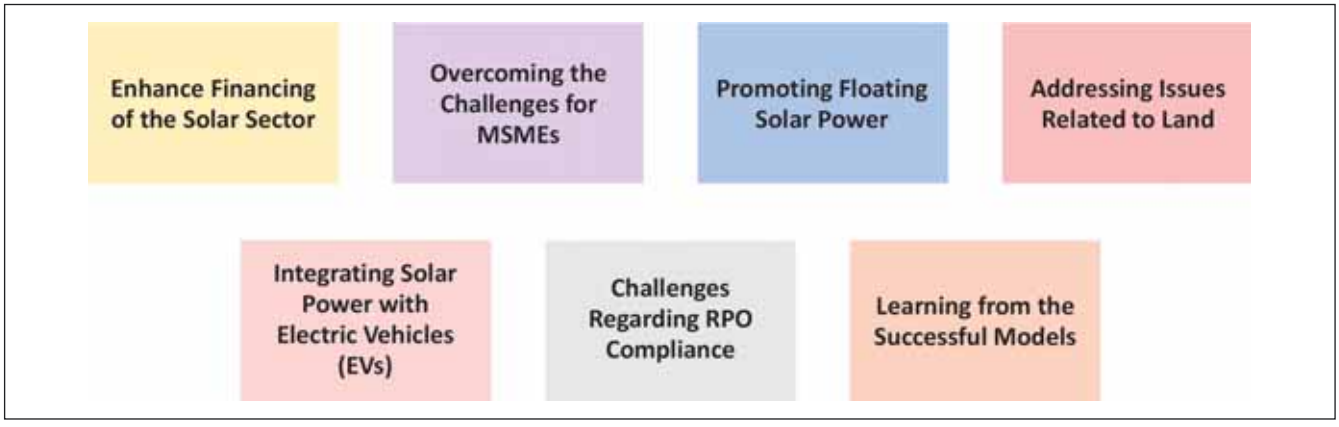
Source: Institute for Energy Economics and Financial Analysis (IEEFA)

One of the challenges India faces from China is in R&D. According to the report 'Viability Assessment of New Domestic Solar Module Manufacturing Units' by IEEFA, China utilizes 1-3% of gross revenue for solar module R&D every year, while India's leading players provide little for R&D investment. Further, even in terms of profit margins, the module suppliers from China can absorb almost 4.3% share of profit from operational revenues, while the Indian counterparts earn an average profit income of less than 3%.

A lot of it has also do with the technology used to produce solar cells. India's transition towards the newer technologies has been slow. China's more advanced mono-Si PV[16] modules constituted around two-thirds of the share of the entire global PV production chain in 2019 by GW volume. However, as per the above-mentioned report, for the top seven Indian domestic module manufacturers in 2019, mono-Si PV modules constituted only 13% of PV production, while 87% comprised of multi-crystalline (or multi-Si) PV modules. As a result, the imports are currently of a superior technology.

The success story of the solar energy, particularly in India, can be ascertained from the fact that the tariff for solar energy has come down from over ` 12/kWh in 2010, to an all-time low of ` 1.99/kWh, in December 2020. However, it may be noted that there are cases where DISCOMs have also cancelled PPAs with solar power producers, leading to crisis in the sector. There has been an increasing trend of the States cancelling or renegotiating the PPAs that were finalized after the bidding process. A case in point here is of Uttar Pradesh which in 2020 cancelled the solar auction process for the installation of 500 MW solar power to get a lower price in the new auction. In February 2020, the auction was bid with a lowest price of ` 3.17 - ` 3.18 per unit; however, in November 2020, in the revised auction, a price of ` 99/unit was realized. While there have been concerns on whether low tariffs are sustainable, even with the tariff corrections in the medium term, solar prices are likely to be competitive than the conventional energy forms.

Exhibit 1: Strategies to Enhance Solar Energy in India



Source: India Exim Bank Research

[16] Monocrystalline solar cells (mono-si) are more efficient because they are cut from a single source of silicon. Polycrystalline solar cells are blended from multiple silicon (multi-crystalline) sources and are slightly less efficient. Thin-film technology costs less than mono or poly panels but is also less efficient

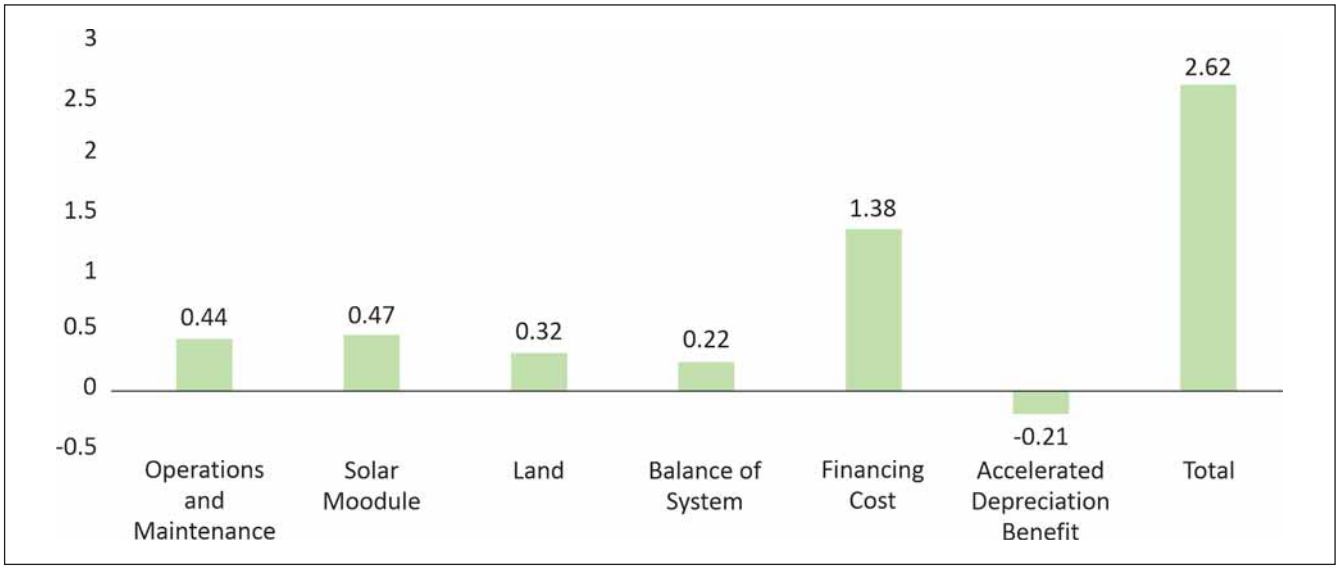
Additionally, recent initiatives of Government of India such as Atmanirbhar Bharat can scale up the manufacturing capacity of solar cells in India. The Government recently approved the proposal of Ministry of New and Renewable Energy (MNRE) for ramping up domestic manufacturing of solar photovoltaic (PV) panels under the production-linked incentive (PLI) scheme. The proposed scheme is envisaged to create additional 10,000 MW capacity of integrated solar PV manufacturing plants in India with an outlay of ` 4,500 crore.

This section identifies select hurdles faced by the solar sector. The suggestions based on the review outcomes from the industry and practitioners would provide useful information for policymakers.

I. Enhance Financing of the Solar Sector

One of the biggest challenges that the world, and not just India, faces in embracing solar energy is the mobilization of funds and investment. More than 70% of the renewable energy projects in India use debt to finance their needs. While the cost of the debt is in the range of 3-6% in the developed world, it could range from 10-15% for the developing nations[17].

Figure 49: Component-Wise Breakdown of Solar Tariff: May 2017 (in `/kWh)



Source: Adapted from Chawla, K., M. Aggarwal, and A. Dutt. 2020. Analyzing the Falling Solar and Wind Tariffs: Evidence from India. ADBI Working Paper 1078. Tokyo: Asian Development Bank Institute

As can be observed from figure, the financing costs constitute the largest share in the tariffs of India's solar energy, which cannot be undermined. While the banks prefer extending short term facilities to power projects, solar power projects cash flows necessitate the requirement of a long-term financing.

[17] Chawla, Kanika and Manu Aggarwal. 2016. Anatomy of a Solar Tariff: Understanding the decline in solar bids globally. New Delhi: Council on Energy, Environment and Water

Encouraging Private Capital through Limited Public Funds

The year 2020 saw an unprecedented rise in the spending of the governments across the world including India. As per the Fiscal Monitor October 2020 database of International Monetary Fund, India's general government fiscal balance was estimated at (-) 13.1% of GDP in 2020 and was recorded at (-) 8.2% of GDP in 2019.

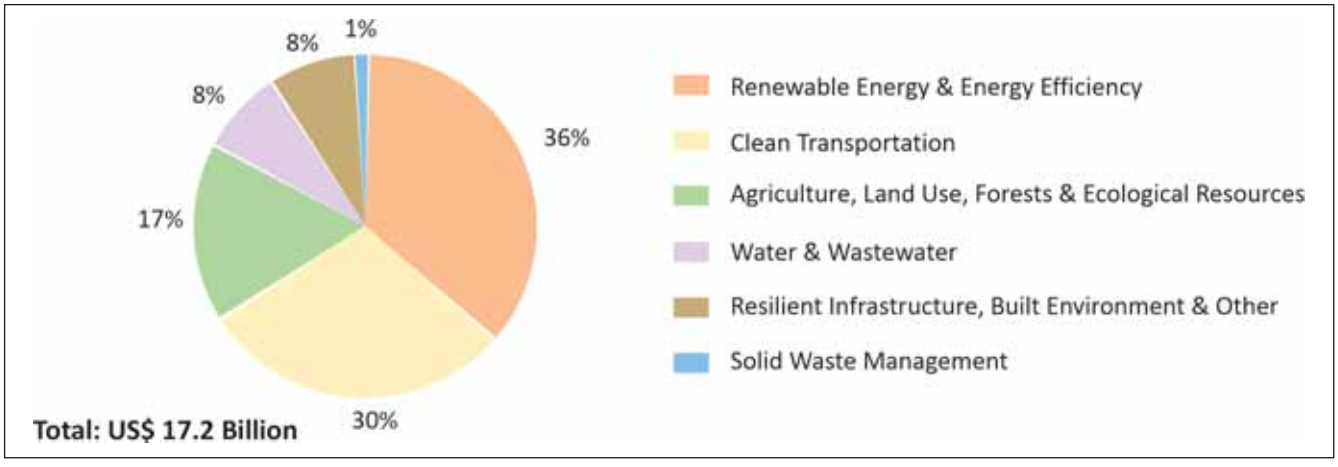
Given the fiscal estimates, it is vital to note that the funds available with the Government of India will be put to a judicious use and will be focused. Some of the ways in which these resources can be utilized are exploring the areas such as pilot projects support, capacity building, and new age instruments such as green bonds, tailored financial instruments etc. which ultimately would help in enhancing the investment from the private sector[18].

Given the persistence of Covid-19 crisis, the private sector's confidence is significantly low, and thus the risk mitigating instruments given above, could be gamechanger in mobilizing funds from the private sector, especially in the developing markets such as India.

Promoting Green Bonds

Green bonds can mobilize resources from domestic and international capital markets for climate change adaptation, renewables, and other environment-friendly projects. They are the same as the conventional bonds, except the fact that the proceeds from this is invested in projects that generate environmental benefits[19].

Figure 50: Sector-wise Commitment of Green Bonds Issued by World Bank (2008 to June 2019)



Source: Green Bond Impact Report, World Bank, 2019; India Exim Bank Research

At the individual level, the World Bank has been one of the largest green bond issuers in the world. The World Bank issued the first green bond in 2008 and during 2008 to 30th June 2019, the World

[18] Global Landscape of Renewable Energy Finance, 2020, IRENA and CPI

[19] UNDP

Bank has issued 158 Green Bonds in 21 currencies for a total of over US$ 13 billion in funding to support the transition to low-carbon and climate resilient growth. The commitments during the same period were US$ 17.2 billion. Out of the US$ 17.2 billion commitments, almost 36% were for renewable energy and energy efficiency segment.

Further, at the global level, according to the Climate Bonds Initiative, the yearly green bond issuance was recorded at US$ 258.9 billion in 2019, up from merely US$ 0.8 billion in 2007. This is an average annual growth rate of more than 100%. It may be noted that the database of Climate Bonds Initiative includes bonds with at least 95% of proceeds dedicated to green assets and projects aligned with the climate bonds taxonomy of Climate Bonds Initiative.

The Climate Bonds Taxonomy identifies the assets and projects needed to deliver a low carbon economy and gives GHG emissions screening criteria consistent with the 2-degree global warming target set by the COP 21 Paris Agreement.

Table 21: Top 10 Issuers of Green Bonds in 2019 (Excluding Supranationals)

Developed Markets	Developing Markets
Fannie Mae (USA)	ICBC (China)
KfW (Germany)	Industrial Bank Co., Ltd (China)
Dutch State Treasury Agency (Netherlands)	Noor Energy 1 (UAE)
Republic of France (France)	Republic of Chile (Chile)
SNCF (France)	Republic of Poland (Poland)
Engie (France)	China Construction Bank (China)
Société du Grand Paris (France)	Bank of Jiangsu (China)
Kingdom of Belgium (Belgium)	China Development Bank (China)
Crédit Agricole CBI (France)	Majid Al Futtaim (UAE)
Kommuninvest (Sweden)	Islamic Development Bank (Saudi Arabia)

Source: Climate Bonds Initiative

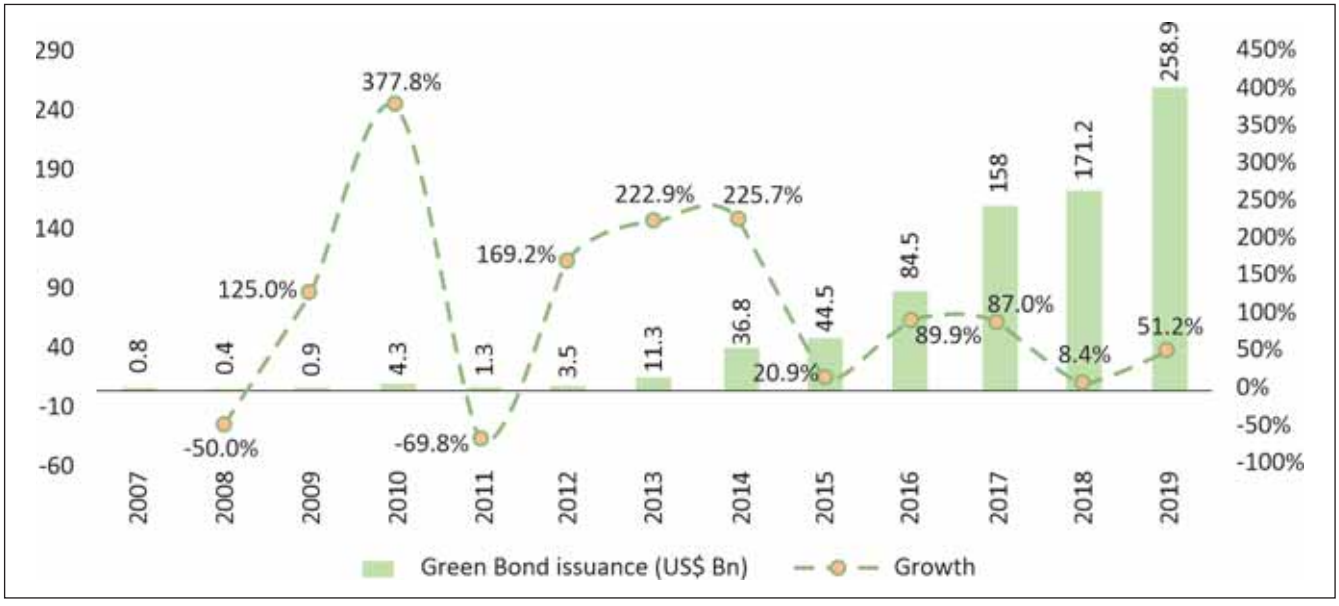
However, almost 75% of this issuance has come in Euro (37.2%) and USD (37.1%), during 2007 to 2019. This was followed by Chinese Yuan (9.7%), Swedish Krona (4.6%), and Australian Dollar (2%).

In the Indian currency, during this period, the issuance amounted to US$ 2.1 billion, which is just 0.3% of the total issuances. Even with respect to the amount issued by countries and number of issuers by countries, India does not feature in the top five countries in 2019.

While India has made progress in Climate Bonds, there is a significant scope for it to bridge the gap between the demand and supply of funds, given the increase in solar supplies in the country. As the cost to raising finance through green bonds is high, with support, the cost can decrease and

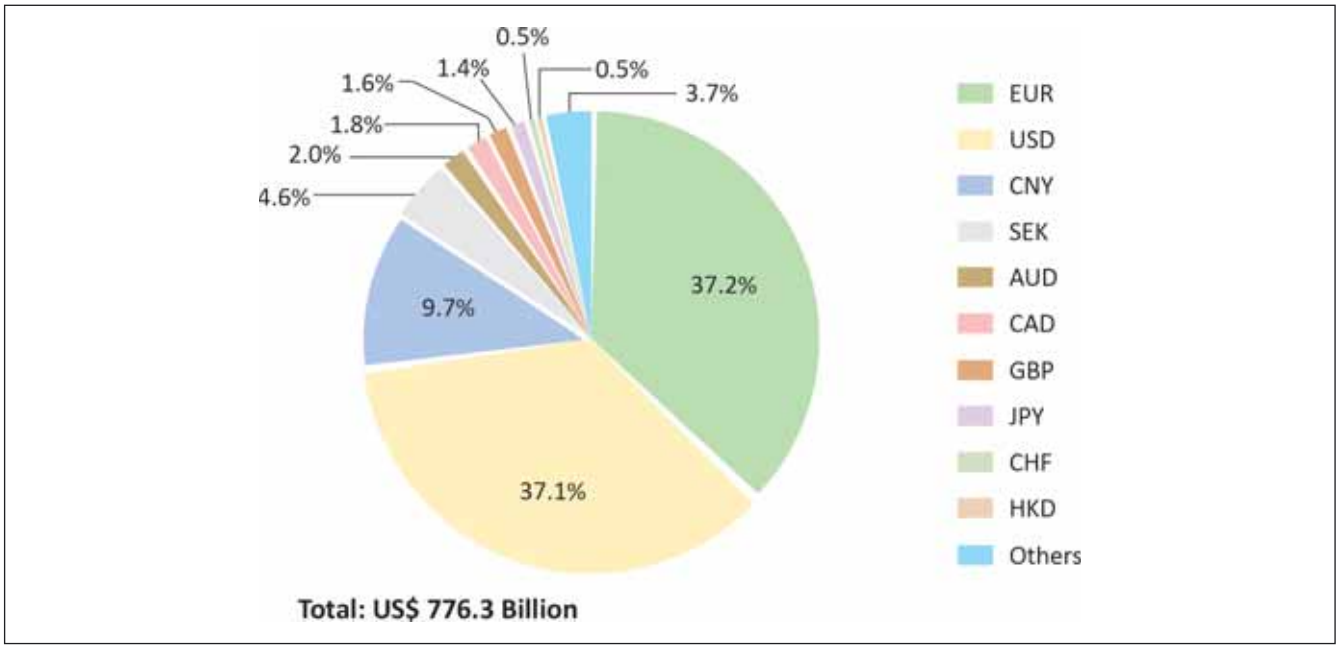
ultimately help renewable and solar sector. For India to grow in this market, there is a need to enhance coordination amongst the issuers, capital markets, policy makers, and the investors which can facilitate the issuances of green bonds as well as put in the necessary confidence amongst the investors.

Figure 51: Yearly Green Bond Issuance: 2007-19



Source: Climate Bonds Initiative; India Exim Bank Research

Figure 52: Currency-wise Issuance of Green Bonds: 2007-19



Source: Climate Bonds Initiative; India Exim Bank Research

For instance, support for the green bond market could be provided through technical assistance and incentives such as subsidizing issuance and reporting costs, funding of demonstration issuances, etc. In fact, as per a recent study by the RBI, titled 'Green Finance in India: Progress and Challenges', due to information asymmetry, the cost of issuance of green bonds in India remains higher than the other types of bonds.

While, in the coming years, the cost might decrease with more awareness and information, the Government may like to provide support to the issuers. For example, the Monetary Authority of Singapore has a scheme named Sustainable Bond Grant Scheme in place which encourages the issuance of green, social, sustainability, and sustainability-linked bonds in Singapore. The scheme subsidizes expenses including issue arranger, audit, credit rating, legal, listing agent, and listing fee.

The support could also be provided by creating bankable project pipelines through reducing the risk of renewable energy assets by risk mitigation instruments, documentation standardization etc. Overall, this would involve creating an environment where the process to issue such bonds becomes easier which can help the renewable energy market with the required finances.

Box 8: ESG Scenario in India

The Environmental, Social, and Governance (ESG) is a form of responsible and sustainable investment that considers the three elements as the name suggests. The essence of the same is that the investors investing in ESG funds can keep a check on the companies, if they are behaving responsibly on these three parameters.

With respect to India, while the awareness around the ESG investing is increasing, it is still in the nascent stage when compared to the other large economies. India has around 23 ESG funds in place while the US has more than 500 funds. Japan (182) and China (119) are also way ahead. Currently, only two of the Indian AUMs, namely, SBI Mutual Fund and Kotak Mutual Fund, are signatories to the UN Principles for Responsible Investment (UN PRI).

To extend the scope of ESG investing in India, SEBI has recently come out with Business Responsibility and Sustainability Report (BRSR) standards, and this will be applicable to the top 1,000 listed companies in India mandatorily from FY 23. As currently, there is no standardized way to grade companies on ESG factors, these regulations could give a better picture of the ESG scenario in India.

From the point of view of financing also, the awareness around the ESG parameters is increasing. RBI too has been encouraging green financing. In 2021, RBI also joined the Central Banks and Supervisors Network for Greening the Financial System (NGFS). NGFS is a group of central banks and supervisors willing to share best practices and contribute to the development of environment and climate risk management in the financial sector, while mobilizing mainstream finance to support the transition towards a sustainable economy.

Focusing on Finance for Off-grid Facilities

While on-grid systems would mean that the consumer's solar facility is connected to the local utility's grid, the off-grid system would not involve that. This means that the consumer could be fully self-sustaining in terms of energy use. While this system could be expensive, it is also the key to the universal electricity access.

According to the World Bank, there are 840 million people in the world without access to reliable power and a range of financing solutions could be needed to give them the access. Further, as per the 'Off-Grid Solar Market Trends Report 2020' by the World Bank, in order to achieve universal access to electricity by 2030, additional funding in the range of US$ 6.6 billion to US$ 11 billion would be needed in the off-grid solar sector.

Since the long-term financing and affordable finance remains a big challenge in the solar energy sector, one of the innovative solutions with respect to the enhanced off grid-deployment could be results-based financing (RBF) in India. RBF refers to incentive structures in which payments are made to companies, or directly to customers after the delivery or installation of a given quota of an output (for example, kilowatts installed). Overall, this exercise is based on milestone completion. Governments in both developed and developing countries have used RBF to encourage the uptake of renewable energy and energy-efficient technologies[20]. This kind of funding can help in faster development of the off-grid solar solutions as it enhances the affordability due to the incentives. India can explore the scope of this by starting this as a pilot project for certain geographies.

Empowering the local financial institutions by enhancing their capacity (for instance, by providing technical assistance in loan evaluations) could also be one of the solutions to scale up the finances for off-grid systems. This is because the local financial institutions will have the required knowledge of the opportunities in the off-grid sector, particularly for the rural and semi-urban sectors[21].

Institutional Investment

Given the ambitious targets that India has kept in the solar energy sector, mobilizing investments through the institutional investors could be a game changing factor. According to the Climate Policy Initiative, India needs an additional US$ 450 billion to achieve its 40% renewable share target by 2030. To achieve this target, solar energy could be one of the most important segments to explore. Foreign institutional investors with US$ 70 trillion and domestic institutional investors with US$ 560 billion of assets under management may prove important in fulfilling the financing requirements of this sector[22].

[20] Funding the Sun: New Paradigms for Financing Off-Grid Solar Companies; World Bank

[21] Global Landscape of Renewable Energy Finance, 2020, IRENA and CPI

[22] Getting to India's Renewable Energy Targets: A Business Case for Institutional Investment; CPI

The Climate Policy Initiative analysis shows that the renewable energy sector is more attractive than other infrastructural sectors, especially the fossil fuel power generating sector. As per the analysis, coal plants display a higher cost variability[23] (40%), as compared to the wind sector (20%), and solar sector (10%). Further, the high NPAs in the thermal power sector, disincentivizes the institutional investors to enter the conventional energy sector. The Standing Committee on Energy in its report titled 'Stressed / Non-Performing Assets in the Electricity Sector', submitted in 2017, noted the twin balance sheet problem involving companies and the banks. As per the report, the thermal power sector is one such sector which has contributed the most to NPAs. While the solar energy sector or renewable energy sector is not devoid of NPAs, the governments in India are leaving no stone unturned to promote this segment as one of the top sources of energy. This coupled with a high growth opportunity in the renewable energy sector, especially the solar sector, makes it attractive for the institutional investors to enter this space.

Further, India's strong economic fundamentals and its recovery post the Covid crisis would be a strong factor for the institutional investors to come into play. It is important to mention that in the E&Y's latest Renewable Energy Country Attractiveness Index (RECAI), India stands at 3rd rank amongst the list of countries evaluated by the E&Y, thereby showing India is an attractive land for renewable energy investments and deployments. However, particularly in the Solar PV technology, India is at the top of the list amongst its peers. The index ranks the countries based on the investments in the renewable energy space and the deployment opportunities.

There are also various challenges for the institutional investments in this space. For instance, there is an off-taker risk in which the buyer might refuse to off-take power from the producer and not fulfil the power purchase agreement. Some other risks could be currency risk, and high perceived risk, amongst others to attract institutional investors. However, for each risk, suitable solutions could be implemented. For instance, for the off-taker risk, a transparent payment security mechanism along with adequate risk coverage could be provided. A case to study here could be of the Rewa Ultra Mega Solar (RUMS) park, the auction of which took place in 2016. The RUMS consisted of a four-tier security mechanism with respect to the payments. In the first tier, a letter of credit was provided by off-takers, that equals a one-month's bill for the energy generated by developers. The second tier involves a payment security fund operated by RUMS which consists of three months of payment assurances in case off-takers delay the payment. The third tier had the provision of state guarantee if there are payment delays, to pay the pending amount to the developers. And finally, the fourth tier involved the state government agreeing to bear the cost in cases where a transmission outage lasts beyond 50 hours. A model such as this could be taken up in the future projects to establish payment security mechanisms.

[23] A variable cost is a corporate expense that changes in proportion with production output. When production increases, variable costs increase; when production decreases, variable costs decrease. A variable cost stands in contrast to fixed costs, which do not change no matter the change in production levels.

II. Overcoming the Challenges for MSMEs

The MSMEs are the backbone of the Indian Economy with six crores of them being in existence and making a significant contribution to the GDP and the exports of the country. Though the MSMEs are scattered and have lower scale of operations than the large-scale enterprises, collectively, their energy needs are significant.

As per the Bureau of Energy Efficiency, India's SME sector has an energy consumption of almost 50 MT of oil equivalent per year which comes out to be 20% to 25% of the energy consumption of India's large industries. With the MSMEs being present in large number in India and having high energy needs, this space holds the key in promoting the use of solar energy. However, while it is expected that the MSMEs hold the key in making India a solar energy hub, they face quite a few challenges.

MSMEs face some barriers which do not suit their requirement. For instance, a lot of MSMEs are not really operating under the organized clusters or areas and the building or the structures from where they are operating may not have the required space for the rooftop solar installation. A lot of this barrier also comes from the fact that some industries have higher and continuous power requirement than the other industries. In this case, the involved entrepreneurs do not see any benefit in moving to the rooftop solar[24].

Further, there are barriers related to the operations and maintenance part of the solar rooftops. Most of the MSMEs do not have the financial capacity to maintain the solar rooftop equipment that they have put in place. It is a dilemma for these firms as maintaining the equipment puts extra financial burden and not maintaining it reduces the life of the equipment. In either case, the rate of return on this investment decreases which is not an incentive for the firm.

Additionally, barriers such as partial knowledge and at times, little to no knowledge of the rooftop solar schemes, plus the financing barriers also exist for MSMEs. In fact, as per a survey conducted by Deloitte and Climate Investment Funds (CIF), around 84% of the respondents were not informed about the solar rooftop schemes and their incentives. The percentage was 76% for textiles and pharmaceuticals industry.

Some solutions to address the above challenges are, for instance, targeting the more attractive clusters, on priority. Various parameters such as the electricity demand, awareness level, financing requirements, amongst others will have to be considered and then focused strategies can be tailormade for those industries.

Further, to create awareness regarding the solar schemes amongst the MSMEs and to fill in the existing knowledge gaps, it is important to explore the initiatives such as conducting workshops,

[24] Scaling up of rooftop solar in the SME sector in India; Deloitte and Climate Investment Funds, April 2019

and seminars and explaining the benefits of the solar systems as well as the schemes that exist for the MSMEs.

III. Promoting Floating Solar Power

Floating Solar is one of the new age innovations in the field of solar energy which has been gaining momentum in the recent days. It is basically solar array floating on the top of a water body. Mostly, they are installed in bodies such as lakes and basins.

In countries such as India, where there is a high population density, and at the same time, acquiring land could be difficult, any opportunity that helps in scaling up of solar capacity, and thereby achieving the ambitious renewable energy targets, should be welcomed. Floating solar power concept is one such opportunity. This system also has some obvious advantages and can use the already existing transmission infrastructure if the floating solar is installed at a hydropower site. Besides, the area will have decreased presence of dust.

As far as the market scenario for the floating solar PV is concerned, it may be noted that it is getting popular with each passing day. In fact, the first floating PV was built in Japan, back in 2007, while the first commercial installation was in the California State of the US in 2008, which was a 175 kWp system[25].

Box 9: Floating Solar Farm in Tengeh Reservoir, Singapore

In July 2021, the National Water Agency of Singapore, Public Utilities Board (PUB) opened one of the world's biggest floating solar panel farms. This project was carried out by a company named Sembcorp. The solar panels span across almost 45 hectares which is equivalent to almost 45 football fields. The capacity of the farm is 60 megawatt-peak (MWp) and has almost 122,000 solar panels installed.

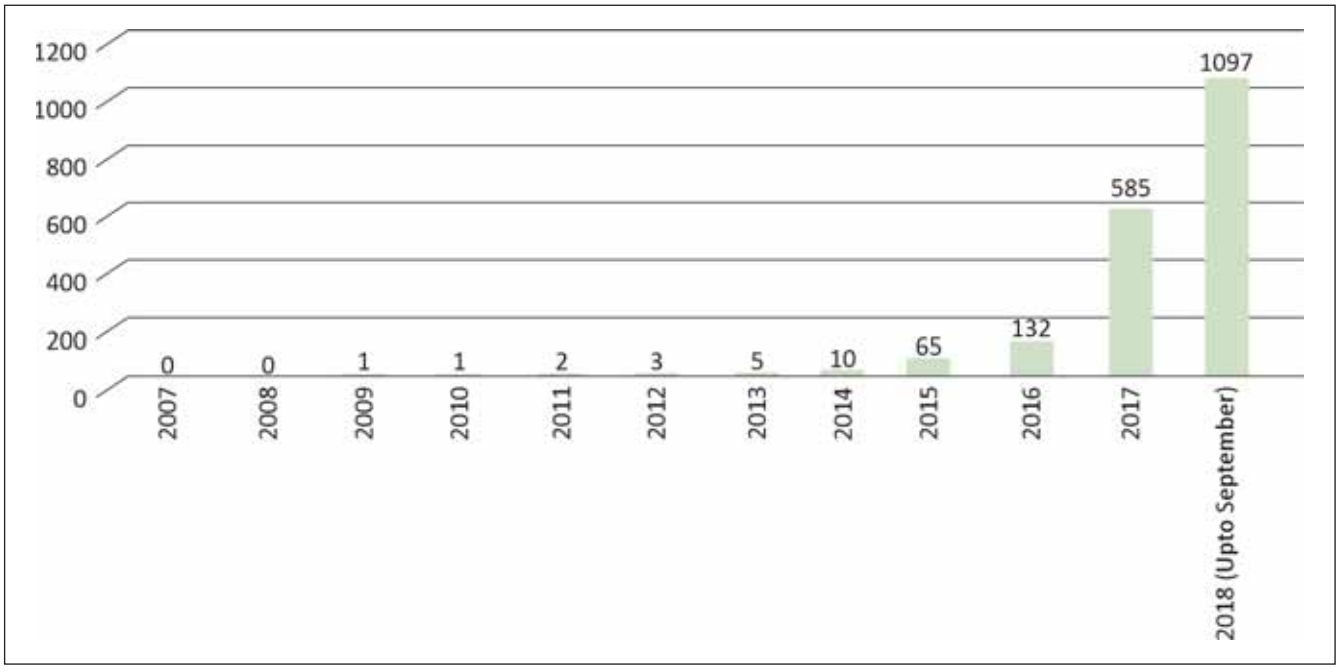
Singapore has a target to quadruple its solar energy production by 2025. This floating solar farm is expected to facilitate the same. Further, the solar farm is also expected to reduce the carbon emissions by 32 kilotonnes annually, which is equivalent to 7000 cars going off the roads.

With this floating solar farm in place, Singapore will be able to power its five local water treatment plants, which can offset 7% of PUB's annual energy needs which in turn, will reduce the carbon footprint of PUB.

As per the World Bank, as of mid-September 2018, the global floating solar capacity reached almost 1.1 GWp, with almost most of the growth coming during 2015 to 2018. It may be interesting to note that this capacity was achieved by land-based solar PV back in 2000 and if the success of this could be replicated in the world, especially in India, then India's ambitious targets could be easy to achieve in the solar space.

[25] World Bank: Where Sun Meets Water; Floating Solar Market Report, 2018

Figure 53: Cumulative Installed Floating PV Capacity (MWp)



Source: World Bank: Where Sun Meets Water; Floating Solar Market Report, 2018

In the coming years, India could also explore the possibilities of marine PV installations. In the present scenario, there are certain challenges to it. For instance, water conditions in the coastal cities could include huge wave and high-speed winds. The salinity of the seawater can also affect the quality of the solar components in the long run, and further, some of the areas in the coastal cities can be ecologically sensitive.

However, with further research and development into the areas of new designs and technologies, India can possibly be the leader in the marine PV installations. This is especially because of its coastal cities, such as Mumbai and Chennai, which are highly developed and densely populated, and are longing for innovative solutions such as this. A breakthrough in the Marine PV space could shape the future of India's solar energy.

In order to promote the floating solar energy, the Government of India as well as the State Governments will have to derive some solutions. First, the stakeholders should be coming up with the clear-cut policies with respect to the regulation of the floating Solar PV systems. This is important as some sites could be ecologically sensitive while some could be vital from the point of view of national security. Further, while the floating solar PV is expected to be cost competitive, initial support from the Governments may be required, especially with respect to undertaking the research and development. In fact, recently, the Government of Madhya Pradesh has announced the operations of the world's largest floating Solar PV which will begin from 2022-23 with a capacity of 600 MW over the Narmada River.

Box 10: Case Study- Solar SeaSystems by SwimSol in Maldives

Swimsol is a global company in the marine offshore PVs and specializes in island renewables. There are almost 1200 islands in Maldives with small areas and plenty of sunshine. After research with Vienna University of Technology and the Fraunhofer Institute in Germany, the company launched the SolarSea (a trademark of SwimSol) in Maldives in 2014.

The company built a unique floating solar platform which can survive waves of tropical shallow water lagoons, as well as the currents, tides, extreme UV, humidity, and is corrosion-proof. SolarSea consists of separate floating platforms of 196m^2 that can be arranged in a system of any required size. Each platform is equipped with 25 kW of marine grade solar panels.

The solar panels installed by the company in the lagoons of Maldives give a 5-10% higher output due to the cooling effects of the water as well as the reflections of the light from the water surface.

The company also provides a zero investment options where in it designs, installs, and maintains the solar system at the client's location, and sells power to the customer through PPAs.

The company in 2019 also launched the world's largest solar power system at sea at the LUX resort in Maldives.

Source: SwimSol

IV. Addressing the Land Issue

As mentioned in the previous chapters, the solar industry in India in the last ten years has displayed some remarkable results, with respect to the installed capacity. However, it is also important to note that given the targets that India has set for the solar energy; the large projects are equally important as the smaller ones.

As per Vivaan Solar, for a solar plant installation company, to set up 1 MW of solar power plant, there is a requirement of 4 acres of land with the crystalline technology and 4.5-5 acres with the thin-film technology. This reveals how significant a role can the land acquisition play when it comes to setting up a solar power plant and ultimately achieving the targets.

In land acquisitions, where a developer needs a large parcel of land, say for a greater than 100 MW capacity, there are a host of challenges that the developer can face. For instance, as soon as the landowner is aware of the land being identified for the solar power project, prices are increased beyond the limit making the project financially unviable as it pushes the overall cost above. This could further enter legal proceedings which again delays the project and ultimately, the project is not executed on time.

The problem is further aggravated for projects with Interstate Transmission System (ISTS). Given that the land is a state subject, each state could take its own time in granting the approvals which

further delays the project. There are also restrictions under the land ceiling acts of different states due to which if the acquisition is going beyond the ceiling limits, the developers have to purchase the land under the names of different companies.

There are also location specific issues involved. For instance, a project being set up in the proximity of the airport, will have to follow the rules of red, yellow, and green zones. While the projects cannot be set up in red zones, in the yellow zone, suitable permissions are required which can take a few months. In fact, even for the green zone, a No Objection Certificate has to be requested by the MNRE from the Ministry of Defence which further delays the projects[26].

As a result of various challenges mentioned above, the state governments will have to work towards solutions, to scale up the commissioning of solar power projects. Besides, the land utilization policies also pose major challenges. A particular piece of land may be demanded by various departments or players depending upon the needs. This could be for airports, rail tracks, industrial parks and each might have to be assessed individually. As a result, a holistic land utilization policy depending on the land requirements of various sectors needs to be framed[27].

Further, digitization of land records is one of the most important factors which can be a game changer for the solar industry in India. Due to the lack of digitization, at times, it takes months to find the rightful owners of the land. In fact, the Government of India in 2008 launched 'The Digital India Land Record Modernization Programme (DILRMP)'. However, strengthening of the same is required as the programme is far from achieving its objectives. While the computerization of land records has shown progress, work has been slow on the transfer of ownership records and maps. This would mean that while the records are digitized, they might not be updated, creating confusions among the entities, such as solar developers.

The concept of land pooling also needs to be promoted in this case. Under this, more than the required land is purchased or acquired for the project, and after the project is complete, a fraction of the land is given back to the owners. With the projects such as highways, airports etc. being completed, the value of the land once given back is much more and is therefore, attractive to the owners, with respect to the returns. In fact, Haryana, and Andhra Pradesh (for its new capital) are already using this concept to attract investments. While in Haryana, land pooling was an initiative of the private entities, for Andhra Pradesh, it was initiated by public agencies.

Another model that could be explored is the leasing model that the Karnataka Solar Power Development Corporation Ltd (KSPDCL) adopted in case of the 2000 MW Pavagada Solar Park. In this case, KSDPCL negotiated the land lease from landowners on a 28-year lease agreement in which the owner would earn rent of ` 21,000 per acre a year, with 5% increase every year and allotted the land to the developers.

[26] Mercom

[27] Addressing Land Issues for Utility Scale Renewable Energy Deployment in India; TERI

V. Integrating Solar Power with Electric Vehicles (EVs)

Global perspectives on EVs today have evolved on the broad outlines of the EV30@30 campaign launched by the Clean Energy Ministerial in June 2017, which aims to reach a 30% market share for EVs in all modes except two-wheelers by 2030. The eleven countries that endorsed the campaign are Canada, China, Finland, France, India, Japan, Mexico, Netherlands, Norway, Sweden, and the UK.

India's current approach towards mobility transformation was first conceived by Niti Aayog with a view to build an ecosystem that would be "shared, connected and electric" and have the potential to cut country's energy demands by 64% and carbon emissions by 37% in 2030[28].

This is expected to result in an annual reduction of 156 Mtoe in diesel and petrol consumption for that year, saving ` 3.9 lakh crore or US$ 60 billion (at US$ 52/bbl of crude). Cumulative savings during 2017-2030 are expected to be 876 Mtoe for petrol and diesel, worth ` 22 lakh crore or US$ 330 billion, and one giga tonne for carbon-dioxide emissions. Not only does this supplement the country's major development goals to meet the climate obligations, it also paves the way to mitigate fuel security risks by departing from heavy dependence on crude oil imports to meet the mobility fuel needs.

EVs have quite a few advantages such as with respect to the fuel consumption, they are cheaper, and do not emit any local pollution. While EVs emit fewer GHG emissions than the internal combustion engine (ICE) vehicles even when fossil fuel-based power is used to charge them, the emissions due to EVs can vary across countries, depending on the grid supply mix. For instance, according to IRENA, the EVs in China emit lesser CO_2 when compared to the ICE vehicles on an average, but in India, it is more for EVs than ICE vehicle because the power mix of India to charge the EVs is mostly coal based.

As a result, it is important for India to focus on decarbonization on both the fronts- transportation, by switching to EVs, and charging of EVs from renewable sources of energy such as solar. It may be noted that each country's dual-decarbonization efforts could depend on their current renewables' scenario.

For instance, the US which has high number of EVs has a low electricity generation from renewables (17% of total as per EIA). However, India has low number of EVs and already has almost 24% installed capacity in renewables with a significant share in renewables installation being of solar. This provides a big opportunity for India to develop a charging infrastructure for EVs which is powered specifically by solar. Recently, in 2018, Magenta Power with Exicom Power Solutions installed India's first solar power Direct current (DC) fast charging station for EVs in Mumbai.

VI. The RPO Compliance Challenge

The Renewable Purchase Obligations (RPOs) is probably one of the most important policy measures of India which is driving her towards achieving the renewable energy targets, especially for the solar

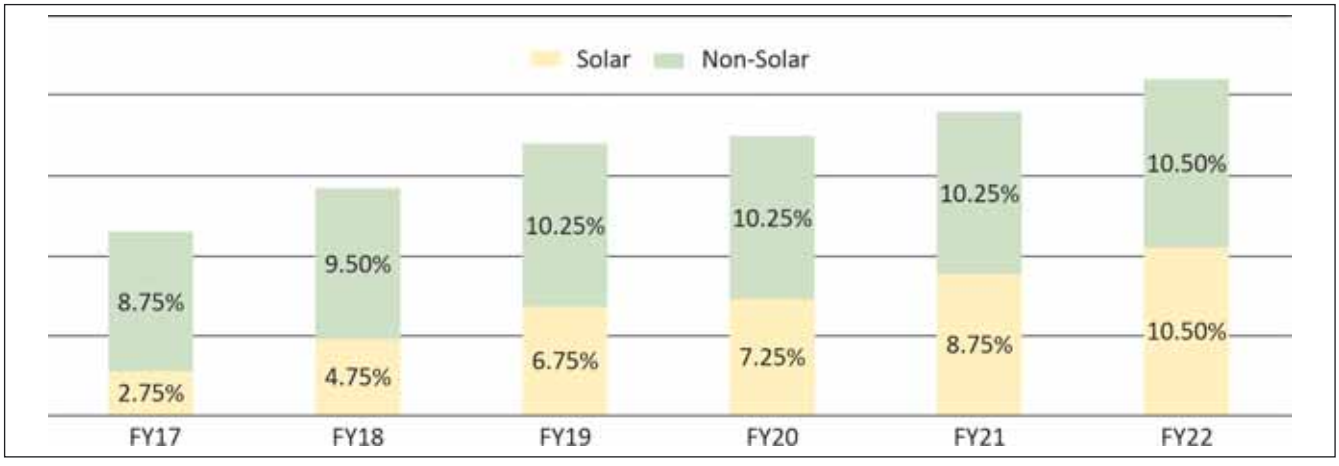
[28] India Leaps Ahead: Transformative Mobility Solutions for Alll, NITI Aayog

energy. Under the Electricity Act 2003, and the National Tariff Policy 2006, RPO is a mechanism by which the obligated entities are obliged to purchase certain percentage of electricity from Renewable Energy sources, as a percentage of the total consumption of electricity[29].

The Ministry of Power sets RPO targets for both solar and non-solar power which are to be adhered and met uniformly by the obligated entities such as the Discoms of all the States and UTs, as specified by the States' Electricity Regulatory Commissions.

In 2018, the Ministry of Power mandated that 21% of all power purchased by a power distribution company during FY 22 will have to be generated from renewable sources. This is much higher than the 17% RPO mandated for FY 19. Out of the 21%, 10.5% should be from the solar and rest from non-solar. The RPO obligation was 6.75% for solar energy in FY 19.

Figure 54: Long-Term RPO Trajectory



Source: Ministry of Power; India Exim Bank Research

While the RPO policy framework is an impressive way to achieve the targets, the challenge however has been its compliance. While the compliance level is not yet publicly available on RPO portal, as per a Lok Sabha Question[30], for 2016-17, sixteen States and UTs had RPO compliance below 60%.

Further, as per the RPO portal, the targets set by the states' regulatory commissions reveal that their RPO targets are mostly falling short for FY 22, especially in the solar power which has a target of 10.5% RPO set by the Ministry of Power (MoP), Government of India.

The Government of India currently has set a fine of up to ` 1 per kilowatt-hour (KWh) of the shortfall for non-compliance of the RPOs. Overall, in order to achieve the near future targets, the MoP, MNRE, State Electricity Regulatory Authorities, State Governments, Discoms, and the recently set up RPO Compliance Cell will have to work together, in not just setting realistic targets, but also making sure that the mandates are complied with.

[29] RPO Portal

[30] Starred Question No. 268 (8th Position) For 03.08.2017

Table 22: Solar RPO Targets Set by States and Shortfall from MoP Targets

State	Solar RPO Target in FY 22	Shortfall from MoP Target
Andhra Pradesh	7%	-3.5%
Assam	8%	-2.5%
Bihar	8%	-2.5%
Delhi	8.75%	-1.75%
JERC (Goa & UT)	8%	-2.5%
Gujarat	8%	-2.5%
Himachal Pradesh	10.5%	0%
Jammu and Kashmir	3%	-7.5%
Jharkhand	10.5%	0%
Karnataka	10.5%	0%
Kerala	0.25%	-10.25%
Madhya Pradesh	8%	-2.5%
Maharashtra	6%	-4.5%
Manipur	10.5%	0%
Punjab	6.5%	-4%
Rajasthan	10.5%	0%
Tamil Nadu	10.5%	0%
Uttarakhand	8%	-2.5%
Uttar Pradesh	4%	-6.5%

Source: Accessed from RPO Portal; Various State Electricity Regulatory Authorities, March 2021; India Exim Bank Research
Note: Some State Electricity Authorities have not released their targets for FY 22 yet (As of March 2021)

VII. Learning from the Successful Models

While the abovementioned strategies have majorly focused on addressing India's internal challenges in the solar energy market, it is equally important for India to learn from some of the good models in the world to enhance the solar energy systems in India. These can include enhancing research capabilities, partnerships, financing, among others.

The German Energy Research Programme

The total installed capacity of renewable energy in Germany has grown from 11.8 GW in 2000 to 125.2 GW in 2019, registering an AAGR of 13.4% during this period. The solar installed capacity, on the other hand, grew from 0.1 GW in 2000 to 49 GW in 2019, recording an AAGR of 42.1%, over the last two decades. As a result, the share of solar in total renewable energy installed capacity increased from 1% in 2000 to almost 40% in 2019.

The underlying strength of the German model in the solar space is its investment in the research. As per the Federal Ministry for Education and Research of Germany, currently there are over 180 universities and 120 research institutes involved in Energiewende, which is Germany's energy transition program. The major goal of Energiewende, which was launched in 2010, is to produce almost 80% of Germany's power demand through renewables by 2050. Germany was also one of the first nations in the world to introduce a law on renewable energy. Germany introduced the renewable energy sources act (EEG) in 2000 to encourage the generation of renewable electricity[31].

While Germany has increasingly faced competition in the solar panel manufacturing from countries such as China in the last decade, the German authorities made sure that the funding to innovate should not be lacking. The German Government has set in place an energy research policy since 1977. The Energy Research Programme is the main element setting out the principles and priorities of the funding policy. The German Government adopted the 7th energy research program called 'Innovation for the Energy Transition' in 2018.

Under the 7th energy research program, the German government in providing around €6.4 billion during 2018-22, for research, development, demonstration, and testing of forward-looking technologies and concepts. This was 45% up on the amount available under the preceding programme for the 2013–2017 period. The 7th energy research program keeps the focus on technology and innovation transfer[32].

Overall, it will be important for India to enhance its research in the renewable energy space, especially for solar energy. It can be in the form of scaling up the funding for the existing institutes as well as setting up new research institutes under the aegis of MNRE or SECI. With enhanced research funding, it can be possible for India to become a manufacturing hub in solar energy related components.

Climate Fund Program of BNDES

Under the social and environmental responsibility, BNDES has in place a Climate Fund program created in 2009. The Climate Fund is one of the instruments of the National Policy on Climate Change and linked to the Ministry of Environment of Brazil to guarantee funds to support projects or studies and financing of projects that aim to mitigate climate change.

The objective of this program is to support the implementation of projects, the acquisition of machinery and equipment and technological development related to the reduction of emission of greenhouse gases and adaptation to climate change and its effects.

There are majorly nine sub-programs under this fund- urban mobility, sustainable cities and climate change, efficient machinery and equipment, renewable energies, solid waste, charcoal, native forests, management and carbon services, and innovative projects.

[31] Curry (2019), Germany faces its future as a pioneer in sustainability and renewable energy

[32] Renewable energy sources in figures, Federal Ministry for Economic Affairs and Energy

The cumulative funding from Ministry of Environment of Brazil to this program crossed Brazil Real 1 billion in 2020. Each project under this program can receive a maximum of Brazil Real 30 million every 12 months. Select projects backed by this fund include power generation technology at the Caeiros Landfill, in São Paulo, and the installation of solar panels for more than 800 individuals and micro companies.

The Government of India may also need to scale up its funding and utilization in the National Adaptation Fund for Climate Change (NAFCC). While the fund was initially established with an allocation of ` 350 crore in FY 16, the subsequent allocations were lesser. In FY 20, only ` 40 crore of the ` 100 crore allocation was utilized. The fund was established to meet the cost of adaptation to climate change for the States and UTs which are particularly vulnerable to the adverse effects of climate change. NABARD is the National Implementing Entity (NIE) for Adaptation Fund (AF) for implementation of adaptation projects under NAFCC by Govt. of India. Under this arrangement, NABARD performs roles in facilitating identification of project ideas/concepts from State Action Plan for Climate Change (SAPCC), project formulation, appraisal, sanction, disbursement of fund, monitoring & evaluation and capacity building of stakeholders including State Governments.

GREEN Operations of JBIC

In 2010, JBIC commenced a new business operation called 'Global action for Reconciling Economic growth and Environmental preservation' (GREEN) to support projects that are expected to have a favourable impact on the protection of the global environment. The environmental projects in which JBIC considers participating include: i) projects for solar power plants and energy-efficient power plants that utilize advanced environmental technologies, and ii) projects that ensure significant environmental preservation effects by introducing energy-efficient equipment[33].

In the past, various institutions such as BNDES in Brazil; ICICI Bank, SBI and IDFC in India; BANCOMEXT in Mexico; Banco de Bogota in Colombia; among others, have been the borrowers of JBIC under the GREEN operations. Recently, in 2020, JBIC signed a loan agreement with NTPC in India to provide with the necessary funds for solar power generation projects and installation of environmental equipment in India as a part of GREEN operations.

Given the wider range of impact that JBIC is having in the developing regions with respect to the GREEN operations, Indian financial institutions could also start a separate business segment similar to JBIC's GREEN, specifically to focus on renewable energy projects. While the JBIC's presence has majorly been in Asia and LAC through its GREEN operations, Indian FIs could target Africa which has a huge potential, especially in solar energy. It may be noted that theoretical reserves of Africa's solar energy are estimated at 60,000,000 TWh/year, which account for almost 40% of the global total, thus definitely making Africa the most sun-rich continent in the world.

[33] JBIC Annual Report 2018

Box 11: World and India in COP 26: Recent Developments

In the recently held COP 26, there were a host of pledges made, given that the latest assessment report of IPCC signaled that the global temperature could exceed an average of 1.5°C of warming, in the next twenty years. It is estimated that if these pledges are fulfilled, the global temperatures could be kept below 2 degrees Celsius, though higher than 1.5 degrees Celsius target set in the Paris climate agreement.

One of the biggest pledges made was the coming together of more than 100 countries which account for 85% of the world forests to end deforestation by 2030. These countries include China, Russia, US, as well as the countries having high deforestation rates such as Brazil, Columbia, Indonesia, Peru, among others. It may also be noted that more than 40 nations representing over 70% of global economy signed up to the Breakthrough Agenda which aims to make clean technologies to clean up polluting sectors affordable and attractive for all nations by 2030.

Further, world's first partnership for interconnected solar grid, known as the Green Grids Initiative - One Sun One World One Grid (GGI-OSOWOG) was also launched at COP 26. The project is being led by India and the UK in partnership with the World Bank and the International Solar Alliance (ISA). It aims to harness solar energy from high sunshine areas and ensure that generated electricity flows to most needed areas. More than 80 ISA members have endorsed this initiative. It may be noted that the US also signed the ISA framework agreement during the COP 26.

With respect to India, it has also announced various targets at the COP 26, most of which have a deadline of 2030. These include raising non-fossil fuel-based energy capacity to 500 GW, lowering total projected carbon emission by 1 billion tonnes, meeting 50% of the country's energy needs through renewable sources, and reducing the emissions intensity of the economy by 45% from 2005 level. India has also committed at COP 26 to achieve net zero emissions by 2070.

Conclusion

India has an ambitious goal in the solar energy sector of installing a capacity of 100 GW by 2022. However, India also realizes that it has a total solar potential of almost 750 GW. As a result, India's goal should be to maximize this potential in the long run. In order to do so, India needs to overcome challenges by implementing various strategies as outlined in this chapter. The implementation of these strategies will not only help India in achieving its target but would also provide the country with a chance to become self-sufficient in the solar PV technologies, and even export globally.

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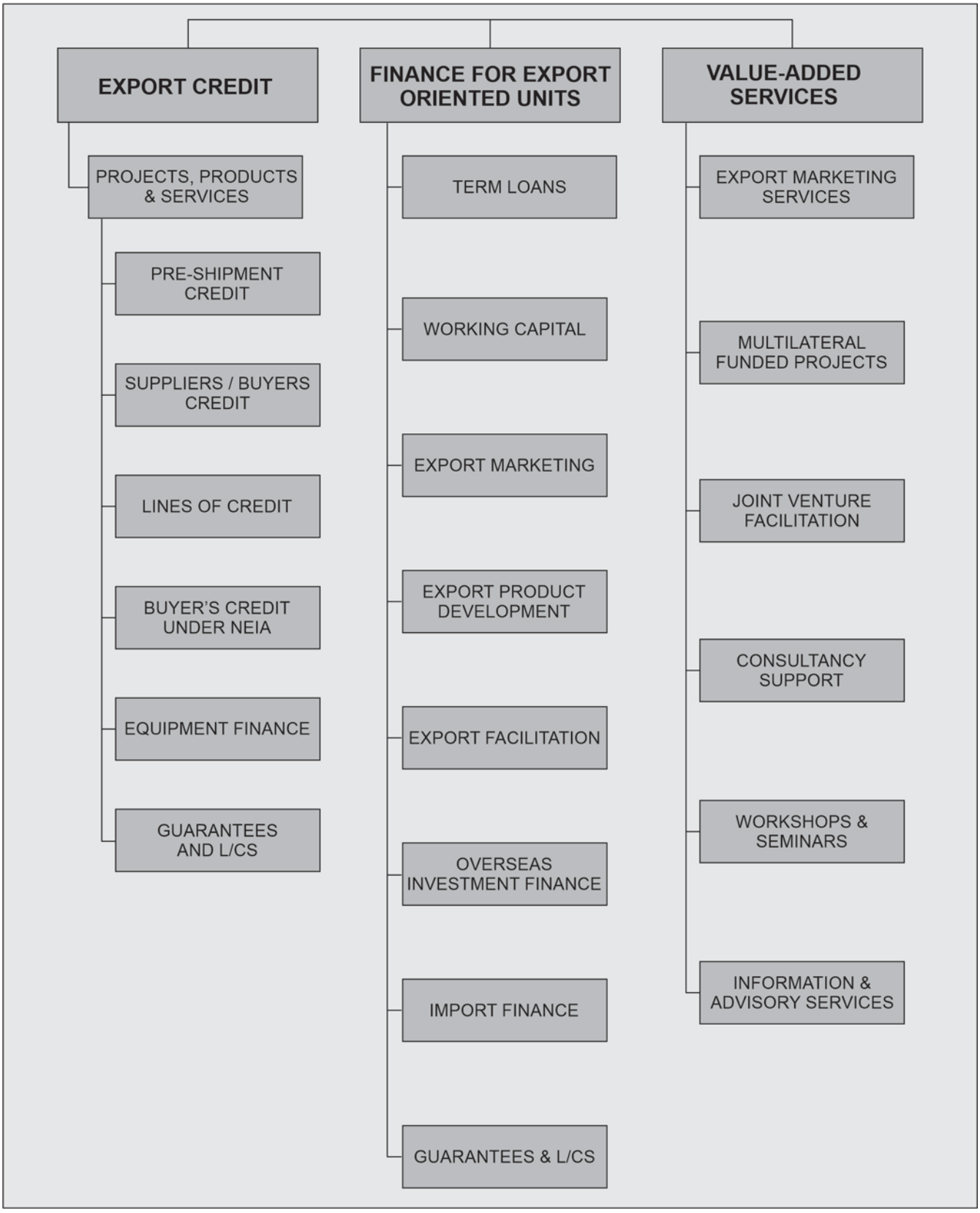

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