INTERNATIONAL SOLAR ALLIANCE

WORLD SOLAR INVESTMENT REPORT

Foreword

Dr. Ajay Mathur
Director General
International Solar Alliance

Driven by a strong business case and falling costs, solar energy has progressed remarkably over the past decade, to become the preferred power source for many countries. Solar energy lies at the heart of a global energy transformation by offering an economically attractive answer to energy security and climate concerns. It has also created new opportunities for sustainable livelihoods for millions of people who lack energy access.

The Sustainable Development Goals and the landmark Paris Agreement, both concluded in 2015, have reinforced the momentum behind this energy transition. But to achieve the economic, social, and environmental objectives set by the international community, a rapid scale-up of investments in solar energy infrastructure is needed; especially in developing countries, where energy demand is set to grow exponentially.

Investments in solar, which have already grown rapidly to reach a record level of USD 220 billion in 2021, will need to accelerate more. Private finance will have to supply the lion's share of new investment with institutional investors playing a crucial enabling role. Sound policies and targeted financial instruments are needed to attract more investors into the renewables sector.

While there a number of different projections of investments required for achieving net zero, one thing in common with all forecasts is the need for substantially ramping up renewable energy investments. There is a need for ramping up annual investments in renewable energy by upto ~400% by 2030. Most of these investments will be drawn for solar and wind technologies as they are expected to meet 90% of the power demand by 2050.

Through this flagship annual World Solar Investment report, ISA aims to review the investments in solar value chain, estimate and track future capital requirements, assess the status of various finance providers, and identify innovative tools and their role in accelerating solar investments.

I congratulate the ISA team and all the stakeholders involved for their work and support, and I look forward to sharing the ISA World Solar Investment Report 2022 with the global solar community.

Abbreviations

AC	Alternating Current
AEM	Anion Exchange Membrane
AFD	Agence Française de Développement
AfDB	African Development Bank
AI	Artificial Intelligence
AIM	American Innovation and Manufacturing
ALD	Atomic Layer Deposition
APAC	Asia Pacific
APV	Agri- PV
ASEAN	Association of Southeast Asian Nations
BCD	Basic Custom Duty
BESS	Battery Energy Storage System
BIPV	Building Integrated Photovoltaics
BMZ	Federal Ministry of Economic Cooperation and Development
BNEF	Bloomberg New Energy Finance
BoM	Bill of Materials
BoS	Balance of System
BSF	Back Surface Field
BTM	Behind the Meter
CAES	Compressed Air Energy Storage
CAISO	California Independent System Operator
CEEW	Centre for Energy, Environment, and Water
CIGS	Copper Indium Gallium Selenide
CIS	Copper Indium Selenide
CPSU	Central Public Sector Undertaking
CSP	Concentrated Solar Power
CTM	Cell to Module
CUF	Capacity Utilisation Factor
CVD	Chemical Vapor Deposition
CZ	Czochralski
DAT	Dual Axis Trackers

DC	Direct Current
DCR	Domestic Content Requirement
DS	Directional Solidification
DW	Diamond Wire
EIB	European Investment Bank
EIM	Energy Imbalance Market
EPC	Engineering, Procurement, and Construction
EPR	Extended Producer Responsibility
ESS	Energy Storage System
EV	Electric Vehicle
EVA	Ethyl Vinyl Acetate
EXIM	Export-Import Bank of the United States
FBR	Fluidized Bed Reactor
FPV	Floating Solar PV
FY	Financial Year
FZ	Float Zone
GDP	Gross Domestic Product
GH	Green Hydrogen
GHG	Greenhouse Gas
GTAM	Green Term Ahead Market
GW	Gigawatt
HDH	Humidification Dehumidification
HJT	Heterojunction
HSAT	Horizontal Single Axis Trackers
IBC	Interdigitated Back Contact
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ILO	International Labour Organisation
IP	Intellectual Property
IPCC	Intergovernmental Panel on Climate Change

IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
ITRPV	International Technology Roadmap for Photovoltaic
KIUC	Kaua'I Island Utility Cooperative
KSEB	Kerala State Electricity Board
LCA	Life Cycle Assessment
LCOE	Levelized Cost of Energy
LID	Light Induced Degradation
MBB	Multi Busbar
MEB	Multiple Effect Boiling
MED	Multiple Effect Distillation
MEH	Multiple Effect Humidification
MGS	Metallurgical Grade Silicon
MSF	Multi Stage Flash Distillation
M-SIPS	Modified Special Incentive Package Scheme
MSP	Minimum Sustainable Price
MT	Metric Ton
MW	Megawatt
NDC	Nationally Determined Contributions
NGO	Non-Governmental Organisation
NREL	National Renewable Energy Laboratory
NTPC	National Thermal Power Corporation
PECVD	Plasma Enhanced Chemical Vapor Deposition
PEM	Polymer Electrolyte Membrane
PERC	Passivated Emitter and Rear Cell
PERL	Passivated Emitter with Rear Locally Diffused
PERT	Passivated Emitter, Rear Totally Diffused
PET	Polyester
PID	Potential Induced Degradation
PLI	Production Linked Incentive
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan
POE	Polyolefin Elastomers
PSG	Phosphosilicate Glass
PV	Photovoltaic
PVDF	Polyvinylidene Fluoride
PVF	Polyvinyl Fluoride
PVPS	Photovoltaic Power Systems Programme
RCRA	Resource Conservation and Recovery Act
RE	Renewable Energy
RO	Reverse Osmosis
RTC	Round The Clock
SCADA	Supervisory Control and Data Acquisition
SHJ	Silicon Heterojunction
SMES	Superconducting Magnetic Energy Storage
SOEC	Solid Oxide Electrolysers
SRV	Surface Recombinant Velocity
SSEF	Shakti Sustainable Energy Foundation
SWCT	Smart Wire Connection Technology
TCO	Transparent Conducting Oxides
TCS	Trichlorosilane
TOPCon	Tunnel Oxide Passivated Contact
TR	Tiling Ribbon
TW	Terawatt
UAE	United Arab Emirates
UHV	Ultra High Voltage
UK	United Kingdom
UMG	Upgraded Metallurgical Silicon
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VIPV	Vehicle Integrated PV
VPP	Virtual Power Plants
VRE	Variable Renewable Energy
WB	World Bank
WEEE	Waste Electrical and Electronic Equipment

Table of Contents

Executive Summary

To avert the deleterious effects of climate change, the world is undergoing a major transition in the energy sector to achieve net-zero targets and limit the increase in average global temperatures to 1.5˚C. As a result, an increasing trend in climate investments has been witnessed in the past years, which is expected to grow in the future as well to meet the targets of the Paris Agreement.

To avert the deleterious effects of climate change, the world is undergoing a major transition in the energy sector to achieve net-zero targets and limit the increase in average global temperatures to 1.5˚C. As a result, an increasing trend in climate investments has been witnessed in the past years, which is expected to grow in the future as well to meet the targets of the Paris Agreement.

Renewable energy occupies a central role in energy transition, and it is evident from the increasing trend of investments in the sector, and more so on increasing solar energy investments. In 2021, solar energy attracted a 56% share in overall renewable energy investments and 21% of the overall power sector investments.

Global investments in solar crossed the USD ~220 billion mark in 2021, witnessing an increase of 18% from 2020 levels. Regionally, solar investments have been skewed in favor of the Asia and Pacific, and Europe and North America regions. The two regions have accounted for 58% and 34% respectively of the global installed solar energy capacity as of 2020. Within these regions, investments have been dominated by economies with a developed solar

Middle East, Africa, Latin America, and the Caribbean contributed to a meagre ~8% of overall solar investments

market, such as the United States of America, China, Vietnam, Japan, Spain, South Korea, Australia, Brazil, Germany, and India; these economies together accounted for 78% of the total solar investments. On the other hand, developing regions of the Middle East, Africa, Latin America, and the Caribbean continue to lag in the race for solar adoption.

There are a number of different investment options at the different stages of the solar supply chain, investments in the solar value chain have grown at a rate of ~ 9% in the last decade. Investments in solar R&D have increased by 30% in 2021, nearly 90% of which was allocated to advance technologies in solar cells. Investments in project development activities dominated the solar share of investments at 93% in 2021. Utility-scale solar attracted the highest investment followed by the residential solar segment and then the commercial and industrial solar segment. Additionally, the off-grid solar sector registered a record increase in investments of 44% compared to 2020 levels though its overall share remains marginal.

With the adoption of solar energy moving beyond energy systems providing clean electricity to the grid for consumption, the role of greening other sectors such as transportation, heating, cooling, and industrialization is also becoming vital. Sector coupling of solar should provide a sharp increase in the overall demand for solar energy in the near future. While the cumulative installed capacity for green hydrogen is forecasted to grow from a mere 0.5 GW in 2021 to an enormous 350 GW by 2030, the electric vehicle market too is projected to grow sharply to USD 824 billion by 2030. To manage the intermittent power from solar technology, increased investments are required in power infrastructure and battery storage. Increasing trends have been witnessed in both segments with investments in battery storage increasing by 50% in 2021.

Concentrated solar supply chains dominated by China resulting in uneven distribution: As of 2021, China-headquartered companies accounted for nearly 76% of the polysilicon, 98% of ingots, 96% of wafers, 88% of cells, and 79% of modules' global production capacities.

As the solar energy industry is poised to reach "terawatt scale", there is a need for a sustainable manufacturing and supply chain ecosystem. Global cumulative investment in solar PV manufacturing facilities doubled in the past decade amounting USD 100 billion in 2021 increasing by 50% during 2014-21 as compared to 2008-14. Additionally, the solar supply chains is highly concentrated in China, and there is need for diversification across the regions. Countries are now taking initiatives to establish a domestic manufacturing. Circularity in the solar manufacturing supply chain is a key problem that needs to tackle in the coming years.

Selecting a right business model with a right framework addressing technical and financial risks will play a crucial role in the uptake of solar energy. Countries have come up with unique and tailor-made business models as per the geographic context for facilitating solar investments in rooftop and utility-scale solar projects, thus creating avenues for more investments from public and private funding institutions. However, there is a need scale up financing in solar sector by taking steps such as creating separate lending categories for solar, dedicated lines of credit from funding agencies, reducing payment risks by providing additional payment security mechanisms, reducing curtailment of solar energy etc.

Private actors have been the main contributors to solar energy financing; this is evident from the fact that the share of the private sector in the solar sector accounts for ~86% of total investments, with project developers occupying the major share of ~56%. Among the private players, large corporations are

contributing significantly to the solar sector. On the other hand, the public actors mainly contribute towards reducing risks for private investors and bringing new technologies and markets to maturity. To be on track to achieve net zero emissions targets, large investments in clean energy projects and supporting infrastructure will be required for the energy transition. Adoption of renewable energy, for power generation and hydrogen production, would require a major share of investments.

However, there is a need for further scaling up the current levels of investment, which has been forecasted by various studies under different scenarios, while aiming at the goal of meeting the net-zero target by mid-century. To realize the target, the annual investment mobilization needs to be scaled up for meeting the capacity addition targets. As in the case of total investment flows, there are large range of annual investment flows projected under different scenarios highlighting an increase from the current annual investments of USD ~200 billion to as high as USD ~565 billion until 2030 and USD ~1 trillion from 2030 to 2050 to meet the annual capacity addition targets. The graph below depicts annual capacity additions requirements under different scenarios. Most of these investments will be drawn for solar and wind technologies as they are expected to meet 90% of the power demand by 2050. It is important to scale up solar PV manufacturing capacities as well as ensure supply chain resilience and energy security; this would push companies to build capacities in a geographically distributed manner and reduce the reliance on one country/region. Additionally, investing in infrastructure developments must be aligned with long-term plans, including regional market integration as the electricity grid is an integral part of the energy transition.

Appropriate Government interventions through necessary policy, regulatory and financial support can help to ensure the development of the solar energy market by unlocking potential investments as well as incentivizing the flow of finance from investors. One major step in this regard is the shifting of subsidies from fossil fuel to solar energy. Also Governments around the world spent approximately $440 billion in 2021 on subsidizing fossil fuel consumption, an increase of 142% over 2020. The shifting of subsidies from fossil fuel to solar energy would not only help the fossil fuel-based economies in their clean energy transition but also help achieve energy security. despite various efforts to accelerate the clean energy transition, fossil fuel investments attracted 44% of total energy investments while solar energy had a share of just 12% in 2021.

While aiming for equitable distribution of resources, there are multiple channels for mobilizing investment in developing and underdeveloped regions. Strengthening banking regulations, developing a robust securities market, and implementing attractive policies can boost private-sector investment flows. Public funding can also play a crucial role in lowering risks and barriers for private capital and enabling a just and inclusive energy transition. Encouraging FDI flow, introducing blended finance and institutional reforms are some of the key levers which can help in attracting investments.

Green bonds have shown a record growth of 71% over 2020 and have the potential to channel additional capital in Solar

Financial innovation can play a key role in accelerated growth of renewables across the globe. As traditional ways of financing solar energy projects, especially in developing and underdeveloped countries, face multiple challenges such as small ticket sizes, lack of creditworthiness of consumers, less bankable sovereigns, etc., development of a wide suite of innovative tools shall allow for easier mobilization of finance. Investors wishing to address climate change and support solar penetration are increasingly turning their attention to innovative and sustainable finance options like Green Bonds, Exchange Traded Funds, Infrastructure Investment Trusts (InvITs), Blockchain etc.

Alongside the development of de-risking tools and innovative financial instruments, activating underutilized large capital pools of institutional investors, developmental financial institutions as well as corporates is necessary for a transition toward a more sustainable, low-carbon economy.

While various market barriers and perceptions of high risks do pose a constraint for investment flows, a collaborative approach among all stakeholders would play a key role in ensuring the efficient mobilization of investments. Bringing together all stakeholders, including developers, financial institutions, the private sector, government, and their agencies, underlines the need for a collaborative platform with a targeted approach to ensuring the mobilization of investments. The platform can be leveraged to draw learning from one another to adopt the best practices across the solar supply chain.

With this flagship report, ISA wishes to keep a track of the investment flows across the solar sector which can aid the large-scale adoption of solar energy.

The report is divided into five broad sections, each section outlining and covering an important aspect of investment mobilization. The first section introduces the trend observed in the investments mobilized for climate change, especially the adoption of renewable energy and role of solar energy. The second section deep dives into the investments made and the trends observed regionally as well as across the solar value chain, including research and development, project deployment, and manufacturing. The section also briefly outlines the business models adopted as well as the conventional sources of investment mobilization. The third section highlights the different projections of investment required to achieve the net-zero target. The fourth section highlights new and innovative tools and enablers that can assist in accelerating solar energy financing. The fifth and final section provides the requirement in terms of enabling the environment for scaling solar investments.

The detailed analysis is based on the available data that can help countries, policymakers, financial institutions, and decision-makers in understanding the current status as well as the trends in the solar investment landscape and guide them in in making focused interventions to accelerate solar energy adoption and clean energy transition.

Global Investments in Energy Sector

Besides these challenges, the adverse effects of climate change have become increasingly common, with natural disasters occurring on larger scales and increased frequency. Greenhouse Gas emissions crossed 50 billion tons of CO_2 equivalent in 2019 and has not yet peaked

The world economy has faced several major disruptions in recent years. The Covid-19 pandemic necessitated restrictions that affected business activities and resulted in a global economic slowdown, while the reopening of the economy brought supply-demand mismatches that led to volatile price changes for key commodities and products. The recent Russia-Ukraine war has also led to regional disruptions in energy flows resulting in record spikes in energy prices especially in Europe. There are also other geopolitical conflicts that have affected energy supply, leading to concerns around energy security.

Besides these challenges, the adverse effects of climate change have become increasingly common, with natural disasters occurring on larger scales and increased frequency. Greenhouse Gas emissions crossed 50 billion tons of CO2 equivalent in 2019 and has not yet peaked[1]. The human and financial cost of climate change makes investments in clean energy all the more important. All the above events have created an urgent need for countries to accelerate their energy transition and reduce emissions. This has further resulted in a potent mix of pressures and incentives for increasing investments in climate and clean energy.

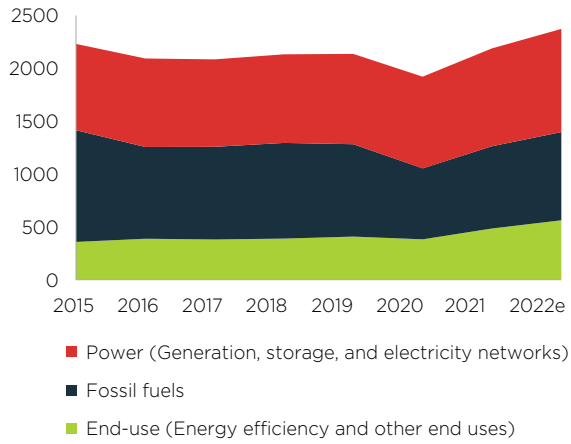
[1] Our World in Data and Climate Watch

2.1 Energy investment overview

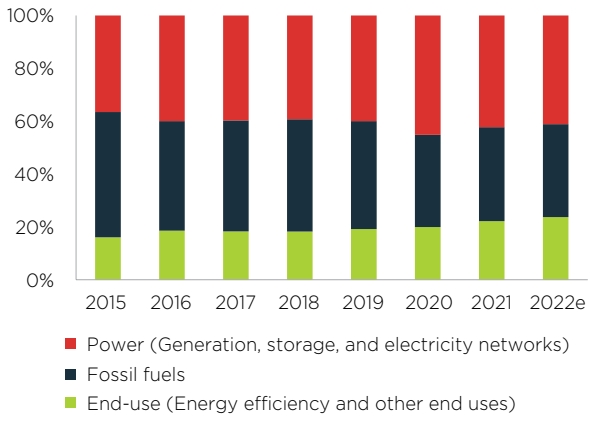
2.1.1 Global Energy Investments have remained flat with fossil fuels still receiving a major share at nearly trillion dollars annually

Investments in the global energy sector touched USD 2.2 Trillion in 2021, reflecting a 14% increase over the previous year. However, over the last 6-7 years, overall investment in the energy sector has stayed stagnant, with investments in 2021. A major dip in investments was seen in 2020, as the Covid-19 pandemic impacted sector operations and expansion significantly. As per IEA projections, energy sector investment growth is 2022 is expected to grow byto 8% leading to an expected investment of USD 2.4 Trillion.

Global Energy Investments (USD Billion)



Global Energy Investments (USD Billion)



Source: IEA

	2015-2021 Growth Rate	Last Year Growth Rate (2020-2021)	Expected Growth Rate (2021-2022e)
Power (Generation, storage, electricity networks)	13.4%	6.7%	5.5%
Fossil Fuels	-26.4%	15.9%	7.2%
End-use (Energy efficiency and other end uses)	35.4%	26.8%	16.1%

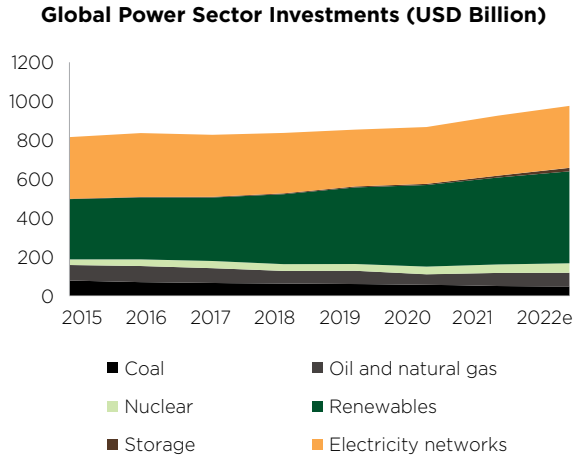
For 2021, overall energy investments were led by investments in the power sector, accounting for just over 40%. This was followed by investment in fuels at 36%, of which 98% is attributable to fossil fuels, and just 2% to clean fuels. Investments in energy end use and efficiency make up the remaining share has been the Power sector investments have grown slightly (13% growth since 2015), primarily through investments in renewable energy capacity and transmission and distribution capacity. Investments in end use efficiency has also grown by 25% since 2015. Fuel investments, consisting primarily of fossil fuels, have declined by 25% as of 2021 but remain extremely high at almost USD 778 billion. However, what is worrying is that the declining trend is set to reverse with, current geopolitical instabilities set to result in increased in investment in 2022, with a 7% y/y growth to ~ USD 850 Billion.

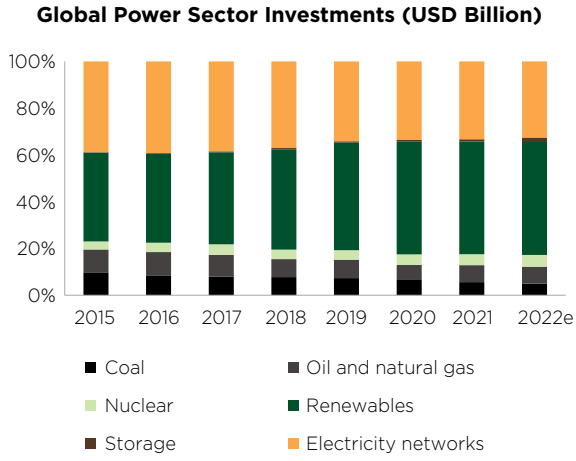
Key messages:

- **Covid-19, geopolitical tensions, and climate change impact have disrupted the global energy sector**
- **Investments in the energy sector has remained mostly flat between 2015 and 2021 through shares of "power generation" and "end use" has increased.**
- **The power sector holds the largest share of energy sector investment as of 2021 at 40%. However, fuel investments, primarily for fossil fuels such as coal, natural gas, or oil, still receives a large share of investments**

2.1.2 Power sector investments has seen a continued shift towards renewable technologies

The power sector, a major source of greenhouse gas emissions, received USD 926 Billion in investments in 2021. This investment is expected to reach USD 977 Billion in 2022, approximately a 5.5% increase on the previous year. Investments in the sector over the last 6-7 years have been primarily driven by investments in renewables The global energy transition has underlined the need for renewable energy. Government support, technological developments, and maturing market conditions have driven growth. **Investments in renewable energy have grown from USD 310 Billion in 2015 to USD 446 Billion in 2021, an increase of nearly 44%.**, Investments in coal has fallen 35% while investments in oil and natural gas have fallen by 16% since 2015.





Source: IEA

	2015-2021 Growth Rate	Last Year Growth Rate (2020-2021)	Expected Growth Rate (2021-2022e)
Coal	-35.2%	-8.5%	-6.6%
Oil and natural gas	-16%	21.2%	5.7%
Nuclear	53.9%	10.6%	12.8%
Renewables	43.9%	6.5%	5.8%
Storage	487.5%	51.6%	94.7%
Electricity Networks	-2.7%	5.7%	3.3%

In 2021, investments in renewables accounted for nearly 50% of the global power sector investments. Investments in the electricity networks, such as transmission and distribution infrastructure, had the second largest share, accounting for ~33% of the power sector investments in 2021. Coal, oil, natural gas, and nuclear investments combined accounted for a 17.5% share, while the storage sector, being a relatively new are had a very small share.

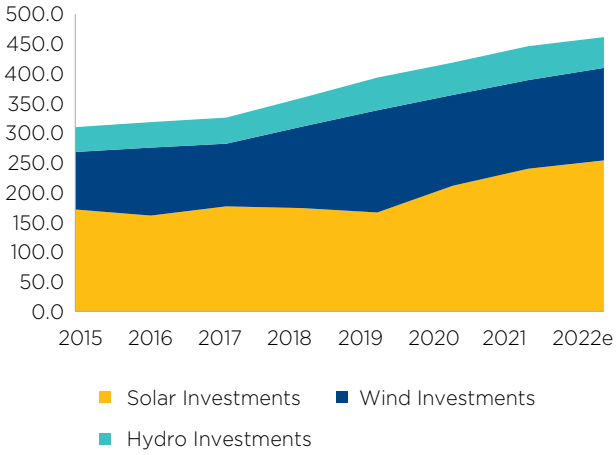
Key messages:

- Total power sector investments crossed USD 900 billion in 2021 and will get closer to USD 1 trillion in 2022.
- Investments in renewables and transmission and distribution networks formed over 80% of all power sector investments in 2021
- Coal, oil, natural gas, and nuclear investments combined accounted for a 17.5% share. However, oil and natural gas investments are expected to increase in 2022 due to the current issues around global energy security

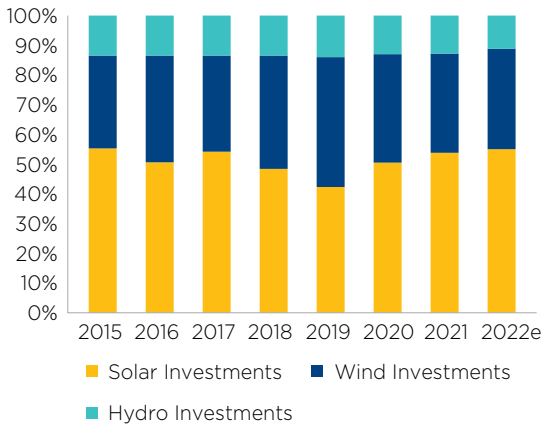
2.1.3 Renewable energy investments have grown with solar getting the largest share

It is apparent that renewable energy has become a focus area for investments in the power sector. Several renewable technology options are available for investments and solar energy has emerged as the one of most attractive in recent years. Investments in solar have grown over 40% between 2015 and 2021, while investments in wind and hydro have grown 54% and 23% respectively. Additionally, solar has commanded the largest share of overall investments (40-55%) in the sector over the last 6-7 years, Investments in solar are also expected to continue growing and should cross the USD 250 Billion mark in 2022.

Renewable Energy Investments by technology (USD Billion)



Renewable Energy Investments by technology (USD Billion)



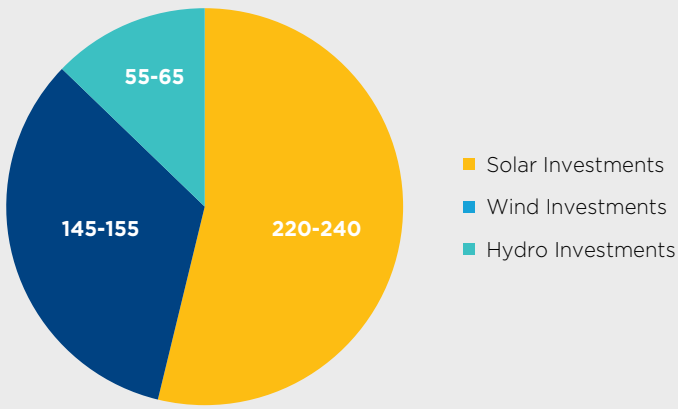
Source: IEA

	2015-2021 Growth Rate	Last Year Growth Rate (2020-2021)	Expected Growth Rate (2021-2022e)
Coal	43.9%	16.7%	5.8%
Oil and natural gas	53.1%	-3.1%	10.0%
Nuclear	22.5%	-5.7%	-3.4%

Note: Distribution of investments within renewables for 2022 is assumed to be same as in 2021

For 2021, solar energy remained the dominant renewable energy technology, with estimated investments of USD 220- 240 billion going to the sector. Wind energy received investments of USD 145-155 Billion in the same year, while hydro investments remained the lowest at USD 55-65 Billion.

Global Renewable Energy Investments 2021 (USD Billion)



Source: IEA

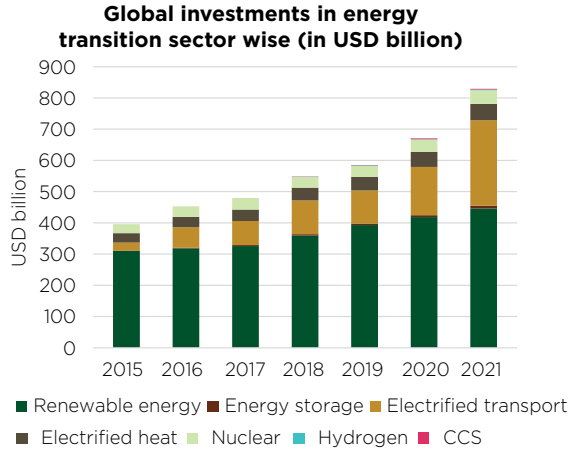
Key messages:

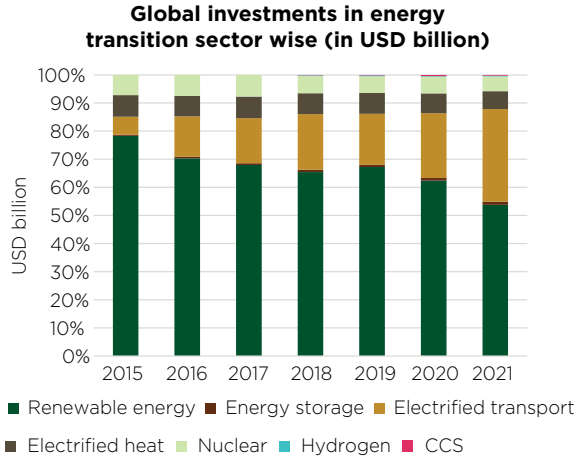
- **Solar has the largest share of global renewable energy investments, due to its technical and financial maturity, as well as benefits due to modularity and flexibility.**
- **Solar has accounted for 40-55% of annual investments in renewables over the last 6-7 years.**
- **Total investments in solar ranged between USD 220-240 Billion in 2021 and are expected to cross the USD 250 billion mark in 2022.**

2.2 Climate finance and the energy transition

Investments in renewable energy generation form a subset of the broader category of investments in climate finance and the energy transition. As per the UNFCCC, Climate finance refers to local, national, or transnational financing—drawn from public, private, and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change.

Climate finance and energy transition investments include investments in electrified transport, electrified heat, development of hydrogen-based technologies, carbon capture, storage, and utilisation (CCUS), among others. Renewable energy sources also form a key component of climate finance activities, with solar energy being the most favored technology option. Global investments in energy transition crossed USD 800 Billion in 2021, over double the total investments in 2015. These investments have been dominated by the renewable energy segment, but new avenues for investment are rapidly emerging. **Electrified transport has become a key aspect of the energy transition, and investments have grown more than ten times since 2015 to cross USD 250 Billion.** The sector saw a 77% increase in investments between 2020 and 2021 alone. The trend of electrification is also extended into the heating sector, which saw an investment of USD 53 Billion in 2021. Additionally, investments in upcoming technologies such as hydrogen and CCUS remains low but are expected to increase in coming years as commercial viability and technical capabilities develop.





Source: BNEF, IEA

	2015-2021 Growth Rate	Last Year Growth Rate (2020-2021)
Renewable energy	43.9%	6.5%
Energy storage	487.5%	51.6%
Electrified transport	983.1%	76.7%
Electrified heat	72.7%	10.7%
Nuclear	53.9%	10.6%
Hydrogen	NA	31.4%
CCS	NA	-21.1%

Although the current investment figures are promising and represent solid progress, far more needs to be done to limit the impact of climate change to 1.5ºC. To maintain this pathway, it is estimated that climate finance will need to cross USD 4 trillion annually by 2030, and USD 6 trillion annually before 2050. Thus, a significant scale up in investments are required in the coming decade alone.

This required scale up presents a significant opportunity for solar energy Since solar PV remains the cheapest option for new renewable power generation in several countries and has attracted major investments in RE sector, the transition to clean energy by increasing production of hydrogen, carbon capture and storage, and electrified heat and transport can be made through leveraging low cost solar technology, providing an avenue for increasing uptake of solar enabling technologies and investments in solar energy. This potential for sector coupling is driven by the flexibility and modularity of solar technologies, and deployment of solar along with other energy transition technologies will mean that investments in solar can well exceed current estimates.

Adaptation and mitigation in climate financing

Climate financing seeks to support either climate change mitigation actions (for example, renewable energy generation, energy efficiency or low-carbon transport) or adaptation actions (for example, disaster risk management, waste and water, or resilient infrastructure). **Mitigation activities represented roughly 90% of the total flows** of which majority went towards renewables, dominated by solar PV and onshore wind energy. **The share of adaptation finance stood at just 7%**[2].

[2] Global Landscape of Climate Finance, December 2021

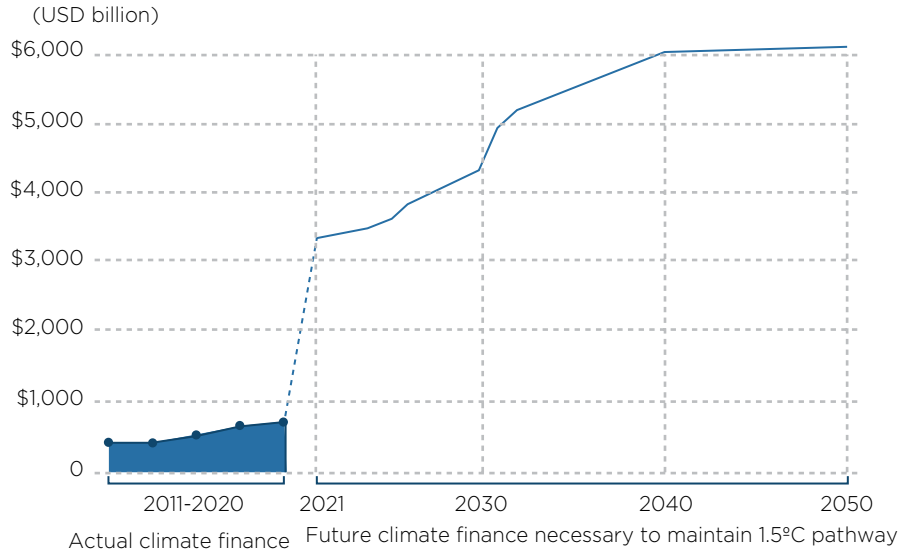


Figure 1: Estimated annual climate investment required through 2050
Source: Climate Policy Initiative

Also, increased share of solar PV in mitigation finance is a validation of the fact that countries across the world are focusing on solar energy as a way of increasing sustainability, meeting climate targets, and increasing resilience to climate change and market uncertainty.

Key messages:

- **Climate and energy transition investments encompass sectors beyond renewable energy and crossed USD 800 billion in 2021. This growth has been driven by investments in renewable energy and electrified transport, which have a combined share of 85% of all investments.**
- **Climate finance will need to cross USD 4 trillion annually by 2030, and USD 6 trillion annually before 2050.**
- **Upcoming technologies for the energy transition such as Hydrogen and CCUS currently account for just a few billion of funding, but can be expected to grow rapidly in coming years**
- **Solar energy's potential and suitability for sector coupling with other clean sectors such as electrified transport or green hydrogen production can see it outdo investment expectations.**

2.2.1 Barriers and gaps in clean energy investments remain to be addressed

There have been promising developments in clean energy investments. Investments in renewable energy, particularly solar, have growth faster than those of fossil fuel sectors over the last 6-7 years. Exit strategies to replace coal power, a mainstay of the power sector, are beginning to be developed. At COP26, more than 40 countries committed to shift away from coal, including major coal using countries[3]. Other exit strategies include ensuring that future

[3] BBC, 'COP26: More than 40 countries pledge to quit coal', 4 November 2021

coal capacities are operated with abatement mechanisms in place, such as carbon capture and utilization/ storage technologies. **However, despite these developments, investments in clean energy remain far from sufficient, and significant scale up is required to meet energy transition targets.** These key challenges include continued subsidies and investments in fossil fuels, a lack of private financing, and unlocking new sources of financing for clean energy investments.

Persistently high fossil fuel investments and subsidies slow down clean energy transition

With a revival of the global economy post COVID-19, a rebound in energy demand has been seen that is being met largely with fossil fuels. For example, China saw substantial ramp up in coal supply investment in 2021 to meet its energy needs. The average level of investment in fossil fuels in 2022 is expected to be higher than the level projected in the net zero scenario. And as a result, transition to clean energy has not picked up at the required pace.

Despite an increased emphasis on a structural shift towards clean energy, commercial institutions continue to put huge investments in the fossil fuel sector and governments across the world continue to resort to fossil fuel subsidies for meeting energy demands. These tend to discourage investments in clean energy.

Fossil fuel subsidies fell to a decade low in 2020 as the pandemic hampered fuel consumption. However, after two years of straight declines, the IEA estimates that governments around the world spent $440 billion on subsidizing fossil fuel consumption over 2021, representing a 142% rise year-over-year.

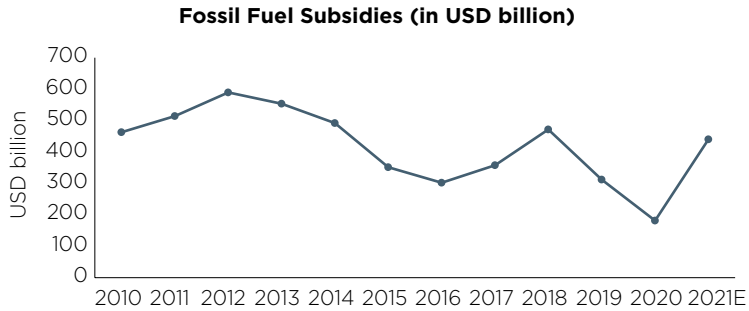


Figure 4: Subsidies provided for energy generated from fossil fuels
(Source: IEA)

Between 2016 and 2020, the 60 largest commercial and investment banks of the world have collectively invested USD 3.8 trillion into fossil fuels

Large global banks continue to invest huge sums in fossil fuels

Bank lending for fossil fuel expansion continues to be very high. Between 2016 and 2020, the 60 largest commercial and investment banks of the world have collectively invested USD 3.8 trillion into fossil fuels. Overall fossil fuel financing remains dominated by four US banks, with JPMorgan Chase, Citi, Wells Fargo and Bank of America.

Financing in fossil fuel sector by top 16 banks (in USD billion)

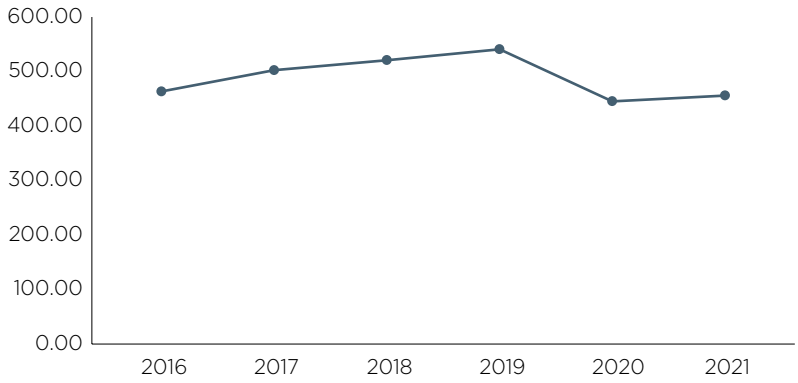


Figure 7: Fossil fuel financing by major banks
(Source: BNEF)

Fossil fuel investments are being driven by the financial industry at large. Hence, despite growing support for the clean energy transition, the fossil fuel industry reaps the benefits of billions in investments and subsidies annually. It should be kept in mind that while current investments in energy is viewed from the lens of energy security, making progress towards climate mitigation cannot be sidelined. **The USD 5-6 trillion per year investment required per year for climate finance to limit temperature rise will require the diversion of these fossil fuel investments into clean energy technologies.**

Private Institutions need to accelerate their pace for climate financing

The two major sources of climate financing are public institutions and private institutions. Public institutions include national, multilateral, and bilateral Development Finance Institutions (DFIs), State-Owned Financing Institutions (SOFIs), government agencies, Multilateral Climate Funds (MCFs), etc. Private institutions include corporations, commercial FIs, funds, institutional investors, etc. For climate finance in 2020, while public financing provided 49% of total financing and private financing contributed to 51% of total climate finance. Public financing witnessed a decrease while private financing witnessed an increase over 2019.

Corporations are the major source of private financing at 40% in 2020 and allocated 75% of finance into renewable energy projects and 20% in low carbon-transport projects in 2019/20 (biennial average). Commercial Finance Institutions have also increased their lending portfolio for clean energy assets. **However, major banks' lending to fossil fuels continues to be high** as shown in above section. **Keeping in view the high environmental cost associated with fossil fuels, private institutions must increase their funds for investments in clean energy and reduce their investments in fossil fuels drastically.** IRENA estimates that, although public investment in the energy transition will need to double, the private sector will need to bear most of the overall financing requirements.

Key messages:

- **Subsidies to the fossil fuel sector are expected to more than double to around USD 440 billion in 2021, a worrying trend that will interrupt the general downward trend seen over the previous few years**
- **Top banks have steadily continued to finance the fossil fuel sector, providing over USD 450 billion in 2021.**
- **Private institutions need to play a significant role in the growth of clean energy capacity.**

2.2.2 Developing innovate financing tools will be key to mobilizing the required funds for clean energy transition

Renewable energy investment is not always conducive to the use of traditional methods of financing, as investor knowledge and confidence has not always be in place for such new technologies, especially in developing countries. This in turn limits project bankability and increases cost of finance for those looking to set up renewable energy capacity.

Additionally, technologies such as solar also provide new opportunities for financing, due to the potential for distributed deployment, modular and scalable plant size, and installations in a variety of applications and sectors. In this environment, the development of new and innovative tools can ensure that finance can be suitably mobilized to help meet sectoral needs. Green Bonds, Exchange Traded Funds (ETFs), and Infrastructure Investment Trusts (InvITs) can all play a role in the growth of solar. Additionally, solar is also conducive to the use of innovative technologies such as blockchain to help aggregate distributed solar deployment. These tools and technologies, among others, can help address some of the barriers to investment in the sector. This will be covered in greater detail in Chapter 5.

Key messages:

- **Renewable energy, including solar, has fundamentally different project characteristics relative to fossil fuel capacity, and will require innovative tools and technologies to drive funding.**
- **Investor knowledge and confidence needs to be developed to secure better financial terms for renewable technologies.**

2.2.3 A new renewable energy charter treaty (RECT) may boost investors' confidence and enhance clean energy investments

The Energy Charter Treaty (ECT) is a 1990s-era trade and investment accord, the ECT was seeking to integrate the eastern and soviet energy industry into western markets. It established a legal framework which aimed to protect foreign investments and foster cross-border trade. The ECT dealt in consequence primarily the fossil fuel industry located in the former soviet republics, now forming the CIS (Commonwealth of Independent States). The major instrument under the ECT is the settlement of international arbitration when for instance by political decision and one of the ECT signatories' private foreign investment would suffer loss of profitability. As on date, the ECT has been signed by 45 countries, including the European Union, and Euratom. The observer status is granted by the ECT to 36 more countries, 12 of which are African.

Disputes under the ECT follow the Investor-state dispute settlements (ISDS). Many of the disputes are based on an estimated loss of profit, when governmental measures prevent a private investor to fully exploit its investments.

Based on its nature the ECT protects in predominantly investments in Fossil fuels, thus locking states into an energy-mix which effectively hampers any change to a low-carbon energy system. ECT could be very well fit when it comes to attracting private investors in the growing markets of emerging countries, notably in Africa. Amongst other benefits (energy trade), it would increase investor's confidence and lower capital cost. As it is very difficult to reform the ECT one should engage to elaborate a specific Renewable Energy Charter for the investments into renewable energy projects. Such treaty shall avoid the pitfalls of the ECT, such as lack of transparency and independence, missing precise definition of investment protection standards such as the estimation of the disputed value, environmental impact and the respect of human rights. This RECT would contrast the ECT, under which investors in fossil fuel production can sue national governments on the claim that the governmental support for renewable energy harms their own profitability.

Scaling Investments for Solar Sector

Global investments in solar projects reached a record level of investment of **USD 205 billion** in 2021, with an average growth rate of **~9%** in the last five years (2017-2021) and **18%** growth in 2021 based on 2020 levels

3.1 Overview of multiple investment options across the solar value chain

The solar PV value chain consists of distinct segments starting from the manufacturing stage for the equipment, all the way to the project development, finishing with the end-of-life stage ensuring circularity within the whole ecosystem. These stages encompass activities with very different industrial dynamics.

In 2021, solar energy value chain has attracted investments of USD ~220 billion across three key segments as depicted in the image below. The details of individual segment and trends are detailed in the subsequent sections.

[1] OurWorldInData and Climate Watch

Research and Development	New Manufacturing Facilities	Project Development
$ 7-8 Billion	$ 5-6 Billion	$ 205 Billion

- **Research and Development and Innovation** focusing on improving efficiency and system performance
- The **manufacturing stage** is focused on producing various products such as polysilicon, wafers, cells, modules, and arrays along with different equipment for project development such as mounting and tracking systems and various electrical components. The manufacturing stage under the solar PV value chain is interlinked with other sectors/ value chains.
- The **project development stage** is more focused on delivering services for the commissioning and maintenance of the projects; these include project development, design, engineering, construction, operation, and maintenance as well as asset management.
- Lastly, the **end-of-life stage** is an upcoming area of work wherein stakeholders are working towards ensuring circularity within the whole solar PV eco-system by following the principles of 3Rs, i.e., Reduce, Reuse and Recycle.

Apart from the stage-specific activities, various activities span across the whole lifecycle such as project management, monitoring, data analysis, consulting and financing as well as training and testing.

These different segments along with the corresponding activities demonstrate the potential of various investment options along the different parts of the solar PV value chain. There are three major investment options along the solar value chain which include manufacturing, solar project development and R&D, the y-o-y investments across solar value chain are depicted in the image below:

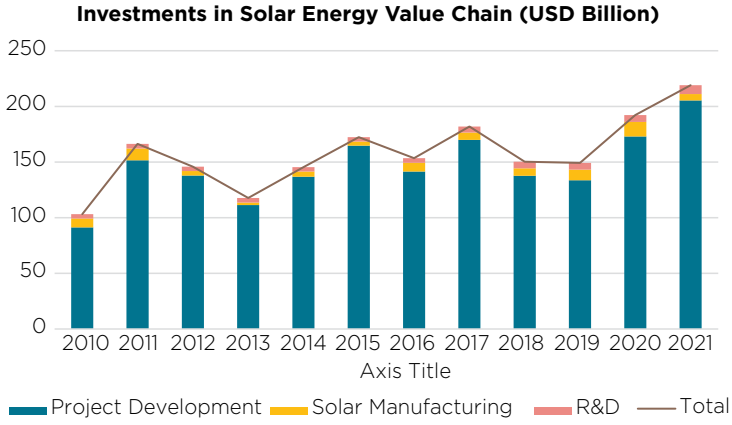


Figure 15: Investments in Solar Energy Value Chain (USD Billion)
Source: BNEF, IEA

While the avenues mentioned above are the most prominent, another major growing investment avenue is through corporate actions. A significant amount is being invested through corporate actions such as private-equity buy-outs, corporate mergers and acquisitions, and re-finance of renewable energy assets including manufacturing setups as well as projects.

Key messages:

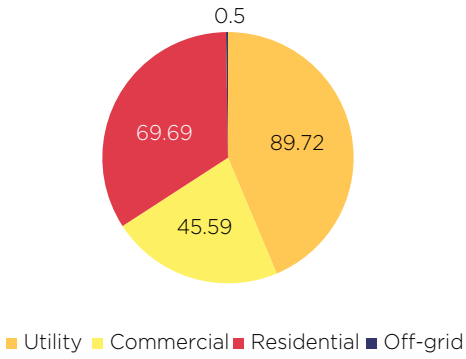
- **Investors have many options for financing solar, including different investment vehicles and stages of the value chain. The end-of-life stage is an emerging area which will require new companies and business models to capitalize on the opportunity**
- **Investments in solar value chain have grown at ~9% in the last decade, dominated by investments in project development activities.**

3.1.1 Solar Project Development: Skewed Investments Hampering Solar Growth in Developing Regions of Africa, Latin America, and the Caribbean

Development, construction, and maintenance of solar energy projects are undertaken with the aim of better quality and greater reliability along with optimization of infrastructure maintenance costs. There is a degree of uncertainty in solar energy project management due to economic and technical factors. A major change observed in solar energy project management is the digitization of the ecosystem, wherein data analytics is being used for ensuring higher transparency in processes.

Solar project development activities can be broadly categorized into four key segments; a) Utility scale; b) Commercial; c) Residential; and d) Off-grid. The image below highlights the segment wise share of investments in solar project development activities in 2021.

Investments in Solar Project Development in 2021 (USD Billion)



United States of America, China, Vietnam, Japan, Spain, South Korea, Australia, Italy, Germany, and India; these economies together accounted for 79% of total solar investments.

The development of new assets as well as maintenance of installed solar power plants are mostly financed by financial lending institutions, corporates, and other sources. Small-sized assets are mostly funded by small residential and commercial investors and private investors. For the management of larger-sized assets, investments are mostly done by private investors, corporations, and project finance.

Global investments in solar projects reached a record level of investment of USD 205 billion in 2021, with an average growth rate of **~9% in the last five years (2017-2021) and 18% growth in 2021 based on 2020 levels**.

However, there is a skewed distribution of investments in the solar sector in favor of the Asia and Pacific, Europe, and North America regions. This is also evident from the fact that solar growth is dominated by Asia and the Pacific region as well as Europe and North America: **these two regions respectively account for 58% and 34% of the global installed solar energy capacity**, respectively, as of 2020. On the other hand, developing regions of the Middle East, Africa, Latin America, and the Caribbean continue to lag in the race for solar adoption.

Within these regions, the investments have been dominated by economies with a developed PV market, such as the United States of America, China, Vietnam, Japan, Spain, South Korea, Australia, Italy, Germany, and India; these economies together accounted for **79% of total solar investments.**[4]

[4] Bloomberg New Energy Finance (BNEF)

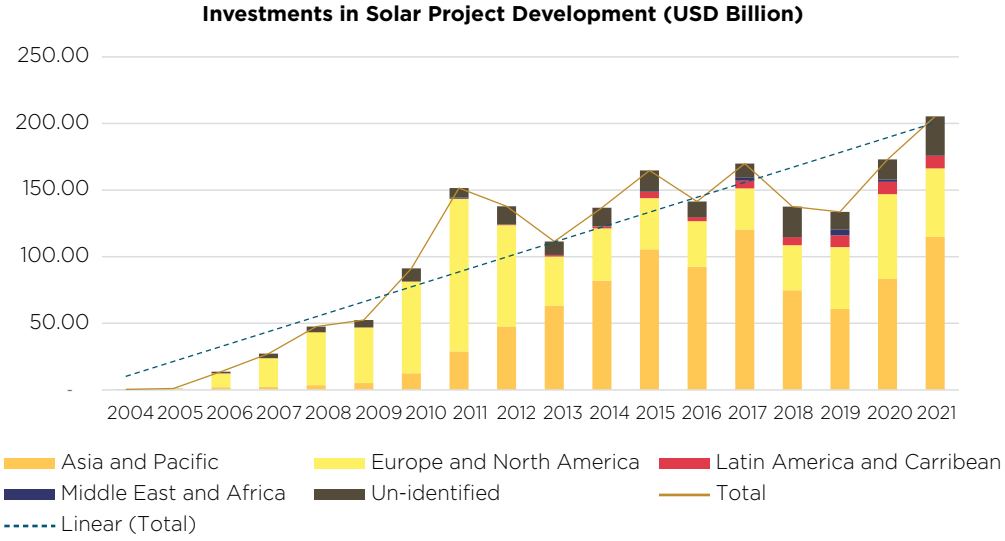


Figure 16: Region-wise investments in solar project development (USD Billion)
(Source: BNEF)

Figure 17: Country-level investments in solar project development for the year 2021 (USD Billion)
(Source: BNEF)

growing from a mere 15% share to a high of 60% over a decade, with average growth rate of ~9% in the last five years and 37% in 2021 from 2020

Asia-Pacific and Europe and North America

The overall growth in solar investments has been mainly contributed by the growth in investments for solar energy achieved in the Asia and Pacific region, **growing from a mere 15% share to a high of 60% over a decade, with average growth rate of ~9% in the last five years and 37% in 2021 from 2020**. However, the increase in investments is majorly accounted for by two countries, namely India and China. Apart from these two, **solar investment in the region declined by 17% from 2020 to 2021[5].**

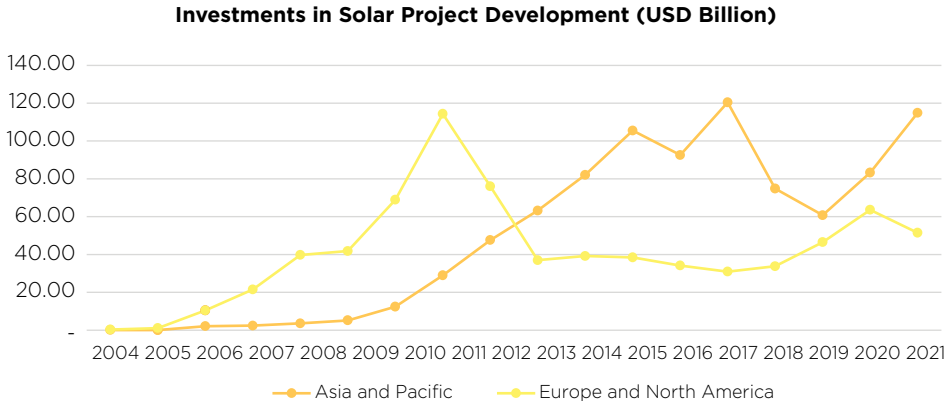


Figure 7: Investments in Solar Project Development in APAC (USD Billion) and Europe and North America
Source: BNEF

01 In India, new investment in Solar PV increased by **68% to USD 7.5 billion in 2021** which has been supported by the implementation of auctions, which have resulted in cheap prices for state-owned utilities.

02 In China, Investment in solar energy grew **115% to USD 79 billion** in 2021 driven by large-scale projects initiated by local and national governments.

03 **Vietnam** has become a major solar PV market as there was a commissioning deadline for its national FIT in 2020, after which investment in solar PV has tapered.

04 In **Japan,** recent amendments to the national FIT has negatively impacted investment.

[5] REN 21

The average growth rates of investments **in Europe and North America grew by ~11%** in the last five years (2017-2021), although the region has seen a **dip in 2021 by 19%**.

In Europe, **solar PV investment has grown nearly 11%** y-o-y (2017-2021) to USD 34.1 billion. However, there was a **dip in 2021,** primarily due to disrupted supply chains. Complex permitting rules and procedures also hamper both solar PV and other renewable energy investments including wind.

USA saw solar PV investment fall by 29% to USD 26.1 billion in 2021, whereas investment in all other renewable energy technologies increased. The drop in investment in the USA is attributed largely to supply chain challenges, combined with permitting and grid connection difficulties, the fall-off in available federal tax credits, and continued uncertainty about tariffs and other trade measures that impact module imports.

Middle East & Africa and Latin America & Caribbean

Emerging and developing economies currently account for two-thirds of the world's population, but only one-tenth of global financial wealth. The developing regions of Africa, the Middle East, Latin America, and the Caribbean have been lagging in the race for the deployment of solar energy systems. This can be attributed to the lack of adequate investment in solar technology and its deployment in these economies. These regions face high debt and equity costs that are up to seven times higher than that in the United States of America or Europe.

For the Middle East and Africa region, while the average growth rates of investments **grew by ~20%** in the last five years (2017-2021), the region saw a sharp drop by 91% y/y **in 2021**. On the other hand, while the average growth rates of investments **in the Latin America and Caribbean grew by ~30%** in the last five years (2017-2021), growth remained flat in 2021.

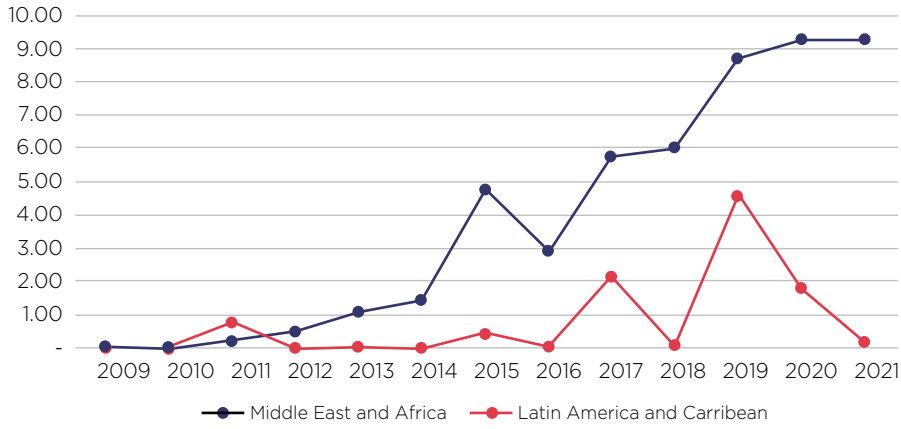


Figure 6: Investments in Solar Project Development in Middle East and Africa and Latin America and Caribbean (USD Billion)
Source: BNEF

Key messages:

- **The skewness of the investments can be witnessed by the fact that Africa, which is home to 17% of the world's population contributes to less than 2% of global solar installed capacity despite having the richest solar resources in the world.[6]**
- **Despite being home to 75% of the global population lacking access to electricity, there is a huge gap between investment mobilized and investment required for the solar energy sector Africa**
- **Developing regions in the Middle East and Africa as well as Latin America and the Caribbean saw a miniscule share of global investments in solar energy**
- **There is also a lack of data available on the investments made at the country level in the solar PV sector, especially for the economies in the developing regions of the Middle East and Africa as well as Latin America and the Caribbean.**

3.1.1.1 Taking stock of solar investments across the four main solar segments

Growth in the demand for solar energy has been dominated by solar energy systems installed across the world for electricity consumption. These solar systems are broadly categorized under four major buckets, i.e., Utility scale, commercial and industrial, residential, and off-grid systems.

Over the past two decades, solar energy has seen exponential growth globally, from a mere 1.47 GW installed capacity in 2000 reaching up to 940 GW in 2021. The rapid expansion of solar capacity can be attributed to many factors including technical, financial, political, and societal. With an overall push towards the adoption of cleaner energy, This increase in demand, along with technological advancements resulting in efficiency improvements and modularity of the installations, has led to falling costs for manufacturing and, thus, falling costs of systems. In 2021, the solar PV sector had another record year with nearly 164 GW of new capacity additions representing ~45% of the global installed generation capacity addition.[7]

[6] WRI, ISA, Bloomberg Philanthropies, 2021, Solar Investment Action Agenda
[7] BNEF Climatescope 2021: Energy Transition Factbook (December 2021)

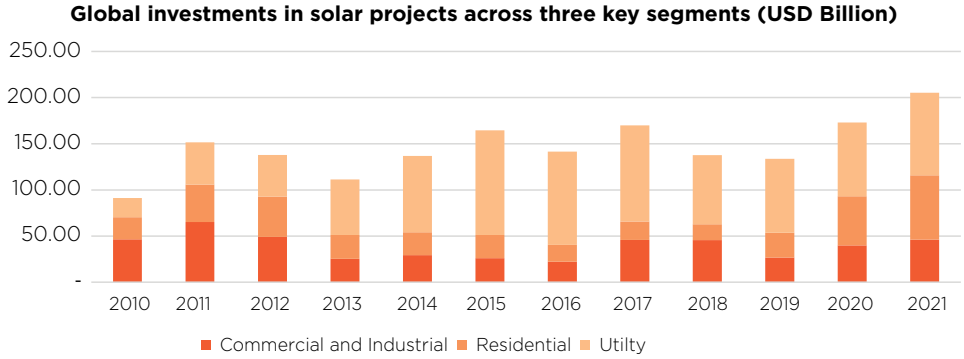


Figure 8: Global investments in solar projects across three key segments (USD Billion)
(Source: BNEF)

Grid-connected includes three segments utility, commercial and industrial and residential solar energy systems are the ones where the system is connected to the utility's power grid allowing for a bi-directional flow of power. Off-grid solar energy systems mean that the system works independently, as the system is not connected to the utility's power grid. Typically, off-grid systems are installed where the power grid is absent, or the reliability of the power supply is very poor.

These grid-connected, as well as off-grid solar energy systems, might also be installed to cater to a specific application for solar energy, such as solar water pumping systems, solar rooftops, and solar mini-grids among others.

Key messages:

- **Governments have introduced conducive policies and regulations that have been encouraging investments into solar energy.**
- **Although conventional methods of raising investments have been proven to be effective over the past, there is a need for new methods for mobilization and scaling up of climate finance of resources, originating from a wide variety of sources to achieve the investments required to fight climate change.**
- **An 81% decrease in the solar PV cost for utility-scale systems between 2010 and 2020 has been another key driver for growth**

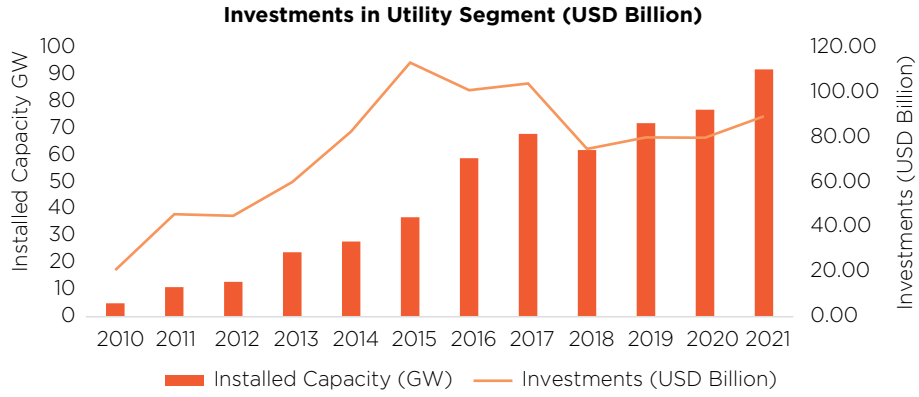


Figure 9: investments in Utility Segment
(Data Source: BNEF, ISA Analysis)

Among grid-connected systems, the adoption of solar energy has been driven by utility-scale or centralized-level installations over the past decade. The share of utility-scale solar installations has increased from 28% in 2010 to 63% in 2020. **Utility segment solar installations have seen an average growth rate of 18% in last decade, while investments in 2021 have seen a growth of 11% y/y.**

Commercial and Industrial Segment

The growth of C&I solar slowed down in 2011, when many feed-in tariff regimes across Europe were discontinued due to the difficult financial conditions stemming from the 2008 economic crisis. However, it rebounded around 2017.

In 2019, while the global fleet of solar PV increased, the major drop in C&I can be explained by the relatively off-year from China which went down from a 28 GW market in 2018, to a 22 GW market in 2019. Specifically, the commercial segment dropped from 17 GW in 2018 (about 60% of annual global C&I installations) to 5.6 GW in 2019 (25% of the global C&I market).

The average growth rate (2017-2021) of investments in C&I segment stood at 26%, while investments in 2021 have seen growth of 21%. y/y

The share of utility-scale solar installations has increased from 28% in 2010 to 63% in 2020. Utility segment solar installations have seen an average growth rate of 18% in last decade, while investments in 2021 have seen a growth of 11% y/y.

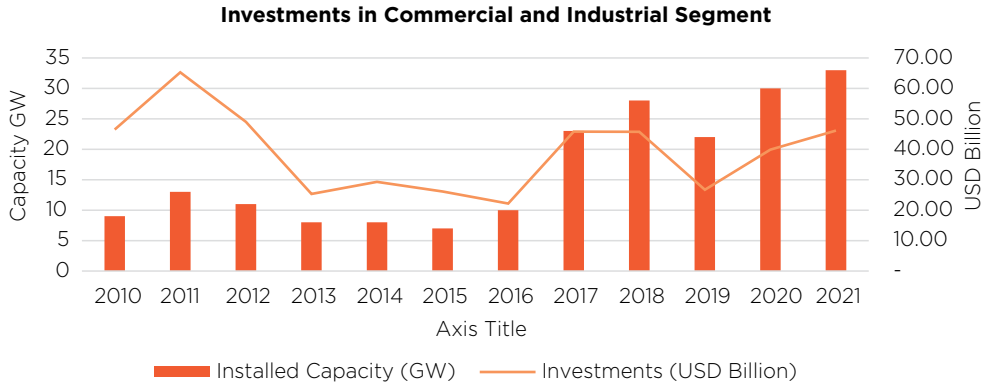


Figure 10: investments in Utility Segment
(Source: BNEF, ISA Analysis)

Residential Segment

Residential rooftop solar has shown a more stable growth compared to C&I solar. The reason is that financial considerations for a household are very different than for a business. C&I players are more focused to payback times to justify their investments, and therefore are more susceptible to changes in the support framework. By contrast, households are somewhat less dependent on economic incentives, since a substantial section of this segment can be driven by different motives (e.g., energy

independence, climate concerns) than purely financial considerations. Although residential solar has also been affected by the end of the European feed-in tariff schemes in the early 2010s, the market contraction has not been as pronounced as for C&I solar.

The total fleet of residential PV systems reached 135 GW in 2021, which is a remarkable result when considering that these systems are typically between 5-7 kW in size (see fig.##). The cumulative residential PV capacity has grown more than tenfold compared to ten years ago.

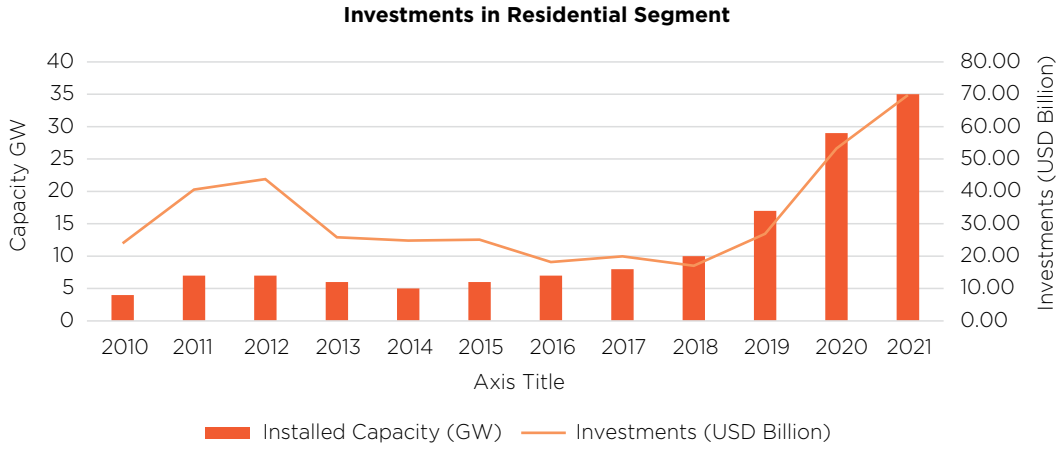


Figure 11: Investments in Residential Segment
(Source: BNEF, ISA Analysis)

The investments in residential segment have seen an average growth of 35% in the last five years and 31% in 2021 compared to 2020.

Off-grid solar showing positive momentum

Off-grid solar solutions have played a pivotal role in ensuring energy access to around. 420 million globally, mostly in the developing regions of Sub-Saharan Africa as well as South Asia. These systems offer various advantages in the terms of access, and reliability and can address challenges of energy access, energy security, and energy transition.

Due to grid expansion and low return of investments owing to project locations and other risks, off-grid solar energy systems were not attracting the same level of investments as grid-connected systems. However, things have become a bit better for the off-grid solar sector in the past couple of years. Investments in the global off-grid solar sector grew by 44%, hitting a record ~USD 450 million in 2021. This has been mainly possible due to the market leaders in the sector who have been able to attract new investors as they reach profitability by diversifying into various energy-adjacent products while responding to consumer demand. The sector has also been able to attract various climate-aligned and impact-driven investors as off-grid solar aligns with their social, economic, and environmental strategies.

Despite the sharp growth, there is still huge potential especially in the developing regions of Africa as well as Latin America and the Caribbean where energy access is the number one hurdle in the journey of sustainable development.

[8] GOGLA.

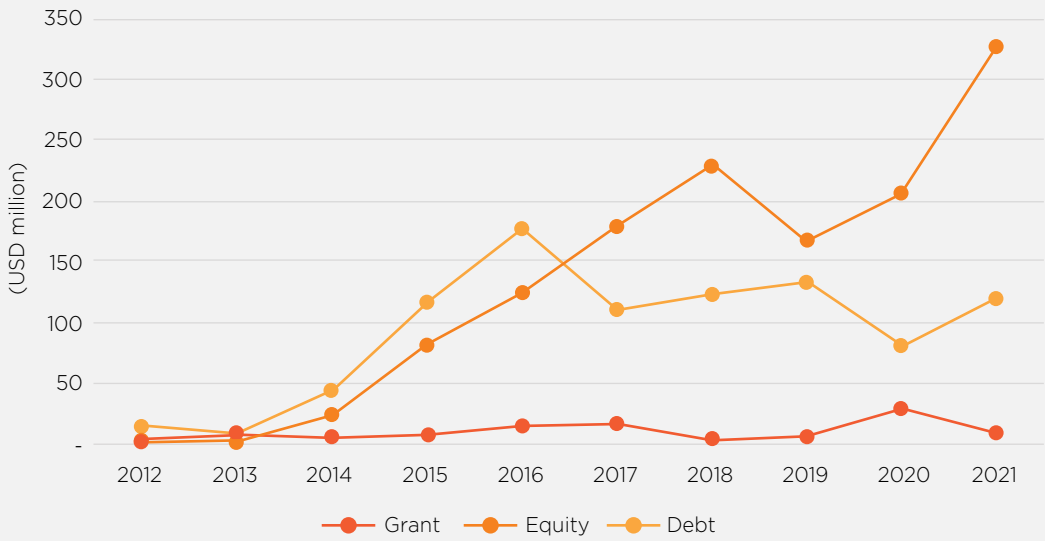


Figure 12: Annual trend of the grant, equity, and debt in the off-grid solar energy space
(Source: GOGLA)

While debt and equity continue to be key financing instruments for off-grid players, the seed and start-up phases have historically relied on grant financing to refine their business models and attain commercial scale.

In 2021, financial commitments in the form of debt have seen strong growth and reached USD 326 million; this is mainly driven by large debt deals by established players in the space. On the other hand, equity (USD 120 million) and grants (USD 10 million) have returned to pre-pandemic levels.[9]

- With the investments in the off-grid space reaching an all-time high in 2021, there is a reason for optimism and gives confidence to investors
- However, a lack of access to finance remains a big challenge, for start-ups.
- More investment is needed to unleash the industry's full potential to achieve climate and energy access goals.

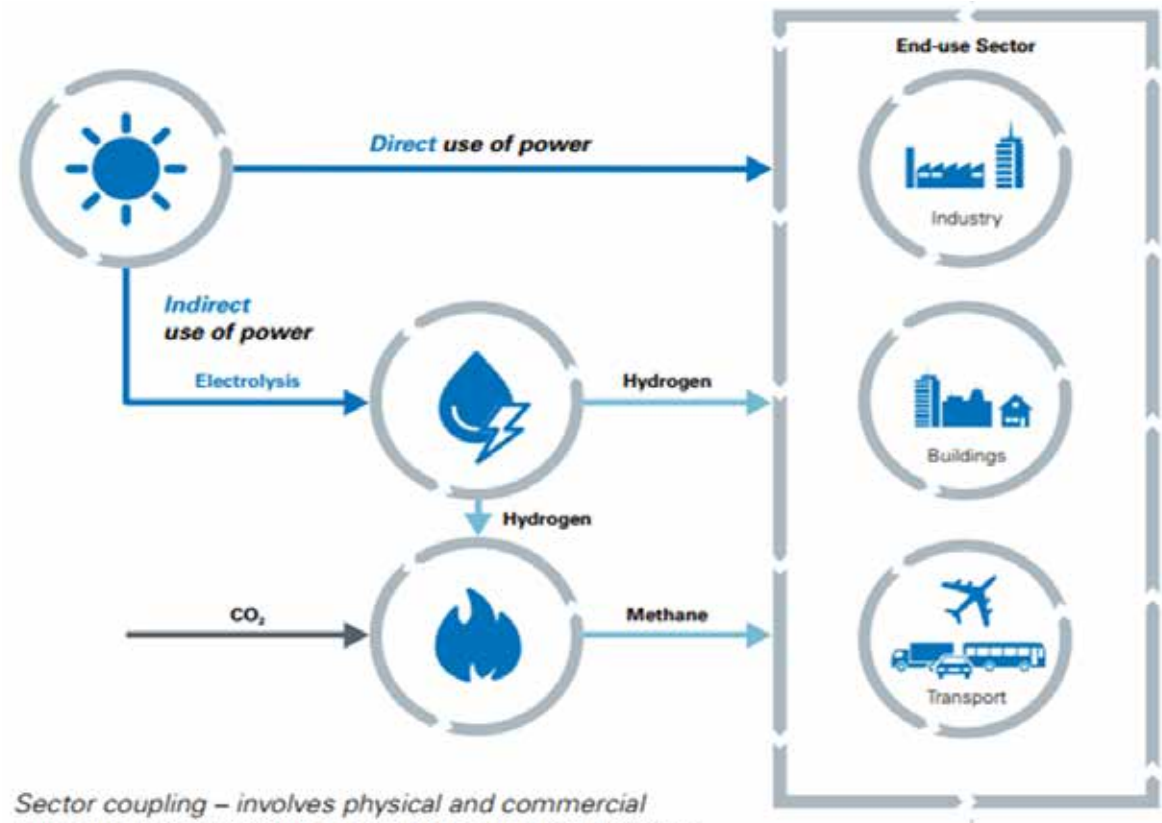
[9] GOGLA Database

3.1.2 Sector coupling of solar shows immense potential for future investments

The role of solar energy as an enabler for energy transition has become more and more obvious, with the adoption of solar energy moving beyond energy systems providing clean electricity to the grid for consumption. The coupling of the solar energy sector offers the potential to be a critical enabler for increasing electrification and greening of various other sectors such as transportation, heating, cooling, and industrialization among others. The potential of coupling solar energy with these other sectors is intended to provide a sharp increase in the overall demand for solar energy.

Ensuring reliability with storage

Integration of solar energy with energy storage systems has provided an opportunity to solve various grid integration challenges linked to solar PV deployment such as grid balancing, reduction of renewable energy curtailments, and, in some cases, provide ancillary services to the grid.



Sector coupling – involves physical and commercial interaction between the power sector and the buildings, transport and industry sectors.

Decarbonizing transportation

The shift from fossil fuel to electrification for transportation has become a crucial step towards the decarbonization of the transport sector. The proposition of powering e-mobility with solar energy is being illustrated with an increasing number of commercial partnerships combining EV charging stations and solar systems for private and public use.

Greening hydrogen for hard-to-abate sectors

Green hydrogen is being widely welcomed as one of the key technologies to be utilized in the fight against climate change and achieving net-zero carbon emissions. It has the potential to act as the key that unlocks energy transition even in the most critical and hard-to-abate sectors, such as refineries, fertilizers, steel, cement, heavy-duty vehicles, aviation, and power. The cumulative installed capacity for green hydrogen is forecasted to grow from a mere 0.5 GW as of 2021 to 350 GW by 2030.[10] To meet this demand at a reasonable cost, scaling-up deployment of green hydrogen technologies and associated manufacturing capacities would be critical. The transition to green hydrogen could provide USD 11.7 trillion of infrastructure investment opportunities over the next 30 years, covering everything from dedicated renewable capacity and electrolyzers to transport infrastructure.[11]

Key messages:

- **Because of a recent push towards integration with energy storage systems, increasing penetration of e-mobility, and adoption of green hydrogen as a clean fuel source in hard-to-abate sectors, the demand for solar PV is expected to increase manifold.**

3.1.3 Solar Manufacturing: Investment boost required for scaling solar manufacturing and supply chains

Over the past years, solar energy has seen a boom in overall adoption, mostly driven by utility-scale adoption. To keep up with the growing demand, it is important to scale up the manufacturing of already developed technologies. While the technology risks are significantly lower, the investment requirements for scaling up manufacturing are high. For that reason, this is mostly financed by large corporations, private equity funds, and by raising capital from the public stock and bond markets. Raising debt from financial lending institutions is also another option.

Scaling up manufacturing is crucial for keeping up with the increasing demand for solar energy, Solar manufacturing space has grown rapidly in the past with production costs, declining over 90% in the last 10 years globally.[12] This reduction can be attributed to factors such as falling raw material costs (especially silicon costs), technology improvements, increasing efficiency, and the rising scale of solar installations.

Investments in solar manufacturing in USD million (2021)

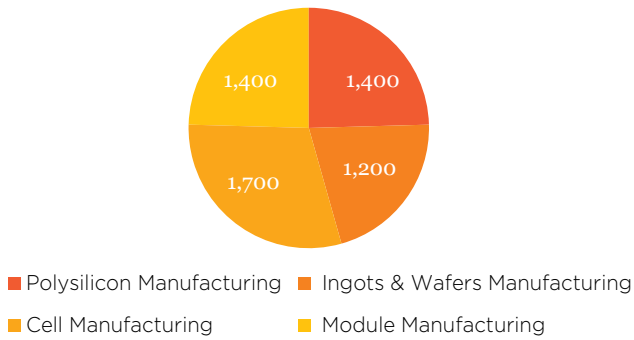


Figure 13: Investments in solar manufacturing in USD million (2021)
Source: BNEF

[10] IRENA, World Energy Transitions Outlook 2022: 1.5°C Pathway, 2022, https://irena.org/-/media/Files/IRENA/Agency/Publication/2022/Mar/IRENA_World_Energy_Transitions_Outlook_2022.pdf
[11] IRENA, 2022, Geopolitics of the Energy Transformation: The Hydrogen Factor (Link)
[12] Link: https://www.pv-magazine.com/2021/09/13/impact-of-increasing-pv-module-prices-on-indian-market/

Global cumulative investment in solar PV manufacturing facilities more than doubled in the past decade to almost USD 100 billion in 2021. In 2014- 2021, global investment in solar PV manufacturing increased 50% from the previous seven-year period.

While annual solar PV installations have increased consistently since 2006, annual investments in manufacturing have been volatile, ranging from less than USD 1 billion to as high as USD 15 billion. This inconsistency results mainly from periods of overinvestment followed by years of underinvestment, widening the supply and demand of several products in the PV supply chain.

Investment levels from 2017 to 2021 were relatively modest, mainly because of the economies of scale achieved, especially in China, where larger production facilities were installed at low capital expenditure.

3.1.3.1 High capital requirements for polysilicon and ingots/wafers production lead to a major share of investments

Polysilicon and ingots/wafers together account for almost 45% share of solar PV manufacturing investments due to high capital requirements. For polysilicon, investments rose rapidly during 2008-2011 because escalating demand for solar PV installations resulted in polysilicon shortages with the spot price reaching a record of almost USD 400 per kg – more than ten times today's price. Having peaked in 2011, investment in polysilicon production plants declined significantly due to overcapacity, with the spot price falling below the historical low of around USD 10 per kg.

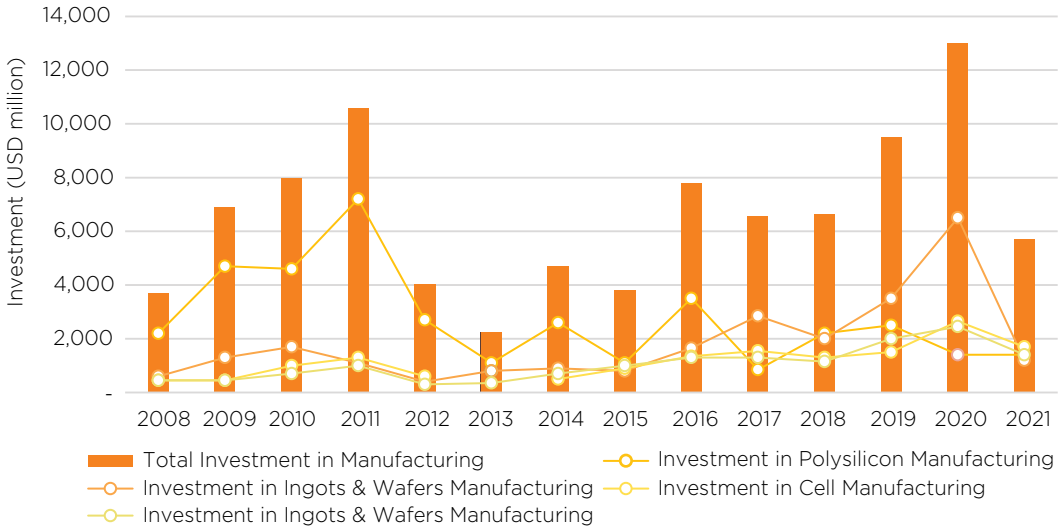


Figure 14: Annual trend of total and segment-wise investments in the solar PV manufacturing space *(Source: BNEF)*

The average growth rate of investments in solar manufacturing in last decade has been 10% Investments in manufacturing fell by by ~50% in 2021 compared to 2020. As per the IEA special report on solar PV global supply chains, the estimated increase in solar manufacturing capacity is depicted in the table below:

Polysilicon	Currently, solar polysilicon has been in short supply after a longstanding supply glut, which caused a significant price increase from H2 2020 onwards. However, significant new capacity is expected to come online in 2022, driving nameplate production capacity up to around 400 GW.
Wafers	The nameplate wafer manufacturing capacity stood at over 350 GW in 2021 and is expected to grow to around 520 GW by end of 2022.
Cells	The global nameplate cell manufacturing capacity stood at just over 400 GW in 2021 and is expected to grow to over 550 GW by end 2022.
Modules	The global nameplate module manufacturing capacity stood at over 450 GW in 2021 and is expected to cross 600 GW by end 2022.

3.1.3.2 Concentrated solar supply chains dominated by China resulting in uneven distribution

Like the investments for solar projects, investments in solar PV manufacturing space have also been skewed with the present solar PV manufacturing supply chains continuing to be highly concentrated in China. China observed a 152% increase in investments between the period 2006-13 to 2014-21. As of 2021, China-headquartered companies accounted for nearly 76% of the polysilicon, 98% of ingots, 96% of wafers, 88% of cells, and 79% of modules' global production capacities.[13] Several companies that are not headquartered in China also make most of their cells and modules in the country. On the other hand, regions such as North America, Europe, and Asia as have observed a decline in the investments in the solar PV manufacturing space.

[13] Bloomberg NEF

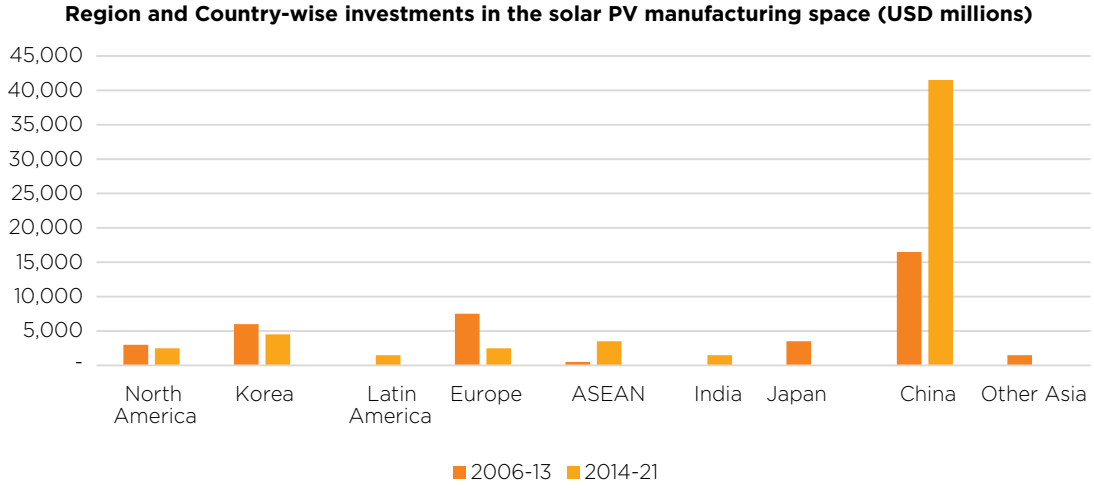


Figure 15: Region and Country-wise investments in the solar PV manufacturing space
(Source: BNEF)

To continue on the track of achieving our climate goals, the solar energy sector shall play a crucial role in deployment on an unprecedented scale. However, the present supply chains, being concentrated in China, might hinder the growth of the solar energy sector. This has been observed with the challenges faced on account of the COVID-19 pandemic, especially high commodity prices and supply chain bottlenecks, which led to an increase of around 20% in solar panel prices.[14] Thus, to keep up with the growing demand, there is not only a need for expansion of solar manufacturing capacities globally, but also for building diverse, resilient, affordable, and sustainable solar supply chains.

3.1.3.3 Ensuring circularity of supply chains holds the potential to unlock new economic opportunities

The solar energy sector has grown tremendously over the past two decades. However, as the solar PV market continues to grow globally, so will the volume of decommissioned panels and other components, thereby resulting in large amounts of waste piling up annually by the early 2030s. While being an environmental challenge, this also presents exceptional opportunities to create value and pursue new economic avenues. It has been estimated that recycling or repurposing solar PV panels at the end of their roughly 30-year lifetime can unlock an estimated stock of 78 million tons of raw materials and other valuable components globally by 2050. If fully injected back into the economy, the value of the recovered material would hold a potential of USD 15 billion by 2050.[15]

[14] IEA, Press Release, July 2022, https://www.iea.org/news/the-world-needs-more-diverse-solar-panel-supply-chains-to-ensure-a-secure-transition-to-net-zero-emissions
[15] IRENA, End-of-life management: Solar Photovoltaic Panels, June 2016

Key messages:

- **With the huge task of realizing terawatt solar capacity additions under the net-zero targets, it is important to scale up the solar PV manufacturing capacities.**
- **To satisfy the demand for solar energy and reduce costs, manufacturers must build production closer to demand centers**
- **Supply chain resilience and energy security requirements should push companies to build capacities in a geographically distributed manner and reduce the reliance on one country.**
- **While solar PV manufacturing space has been growing over the years, circularity in the solar manufacturing supply chain is a key problem that needs to be tackled in the coming years.**

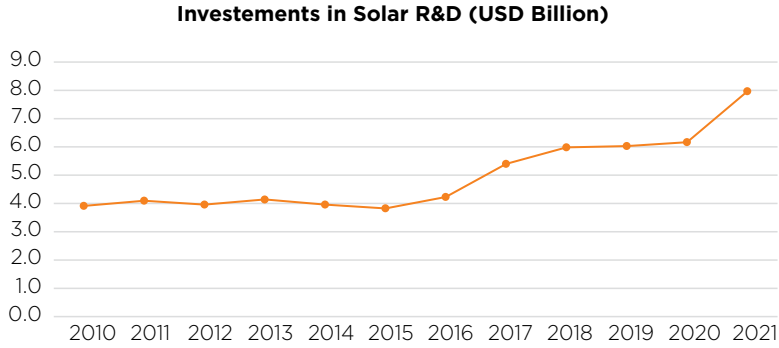
3.1.4 Research and Development Spending in Solar Energy Increased by 30% in 2021

Research and development have been a key driver in decreasing the costs of solar energy and its large-scale adoption. The funds, which are tied to undertaking research and development for the advancement in technology, in terms of seed or early-stage funding, are termed "pre-revenue" as the return on the investments is negligible or limited initially.

The seed or early-stage funding in clean energy for research and development is mainly provided by governmental agencies, research bodies, and corporations. The financial support provided by the governments is mostly in the form of a grant, which does not have to be paid back; this financial support sometimes requires matching funds from private investors and/ or foundations. Venture capital money is also another source of funding that is available at this stage. However, venture capitalists tend to invest in technologies that are "in vogue" during that period. A major challenge in realizing venture capital funds is that solar technologies require much more capital and time to develop and test than what most venture capital firms are comfortable with. Raising debt from financial lending institutions is also another option for raising a part of the required investments.

The strategic importance of energy innovation, including research and development (R&D) and demonstration, remains as high as ever. Without a significant increase in energy innovation spending, climate goals and long-run economic prospects are at risk. But the market uncertainty that has resulted from the Covid-19 pandemic and the destabilising war in Ukraine is affecting spending on energy innovation, just as it has affected investment in other energy assets. Policy support for clean energy innovation mitigates this uncertainty by bolstering public and private efforts while directing them towards long-term sustainable outcomes.

As of 2021, China-headquartered companies accounted for nearly 76% of the polysilicon, 98% of ingots, 96% of wafers, 88% of cells, and 79% of modules' global production capacities.



In 2021 investment in R&D rose to USD 8 billion an increase of 30% compared to 2020 Nearly 90% of this investment was allocated to advance technologies in solar cell, out of which 70% share was from corporates.

3.2 Sources of financing for renewable energy projects

Financial closure for renewable energy projects is essential for ensuring the success of the project. Various types of financing instruments exist to support the scaling up of the adoption of different renewable energy technologies, which are largely dependent on the location of the project as well as the stage of development of the technology and/or project. These instruments can be broadly grouped based on their characteristics.

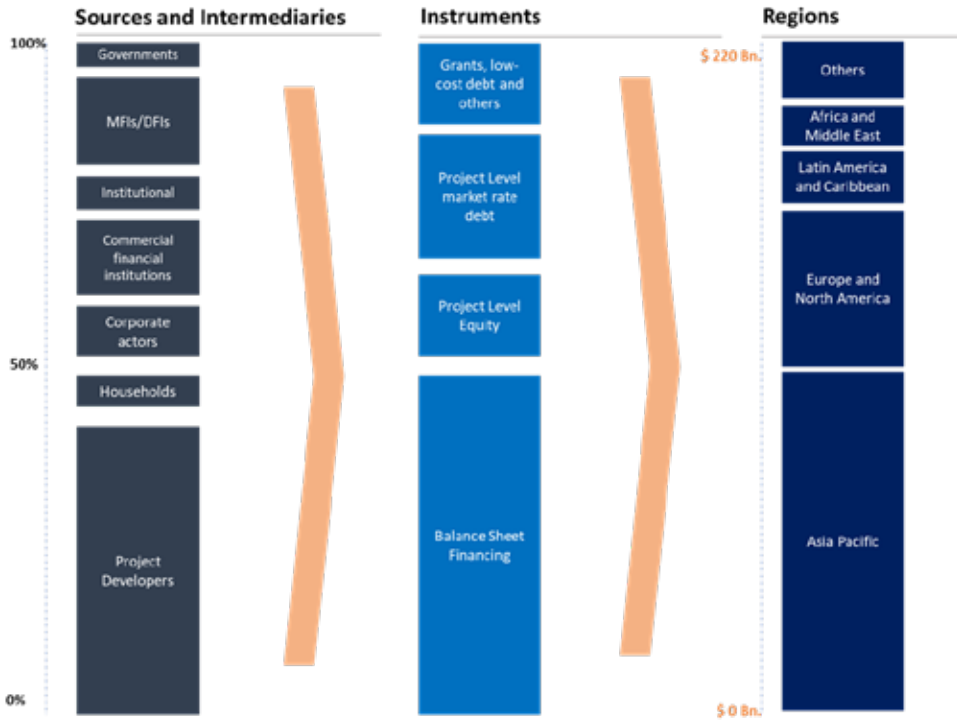


Figure 17: Landscape of renewable energy finance

Grants, Low-cost debt and others: Capital grants are provided to fund a part of the investment costs of a project and reduce the cost to increase its competitiveness to reduce the ultimate price for the customer. These grants are considered to be highly risky as they give no control over the project and no recourse to the public sector. Low-cost (or concessional) debt, which refers to loans extended at terms preferable to those prevailing on the market.

Project level market rate debt -This refers to loans extended to projects at regular market rates and funds raised through issuance of bonds

Project-level equity -., Equity investment relying on the project's cash flow for repayment

Balance sheet financing, - Direct debt or equity investment in a recipient entity by a company or financial institution

Venture Capital Financing

Venture capital funds are pooled investment funds that manage the money of investors who seek private equity stakes in startups and small- to medium-sized enterprises with strong growth potential. These investments are generally characterized as very high-risk/high-return opportunities as they intend to develop high-risk projects and tend to overcome financial barriers faced during project implementation. Under this financing, the investors, i.e., the venture capitalists tend to have an exit option, in form of an initial public offering (IPO) or overall sale of the company, after ensuring a return on their investment. Due to the high-risk nature of the project and, thus, its returns, this type of funding is considered to be high-risk. For an investor to be able to readily exit their investment, there is a requirement for a sufficiently developed financial market.

Key messages:

- **The selection of financial instruments must always take account of the needs of an individual project or program as well as legal and practical restrictions s while addressing the risks.**
- **Attracting debt and equity funding in the least developed countries (LDCs) is difficult due to the perceived high risk and lack of market depth. Public or grant-financed guarantees and other programs may help developing markets access international and domestic debt and equity**

3.2.1 The private sector leads renewable energy investments

Public and private actors have different aims while investing in renewable energy. Whereas the private sector tends to focus more on regions and technologies with favorable investment environments, public actors concentrate on hard-to-enter sectors and markets that require more work to reduce capital and technology costs.

Private finance[16] was a major contributor to solar energy projects, accounting for 86% of total investments between 2013 and 2018. Whereas public sector contributed to 14% of total investments in solar in 2013-2018, majority finances coming from development finance institutions. The figures from 2018 to 2021 have been arrived at by assuming the average share of public and private financing respectively from 2013 to 2018.

[16] Private investment players include project developers, non-energy producing companies (corporate actors), commercial financial institutions, households, institutional investors and private equity, venture capital, and infrastructure funds

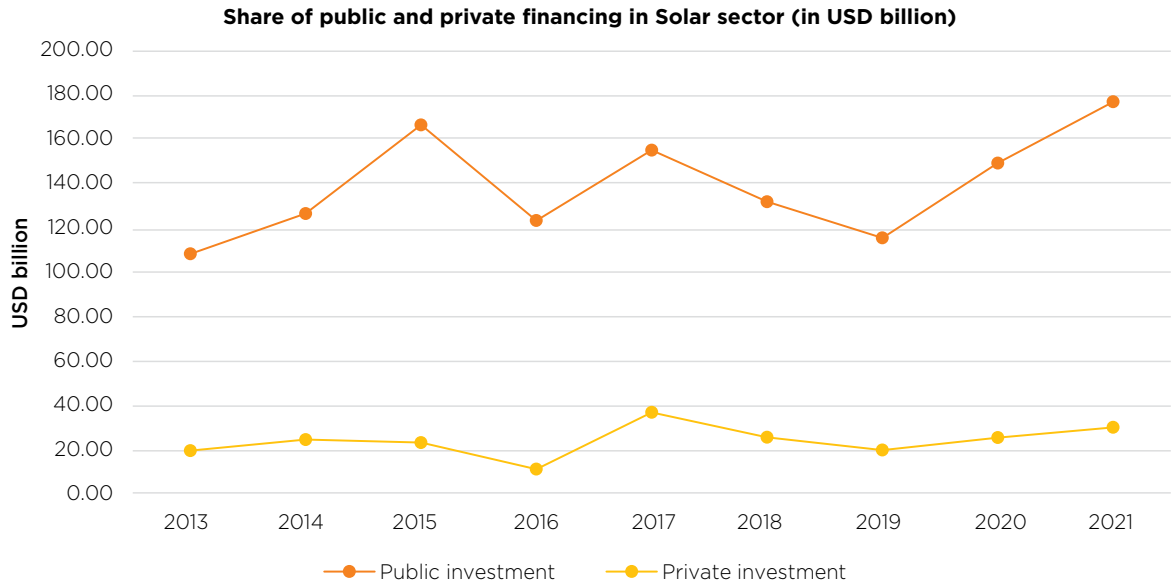


Figure 2: Share of public and private financing in the solar sector[17]
(ISA analysis)

If we look at the split amongst the private financing, project developers providied an average of 56% of the total private finance in solar space.

The second largest contribution was by commercial financial institutions. In this case as well, the figures from **2018 to 2021 have been arrived at by considering the average share of each from 2013 to 2018**.

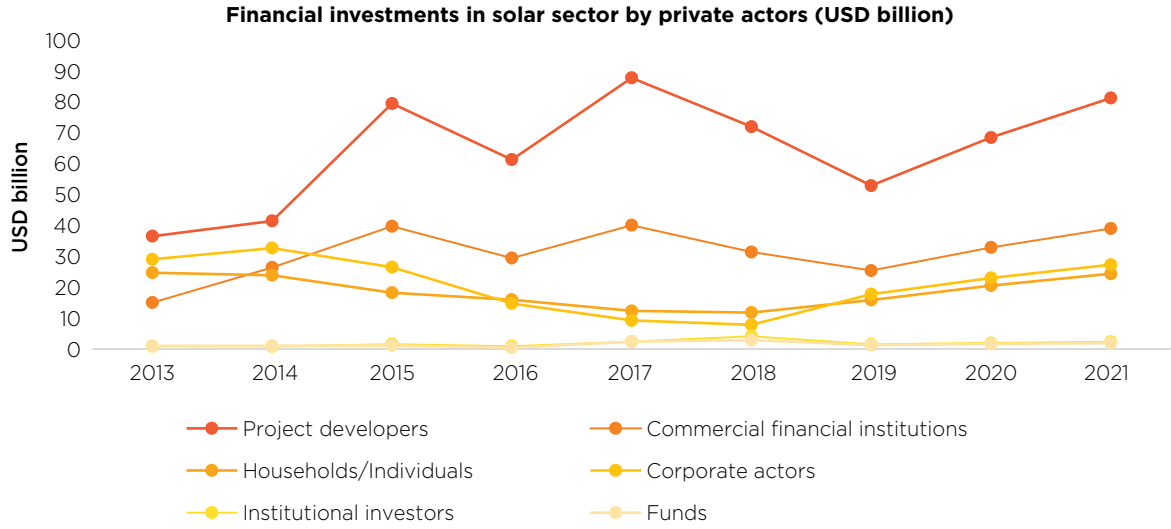


Figure 3: Contribution in solar financing by private sectors
(Source: ISA analysis)

Lack of Data Transparency: There is need to enhance data transparency and track investments specific to solar segment to understand the progress and bottlenecks hampering the sector.

Due to lack of recent data availability, the analysis was conducted based on the past data until 2018 and estimating values for 2018 to 2021. Trends and insights depicted might have changed in the last four years.

[17] Values arrived at by considering percentage of solar investments in total RE investments as per IEA

Key messages:

- **Private actors are the main contributors to solar energy financing whereas public actors mainly contribute towards reducing risks for private investors and bringing new technologies and markets to maturity.**
- **Project developers and commercial financial institutions remain the key contributors of solar financing amongst private players.**
- **Though trends of solar investments have been quite promising from the private players, exact conclusions cannot be arrived at for the latest developments because of a lack of data after 2018.**

The sub-sections below highlight investments of key public and private actors and how their contributions play an important role in transitioning to clean energy

3.2.2 Fossil fuel investments by commercial financial institutions significantly higher than solar fuel investments

Commercial financial institutions which include commercial and investment banks continue to contribute a significant amount to renewable energy, representing on average 25% of total private finance in 2017-18. Having said that investments in renewable energy and solar sector has been significantly less when compared to investments in fossil fuel.

In 2021, investments in renewable energy sector by such institutions further dropped by 22% after the economic slowdown in 2020. On the other hand, their investments in the fossil fuel sector grew to meet the higher energy needs.

Though banks have been talking about contributing significantly to clean energy space, the numbers show otherwise. As per a study by the environmental organization, Urgewald, in the past 3 years, banks have raised USD 1.5 trillion for the coal companies and have given around USD 400 billion in loans to them directly. On the other hand, investments made in solar by these banks is quite low. The figure below highlights the investments made in solar sector by top 16 banks.

As per a study by the environmental organization, Urgewald, in the past 3 years, banks have raised USD 1.5 trillion for the coal companies and have given around USD 400 billion in loans to them directly.

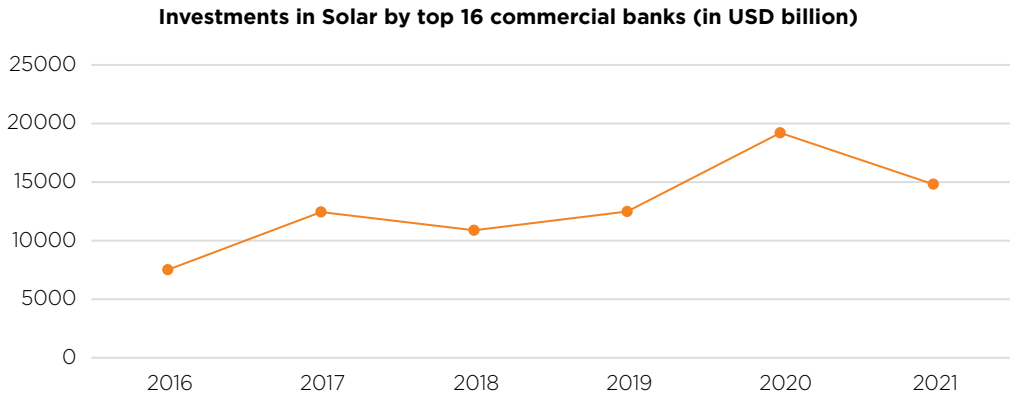


Figure 4: Solar investments by top 16 commercial banks
(Source: BNEF)

The figure below provides the trends of investments by the top 5 banks in the solar sector in the last 6 years.

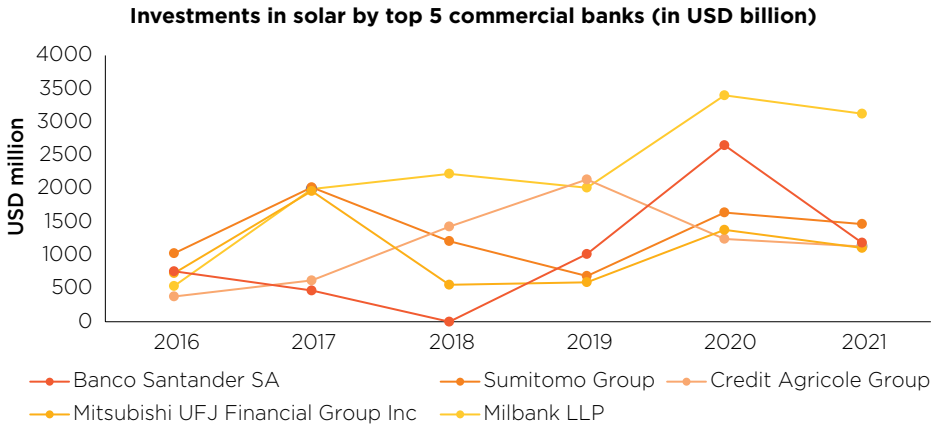


Figure 5: Solar investments by top 5 banks over the years
(Source: BNEF)

The figure below draws out a comparison between investments in fossil fuel and investments in solar sector by few prominent commercial banks over the last 6 years.

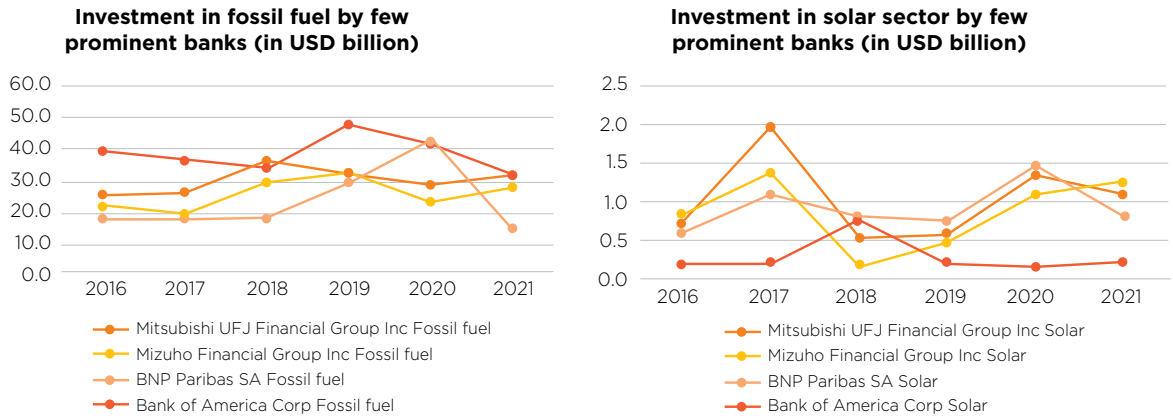


Figure 6: Investments in fossil fuel and solar energy respectively by select commercial banks *(Source: BNEF)*

The figures are nowhere near promising clean energy transition. The banking industry has been widely criticized for helping oil, gas and coal companies raise more than $4.5 trillion since the Paris climate agreement was announced at the end of 2015. Forcing banks to explain their plan and way forward for energy transition, as well as how they will navigate issues such as so-called stranded assets, will show who's contributing to the climate change.

The banking industry has been widely criticized for helping oil, gas and coal companies raise more than $4.5 trillion since the Paris climate agreement was announced at the end of 2015. In October 2021, it became one of the first financial institutions to set a "fossil fuel exit strategy" and a validated science-based target.

There are few banks who have been investing in climate change in the right manner. One such bank is La Banque Postale. In October 2021, it became one of the first financial institutions to set a "fossil fuel exit strategy" and a validated science-based target. The bank has committed to a complete withdrawal from coal as well as conventional and unconventional oil and gas (upstream and midstream activities) by 2030. It has decided to refrain from financing oil and gas energy projects, not provide any financial services to the sector, and end legacy services by 2030. It has also stated to discontinue support to businesses that are actively involved in lobbying on behalf of fossil fuel industry.

Banks coming up with openly with such strong commitments will help in faster transition towards clean and sustainable energy.

One unique approach that is being followed in the United States to increase solar installations in the residential sector for large banks to liaise with specialized financiers and local installers, who have the required expertise and access to large base of high-income homeowners. Since these large commercial banks lack the ability to establish contractor relations at scale, they rely on specialized financiers for establishing such connections. One of the largest consumer banks in the mid-western United States, Fifth Third Bank acquired home solar financier Dividend Finance, a leading fintech point-of-sale (POS) lender in May 2022 to enter the growing US solar market. Dividend Finance provides financing solutions for residential renewable energy and sustainability-focused home improvement. It offers a range of loan products across multiple proprietary POS platforms and has built a one-stop solution that enables contractors to offer the best financing experience for their customers. Dividend's digital lending platform is designed for customizability, providing contractors with the tools to win new business and borrowers with a streamlined process for financing home improvement projects. In addition to a robust contractor network and a leading technology platform, Dividend has a national customer footprint focused on prime and super-prime borrowers. As per BloombergNEF, Dividend Finance raised over USD 1 billion to finance solar loans in 2021. This acquisition will help Fifth Third Bank in achieving its goal of a more sustainable future and ESG targets and facilitate solar penetration in residential sector.

Local banks also need to step up their solar investments especially in distributed and small scale solar projects

Though large commercial banks have somewhat increased investments to solar space when it comes to financing by private actors, local financial institutions (FIs) have not stepped up their solar lending because of institutional challenges, risk of payment defaults, bad debt, etc.

The development of small-scale solar projects such as rooftop solar projects has not taken off as local FIs have not been very keen to lend money. In absence of affordable financing options by the local banks, uptake of solar systems has been slow, especially in rural and developing regions. In Africa, companies that invest in small scale off-grid renewable energy solutions grapple with limited access to credit because of risk profiling that is of concern to providers of local debt financing. Where financing is offered, the interest rates can be extremely high. With the arrival of leasing and solar-as-a-service providers, there is a need for credit enhancement products to increase the availability of local currency finance for sustainable energy projects.

In India, local banks have been financing large commercial solar projects but their lending to the residential rooftop segment is minimal owing to small ticket sized loans, lower risk appetite, and policy and regulatory challenges. For instance, while State Bank of India (SBI) sanctioned about INR 186 billion for ground mounted solar PV in FY 2020-21, rooftop solar received only INR 18 billion[18].

Key messages:

- **Investments by commercial financing institutions is heavily skewed towards fossil fuel and it is high time that they make commitments and fulfil them to eliminate carbon emissions from their portfolios**
- **Investments by local banks must be encouraged to promote easy financing options for small-scale developers and small solar applications.**
- **Innovative options such as a dedicated line of credit by multilateral funding agencies can be provided to smaller banks for designing affordable financing products such as top-up home loans, zero down payment loans, etc. to encourage more investments in the solar sector.**
- **Investments must also be directed in the solar sector for capacity-building activities and promotional and awareness creation activities in terms of setting up of solar kiosks, developing solar portals, dedicated training programs, etc.**

3.2.3 Investment from Development financial institutions has decreased considerably over the past years

National, multilateral, and bilateral DFIs provided the largest share of public investments in solar sector averaging 43% per year between 2013 and 2018[19]. DFIs played a key role in investing in solar energy projects, especially in emerging economies. They also support solar deployment through technical assistance programs and work closely with country governments and other local bodies for implementation. However, investments from top ten DFIs in solar have declined considerably, registering a decrease of nearly 80% between 2018 and 2021.

[18] SBI Sustainability Report, 2020-21

[19] Average of solar investments in RE between 2013 and 2018 is 52% and share of DFIs in RE between the same period is 83%. So, solar investments by DFIs in the same period is considered as 52%*83% i.e., 43%

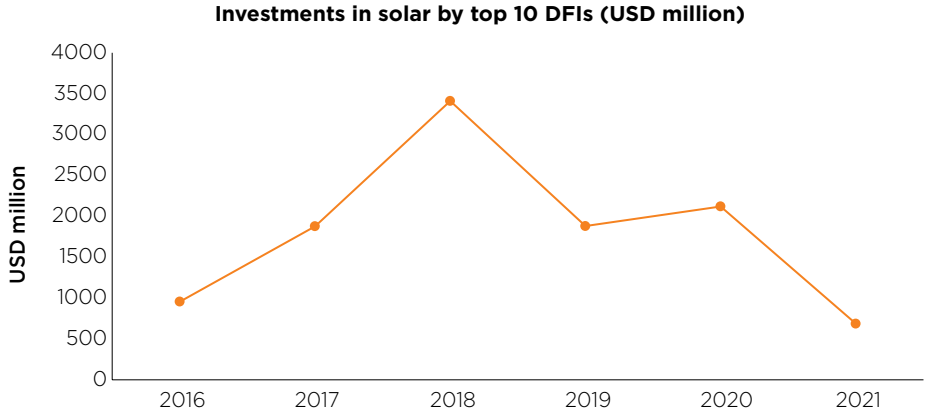


Figure 7: Investments in the solar sector by top 10 DFIs
(Source: BNEF)

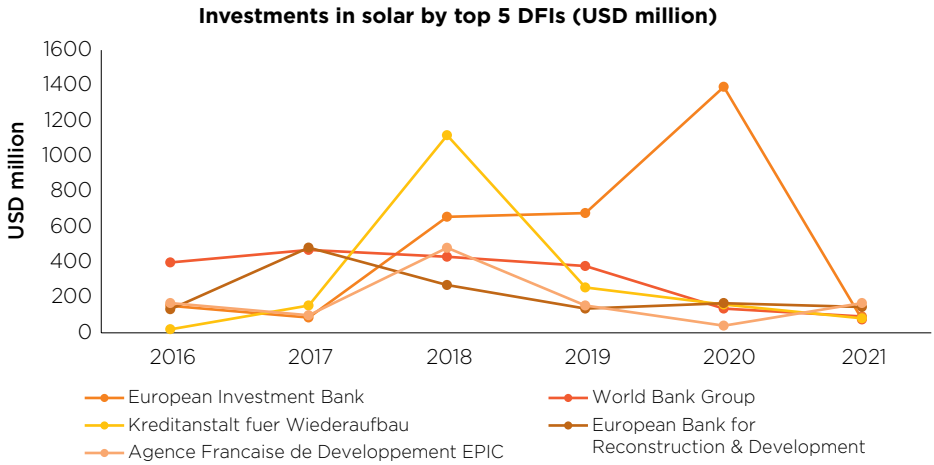


Figure 8: Solar investment trends of top 5 DFIs
(Source: BNEF)

Concessional finance from DFIs is crucial to meet the USD 100 billion commitment by the developed countries

The USD 100 billion annual commitment was a promise made by rich nations to help developing and underdeveloped countries adapt to climate change and mitigate further rises in temperature during COP15 in 2009 and reaffirmed in the Paris Agreement. Though the amount is smaller compared to the investment required to avoid dangerous levels of climate change, it is an important symbol of trust and foundational to progress on climate justice.

However, data suggests that the rich countries have failed to deliver on their promise and have fallen short of the target every year. In 2018, the contribution made was USD 78 billion, in 2019 it was USD 80 billion, and the figures are estimated to be same for 2020. The USD 100 billion commitment is central to COP26 priorities, including adaptation and resilience, nature and biodiversity and support for poor and vulnerable countries, and it is high time the developed countries meet their targets collectively and individually. The multilateral development banks must be prepared to triple their level of financing by 2025 from 2018 levels to greatly expand their support for green recovery and sustained transformation in developing countries and help them greatly increase the scale of investments to support climate and sustainable development.

The box item below highlights the investments targeted in South Africa by the African Development Bank for transitioning to clean energy.

African Development Bank announces plan for greening of South Africa without additional debt

South Africa is coal-dependent and has huge amounts of debt. The African Development Bank has proposed a plan to mobilize USD 40 billion for a greener South Africa without adding to country's debt. The bank has been interacting with the members of the Group of Seven rich nations and plans to establish an energy transition facility that will be used for any African nation to receive concessional funding and guarantees. This facility will serve as a special purpose vehicle to raise money in capital markets. The money raised will subsequently be used to transition all the coal-based and heavy-fuel power generation in Africa to a greater use of renewables. The pilot is being developed for South Africa and will subsequently be used across other African countries.

The financing pledged will be far from enough. According to a May 27 report by the Blended Finance Taskforce and the Centre for Sustainability Transitions at Stellenbosch University, even after the said financing support, the country will require USD 250 billion to transition to green energy over the next three decades.

Key messages:

- **A decreasing trend in solar investments have been seen from DFIs which needs to be reversed**
- **All developed countries need to increase their climate finance commitments, especially after the COVID – 19 crises as investments in developing countries have declined.**
- **Developing and underdeveloped economies require financial support from DFIs to increase solar penetration and capacity building.**

3.2.4 Huge potential for Institutional investors to fast-track clean energy transition

Institutional investors include asset management firms, pension funds, insurance companies, sovereign wealth funds, foundations, and endowments, manage about USD 87 trillion of assets. However, they have accounted for only 1% of annual investments between 2013 and 2018 in the renewable energy sector[20]. If we consider an average of 52%[21] of solar investments in total RE between 2013 and 2018, the investment share by such institutions can be estimated to be a mere 0.52%. These investors do not disclose their investments individually in various clean energy sectors which is a huge challenge. The figure below provides the estimates of solar energy estimates made by institutional investors between 2013 and 2018; the values from 2019 to 2021 have been arrived at by considering the average of investments made between 2013 and 2018.

[20] Global Landscape of Renewable Energy Finance 2020, IRENA
[21] World Energy Investment, 2022, IEA

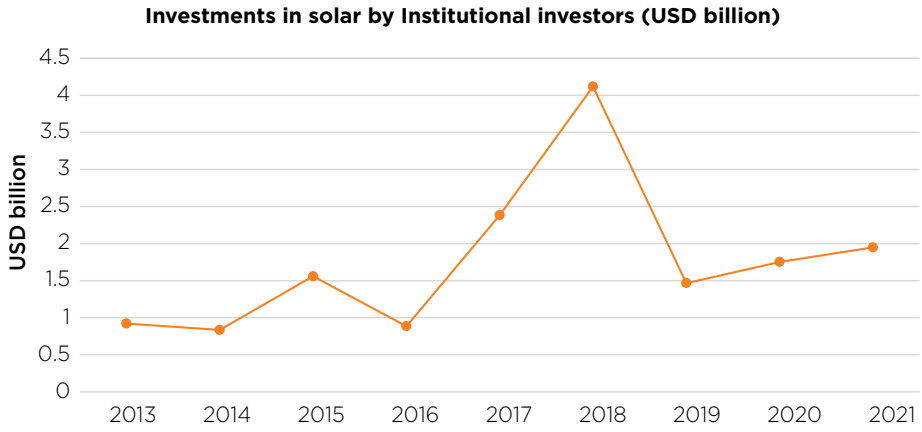


Figure 9: Investments in solar by institutional institutions
(Source: ISA analysis)

As per an analysis by IRENA of 5800 institutional investors, over the past two decades, 20% of them have made indirect investments via renewable-focused bonds while only 2% have invested directly in renewable energy projects. Though most of the institutional investors don't clearly mention their investments in clean energy, some have set examples by announcing their plans for clean energy transition.

Allianz sets an example for other insurers with its oil and gas exit strategy

The world's fifth largest insurance company announced in May 2022 that it will be withdrawing coverage and investments from a wide number of fossil fuel projects as of next year and will stop insuring its existing fossil clients when their policies come for renewal. The company has drawn the line on upstream oil and gas projects, new "midstream" facilities for oil and gas processing, transportation and storage, and new oil-fired power plants, as well as Arctic and Antarctic exploration, coalbed methane, extra-heavy oil, tar sands/oil sands and ultra-deep sea projects at depths below 1,500 meters.

The exit strategy includes the biggest fossil producers each extracting more than 60 million barrels of oil or equivalent in 2020, that account for 85 percent of global production. It also singles out companies that get at least 10 percent of their revenues from tar sands/oil sands operations.

The ambitious policy has received accolades from many supporters of climate change. Allianz is being highly praised for sending a clear signal to the oil and gas sector and governments that new oil and gas developments are not compatible with the 1.5 degrees C climate target. Is has raised the bar for other insurance companies to level up their commitments to climate change.

Key messages:

- **Activating underutilized large capital pools of institutional investors is necessary for a transition toward a more sustainable, low-carbon economy**
- **Since institutional investors focus more on indirect investments and large ticket sizes, projects should be designed for leveraging such investments**
- **More institutional investors should disclose their clean energy investments and must also come up with fossil fuel exit strategies to accelerate clean energy transition**

3.2.5 Tapping the resources of non-energy-producing companies is crucial for driving additional investments in solar

Dramatic cost reductions in solar PV have increased its attractiveness for corporations as a clean and reliable energy source and they are encouraged to invest in solar not just for meeting their ESG goals but also for cost savings, long-term price stability, and energy security.

Corporate actors account for about two-thirds of the world's end use of electricity and their electricity demand is projected to reach over 24,750 terawatt-hours (TWh) by 2050 and 86% of this projected demand should be fulfilled by renewable energy to be in line with global climate targets. Existing company targets, commitments, and ambitions would lead to only 3,800 TWh generated from renewables in 2050, leaving some 17,500 TWh of untapped opportunity in the sector[22].

[22] Global Landscape of Renewable Energy Finance 2020, IRENA

Key messages:

- **Non-energy-producing corporations have tremendous potential to drive further investments into solar and clean energy.**
- **To meet the future estimated demand of these companies, an estimated 105 GW of new solar and wind capacity would need to be added by 2030, requiring the mobilization of almost USD 100 billion[23]. Hence, the participation of these companies in the energy transformation is critical to achieving a decarbonized energy system.**

3.2.6 Oil and gas players need accelerate solar energy investments to meet their clean energy targets

Though we have seen an increasing trend in solar investments by oil and gas companies, the share of investments is quite low. Oil and gas companies around the globe contributed to only 3% of renewable energy investments[24] and roughly 1.68% of solar investments 2021[25].

The image below highlights the trend of investments in clean energy by oil and gas companies.

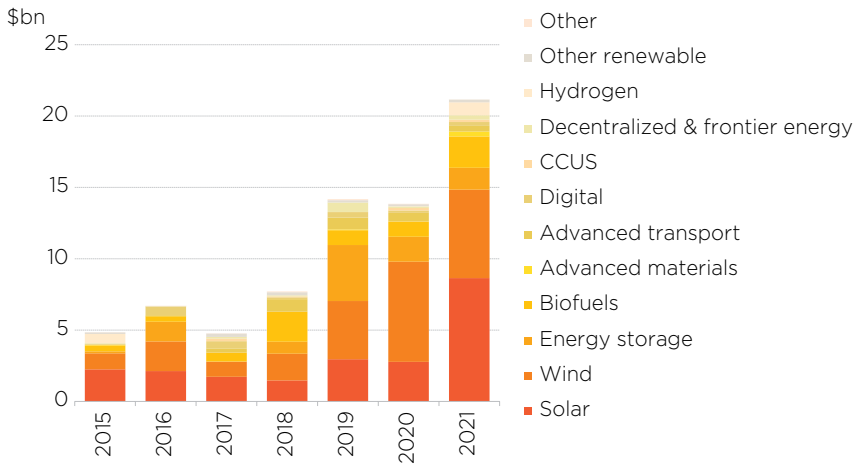


Figure 10: Investments in various clean energy sources by top oil and gas companies *(Source: BNEF)*

However, the investments made are miniscule compared the profits these companies make. The figure below shows investments in the solar sector by some major oil and gas companies across the world.

[23] Global Landscape of Renewable Energy Finance 2020, IRENA

[24] Renewables 2022, Global status report

[25] Solar investments accounted for 56% of total RE investments in 2021 as per IEA. So, total investments in solar by oil and gas companies can be estimated to be 56% of 3% which results in 1.68%

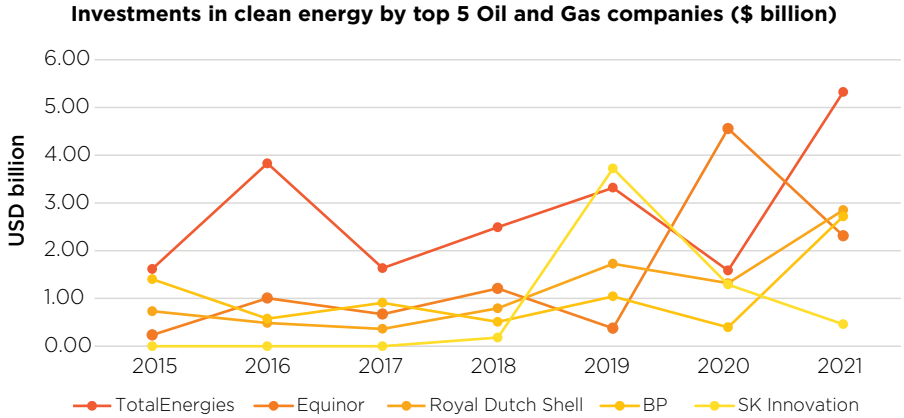


Figure 27: Investments in solar by top 5 oil and gas companies
(Source: BNEF)

European oil and gas companies not doing enough for clean energy transition

As per an analysis by News 4 in August 2022, Europe's largest oil and gas companies – BP, Shell, TotalEnergies, and Equinor, are investing dramatically more in fossil fuels than renewables and low carbon energy. They invested only a mere 5% of their pre-tax profits in green projects. Moreover, BP, Shell, and Equinor only publish figures on renewables investment alongside 'low carbon' energy which can include more contested, non-renewable energy technologies.

In the first six months of 2022, BP invested £300 million into renewable and low carbon, equivalent to just 2.5% of its £12.2 billion profits. Whereas it invested nearly £3.8 billion in new oil and gas projects, more than 10 times its low carbon investments.

Shell invested equivalent to 6.3% of its £17.1 billion profits into low carbon energy and invested nearly three times more in oil and gas. A Dutch court ordered Shell to cut its emissions faster in response to a lawsuit filed by environmental groups in May 2021.

With increased pressure from various investors to move out of high carbon activities and transition to clean energy, several oil and gas companies have set renewable energy and solar energy commitments. While some of these companies have installed solar PV capacities to power their oil field operations and address emissions resulting directly from company operations, some have acquired existing renewable energy companies or projects to diversify their portfolios and meet RE targets. The box item below highlights one such acquisition carried out by the oil and gas giant, Shell.

Shell steps into Indian Renewable Energy sector through acquisition

Shell tops other oil and gas firms in BNEF's Business Model Transition Scores in managing climate risk and has been taking crucial steps towards mitigating climate change. The oil and gas major has completed its acquisition of Indian renewable power producer Sprng Energy for USD 1.6 billion in August 2022. The deal is India's second largest 100% acquisition and third biggest clean energy transaction overall. Shell will get Sprng's 2.1 gigawatts operating and 0.8GW under-construction projects in India. Sprng's operating portfolio comprises 1.6GW of solar and 0.5GW of onshore wind plants. Shell has 1GW of existing operational capacity and another 3.7GW in pipeline globally.

India is the world's top emerging power market according to BNEF's Climatescope 2021 and has a huge growth potential when it comes to clean energy. The deal highlights Shell's approach to focus on emerging markets to build its clean energy business – likely due to higher returns and better growth prospects than developed economies. Shell previously acquired minor stakes in India's Husk Power Systems and Cleantech Solar.

Among the big names in the industry, European-based companies, TotalEnergies, BP, Shell, Equinor, Eni, and Repsol, are leading the way by adding renewable resources to their portfolios. TotalEnergies says 25% of its investment will be in renewables up to 2025. Most big industry players have set intermediate targets for installed renewable energy capacities by 2030, while at least two companies have set longer-term targets: Royal Dutch Shell (UK) aims to install 60 GW of renewable capacity by 2050, and Eni aims to install 230-450 GW. **Equinor and SK Innovation are leading the race with more than 60% growth annual growth rateduring the 2015-2020 period.**

Key messages:

- **Major oil and gas companies have large, profitable core operations but need to increase solar investments and diversify their portfolio to minimize energy transition risk, to meet them RE targets, and to contribute largely to clean energy transition.**
- **While most oil and gas majors are investing more in renewables and planning to reduce emissions over the next decade,, the investments need to be increased manifold, and the companies should be obligated to disclose percentage spent on clean energy in various countries.**
- **Investing in solar projects can bring new revenue sources for these companies while addressing investors' Environmental, Social, and Governance (ESG)[26] concerns.**

[26] Environmental, social and governance, or ESG, criteria is a term used to identify metrics that allow stakeholders to assess a company's sustainability and associated future risks

3.3 Unique business models adopted for facilitating solar uptake and investments

To attract large amounts of solar investments, adopting the right business model is crucial as different types of business models attract different types of investors depending upon the investment structure, economic condition of the region, need for electrification through solar installations, etc.

The two most prominent sub-sectors of solar installations are utility-scale solar systems and rooftop solar systems. Solar PV made up almost half of new investments in renewable energy in 2021, with spending divided amongst these two sub-sectors.

The utility-scale solar sector comprises large-scale solar installations such as those found in solar parks. Such large-scale projects are mostly financed by the government followed by Independent Power Producers (IPP). Another model that has been gaining prominence on the utility scale is the Public Private Partnership (PPP) model wherein the project ownership lies with both, the government, and the private developer. The table below highlights the type of financing for various utility-scale solar business models:

Table 1: Types of financing for utility-scale solar business models

S. No.	Business Model	Description	Type of Financing
1	Government-owned model	• PMC* contractor helps the government in project preparation and selecting potential EPC service • EPC** contractor builds the project and exits after completing the defect liability period • O&M activities are outsourced to EPC/ O&M players	Equity/Debt finance from financial institutions/ grants from international aids/ government funds/ soft loans
2	Public-Private Partnership model	• Public and private sectors pool resources and share risks • Government helps in identifying and acquiring/ leasing land parcels and getting necessary clearances whereas private players provide capital investments, set up solar plants, take care of O&M, and sell power to grid or power distribution utilities • The developer may be supported by the government with long-term PPAs, assured grid availability, RE certificates, capital subsidy, viability gap funding (VGF), etc.	**Governments:** may pool funds from different sources including support from financial institutions/international aids/ government funds **Private Developers:** May raise equity and debt either based on balance sheet/ project finance from financial institutions/ grants from international aids/ government funds/ soft loans
3	IPP model	• Private Developer engages in end-to-end activities of land acquisition, getting required clearances, setting up solar plant, operating the plant and selling solar power to the grid or power distribution utilities • The developer may be supported by the government with long-term PPAs, assured grid availability, RE certificates, capital subsidy, viability gap funding (VGF), etc.	Finance (mix of debt and equity) by private entity/ capital subsidy/ government funds

**PMC: Project Management Consultant; **EPC: Engineering Procurement and Construction*

Since utility-scale solar is a large-scale project with a big-ticket size, they tend to attract more investments from lending institutions. Large-scale projects are set up in PPP or IPP model. Lending institutions carry out due diligence of the private developers in terms of creditworthiness, ability to service the debt, payment histories, project portfolios, sustainability metrics (Environmental, Social, and Governance), etc. They also consider the risk appetite and track records of counterparties involved in PPAs such as distribution utilities (DISCOMs) and intermediaries like (Solar Energy Corporation of India (SECI) or National Thermal Power Corporation (NTPC) in the Indian context).

The rooftop solar sector comprises of commercial, industrial, and residential rooftop segments. Two types of business models are predominantly adopted for setting up solar installations on the rooftops – The capital expenditure (CAPEX) model and the operational expenditure (OPEX) model. The table below highlights the type of financing for various distributed solar business models:

Large-scale projects are set up in PPP or IPP model. Lending institutions carry out due diligence of the private developers in terms of creditworthiness, ability to service the debt, payment histories, project portfolios, sustainability metrics (Environmental, Social, and Governance), etc.

Table 2: Types of financing for distributed solar business models

S. No.	Business Model	Description	Type of Financing
1	CAPEX model	• Consumer pays the upfront cost either through equity or debt financing and takes care of O&M expenses • Consumers benefit from the reduced electricity bills and depreciation benefits as a result of solar installations • Consumers own the system The government may or may not provide subsidies for facilitating installations	Equity from own funds, though government subsidies and bank debt financing or green bonds may be used
2	OPEX model	• The project developer invests in the solar systems to be installed on the rooftops of concerned consumers and bears the O&M expenses • Consumers enter into a long term legally binding agreement for the roof as well as PPA with the developer up to 20- 25 years • Consumers benefit from the reduced electricity bills because of solar installation. • Upon expiry of the PPA term, ownership of the project may be transferred to the consumer • The government may or may not provide subsidies for facilitating installations	End customer may provide a small amount of equity, but developer will be primary equity provider, with debt financing arranged from commercial lenders or packaged as an SPV. Government subsidies may go to developer or directly to end user

The uptake of solar in the rooftop sector, especially the residential segment, has been slow despite the huge potential. This is primarily because of policy and regulatory challenges, small ticket sizes, and a lack of affordable financing options. Lenders are not keen on investing in this sector because of the higher risks involved in terms of payment defaults, small ticket-sized loans, and the large resources required for carrying out background checks of small-scale consumers. Efforts must be taken to adopt and popularize unique business models across countries that mitigate payment risks and to design financing options that mobilize funds towards the rooftop segment.

To facilitate the uptake of solar PV in the rooftop segment, some unique business models have been developed that not only mitigate operational challenges but also help in mitigating payment risks from the consumers, thereby providing an attractive market opportunity for the financing institutions. Certain models emphasize utilities for carrying out demand aggregation activities and roping in funding institutions for providing finances for setting up solar installations. Such steps reduce payment risks for developers as utilities ensure timely payments through monthly electricity bills. Some of the unique business models adopted are illustrated below:

i. Master (Renewable Energy Service Company) RESCO model: This model has been adopted in select Indian states. The figure below illustrates the schematic diagram for the same:

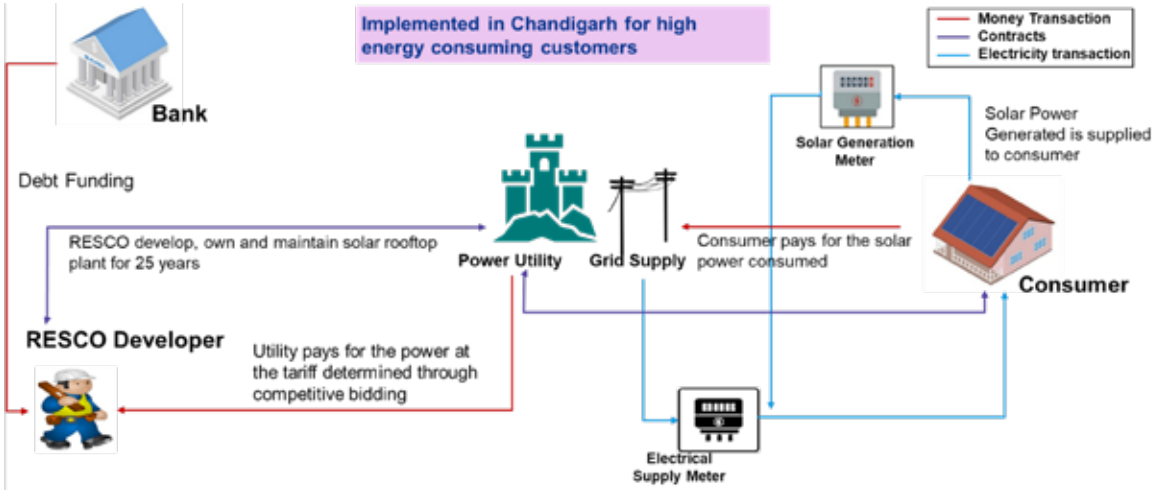


Figure 13: Master RESCO model adopted in Chandigarh, India

Under this model, the utility acts as a developer or selects developers through competitive bidding. The consumer benefits from the reduced tariff and continued reliable power supply while the utility benefits by retaining high-paying consumers, savings in power purchase from power plants, and shifting to a cheaper power source.

ii. **Utility as an aggregator model:** Proposed in the Indian state of Andhra Pradesh, the business model aims to present a win-win situation for both consumers and distribution utility. The figure below illustrates the schematic diagram for the same:

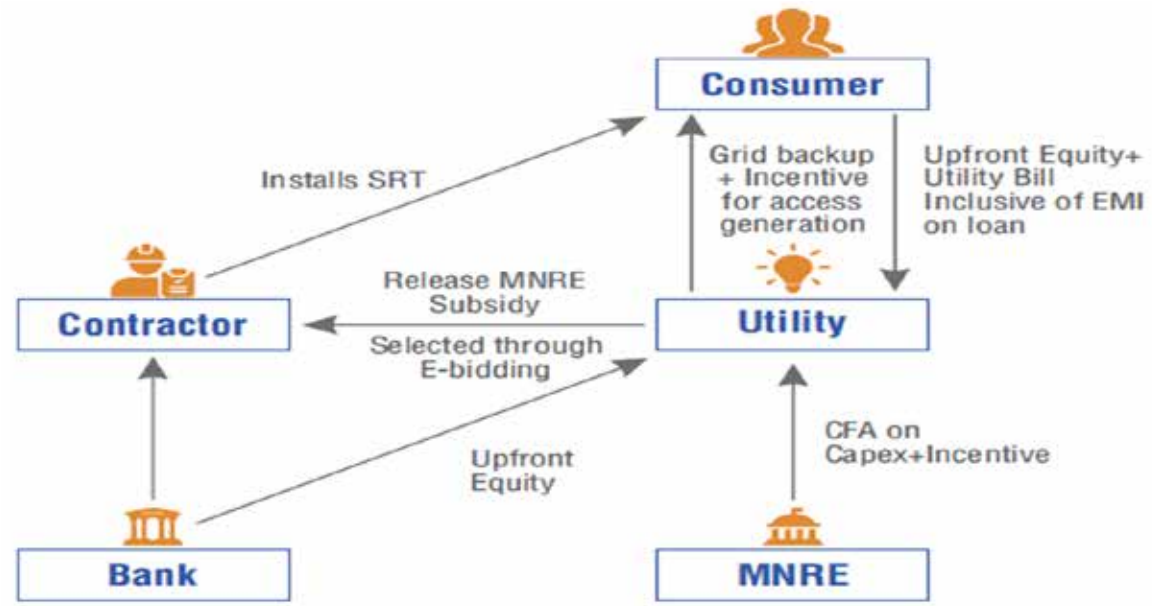
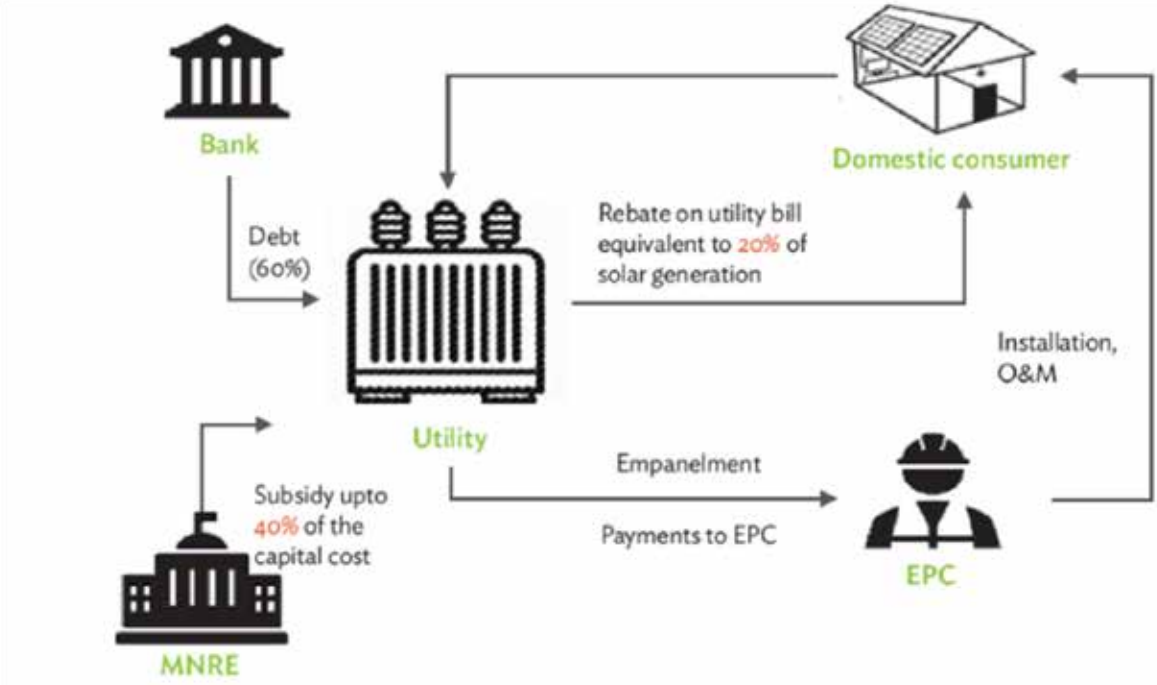


Figure 14: Utility as an aggregator rooftop model adopted in Andhra Pradesh, India[27]

[27] SRT: solar rooftop system, MNRE: Ministry of New and Renewable Energy (Indian Government), CFA: Financial Assistance by Government, EMI: Equated Monthly Installment

Under this model, consumer is the owner of rooftop solar system and distribution utility acts as an aggregator of consumers and facilitate access to debt with the help of empaneled agencies selected through competitive bidding process. The distribution utility further collects monthly bills that includes the equated monthly instalment (EMI) payment and submits the entire amount to the bank, thus mitigating payment defaults.

iii. **Rooftop leasing with Utility investment:** This business model was adopted in the Indian state Kerala under its Soura Program . The figure below illustrates the schematic diagram for the same:



EPC = engineering, procurement, and construction; MNRE = Ministry of New and Renewable Energy; O&M = operations and maintenance.
Source: ADB Solar Rooftop Investment Program Technical Assistance.

Figure 15: Roof leasing with Utility investment model adopted in Kerala, India

In this model, the utility invests in, installs, commissions, and maintains the rooftop solar plant on the consumer's roof under gross- metering arrangement. The consumer receives a rebate on the utility bill in terms of energy credits equivalent to a part of the generation from rooftop solar system.

Digitization is another aspect that is being explored to increase penetration of rooftop solar. One unique tool that has been developed by a startup, Legends Solar, is Legends Rooftop. It is an online, on demand solar investment platform that allows investors to purchase off-site rooftop solar panels as a financial investment anywhere from a single solar panel to an entire array on a remote commercial rooftop. Users can select the number of panels they want to invest in starting from few hundred dollars. The platform tracks performance of the panels and banks the energy savings created by the solar project in the user's account. Additionally, the platform tracks solar production, amount of carbon abated, total cash earned, and dividend payments. Legends Rooftop provides a unique approach to raising equity for new solar facilities by bringing onboard a wider and diverse set of retail investors.

Digitization is another aspect that is being explored to increase penetration of rooftop solar. One unique tool that has been developed by a startup, Legends Solar, is Legends Rooftop.

Key messages:

- Somee countries have come up with unique and tailor-made business models as per the geographic context for facilitating solar investments in rooftop and utility-scale solar projects that ensure mitigation against technical and financial risks, thus creating avenues for more investments from public and private funding institutions
- Financing must be scaled up in the solar sector by taking steps such as creating separate lending categories for solar, having dedicated lines of credit from funding agencies, reducing payment risks by providing additional payment security mechanisms, and identifying off-takers before auctions, etc.
- Solar Energy attracts investments through various sources amongst different business models adopted. However, due to a lack of data exact conclusions cannot be arrived at.

Investment Required in Solar for Meeting Net Zero Targets

Despite the progress made over the decade, the average growth rate of 16% of the solar energy capacity additions in the last five years, driven by the solar investments with an average growth rate of 9%, is inadequate to meet the rate required to achieve our net-zero targets by 2050. Apart from ensuring a quantum jump in the growth of solar capacity, there is also an urgent need to ensure that the growth in solar sectors occurs equitably, especially in reaching regions with the highest levels of energy poverty.[28]

While keeping the global temperature rise below 2^0C is technically feasible, the current trend of emission reductions is far from the path to meeting our climate goals. Being a major contributor with a quarter of the global greenhouse gas emissions, the transition of the power sector to the adoption of clean energy sources is expected to play a key role. To reach climate targets, energy-related emissions have to be reduced by 70% by 2050 compared to current levels. A large-scale move to renewable power may yield 60% of those savings; 75% if renewables for heating and transportation are included; and 90% with increased energy efficiency. Due to immense uncertainty in the future and insufficiency of data, it is challenging to estimate the required investment needs to meet net zero targets by 2050.

This chapter highlights the net-zero pledges which have been driving the energy transition and then presents an analysis of various investment projections based on the multiple scenarios for the energy transition, with a focus on the adoption of renewable energy especially solar energy, to meet net-zero commitments. The analysis provides a broad overview of the investment required for the energy transition in total and underlines the specific requirements for solar energy. An estimate of the investment required for the different applications of solar as well as manufacturing as well as infrastructure augmentation is also given. This forms the basis of the assessment and monitoring of the year-on-year progress made by the countries in solar energy towards their net zero journeys.

[28] IRENA, Global Energy Transformation: A Roadmap to 2050, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf

Tracking Investments to Achieve Net Zero Targets

Besides these challenges, the adverse effects of climate change have become increasingly common, with natural disasters occurring on larger scales and increased frequency. Greenhouse Gas emissions crossed 50 billion tons of CO_2 equivalent in 2019 and has not yet peaked

4.1 Net-zero pledges of countries and corporates driving the energy transition

The world of energy has always been in transition as is witnessed by the progress of technology from manual to electric, from chemical to mechanical, and from fossil fuels to renewable energy.

The past decade has set a strong momentum to transform the energy systems for the decades ahead. ***"Energy transition to a net-zero economy"*** has been a hot topic of discussion for leaders across the globe. Recent developments show a strong interest in energy transition :

01 More than 128 countries and self-governing territories have pledged to achieve the net-zero emissions target, representing at least 83% of the global GHG emissions, 91% of the global GDP, and 80% of the global population.

02 Apart from countries, 702 companies from the Forbes 2000 list have also set their respective target to be carbon neutral or be a net-zero emitter. Most of the companies are headquartered in the United States of America, followed by Japan, the United Kingdom, France, and Germany.

[29] Net-Zero Tracker, Net-Zero Stocktake 2022, June 2022, https://ca1-nzt.edcdn.com/@storage/Net-Zero-Stocktake-Report-2022.pdf?v=1655074300

Key messages:

- **Climate change represents an existential threat to human civilization, highlighting the need for immediate action.**
- **Many countries as well as major corporations have committed to Paris Agreement's long-term goal and have set net-zero targets.**
- **These net-zero targets are expected to play a crucial role as an enabler for mobilizing investments required to fight climate change.**

4.2 Solar investments need to be ramped up in line with overall renewable energy investments to meet net-zero goals

To be on track to achieve net zero emissions targets, large investments in clean energy projects and supporting infrastructure will be required for the energy transition. Adoption of renewable energy, for power generation and hydrogen production, would require a major share of investments. The world has already witnessed a rise in investments reaching a record high of USD 800 billion during 2020-21. The renewable energy segment recorded received investments of USD 446 billion in 2021, out of which USD 220 billion was mobilized for the adoption of solar energy.[30]

However, there is a need for further scaling up the current levels of investment, which has been forecasted by various studies under different scenarios, while aiming at the goal of meeting the net-zero target by mid-century. While different projections and scenarios highlight different investment requirements, one thing in common with all forecasts is the need for substantially ramping up the investment in the adoption of renewable energy for meeting the net-zero transition goals. After 2030, the ramping of the investments has been estimated to gradually slow down or saturate owing to the maturity of the market achieved with a reduction in costs for renewable energy technology. Most of these investments will be drawn for solar and wind technologies as they are expected to meet 90% of the power demand by 2050.[31]

Several long-term energy transition scenarios have predicted terawatt-scale solar installations. The ISA's World Solar Market report describes the forecasted solar capacity additions which shall be required for net zero. To achieve the capacity addition targets, there is substantial need for ramping up of investment flows. As different scenarios assume different parameters for estimating investment flows, there is large variation in the investment projections for the coming years.

While several stakeholders provide forecasts of PV market evolution in the short term, only a limited number of medium to long term forecasts are available. This is a consequence of the fact that longer term forecasts are a much more difficult task. Due to the longer timeframe under scope, those forecasts cannot rely on current market dynamics and foreseeable policy

[30] BNEF, Energy Transition Investment Trends 2022
[31] IRENA, Global Energy Transformation: A Roadmap to 2050,

and regulatory trends. To overcome this challenge, the studies taken into examination use a top-down approach based on climate and energy objectives in the long term 2050.

The long-term analysis includes the academic research from LUT University in Finland and Australia's University of Technology Sydney (UTS), Stanford University, which are among the universities whose energy system modelling groups have studied the transition to 100% renewable energy systems at the global scale. These two studies carry out a cost-optimization modeling based on the objective of achieving 100% renewable energy by 2050, determining cost-efficient pathways to achieve this target.

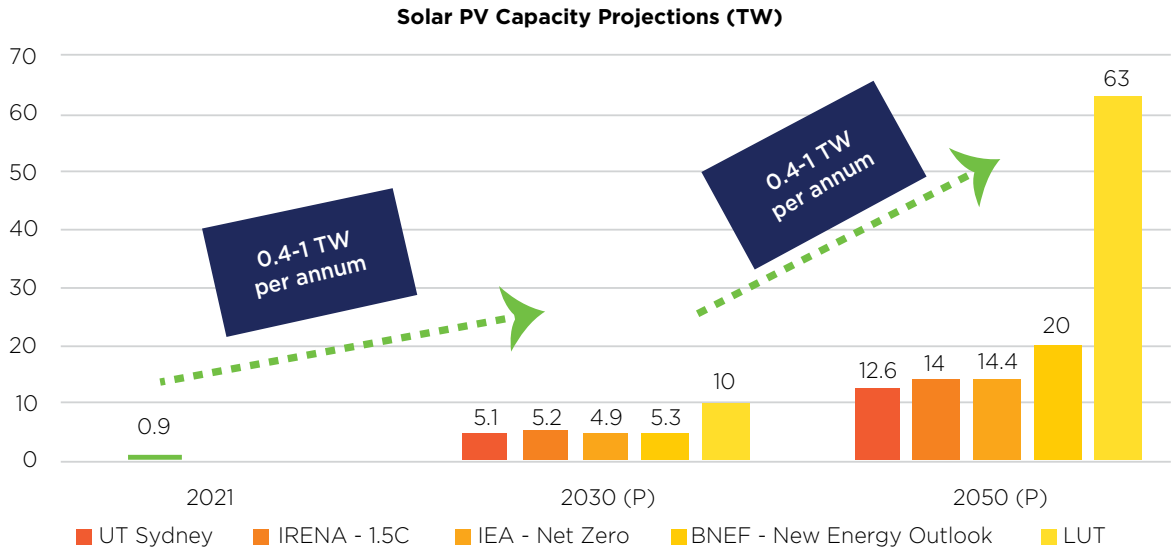
A second group of studies that are included in this assessment comes from other non-academic groups, including intergovernmental organisations International Energy Agency (IEA) and International Renewable Energy Agency (IRENA), and Bloomberg New Energy Finance (BNEF). Differently from the academic papers taken into account, these studies do not model 100% RE energy systems, but have other long-term goals. The IEA Net Zero Emissions by 2050 (NZE) Scenario from the World Energy Outlook 2021 aims to limit GHG emissions to net-zero by 2050, while IRENA's 1.5°C Scenario from the World Energy Transition Outlook 2022 has the objective to comply with the 1.5°C goal from the Paris Agreement.

An analysis for different sources estimating annual solar investments until 2050 are highlighted in the table below:

Organization	Year	Title	Goal	Solar PV capacity projections by 2050 (GW)
University of Technology Sydney (UTS	2019	Achieving the Paris Climate Agreement Goals - Global and Regional 100% Renewable Energy Scenarios with Non-Energy GHG Pathways for +1.5°C and +2°C	100% RE by 2050	12684
IRENA	2022	World Energy Transitions Outlook 2022	Meet Paris Agreement at 1.5°C by 2050	14036
IEA	2021	Net Zero by 2050	Net-zero emissions by 2050	14458
BNEF	2021	New Energy Outlook 2021	Meet Paris Agreement, net-zero emissions by 2050	20000
Stanford University	2022	Low-cost solutions to global warming, air pollution, and energy insecurity for 145 countries	100% RE by 2050	25579
LUT	2021	Low-cost renewable electricity as the key driver of the global energy transition towards sustainability	100% RE by 2050	63377

To realize the target, the annual investment mobilization needs to be scaled up for meeting the capacity addition targets. As in the case of total investment flows, there are large range of annual investment flows projected under different scenarios highlighting an increase from the **current annual investments of USD ~200 billion to as high as USD ~565[32] billion until 2030 and USD ~1 trillion from 2030 to 2050** to meet the annual capacity addition targets. The graph below depicts annual capacity additions requirements under different scenarios.

[32] Annual investments requirements are estimated based on forecasted average capex (utility, residential and commercial and industrial segment) of USD- 565/kWp for the 2022 to 2030 period and USD ~371/kWp for 2030 to 2050 period.



Annual investments in the energy sector in emerging and developing markets have fallen by around 20% since 2016, and face debt and equity costs that are up to seven times higher than in the United States of America or Europe.

As we continue to scale solar deployment across the world and advance towards our net-zero targets, it is imperative to ensure that finance and investment are scaled quickly and distributed equitably among economies. While developed PV markets have been able to easily attract investments due to their favorable environment, emerging markets and developing economies need a push to increase solar investments. Emerging markets face various multifaceted challenges, which compromise the risk-adjusted returns for investors and the availability of bankable solar projects.

These investments will bring major economic and societal benefits, but they require far-reaching efforts to improve the domestic environment for clean energy investment, especially in developing countries – in combination with international efforts to accelerate the inflow of capital.[33] Annual investments in the energy sector in emerging and developing markets have fallen by around 20% since 2016, and face debt and equity costs that are up to seven times higher than in the United States of America or Europe.[34]

[33] IEA, 2021. Financing Clean Energy Transitions in Emerging and Developing Economies. International Energy Agency, World Bank, and World Economic Forum.

[34] https://www.iea.org/news/it-s-time-to-make-clean-energy-investment-in-emerging-and-developing-economies-a-top-global-priority

Apart from the current applications of grid-connected solar energy systems, there is huge potential for the expansion of solar PV applications like mini-grids, standalone systems, solar home systems, and various other off-grid applications like solar desalination.

As solar energy is expected to play a vital role in the journey towards net zero, it would require continuous investment flows in line with meeting the forecasted capacity additions. Increasing demand for solar energy would also require supply-side interventions through scaled-up manufacturing capacities.

Key messages:

- **All projections and scenarios for meeting net zero targets underline the need for substantially ramping up the investment in renewable energy.**
- **As solar and wind energy are expected to meet 90% of the electricity needs by 2050, they shall also draw a majority share of investments and, thus, require similar scaling up to meet our targets.**
- **Solar is expected to play a key role in the energy transition with several long-term energy transition scenarios predicting terawatt-scale solar installations for meeting net-zero targets.**
- **To ensure large-scale adoption of solar energy, the momentum of growth of the investment flows shall be required to be maintained. While different projections provide different estimates for solar investment flows, the total investment flows has been estimated to be increased by 3-times to 18-times for being on track for achieving net-zero.**
- **Apart from the quantum growth in investments, it is also essential to ensure equitable distribution of investments which must be achieved by addressing the challenges faced by the developing and underdeveloped regions.**
- **While major developed regions have achieved maturity in terms of investment for solar PV capacity additions, developing and underdeveloped regions such as the Middle East and Africa and some countries in the Asia and Pacific shall require an overall substantial ramping up of investments.**
- **While the major economic and societal benefits of mobilizing investments are well-known, significant efforts will be required to improve the domestic environment for clean energy investment, especially within developing and underdeveloped economies.**

4.2.1 Investment in off-grid solutions holds the key to ensuring universal energy access in developing and underdeveloped regions

Given that as many as 840 million people around the world still lack access to electricity even today, there is a huge potential for growth, which would require substantial financial investments to accelerate the deployment of off-grid solar solutions for ensuring energy access to all.

As per the World Bank,to achieve universal access, the off-grid solar sector would require between USD ~11 billion between 2020 and 2030. Of this total need, USD 6.1 - 7.7 billion will need to come from investments in off-grid solar companies, and up to USD 3.4 billion represents public subsidies to bridge the affordability gap.[35]

As the sector matures and the productive use of off-grid solar solutions such as solar water pumps, cold storage, and other products servicing public institutions increases, companies are increasingly focused on the financial sustainability of the sector and the need to demonstrate profitability.

Key messages:

- **Off-grid applications shall be a key solution for overcoming the challenge of ensuring universal energy access, especially in developing and underdeveloped regions.**
- **While off-grid solutions are expected to draw investments from solar companies, the success of these solutions would also rely on public subsidies for bridging the viability gap.**

4.2.2Ensuring growth and security of global solar supply chains plays a crucial role in the quest for net-zero

Meeting energy transition goals for global solar deployment would also require substantial investments for expansion of the present manufacturing capacities. As per IEA, the name plate capacity and annual production of solar PV modules stands at ~460 GW and ~190 GW respectively. To keep up with growth in annual solar demand as indicated the section above, the manufacturing capacities would also be required to scaled to as high as ~ 1400 GW to meet annual PV demand during 2022 to 2030 period and to ~3700 GW during 2030 to 2050 period. This would also lead to a significant increase in the annual critical mineral demand for the solar PV industry.

Energy as well as a capital-intensive segment under the solar supply chains, i.e., manufacturing polysilicon, ingots, and wafers is projected to attract the majority of the investment flows. The increase in demand for minerals would also be likely to draw the attention of investors.

The present solar supply chains heavily rely on China for meeting the demand for solar panels. The concentration of the supply chain makes it susceptible to incidents within and outside the control. This has been highlighted by the recent disruptions caused due to the COVID-19 pandemic as well as Russia's invasion of Ukraine. This underlines the need for diversifying the solar supply chain. The ISA's World Solar Technology report provides an analysis of the present solar manufacturing capacities globally and the regional trends.

[35] World Bank, Off-Grid Solar Market Trends Report 2020

Key messages:

- To keep up with ever increasing demand for solar energy, it is vital to ensure the scaling up of present manufacturing capacities.
- Energy and capital-intensive clusters of the solar manufacturing supply chain, i.e., polysilicon as well as ingots and wafer manufacturing are expected to attract the maximum share of the investment.
- Along with scaling up capacities, diversifying the solar supply chains would also help in addressing the bottlenecks due to concentrated supply chains.

According to BNEF, annual investments for grid maintenance is projected to increase year-on-year to USD 636 billion until 2050 to support grid integration of clean energy technologies, 41% of the investments would be utilized for replacements of the present infrastructure; as the present grid infrastructure has continued to age, there is a need to replace the old and inefficient technology with new and efficient technology. This would be closely followed by network reinforcements and new connections holding an average of 38% and 21%, respectively.

4.3 Investments in transmission infrastructure and enhancing regional interconnectivity

While energy system across the world is undergoing a transition, there is also a need to strengthen electricity grids at the same pace as power capacity. With technological advancements and rapid urbanization, the electricity grid infrastructure has witnessed continued expansion. Power plants, power lines, substations, and transformers all communicate and work in tandem to deliver the right amount of energy when and where we need it.

However, with a growing population and advancements in technology, we consume

substantially more electricity than we used to; electricity use today is more than 16-times greater than it was in the 1950s. There is a need to modernize the grid, especially for the integration of variable energy resources.

According to BNEF, annual investments for grid maintenance is projected to increase year-on-year to USD 636 billion until 2050 to support grid integration of clean energy technologies, 41% of the investments would be utilized for replacements of the present infrastructure; as the present grid infrastructure has continued to age, there is a need to replace the old and inefficient technology with new and efficient technology. This would be closely followed by network reinforcements and new connections holding an average of 38% and 21%, respectively. The investment requirements for augmenting T&D infrastructure under other scenarios will be assessed in the upcoming ISA annual investments reports.

The replacement of fossil fuels with renewable energy sources also underlines the need for interconnected regional grids. The interconnected regional grids would also help in addressing the risk associated with intermittency of sources by providing cross-border access through structural and sustainable flexibility on a large perimeter and allowing the flow of power over long distances from a region with excess generation to a region with increased demand. The interconnected grid would be instrumental in achieving the goal of meeting the mitigation targets for emission reduction through increased deployment and trading of renewable energy through resilient and cost-effective infrastructure.

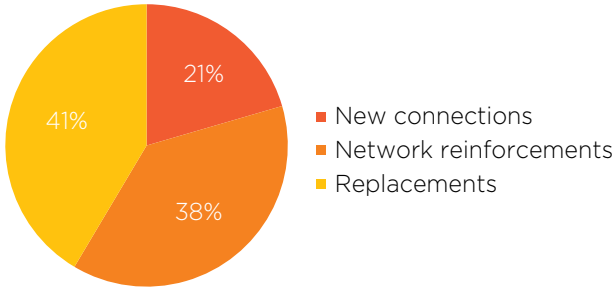


Figure 31: Average split of the annual investment requirements for future grid augmentation
(Source: BNEF)

The GGI-OSOWOG joint initiative, launched by Hon. Prime Minister of India, Shri Narendra Modi, and the, then, Hon'ble Prime Minister of United Kingdom, the Rt Hon. Boris Johnson at COP26 in November 2021 supports the idea of the interconnection of all forms of renewable energy generators, storage, and loads across continents with a trans-continental power transmission grid – *One Grid for One Sun in One World*. The recovery strategies from the shocks observed due to COVID-19 pandemic will present opportunities for it to become greener and more resilient. The GGI-OSOWOG initiative can catalyze investments in sustainable energy solutions, expand energy access, among its other socio-economic impacts.

Key messages:

- **Investing in infrastructure developments must be aligned with long-term plans and reflective of broader strategies, including regional market integration as an electricity grid is an integral part and a key enabler of the energy transition. This is particularly important in the coming decade as the share of renewables as well as the demand grows, requiring system flexibility and modern interconnected, efficient, and reliant grids.**

4.4 New and innovative solar applications expected to attract huge investments

While solar applications are currently restricted to mostly electricity generation, synergies of the solar energy sector with other areas cannot be overlooked as it is expected to play a crucial role in the path towards net zero. From utilization in various end-use sectors to supplying clean energy for charging electric vehicles to producing hydrogen fuel, there are various applications for ensuring effective utilization of solar energy. These applications would require a large amount of investments to ensure large-scale adoption as well as cost reductions, which will further boost investment and cost reductions in solar itself. Thus, we must forecast and plan for the growth and cost reductions in both solar itself as well as innovative applications like green hydrogen and electric mobility.

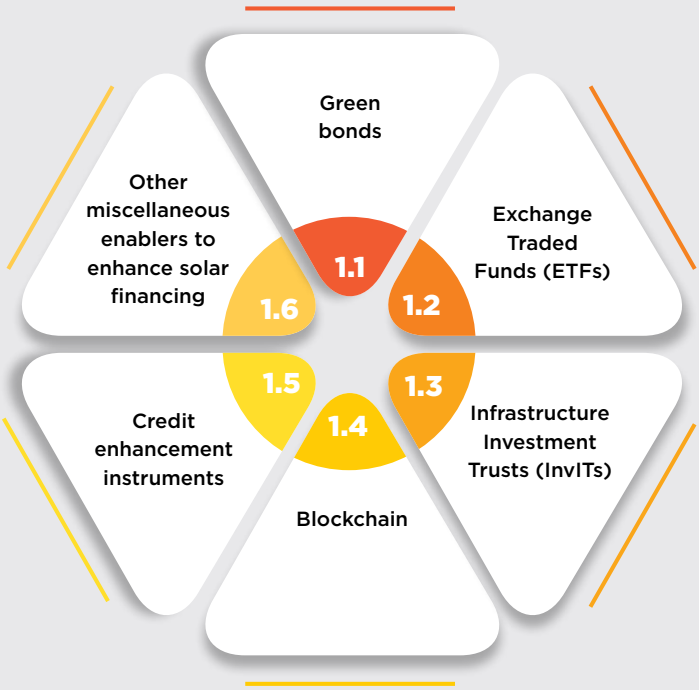
Key messages:

- **Solar energy is expected to play a crucial role as an enabler for ensuring clean energy transition across sectors through various innovative applications, especially in the end-use sector as well as the growing hydrogen and electric mobility sectors.**

Innovative tools and Enablers to Accelerate Solar Financing

Financial innovation can play a key role in accelerated growth of renewables across the globe. As traditional ways of financing renewable energy projects, especially in developing and underdeveloped countries, face multiple challenges such as small ticket sizes, lack of creditworthiness of consumers, less bankable sovereigns, etc., development of a wide suite of innovative tools shall allow for easier mobilization of finance.

Investors wishing to address climate change and support solar penetration are increasingly turning their attention to innovative and sustainable finance options. Some of the innovative tools and enablers for financing solar that will be discussed in the subsequent sections are given below:



5.1 Green bonds have shown a record growth of 71% over 2020 and have the potential to channel additional capital in Solar

Green bonds are fixed income instruments or debt securities that are earmarked to raise money for environmentally beneficial projects and encourage sustainability. These bonds help bridge the gap between capital providers and green assets by providing issuers access to long-term capital and investors with greater visibility over the usage of funds. Over time, green bond market has attracted a diversified and more mainstream investor base with large portfolios including those with sustainability-related mandates and are increasingly seeking green and low-carbon investment opportunities.

Growth witnessed in green bonds market

The first ever green bonds were issued by the multilateral financing agencies -European Investment Bank (EIB) in 2007[36] followed by The World Bank (WB) in 2008[37] to support lending for eligible projects that seek to mitigate climate change or help affected people adapt to it. The green bond by EIB issued in July 2007 allocated EUR 600 million to 14 renewable energy and energy efficiency projects[38]. Over the last decade, issuance of green bonds has increased exponentially, reaching a value of more than USD 500 billion worldwide in 2021 alone and USD 1.6 trillion cumulatively since its market inception in 2007, thus becoming a key instrument to hedge climate change[39]. While Europe accounted for more than 50% of the global green bond issuances in 2021 followed by Asia-Pacific. In terms of country, United States maintained its lead in issuing green bonds with a total value of USD 82 billion in 2021 followed by China.[40] Also, while the US dollar and Euro were the top two currencies of issuances, green bonds are now issued in over 30 currencies[41].

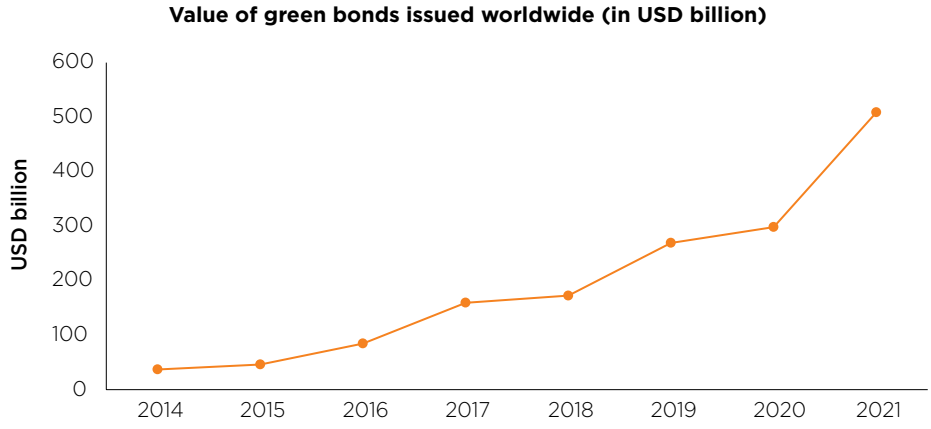


Figure 32: Growth in value of green bonds worldwide

[36] https://www.climatebonds.net/market/explaining-green-bonds
[37] https://treasury.worldbank.org/en/about/unit/treasury/ibrd/ibrd-green-bonds
[38] Renewable Energy Finance Green Bonds, IRENA, January 2020
[39] https://www.statista.com/topics/9217/green-bonds-market-worldwide
[40] https://www.statista.com/topics/9217/green-bonds-market-worldwide
[41] Renewable Energy Finance Green Bonds, IRENA, January 2020
[42] Statista

Corporates taking the lead in green bond issuance

Over the years, many private and public institutions including governments, government agencies, big corporations, and financial institutions have issued green bonds and outpaced multilateral funding agencies that used to drive the market earlier. In 2021, corporations contributed to 43% of global green bond issuances by value[42]. The figures below provide the trends of green bond issuances region wise and share of institutions in 2021 respectively. However, for new markets, multilateral funding agencies remain important. For instance, African Development Bank issued around 80% of outstanding green bonds in Africa in 2019[43].

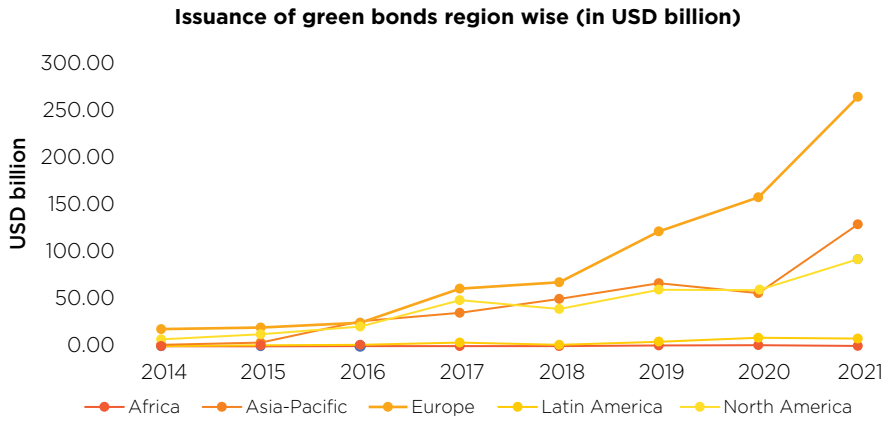


Figure 33: Issuance of green bonds region wise
(Source: Statista)

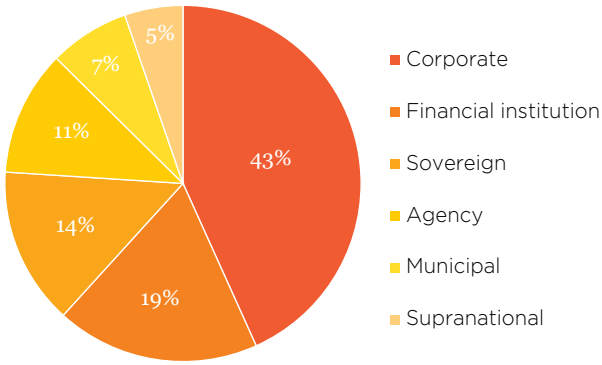


Figure 34: Issuance of green bonds by the type of Issuer, 2021
(Source: Statista)

Renewable projects attract majority of use of proceeds of green bonds

Most green bonds finance multiple categories such as renewable energy, energy efficiency, clean transportation, etc. As per an IRENA analysis, out of the 4,557 green bonds issued between 2007 and 2019, USD 461 billion (around 56%) of the total amount had renewable energy as one of the use of proceeds categories and 350 green bonds with total value of USD 127 billion (around 16%) were earmarked solely for renewable energy projects[44]. In the period 2010-2019, renewable energy dominated the green bonds market while accounting for 23% of the proceeds being directed to it followed by energy efficiency projects[45].

[44] Global Landscape of Renewable Energy Finance 2020, IRENA
[45] Global Landscape of Renewable Energy Finance 2020, IRENA
[43] Renewable Energy Finance Green Bonds, IRENA, January 2020

Green bond issuances by use of proceeds, by cumulative volume, 2010-2019

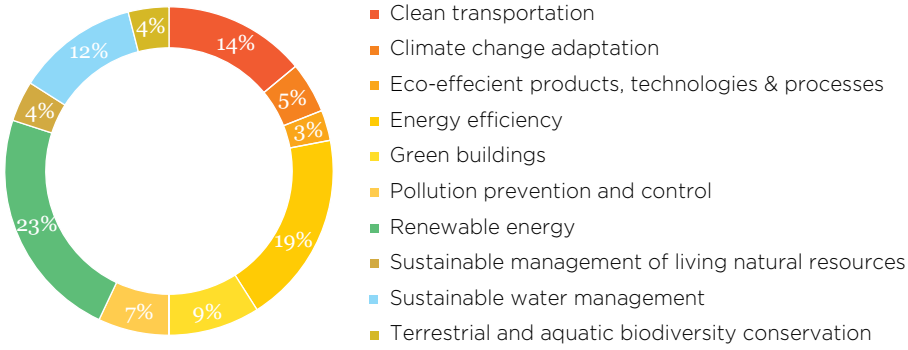


Figure 35: Share of green bond issuances between 2010 and 2019 by use of proceeds *(Source: IRENA)*

Green bonds can mobilize investments from institutional investors

Majority of the green bonds are used for re-financing existing assets rather than funding new assets. Also, green bonds dedicated to renewable energy have large ticket size as compared to other green bonds. For instance, average size of green bonds issued in the 2007-2019 period was USD 180 million whereas that of green bonds dedicated to renewables had an average issuance size of USD 364 million (analyzed by IRENA). This makes renewables-dedicated green bonds particularly attractive to investors, like institutional investors, who prefer larger transactions. Moreover, by investing in renewables-dedicated green bonds, these investors can lower their investment risks by gaining access to a diversified portfolio of already operating renewable energy assets.

Advantages and disadvantages offered by green bonds

Investing in green bonds provide a way for the corporates and institutions to signal their green energy commitments and provide adequate financial returns. Also, green bonds help investors to diversify their portfolios in green energy which otherwise might have been difficult to invest owing to various policy regulatory challenges, associated risks with RE investments, etc. With comparatively lower interest rates, they often come with tax incentives, making it a more attractive investment tool.

One disadvantage of green bonds is that at times issuers can resort to greenwashing and use the proceeds from such bonds for funding projects which may be not aligned with green goals. The box item below explains the concept of greenwashing in detail.

For instance, average size of green bonds issued in the 2007-2019 period was USD 180 million whereas that of green bonds dedicated to renewables had an average issuance size of USD 364 million (analyzed by IRENA).

Greenwashing could hamper the growth of clean energy

Greenwashing means companies or countries giving the false impression of being environmentally conscious, in order to deceive its various stakeholders. It is the practice of channeling proceeds from green bonds towards projects or activities having negligible or negative environmental benefits.

In the energy sector, certain energy providers lie about the source of energy that is being marketed as 100% green energy. In such cases, energy might be generated form the conventional sources and these generators buy certificates to comply with their renewable energy targets.

With respect to green bonds, greenwashing has been witnessed in quite a few cases. One example is of China which is the world's largest emitter of greenhouse gases and second largest green bond issuer (as per 2020 data on Statista). The country faces criticism for using green bonds to finance coal-burning power plants. Although these power plants were installed with new greener facilities, they still emit excessive levels of greenhouse gases.

Such instances make greenwashing a huge challenge in trusting the companies with using the proceeds from green bonds and increased reporting by companies of usage of proceeds will help in better utilization of green bonds and strengthening the green bond market for increasing investments in clean energy.

Sustainable Linked Bonds (SLBs) – Time to investigate and assess their real purpose

Unlike most green bonds and green loans, sustainability-linked finance can be used for general corporate purposes rather than a discrete project and doesn't require details of use of proceeds at the time of borrowing. It is up to the borrowing company to work out how to utilize the funds to achieve a set of agreed sustainability targets.

As per BNEF research, more than 100 SLBs worth almost euro 70 billion that were sold by global companies to investors in Europe—the most mature market for sustainable finance products. It wasfound that the majority are tied to climate targets that are weak, irrelevant, or even already achieved. Companies are getting something for nothing. Cheaper financing and an enhanced green reputation come without any real effort to deliver on climate goals and no chance of financial penalty.

Another disadvantage is that these bonds usually come with a maturity period of 10-15 years whereas green projects might require more time to show returns, hence resulting in failure to provide liquidity to some investors. Moreover, developers with lack of creditworthiness might find it difficult to issue bonds at lower rates.

Also, there is lack of regulation in the green bond market. Even as increased regulation is brought in, there is still uncertainty as to what the standards are for various green terminologies, and that sort of uncertainty is fertile ground for unethical usage of proceeds from green bonds.

Despite these issues, green bonds are a great tool to raise capital at cheaper rates and has huge potential to address climate transition challenges.

[46] Statista

Green Masala bond is addressing climate financing challenges in India

Indian Rupee denominated bonds, called masala bonds, are debt instruments that were introduced in 2014 with an objective to fund infrastructure projects internationalize Indian rupee, and ignite internal growth through borrowings. These bonds are issued in international capital markets by Indian entities, both private and public. Foreign investors who want to invest in Indian assets can subscribe to these bonds.

The first masala bond was issued by the World Bank-backed IFC in November 2014 through which INR 1billion were raised to fund infrastructure projects in India. Later in 2015, green masala bond was introduced that was issued on London Stock Exchange and raised INR 3.15 billion to be used by private sector for addressing climate change in India. These masala bonds are attracting significant interests from power developers as they enable developers to access international capital, reduce cost of debt by accessing foreign loans with no hedging requirement, and reduce exposure with Indian lenders. In August 2016, NTPC issued first corporate green masala bond worth INR 2,000 crore at ,.

Key messages:

- **As green bonds are suited for a variety of investors, they provide access to a wider pool of capital required for mitigating impacts of climate change. With public and private investors embracing social responsibility, popularity of green bonds can channel substantial capital in renewable energy.**
- **Green bonds are particularly important for mobilizing institutional investors because they manage about USD 87 trillion of assets and still do not contribute significantly to clean energy transition projects. Also, such institutions have indicated strong preference for indirect investments in RE assets through funds or bonds.**
- **Companies must be obligated to disclose the use of proceeds from green bonds to ensure there is no greenwashing happening and capital is put to correct use.**

5.2 Solar Exchange-Traded Funds have become an attractive asset showing strong returns

An exchange-traded fund (ETF) is a type of pooled investment marketable security that shares characteristic features of both mutual funds and stocks. It can contain all types of investments including stocks, commodities, or bonds. It is a type of fund that holds multiple assets that diversify the risks for investors. An ETF can be structured to track anything from the price of an individual commodity to a large and diverse collection of securities to specific investment strategies. Its price fluctuates throughout the trading day as it is bought and sold, and it tends to be cost effective.

Advantages and disadvantages offered by ETFs

ETFs are easily tradable throughout the day, provide transparency as they are listed, and provide access to multiple stocks/bonds across industries in the form of diversified pool of securities. While providing

risk diversification for investors, they usually come with low expense ratios and fewer broker commissions. They also come with tax benefits and are considered less risky compared to stocks and mutual funds as most of them are passively managed i.e., replicate the performance of a broader index – either a diversified index such as the S&P 500 or a more specific targeted sector or trend.

One disadvantage of ETFs is that ETF companies listed on the stock exchange are subject to price fluctuations as per market trends and earning a profit or incurring a loss depends heavily on stock market conditions. Moreover, the actively managed ETFs, wherein portfolio managers are more involved in buying and selling shares of companies and changing the holdings within the fund, attract higher expense ratio.

Growth witnessed in ETF market

ETFs were first developed in 1990s in the USA with an aim to provide access to passive, indexed funds to individual investors. The first ever ETF is credited to the SPDR S&P 500 ETF (SPY) launched by the State Street Global Advisors in 1993. Since then, ETF market has shown tremendous growth. They are now used by all types of investors and traders across the world and represent everything from broad market indices to niche sectors to alternative asset classes. From one fund in 1993, ETF market has grown to have 8,552 ETFs by the end of 2021 with assets of total value USD 10.02 trillion.

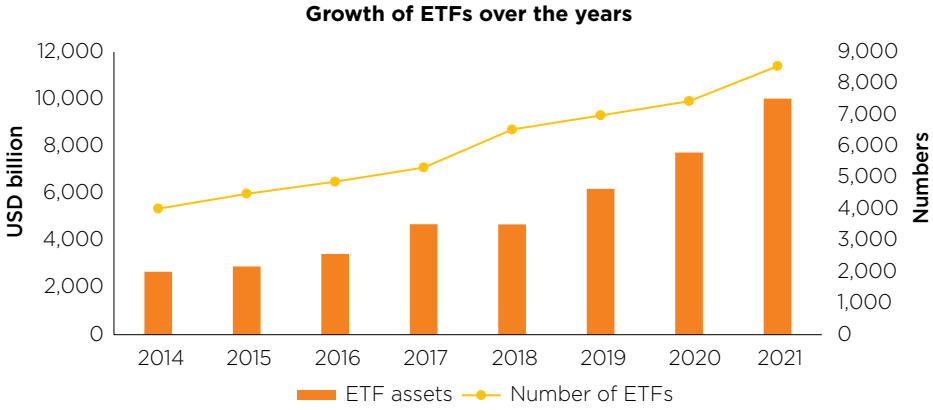


Figure 36: Growth of ETF market over the years
(Source: Statista)

Clean energy ETFs and solar energy ETFs are gaining momentum

Clean energy ETFs invest in stocks in the alternative energy sector, which might include solar energy, wind, hydroelectric and geothermal companies and can diversify an investor's portfolio. Solar energy ETFs on the other hand provide investors access to investments in the solar power industry. Though there are only 2 ETFs particularly dedicated to solar industry as on date, solar energy equities are part of the holdings of several broader renewable energy or clean energy ETFs. The top performing clean energy ETFs are listed below along with their total market value i.e., assets under management (AUM) value.

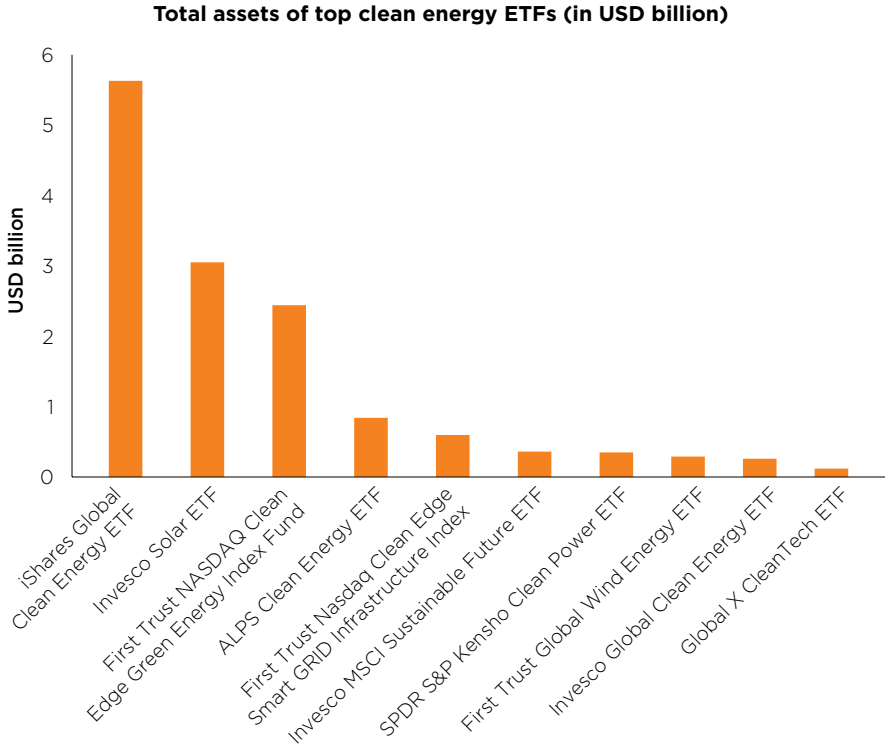


Figure 37: Total AUM value of top alternate energy ETFs as on 20.09.2022
(Source: etfdb.com)

Invesco Solar ETF has shown tremendous growth over the past 5 years

The first Solar ETF, Invesco Solar ETF, was introduced on April 15, 2008, by Invesco and aims to mirror the MAC Global Solar Energy Index. The index is comprised of a variety of companies engaged in the solar power industry, including companies that manufacture parts for solar power equipment, companies engaged in the installation or infrastructure of providing solar energy, and companies that market solar energy to power companies and the public.

Symbolized as TAN, the ETF delivers targeted exposure to solar sector. There are 35 individual components, including both U.S. and international stocks, in TAN. Its hyper-targeted focus makes it for those investing in the solar power space. Priced at USD 81.66 as on 20th September 2022, it has nearly USD 3.05 billion worth of total assets under management and an expense ratio of 0.69%. The figure below highlights the performance of TAN.

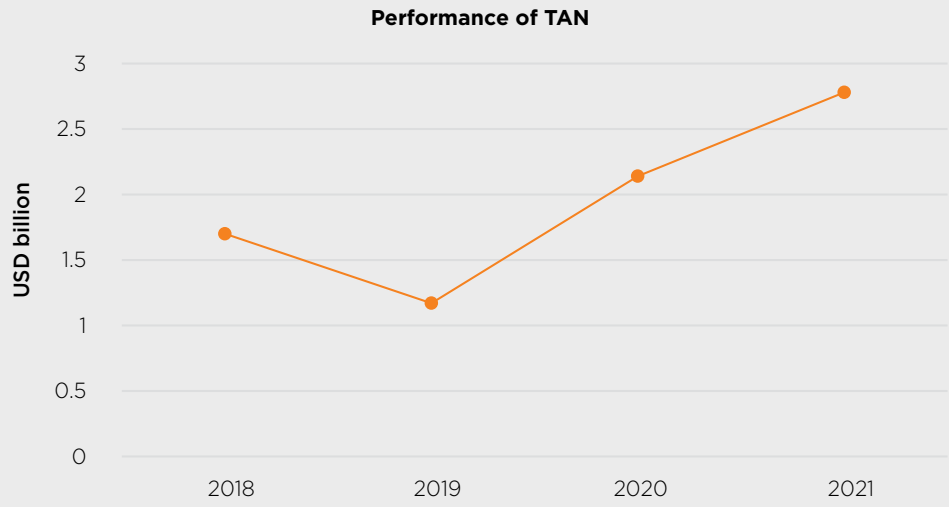


Figure 38: Performance of TAN over different time periods
(Source: etfdb.com)

With countries increasingly focusing towards solar, the ETF is expected to further grow in volumes and asset value.

Key messages:

- **ETFs are a great tool for investors to diversify their portfolio as they are simple marketable tools and can either be used for long term investment purposes or short-term market timed investment strategies at relatively low cost without actually investing and managing the assets.**
- **Though there are only 2 solar ETFs in the market, many solar energy equities are contained in the portfolios of broader-based renewable energy ETFs.**

5.3 Market of yieldcos is gaining momentum after a bubble burst and are gaining popularity as InvITs

Yield companies (yieldcos) are an emerging asset class of publicly traded renewable energy companies that raise funds for RE project development. A yieldco is an entity that is a subsidiary of its parent company and is formed to own only operating assets of its parent company, such as solar or wind farms under operation, and raise funds by issuing shares to its investors with a promise of predictable, low risk dividends. The cash flows obtained from raising the equity is used to finance new assets that are eventually sold to yieldcos once operational, effectively creating a sort of revolving credit facility which can be cheaper than through project financing.
The operating energy plants under yieldcos are mainly tied up with utility companies in long term, fixed fee PPAs that create stable cash flows over the years, implying steady dividends for investors. Yieldcos are also known as Infrastructure Investment Trust (InvITs).

Yieldcos/InvITs have seen their fair share of ups and downs

Yieldcos first came into existence in 2013 in the USA, with developers such as NextEra, SunEdison, etc. leading the way. From July 2013 to June 2015, seven yieldcos in USA were listed

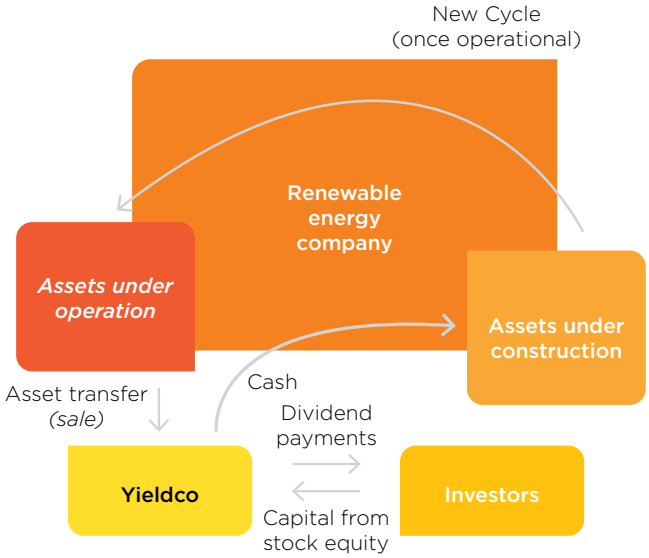


Figure 39: Illustration of flow of yieldco cycle

and the structure was well received by the investors as the companies raised over USD 3.5 billion. These companies hit historical peak valuations in very short timeline. Thereafter the yieldco bubble burst was observed in 2015 when these companies lost 55% of their market capitalization between July 2015 and February 2016 and the market went on a downward spiral, primarily because of the bankruptcy of SunEdison[47].

The yieldco burst was followed by restructuring within the companies and over the years the remaining companies have become more stable and mature with increasing share prices and have been gaining investor interest. Yieldcos are now known as InvITs. The figure below shows the major InvITs in the climate index along with their price trends over a period of 5 years.

When compared to S&P 500 which the most commonly followed equity indices tracking the stock performance of 500 large companies listed on stock exchanges in the United States, TAN has performed exceptionally well with a growth of ~200% in last five years, while S&P 500 index has seen a growth of ~40%, as shown in the figure below.

[47] www.stern.nyu.edu/sites/default/files/assets/documents/Mitidieri_Glucksman%20Paper_final_200526.pdf

Figure 40: Price trends of major yieldcos/InvITs in climate change (as on 20th September 2022)
(Source: Google finance)

Advantages and disadvantages of yieldcos/InvITs

They provide high dividend yields to investors and offer potential for dividend growth by acquiring new cash flow generating assets. They avoid riskier aspects of investing in renewable energy projects as they comprise of fully developed assets that generate stable cash flows, ensuring less volatility.

One key risk associated with InvITs is that the if they try to grow too fast in a short time span and take on large amounts of debt. Also, since the model derives growth from debt and equity markets, its success depends on market sentiments. For instance, low share prices can result in a lack of growth capital needed to acquire its sponsor's assets and grow their dividends at rates investors expect.

InvITs market in India

India has been witnessing huge investments in clean energy sector. Securities and Exchange Board of India (SEBI) saw the opportunity for InvITs to manage operative assets while raising capital for new projects and issued regulations for India's own InvITs. The box item below provides an overview of the same.

InvITs provide an attractive avenue for IPPs to monetize operational projects

Regulated by SEBI, InvITs are investment instruments just like mutual funds that pool money from investors into a single trust. In return, investors get regular dividends as 90% of the net cashflows must be directed to unitholders. While public InvITs must invest at least 80% of its value in completed and revenue generating projects, private InvITs can have any mix of under construction and completed infrastructure projects.

An InvIT allows IPPs to raise money from multiple retail and institutional investors and the freed-up capital can be used to pay off other debts, and/or invested in building new projects or acquisitions. Institutional investors see InvITs as a low-risk instrument and the best tax neutral way of investing in a diversified and defined pool of infrastructure projects that give regular cash returns.

Currently, Virescent Renewable Energy Trust is the only renewable InvIT in India and has raised INR 650 crores through a domestic bond issuance. The proceeds will be utilized to fund its immediate acquisition related debt requirements as it will scale up its portfolio from existing 450 MW of operational solar projects.

Key messages:

- **The structure of yieldco/InvIT provides access to high return, low risk secutries**
- **Since InvITs provide stable cash flows over time, they can mobilize funds from institutional investors as such investors are inclined to invest in operating assets that provide stable returns.**

5.4 Blockchain technology can be a game changer for the distributed solar segment

Blockchain technology can help in managing all transaction related data in a secure, efficient, and transparent manner. Blockchains are essentially immutable digital ledgers that can be used to securely record all transactions taking place on a given network. Once data is sealed within a block it cannot be changed retroactively. The technology enables decentralized communication and co-ordination by building infrastructure to allow peers to safely, cheaply, and quickly connect with each other without a centralized intermediary.

Complexity in power sector has been increasing because of greater capacity additions year on year, both renewable and nonrenewable, to meet the growing energy demands. The highly centralized market structure and regulatory environment make power a very suitable sector for blockchain technology with minimal transaction fees and faster payment processing. With smart contracts (digital contracts that are programed to self-execute upon fulfilment of certain conditions) consumers can buy and sell electricity without involving an intermediary, thus saving on commissions. Also, with the help of blockchain technology, distributed renewable energy producers (e.g., rooftop solar) can be awarded renewable energy certificates in real time as their power is generated.

Table 3: Challenges of solar financing that blockchain can solve

Use case	Description	Blockchain's application
Mismatch in capital supply and developers' needs	• Need for early-stage risk capital is mismatched with investors' risk appetite.	• Standardizes performance and financial metrics for investors to holistically assess the performance of different projects. • Automates matchmaking of investors and developers based on a pre-determined risk appetite to save parties time in negotiation
High investment costs	• Costly to source bankable projects, particularly in hard-to-reach markets with limited foreign presence. • High transaction costs in legal fees and third-party commissions for sourcing, due diligence, etc.	• Digitizes the deal flow process and minimizes intermediaries required for transparent and traceable transactions. • Enables investors and developers to view a partners' rating and historical performance to make informed decisions. • Automates matchmaking of investors and developers based on set criteria.
Complex frameworks and standards	• Lack of standardized rules and processes, information disclosure standards, and certifications makes it difficult for parties to collaborate.	• Establishes standardized processes and information requirements for due diligence, investment and development metrics, and performance tracking.
Lack of bankable energy projects	• Lack of bankable projects due to poorly drafted power purchase agreements and lack of standardized due diligence and investment frameworks.	• Digital power purchase agreements that standardize term agreements and eliminate the need for complex legal paperwork.

Proven uses of blockchain in energy sector

Sun Exchange, *based in South Africa, is using a blockchain-based micro-leasing marketplace to democratize renewable energy financing through crowdfunding. It is the world's first peer to peer solar panel leasing platform that enables people and businesses all over the world to earn while making a positive impact.*

Through SunExchange anyone, anywhere in the world, can own solar energy-producing cells and build wealth by leasing those cells to power businesses and organizations in emerging markets, with installations and maintenance taken care of by one of Sun Exchange's carefully selected installation partners.

The process starts with SunExchange identifying schools, businesses, and organizations that want to go solar, followed by conducting economic and technical feasibility. Thereafter a crowd sale for the solar cells is organized that will power the project. Through this crowd sale, any individual or organization, anywhere in the world, can sign up to be a Sun Exchange member and buy solar cells, even starting with a single solar cell. Once the cells are sold out, installation of solar projects begin by the appointed local construction partners which typically takes four to six weeks but can be longer for larger projects. Once the generation begins, schools, businesses and organizations that have got the installations pay the cell owners for using the clean energy generated from the cells, and the investors receive monthly income into their SunExchange wallet. By April 2022, Sun Exchange had enabled more than 40 solar projects.

Blockchain technology also offers solutions to make power PPAs more efficient and transparent. Smart contracts on a blockchain-based marketplace can enable transparent transactions between power producers, purchasers, and investors on a common shared ledger. For instance, Mojo Power in Australia uses a blockchain platform to facilitate PPAs for solar PV retail at a competitive rate and with full transparency.

OneWattSolar, *the Nigerian Cleantech startup, is a fin-tech energy blockchain ecosystem that uses crypto-currency-based crowdfunding to fund the installation of solar energy infrastructure for private property owners on a lease to buy basis. Using an innovative energy-as-a-service model, OneWattSolar pays for, installs, owns and operates Solar Rooftop Energy Unit, thereby enabling energy consumers to access solar energy with zero up-front investment, no out of pocket expenses and 24/7 access to electricity while the consumers pay monthly for the energy consumed. In the year 2021, OneWattSolar raised a total funding of USD 7.3 million*

Key messages:

- **Blockchain platforms can reduce friction and allow complex marketplace interactions to scale without compromising trust, thus contributing to low-carbon power generation. Smart contracts enabled by blockchain offer several efficient, effective and affordable solutions to help transform the power sector**

5.5 Credit enhancement instruments have the potential to mitigate risks and pump in additional capital

Bringing a project to financial closure requires all risks of a project to be allocated, mitigated, or transferred. This is no less true for renewable energy projects. Yet for projects in emerging countries, the main "residual" risks that few investors are able or willing to take are often related to the country itself. The buyer of the power may not be creditworthy, there is a risk that the legal and tax environment will change over time, or a new government may want to change the tariffs, among others. Credit enhancement instruments provide higher safety from payment defaults and other risks.

A brief overview of some of the credit enhancement instruments is provided below:

a) **Letter of Credit (LC):** It is a standard document offered by banks guaranteeing the project developers of payments of a specified part as decided at the time of signing PPAs. LCs can be invoked in case of counter parties defaulting on payments. Usually, LCs have a term of 12 months and are reviewed yearly for making any changes.

b) **Government Guarantees:** Government issue guarantees for renewable energy projects to mitigate currency, regulatory, and power offtaker risk, enabling financing. Typically issued by the treasury or ministry of finance, government guarantees are often required by investors and lenders for projects in developing countries. Particularly commercial lenders may require a government guarantee when they are not confident about the project's financial viability without government backing.

c) **Political Risk Insurance:** Investors are highly sensitive to the potential impact of political risk, especially in countries with an unstable political system or inadequate rule of law, making the transfer of such risks essential. Political risk insurances are typically issued by public finance institutions and can provide a broad coverage of risks related to government action. Such insurances can also be used to address policy and offtaker risks.

d) **Partial Credit Guarantee:** Provided by development institutions, partial credit guarantee can cover part of the debt service default by the borrower regardless of the cause of default for a specific period of the debt term for a public investment. It can cover a wider range of risks including currency risks and technology risks in small and medium sized renewable energy companies to enhance their credit. In addition, partial credit guarantees can be used to reduce power off-taker risk in developing countries by enhancing public utility creditworthiness.

e) **Partial Risk Guarantee:** Provided by development institutions, this instrument covers a wide range of political risks including transmission line and grid interconnection risk because such infrastructure systems are often owned by government entities. Depending on the specific coverage on the contractual agreements, a partial risk guarantee can also be used to mitigate policy and regulatory risks. Moreover, the guarantee can be used to back up a government commitment in the early stages of power sector reform to ensure reliable and timely enforcement of the measures required for the reform.

The figure below highlights the structure and key features of partial risk guarantee provided by the Asian Development Bank (ADB)

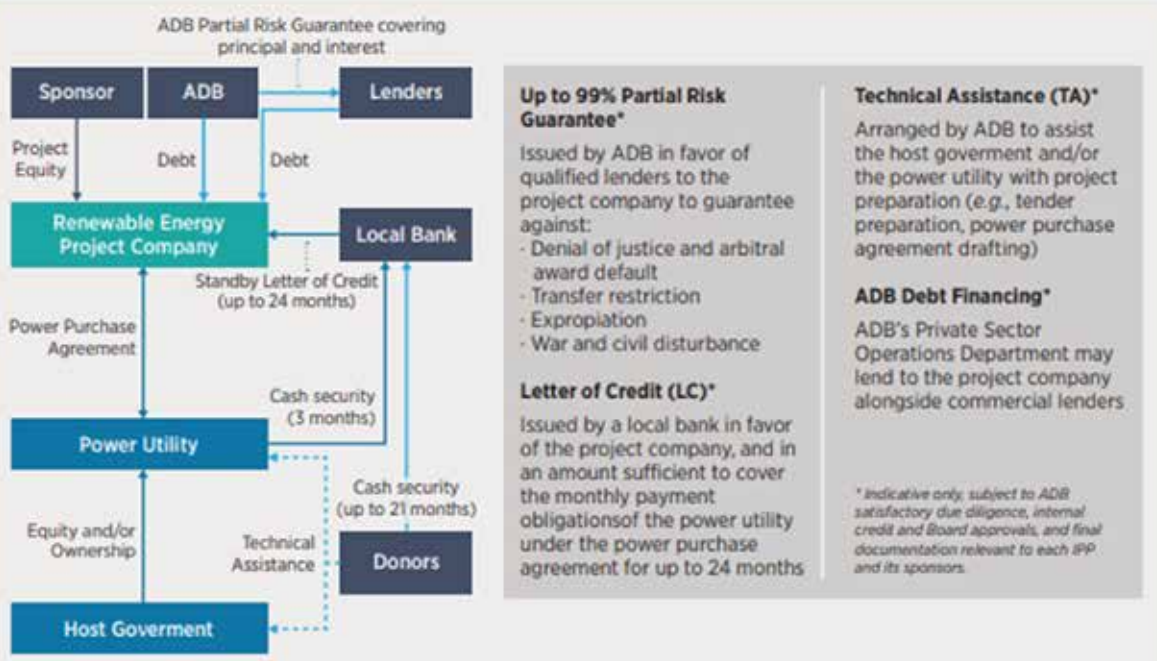


Figure 10: Structure of the ADB's Pacific Renewable Energy Program

Key messages:

- **Credit enhancement instruments can provide the initial critical support for investment in renewable energy projects in developing and underdeveloped countries by mitigating the risk, enhancing asset's credit quality, reducing cost and increasing investor confidence**

5.6 Other enablers to enhance renewable energy financing

In addition to the innovative tools mentioned above to finance renewable energy projects across the world, there are some other dedicated bodies that work towards increasing renewable energy investments in a focused manner.

5.6.1 Dedicated Financial Institutions (FIs) provide a focused approach to increasing uptake of renewable energy projects

With the increased focus on clean energy transition, certain countries have formed dedicated organizations that look after financing and development of renewable energy projects.

In India, the public sector undertakings () that look after growth of RE sector are SECI and IREDA. Both these organizations are under the administrative control of Ministry of New and Renewable Energy (MNRE), Government of India. A brief overview of each is given below:

Indian Renewable Energy Development Agency Limited (IREDA): Founded in 1987, IREDA promotes, develops, and extends financial assistance for renewable energy and energy efficiency/ conservation projects in India. For development of solar parks, it also acts as implementing agency in certain cases and is responsible for disbursement of financial assistance to solar park developers.

Solar Energy Corporation of India (SECI): Founded in 2011, SECI is the only government company dedicated to solar energy sector and was established to facilitate the implementation of National Solar Mission, the aim of which is to establish India as a global leader in solar energy by creating an enabling policy framework for deploying 100 GW of solar projects by 2022.

Similarly, in Brazil, **Energy Research Office (EPE)** was founded in 2004 with an aim to support the Brazilian Ministry of Mines and Energy (MME) with research on energy planning covering electricity, oil, natural gas and its derivatives and biofuels covering cover the areas of engineering, economics, modeling, policy and environment and where they overlap. It's a 100% state owned entity whose purpose is to ensure sustainable development of the country's energy infrastructure.

Apart from such dedicated organizations, there are several dedicated green banks emerging in several countries that facilitate flow of low-cost capital into clean energy sector. Some examples include Clean Energy Finance Corporation of Australia, NY Green Bank and Connecticut Green Bank in USA, Triodos Bank in United Kingdom, etc. among others.

5.6.2 Dedicated climate funds provide huge grants for facilitating clean energy transition

There has been a proliferation in the number of climate funds that have been established to support countries with their climate change mitigation and adaptation actions, as well as readiness activities. These funds have been created by various public and private institutions including multilateral and bilateral financing institutions, banks, etc. The box item below provides an overview of the largest climate fund, the Green Climate Fund (GCF).

GCF achieves a new milestone with USD 10 billion dollars of approved funding

Green Climate Fund (GCF) is a unique global platform that was established by the governments of 194 countries to respond to climate change and to help vulnerable societies adapt to the unavoidable impacts of climate change. Created by the United Nations Framework Convention on Climate Change (UNFCCC) in 2015. The fund aims to dedicatedly help developing countries shift to low emission and climate resilient development pathways. GCF has reached an important milestone of approving total funding worth of USD 10.8 billion spread over for 200 projects in 128 countries[1]. The figures below highlight the total investments done in energy access and power generation projects and investments done solely for solar projects by GCF.

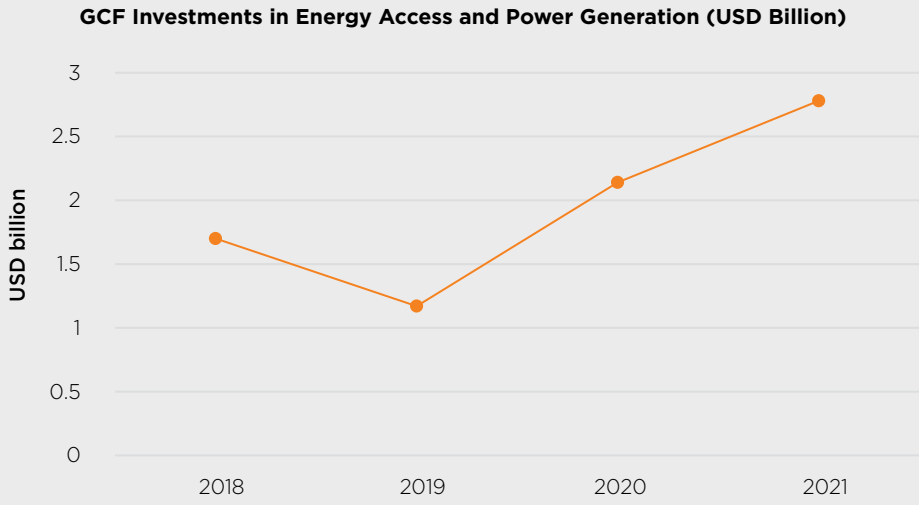


Figure 11: Investments by GCF for energy access and power generation projects
(Source: GCF Annual Reports, 2018-2021)

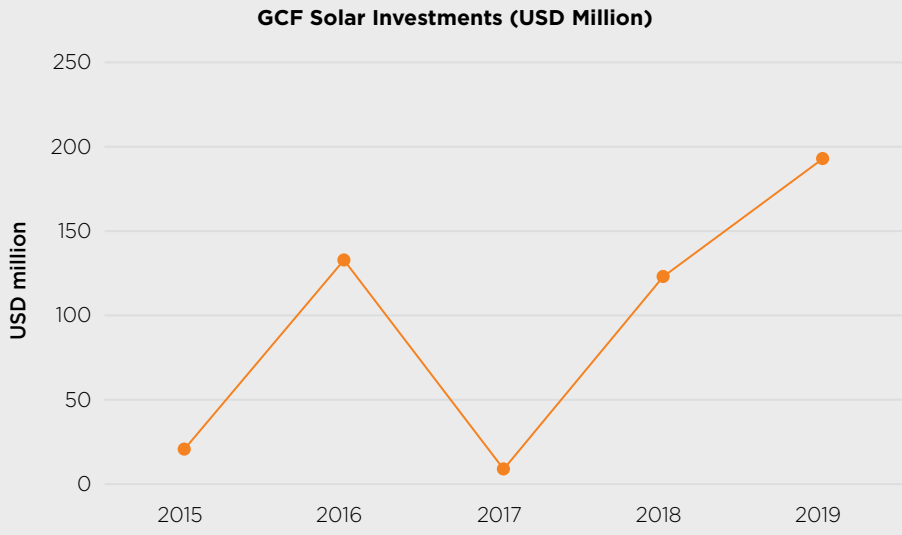


Figure 12: Investments by GCF in solar projects
(Source: IRENA)

5.6.3 Countries are using crowdfunding to promote small scale renewable energy projects

Lack of sufficient affordable financing options for renewable energy projects has given rise to a unique approach for raising funds for such projects, especially small scale RE projects. The approach includes crowdfunding in groups and communities to kick off new and often smaller projects, which otherwise wouldn't have been possible through conventional financing methods. It allows investors to raise money easily as compared to taking loans and provides an opportunity to support a local project that can yield good returns over its lifetime.

There are various platforms through which crowdfunding can be done. Depending upon the type and size of project and investments required, a suitable platform can be selected. Some of the popular crowdfunding platforms are listed below:

Table 4: List and description of some of the popular crowdfunding platforms

Crowdsourcing platform	Description
Citizenergy	Specializes in sustainable energy projects and gives investors the chance to own equity, loan finance, or purchase a bond in renewable energy projects throughout Europe, providing such projects access to essential finance
Lumo	Owned by the French Bank, Societe Generale, it allows investments of smaller sums of money to fund sustainable energy projects. Investors receive a return in interest derived from the green energy that the projects generate and sell
Fundeen	Often described as a fintech, Fundeen allows investors to choose renewable energy projects to invest in from a small amount of 500 euros and gain from returns

Crowdfunding has great potential and countries are usingto it for raising funds, with France leading the way. One of the most successful campaigns of crowdfunding was the Toreillas Solar Park in France. Here, 96 greenhouses contain a total of 37,000 solar panels, which saves 1,100 tons of CO2 each year. The park supplies electricity to 2,500 homes and generates a total of 9.6 MW of clean, green renewable energy[48]. In 2021, Oakridge rooftops raised an undisclosed amount through a German crowdfunding platform for its solar projects in India. It will use the money for its portfolio of urban solar projects in New Delhi.

5.6.4 Blended Financing is a key to mobilizing additional funds into clean energy sector

Blended financing is the strategic use of development finance for the mobilization of private financing to finance sustainable development in emerging and frontier markets to achieve sustainable development goals (SDG). It attracts organizations with different financing objectives to invest alongside each other while achieving their own objectives, be it financial returns, social impact, or both. With the purpose of getting the project off the ground, blended financing combines an initial investment, often from a philanthropic or government entity, with a subsequent commercial investment. The initial concessional funding absorbs much of the risk thereby making the development project more attractive to investors seeking market rate returns at a lower risk.

Some of the unique blended financing mechanisms new to the solar energy sector are illustrated below that can help in accelerating investments in the sector.

One unique example of a financing program that has gained accolades and has even been nominated for The Africa Solar Industry Association (AFSIA) Solar Awards 2022 is the new $500M Gigaton Empowerment Fund by SunFunder. The box item below illustrates the Fund in detail.

[48] https://www.trvst.world/renewable-energy/crowdfunding-renewable-energy/

The $500M Gigaton Empowerment Fund

SunFunder started as a crowdfunding platform and offers innovative financial solutions by bringing together investors in blended debt funds. It has built an extensive track record of distributed solar investments in Africa and financed 60 solar companies over the last decade. With more than 50 investors onboard in their blended funds – from institutional to impact investors – they have introduced the new $500 million Gigaton Empowerment Fund.

There is a huge demand of investments from the pipeline of investable projects to be undertaken in the developing economies, and the Gigaton Empowerment Fund will accelerate financing to increase climate action and energy access. It will do so by raising blended debt funds from institutional and other investors, offering access to a diversified emerging market solar portfolio enabling the investors to put capital to work in the rapidly growing and impactful distributed solar sector. The fund will have a bespoke blended structure and will make more than 130 clean energy investments, improving energy access for over 10 million people while reducing more than 18 million tons of CO_2 emissions.

Another famous impact investment platform that crowdsources debt for clean energy startups in developing economies is Charm Impact. It uses innovative blended finance structures to offer loans from £10,000 - £250,000 for enterprises in Sub-Saharan Africa, South, and Southeast Asia, and is focused on supporting early-stage, local entrepreneurs to gain access to finance and develop a credit history in order to grow and scale their businesses. Together with iGravity, Charm Impact has launched Charm Impact Bond which has been illustrated below.

The Charm Impact Bond

The Charm Impact Bond (CIB) is a $12.5 million blended finance instrument that aggregates multiple small clean energy companies into a single platform. Sponsored and seeded by iGravity through its Impact Investment Index, the CIB is a financially inclusive instrument through which entrepreneurs get access to capital that would otherwise be unattainable to them due to their creditworthiness. Through CIB, entrepreneurs can access loans ranging from $12,530 – $438,443 for a period of up to 36 months, and companies with a higher impact are rewarded with lower interest rates.

CIB's financing blend consists of private investor capital and subordinated capital that de-risks the private capital, onboarding a greater number of companies. Initial recipients of the bond include Winock, a locally owned solar business system distributor in Nigeria, Biomassters, a female led and part locally owned pellet cooking company in Rwanda and Powerstove, a locally owned clean cookstove manufacturer in Nigeria.

5.6.5 Microfinancing can support clean energy transition for vulnerable sections of the society

Rural locations, especially in developing and underdeveloped countries, have sizeable population that lack access to electricity. Because of remoteness of such regions, expansion of electricity supply through a centralized grid system becomes difficult and as a result these people often rely on expensive fossil fuels such as diesel and kerosene. Hence, despite increasing demand for small scale renewable energy products among low-income consumers around the world, many are unable to access them because of high upfront cost and lack of affordable financing options. Microfinance can bridge this gap.

Microfinancing of renewable energy technologies could provide strong impetus for governments of developing countries to increasingly promote the successful and benefiting use of such technologies and therefore pave the way of a more sustainable future. Microfinance can make energy systems more affordable and can benefit both the user and the supplier. While the user can use electricity to increase productivity and improve quality of life, microfinance institutions find in renewable energy a new loan item that will strengthen their user's economic activity and diversify their own lending portfolios.

The financing option is particularly lucrative for clean energy technologies because the monthly savings on fuels exceed the monthly loan payments and provide several long-term economic benefits for the user in the long run.

Success of microfinancing in Kenya

Kenya represents the most developed financial services market in East Africa, with the highest rate of market penetration of financial products and services. The industry has grown significantly over the last 10 years, both in terms of the gross loan portfolio disbursed and the number of active borrowers served. Similarly, the diversity of financial products and services available to low-income people is notable. Mobile banking and digital financial services are most developed in Kenya and complimentary regulatory policies related to deposit collection, branchless banking and agent banking have helped the industry grow rapidly in the last decade

In one such case of access to clean energy in Kenya, off-grid solar solutions provider d.light in partnership with micro lender Musoni provided low income consumers access to solar energy at affordable prices in 2017. Around 600,000 Kenyans got access to solar home systems through an arrangement whereby Musoni absorbs the upfront cost of solar systems and customer services the loan over a certain time in regular small instalments. These people reduced kerosene consumption substantially while getting access to clean energy for lighting and running other household appliances such as radio and TV, etc[49].

Key messages:

- **Dedicated funds and institutions can help in focusing resources on clean energy transition.**
- **Increasing adoption of unique solutions such as microfinancing and crowdfunding for green energy financing can accelerate the journey towards net zero**

[49] Energy Economics: The impact of off-grid solar home systems in Kenya on energy consumption and expenditures

Enabling Environment for Scaling Solar Investments

To scaleup investment flows which are required for the adoption of solar energy under the net zero journey, multiple interventions would be required across the value chain to enable investments, especially for developing and underdeveloped regions.

This chapter describes the key levers which would be required to accelerate the investments in renewable energy. The requirements of an 'enabling environment' which are essential for steering investments towards the solar energy sector are highlighted with a special focus on developing, and underdeveloped regions. This chapter also underlines the importance of enhancing investments into research and development, as well as solar manufacturing. It concludes by underlining the need for collaboration among the key stakeholders, for mobilizing the required investments.

6.1 Policy and regulatory support is a key for unlocking investments for renewable energy adoption

While the trends over the past decade have shown that solar energy investments have grown positively, there is scope for further scaling up of investments to ensure the world meets its sustainable development goals. In recent times, renewable energy has become more attractive to investors as it proved its resilience during the COVID-19 pandemic. As highlighted in Chapter 4, there is a need to substantially ramp up the investments up to 4x from the current levels to achieve the clean energy targets.

Various levers are crucial for unlocking potential investments, by assisting in the development and implementation of an effective net zero investment strategy. These parameters impact the decision-making process of stakeholders to ensure that they are defining and implementing their mandates accordingly

Various levers are crucial for unlocking potential investments, by assisting in the development and implementation of an effective net zero investment strategy. These parameters impact the decision-making process of stakeholders to ensure that they are defining and implementing their mandates accordingly.

The overarching framework to accelerate clean energy investments should encompass the following key areas:

1) **Regulatory framework supporting investments in renewable energy**

   The presence of appropriate governance and regulatory framework provides the basis for realignment of the broader actions under the investment strategy for an investor to achieve the net zero goal. The development of a renewable energy strategy or action plan, especially linked to international commitments in form of NDCs, can help in attracting investment into the space. The existence of a regulatory framework would also allow the private sector in engaging and providing investment.

2) **Targets and objectives planned for renewable energy expansion**

   Renewable energy targets, set in line with science-based pathways that are consistent with achieving net zero global emissions by 2050, can assist in setting the direction and ambition of a net zero investment strategy and also act as a means to monitor the effectiveness of this strategy. These targets must be determined by identifying the relevant sectors, such as electricity, heating, and cooling as well as transport. This will also help in assessing the current exposures and starting points for investors. Increasing the alignment of investment and assets with net zero pathways is crucial for achieving the targets.

3) **Financial incentives for renewable energy**

   Financial support in form of incentives can help to ensure trust among the investors about the possible revenue streams within the market in place. Apart from long-term PPAs as well as practical guidelines for acquiring permissions for project development, direct fiscal incentives such as capital subsidies, grants or rebates, investment tax credits, tax reductions, and production tax credits are some of the forms of financial and regulatory support by the Government that can incentives the renewable energy sector.

4) **Enabling infrastructure for grid integration of renewable energy**

Ensuring grid integration of renewable energy projects is a crucial aspect of project development for guaranteeing evacuation of power generated and safeguarding the revenue stream. Government support in the form of regulations can help ensure smooth integration of renewable energy projects and accurate compensation being provided to the project developers/ operators. Prioritization of renewable energy projects to access the grid for connection and dispatch through adequate provisions in the grid code is considered to be a key initial step towards market development. Compensation for lost generation due to curtailments after project commissioning can also help towards incentivizing the developers/operators. Permitting access to the grid infrastructure for projects and consumers as well as the establishment of a power exchange would help in expanding the market for renewable energy.

5) **Addressing counterparty risk**

Augmenting the creditworthiness of the counterparty under PPAs through a letter of credit, escrow account, and payment guarantees can help ensure payment risk mitigation. This assists in guaranteeing the bankability of PPAs, which is another key aspect; it is important to ensure the long-term offtake agreement is being executed with a creditworthy customer and has a sufficient tenor to enable repayment of long-term debt, by providing an adequate and predictable revenue stream. Thus, it is important to ensure regular monitoring of the transparency of utilities' performance, which is generally the main customer for renewable energy projects. Section mentioned below details various risk mitigation tools which may be utilized to overcome the different risks encountered especially for developing and underdeveloped regions.

Key messages:

- **Appropriate Government interventions through necessary policy, regulatory and financial support can help to ensure the development of the renewable energy market by unlocking potential investments as well as incentivizing the flow of finance by the investors.**

6.2 Policy and regulatory support is a key for unlocking investments for renewable energy adoption

Solar energy is expected to be at the forefront of the energy transition journey towards net zero. Focusing on driving investment towards the key industry actors and increasing access to finance for projects at critical junctures will help in ensuring the viability of projects in the growing solar PV market.

The section below highlights the key drivers for ensuring investments in research and development as. Recommendations are given to overcome challenges in developing and underdeveloped regions The section also looks into new financing methods. Lastly, the section explores the challenges faced by the solar manufacturing sector and provides recommendations that may be adopted for increasing the supply to match the increasing demand.

6.2.1 Shifting subsidies from fossil fuel to a solar-based economy

Many countries continue to rely on fossil fuels to meet their energy needs; this is especially true for many developing and underdeveloped countries. As most countries are fossil fuel-based dependent, their markets are also impacted by the volatility of fossil fuel prices and subsidies offered for fossil fuel consumption. Globally, fossil fuel subsidies were USD 5.9 trillion or 6.8 percent of the global GDP in 2020 and are expected to increase to 7.4 percent of GDP by 2025 as the share of fuel consumption in emerging markets continues to climb.[50]

While solar continues to achieve cost competitiveness, supply-side subsidies will be required in the early stages of the energy transition, especially for developing and underdeveloped countries and some sectors of solar deployment, as highlighted in Chapter 4. A measured transition of subsidies from fossil fuels to solar energy would help ensure the sustainability of the clean energy transition. These subsidies can be reduced in the future as solar technologies become more cost competitive as compared to other fuel sources.

Key messages:

- **The shifting of subsidies from fossil fuel to renewable energy would not only help the fossil fuel-based economies in their clean energy transition but also help achieve energy security.**

[50] International Monetary Fund, Fossil Fuel Subsidies, https://www.imf.org/en/Topics/climate-change/energy-subsidies

6.2.2 Multiple channels for mobilizing investment across developing and underdeveloped regions to overcome skewed investment allocation

Despite the benefits offered by solar energy and the pressing need for accelerated adoption of solar systems, there hasn't been a uniform deployment of solar technologies across the world. This has contributed to the skewed allocation of investment as highlighted in Chapter 3. Despite the immense solar energy potential, most developing and emerging economies in Africa, the Middle East, Latin America, and the Caribbean, saw a minuscule share of global investments in solar energy.

There is a large gap between the investment required and the investment realized which can be attributed to the stability of the political and economic environment. Systemic challenges, highlighted in Chapter 3, present in these developing and underdeveloped regions add to the risk profile of projects which in turn hinders the flow of investment. Thus, it is imperative to identify the barriers faced in scaling solar deployment in developing and underdeveloped countries and address them with the collective action of stakeholders, to ensure equitable distribution and allocation of investments in the regions.

6.2.2.1 Strengthening financial and capital markets

Most developing and underdeveloped countries have weak financial and capital markets that fail to provide mobilization of savings, and allocation of financing to renewable energy companies. In addition, local commercial banks are too small and are often risk-averse in providing funding for large infrastructure projects; they generally offer loans with large collateral requirements and for short tenure making it unviable for developers to develop solar projects. In addition, financial instruments such as bonds, private equity, etc. are also limited in these economies.

The ddevelopment of robust banking and capital markets and removing market distortions can ensure the sustainable inflow of investments. Developing and underdeveloped countries need to strengthen banking regulations and build well-regulated securities markets. At the same time, it is equally important to demonstrate the financial viability of new and innovative business models for various solar applications which in turn can help lower the risk associated with the models.

India Increases Priority Sector Lending Cap to Solar

In an attempt to increase investment flows for solar adoption through strengthening of capital market, Reserve Bank of India (RBI) issued circular notice in 2020 detailing out increasing investment limits by two-fold for priority sector lending for solar energy. Limit of bank loans have been increased to INR 30 crores for solar generators as well as INR 50 crores for start-ups. The revised guidelines also included loans to farmers for installation of solar power plants for solarization of grid connected agriculture pumps as fresh categories eligible for finance under priority sector.

6.2.2.2 Ramping up private sector engagement

The debt burdens are on the rise in many economies across the world and many governments in emerging and developing economies do not have the fiscal space to mobilize resources for a sustainable recovery. The situation has aggravated with the resources being allocated towards fighting the COVID-19 pandemic. According to the World Bank, the external debt of low- and middle-income countries in 2020 rose, by

ISA has recognized the key role of the private sector in driving force the growth of solar energy. The private sector contributes to nearly 90% of solar investments in ISA member countries. To support the private sector, ISA has developed a focused Private Sector Engagement (PSE) Strategy to deliver on the goal of mobilizing USD 1,000 billion investment for solar by 2030. Through this strategy, ISA aims at reducing barriers to industry growth by working across two thematic pillars, namely Enabling Policy Frameworks and Catalyzing Investments, thereby, driving the convergence of new policy frameworks, investment strategies, and market intelligence in and across regions.

an average of 5.6%, amounting to USD 8.7 trillion.[51] This has impacted the ability to develop economies to boost investment in the solar sector.

In such a scenario, the role of the private sector in resource mobilization becomes vital. To engage with the private sector, initiatives must be taken in delivering quick wins and adopting a results-focused approach. As the private sector seeks consistency in policy areas relating to project preparation, execution, and post-implementation services, there is a need to revisit the policies and regulations. These must be aligned to reduce various risks related to land access, taxation, offtake, and grid integration.

6.2.2.3 Enhancing the flow of Foreign Direct Investments (FDI)

FDI is an important investment tool, especially for developing and underdeveloped countries. They have proven to be resilient during financial crises; this is evident from the various instances of the financial crisis that have occurred across the world including that in Latin America during the 1980s, Mexica during 1994-95 as well as East Asian countries during 1997-98.[52] Additionally, FDI can contribute toward employment generation, technology diffusion, economic growth, and sustainable development for the host country. However, potential risks should be minimized through good governance and capable institutions as well as an effective regulatory framework.

However, as of 2021, 1193 projects across the world have announced international project deals worth USD 502 billion, out of which only 393 projects in the developing economies announced international project deals worth USD 183 billion, thus highlighting the skewness of investment mobilization observed for the developing economies.[53]

Thus, encouraging FDI would help in ensuring capital flow in developing economies. Providing transparent and consistent regulations for all kinds of firms, whether foreign or domestic will help the growth of solar. Key enablers such as ease of doing business, easy access to imports, flexible labor markets, and protection of intellectual property rights would help in ensuring an increase in FDI flows.

6.2.2.4 Blended finance can help bridge the gap in ensuring the viability

Mobilizing capital on a large scale would not only require a dramatic increase in the role of the private sector, but also an enhanced role for international and development finance through blended capital, wherein commercial capital (equity, junior debt, senior debt, etc.) is subsidized through grants.

A **blended finance mechanism** has great potential to accelerate high-impact private sector investments in new and challenging markets. It can play a central role in creating and growing markets in developing countries. It has been observed that the participation of DFIs through blended finance structures typically reduces the perceived risk of third-party investors

[51] World Bank, International Debt Statistics 2022, https://openknowledge.worldbank.org/bitstream/handle/10986/36289/9781464818004.pdf?sequence=4&isAllowed=y
[52] IMF, How Beneficial Is FDI for Developing Countries, https://www.imf.org/external/pubs/ft/fandd/2001/06/loungani.htm
[53] United Nations Conference on Trade & Development (UNCTAD)'s World Investment Report 2022

ISA is designing a Blended Finance Risk Mitigation Facility (BFRMF) with a fund size of over USD 700 million and a pan-Africa mandate in its initial phase. The Facility is aimed at stimulating high-potential solar technologies by attracting private capital to flow into underserved markets in Africa by providing interventions at two main levels - stimulating demand through technical assistance and attracting commercial capital providers. The Facility is expected to spur follow-on investments to the tune of USD 5-10 billion over the next 10 years, bringing energy access to 35-40 million households and mitigating 0.5-1 million tonnes of carbon emissions.

and lowers the overall cost of capital.[54] Blended finance is, therefore, an essential leveraging tool that DFIs can deploy to magnify the effect of their funding and crowd-in private sources of capital. Greater use of co-financing to raise capital for green technologies and project finance will encourage the sector's shift away from self-financing via balance sheets and towards greater financing by global capital providers.

Allocation of grants shall trigger a virtuous loop for initial upscaling of the adoption of solar technologies and lead to scaling economies for solution providers, enhancing the viability of solar solutions for consumers as well as providers, enhancing the attractiveness of investment and adoption of solar, and empowering local entrepreneurship to drive change in the field of solar. This would particularly help to provide the necessary financial assistance to various new and growing start-ups, especially working in ensuring energy access in developing and underdeveloped regions.

6.2.2.5 Building institutional capacity and a conducive environment can accelerate new investments channels

In developing and underdeveloped countries, there is a limited institutional capacity for mobilization of investment in the solar sector. To address the same, there is a need to enhance institutional capacity along with the creation of a conducive environment for attracting investors. Effective drafting, implementation as well as monitoring, of policies is required.

- **Institutional capacity building** directed at local enterprises, financial investors, and policymakers offer the potential to increase the effectiveness of the limited concessional funds available as well as reduce political, economic, credit, and operational risks associated with investing in solar projects. This would also entail **putting up the required infrastructure** for setting up the facilities for the vocational training of specialized workers, bankers, and local project developers among others; these would help in building up the institutional capacity for the developing economy, thereby, increasing the confidence in the growing market among the investors.
- **Empowering the state-owned enterprises,** especially utilities, would be beneficial in guaranteeing the required investment in network development for building the required infrastructure to ensure the smooth integration of solar energy as well as balance the intermittency of the energy resource.

Learnings can be drawn from successful countries that have been leading in the journey of solar adoption by being able to put in place the required institutional capacity through necessary policy and regulatory interventions.

6.2.2.6 A pipeline of bankable projects will accelerate investments

Lack of "ready-to-go", bankable projects is one of the biggest constraints to infrastructure development in developing and underdeveloped countries. It is estimated that 80% of infrastructure projects fail at feasibility.[55]

[54] IRENA (2016), 'Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance,' IRENA, Abu Dhabi
[55] https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/draft_develop_bankable_transport_infrastructure_project_24sep1_0.pdf

Efficient early-stage screening and support in the development of project proposals can improve the chances of financial closure and successful execution. The pre-development stage is important and includes the preparation of pre-feasibility and feasibility studies, including technical, financial, economic, and environmental assessments. Government guarantees and support letters would also help in enhancing the bankability of a project and, to some extent, reduce some of the political risks.

Key messages:

- **The shifting of subsidies from fossil fuel to renewable energy would not only help the fossil fuel-based economies in their clean energy transition but also help achieve energy security.**
- **Public funding will play a crucial role in lowering risks and barriers for private capital and enabling a just and inclusive energy transition.**
- **Strengthening banking regulations and developing robust securities markets will enable investments in the solar sector**
- **Policies to enable private-sector participation will boost investment flows.**
- **Encouraging FDI would increase the volume of capital as well as decrease the cost for developing economies.**
- **Blended finance can play a central role in creating and growing markets in developing and underdeveloped countries**
- **Institutional reforms in regard to administrative and management capacity are crucial in implementing the energy transition.**
- **While developing a solar project, it is important to structure the investment proposal to match the needs of the respective investor.**

6.2.3 Innovative tools and new sources of capital for mobilization of investments

To scale investments, there is a need for new and innovative financing options. This will require efforts from governments, financial institutions, as well as private investors which can mutually reinforce each other.

The section below explores new investment options which can also help bring in new investors who have unknot been tapped till now. The section later builds on the new and innovative tools which can be explored for de-risking investment mobilization, especially for developing and underdeveloped countries.

6.2.3.1 Innovation in financing and de-risking tools

Traditionally, infrastructure investments have been financed with public funds. However, increased public debt to GDP ratios, have constrained investment in infrastructure. Therefore, it is increasingly acknowledged that alternative sources of financing are needed.

It is imperative to ensure the identification of effective and de-risking financing approaches, instruments, and vehicles that could broaden the financing options available for infrastructure projects. This will increase and diversify the investor base, potentially lowering the cost of funding and increasing the availability of financing. There is a range of incentives and risk mitigation tools, that can foster the mobilization of financing for infrastructure, particularly those related to mitigating commercial risks.

Some examples of risk-mitigation instruments are guarantees, letters of comfort or intent, hedges against currency risks (e.g., forward contracts and swaps), letters of credit, and insurance products. The table below summarizes the types of risks encountered in many energy-transition projects and the instruments available to public capital providers to address them.

Nature of Risk	Risk-mitigation tool(s)
Political risk	Government guarantee Political risk insurance Export credit guarantee
Policy or regulatory risk	Government guarantee Export credit guarantee
Currency risk	Government guarantee Currency risk hedging Loans in local currency
Counterparty (power off-taker risk)	Government guarantee Political risk insurance Credit guarantee Export credit guarantee Liquidity facility The termination clause in the PPA
Technology risk	Specialized insurance products
Liquidity risk	Letter of credit Escrow account Liquidity guarantee
Natural disasters	Property and casualty insurance

6.2.3.2 Unlocking institutional capital for ramping up solar investment

Institutional investors such as pension funds, insurance companies, endowments, and sovereign wealth funds represent one of the largest capital pools in the world, yet their potential role in financing the energy transition has so far remained largely untapped. It is estimated that institutional investors manage a portfolio of USD 90 trillion in total assets. Around USD 2.80 trillion per annum is potentially available from pension funds and insurance companies for new clean energy investments.[56] Hence, they are expected to play a crucial role in scaling up the investments.

While institutional investors are starting to show interest in sustainable and responsible investment due to their fiduciary duties, institutional investment in renewables is largely underutilized so far. To harness this potential would require a range of coordinated actions that include regulatory and policy actions, capital market solutions, the creation of bankable project pipelines by countries as well as institutional changes on the part of institutional investors.

Key messages:

- **De-risking energy transition projects is imperative if long-term funding is to be made available at reasonable rates.**
- **Institutional investors represent one of the largest capital pools in the world, yet their potential role in financing the energy transition has so far remained largely untapped.**

6.2.4 Expansion and diversification of the solar manufacturing sector are crucial for keeping up with the increasing demand

Meeting the growing demand for solar, in line with the international energy and climate goals, shall require a major expansion of the manufacturing capacities, while ensuring the resiliency of the global solar supply chains; this is a crucial aspect while aiming toward net zero as highlighted in Chapter 4.

The overall long-term financial sustainability of the solar PV manufacturing sector is critical for the timely and cost-effective achievement of clean energy transitions. Presently, many companies along the solar PV supply chain depend on government support to maintain profitability. Bankruptcy risk and low profitability might slow the pace of clean energy transitions if companies are unwilling to invest because of low returns or are unable to withstand sudden changes in market conditions. Thus, it is important to ensure the financial sustainability of the solar PV manufacturing sector, through necessary policy and regulatory means.

Another key risk that has been impacting is the trade policy risk; trade restrictions and sudden supply-chain disruptions on account of the COVID-19 pandemic and Russia's invasion of Ukraine have highlighted the vulnerability of the present supply chain. This underlines the need for diversifying the presently concentrated supply chains. Domestic manufacturing can also help to reduce manufacturing emissions through more efficient logistics.

[56] IRENA (2016), 'Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance,' IRENA, Abu Dhabi

The cost competitiveness of existing solar PV manufacturing poses a key challenge to diversifying supply chains with China being a much more cost-competitive location for manufacturing with costs lower by 10% as compared to India, 20% as compared to the United States, and 35% as compared to Europe.[57] Apart from policy and regulatory support for incentivizing the establishment of local solar manufacturing capacities, ensuring economies of scale and vertical integration of manufacturing can reduce costs and improve competitiveness for the manufacturers.

Key messages:

- **Apart from scaling up capacities, it is important to ensure the resilience of global solar PV supply chains which would entail diversifying manufacturing capacities.**

6.2.5 Driving investments for research and development and ensuring sector coupling can boost solar adoption

Looking at the ongoing global energy transition as a technology revolution can provide a good indication of how capital is likely to flow to new technologies over time and help policymakers choose the policies and enabling frameworks required to meet investors' needs at each stage of technology development, thus accelerating the energy transition.

While investment at a very early stage of growth this generally led by inventors/ startups as well as public funding, in the latter stages, under which the market share of the newly developed/ technology increases, there is greater participation from the private sector. Additionally, whilst solar PV for electricity generation has been primary use, new technologies and applications such as EV charging, green hydrogen, heating, and cooling, as well as recycling of solar PV shall require investments to ensure continuous research and development.

Supportive policy and regulatory frameworks for research and development can help drive private sector investments at an early stage.

6.3 Collaboration among public financial institutions, private investors, government, and developers is the key to mobilizing investments

The barriers to scaling solar investment vary by the type of technology as well as the market. These include perceived and real financial and political risks, regulatory instability, as well as a lack of bankable projects for investment. Proven solutions to each of these barriers do exist, however, implementing them at scale will require a concerted effort from governments as well as private investors. Thus, accelerating solar investment and finance at the pace needed will require investment and action by governments, financial institutions, and private investors – and these actions will reinforce each other.

[57] https://www.iea.org/reports/solar-pv-global-supply-chains/executive-summary

With limited public funding, private finance is needed to provide a major share of the overall investment requirements. As per UNFCC, the private sector is forecasted to provide 70% of primary investments globally, with nearly half of them directly financed by corporate balance sheets; this share may vary between 50% to 95% across regions depending upon the level of maturity of the market within the region.[58] Actors across the financial system, including institutional investors, funds, venture capital as well as commercial financial institutions would play a vital role to play in driving mobilization and meeting the net zero investment targets.

While underlying market barriers and perception of high risks do constrain the investment flows, especially in developing and underdeveloped regions, enabling policies and a predictable financial environment can help ensure predictable revenue streams and overcome the barriers. Hence, to ensure mobilization of private finance, well-targeted public support through policy and regulations targeting net zero, market development, and risk mitigation instruments including blended finance are expected to be key enablers. Access to domestic capital, through local financial institutions, can also help in developing markets.

Thus, collaboration among developers, investors, public financial institutions, and government can help ensure efficient mobilization of required investments to be on track to achieve our net-zero targets. This underlines the need for a platform that assists in bringing all the key stakeholders who are intended to play a crucial role in the mobilization of investments in the solar energy sector. The platform could be leveraged to draw out from the learnings of the practices and approaches adopted by other countries that have been successful in their solar journey in recent times would also help countries.

[58] https://climatechampions.unfccc.int/whats-the-cost-of-net-zero-2/

Climate Investment Platform: Collaborating for Capital Mobilization

IRENA, in collaboration with UNDP, SE4ALL, and GCF, launched a joint initiative 'Climate Investment Platform' (CIP) as a collaborative demand-driven platform for mobilizing capital towards renewable energy in developing countries. It is designed to provide tailored technical assistance for projects in Member countries. Investment Forums are an operational framework for CIP implementation as they add significant value in enabling investments in renewable energy projects. The Forums aims to strengthen the ability of decision-makers to produce a strong enabling environment for investments; and also help the developers to prepare bankable projects and access finance.

Key messages:

- **Market barriers and perception of high risks do pose a constraint for the investment flows, however, a collaborative approach among all stakeholders would play a key role in ensuring efficient mobilization of investments.**
- **Bringing together all stakeholders, including developers, financial institutions, the private sector, government, and their agencies, underlines the need for a collaborative platform with a targeted approach to ensuring the mobilization of investments. The platform can be leveraged to draw learning from one another to adopt the best practices across the solar supply chain.**

Way Forward

Investments in renewable energy have seen an increasing trend and despite the economic slowdown resulting from the pandemic, renewable energy investments have reached an all-time high in 2021, with majority investments being made in solar energy sector.

The various uncertainties in global energy landscape have highlighted the need for countries to become self-dependent in terms of energy requirements and increase penetration of solar energy adoption, solar energy being available in abundance and cheaper than other non-renewable forms of energy. Of the projected investments required, solar energy is expected to draw majority investments as solar and wind technologies together are expected to meet 90% of the electricity needs by 2050.

After the detailed analysis of the global investment landscape of the solar sector, the following conclusions have been arrived at that need interventions by concerned stakeholders for increasing solar adoption and solar investments.

- Though solar investments have shown an increasing trend, the investments must be increased significantly to address global climate change and to accelerate clean energy transition led by solar energy
- There is a need to enhance data transparency and track investments specific to solar segment to understand the progress and bottlenecks hampering the growth of the sector. Due to lack of specific solar related data and recent data availability in various cases, the analysis was conducted based on limited data points and based on certain assumptions. Hence, the trends and insights depicted might be different or might have changed in the past years
- Solar installations are slated to increase in future with increasing cost competitiveness and gaining popularity of solar enabling technologies. To support the intermittent power from solar technology, increased investments are required in power infrastructure and battery storage
- Presently the solar supply chains are concentrated in certain geographical locations, China being the leader. To keep up with the growing demand, there is not only a need for expansion of solar manufacturing capacities globally, but also for building diverse, resilient, affordable, and sustainable solar supply chains
- Investments are highly skewed in renewable energy sector. While major developed regions have achieved maturity in terms of investment for solar PV capacity additions, developing and underdeveloped regions such as the Middle East

and Africa and some countries in the Asia and Pacific will require substantial ramping up of investments. Various credit enhancement instruments can provide the initial critical footing in such regions by absorbing the risks. Microfinancing and crowd funding can also be useful for upscaling investments in such regions

- Policy and regulatory support from government will be required to mitigate investment risks in solar sector to mobilize more funds and engage more players including major corporations, oil and gas companies, institutional investors, etc. Shifting investments from fossil fuels to renewable sector will require regulatory support and will help in clean energy transition
- Increase in off grid solar technologies is showing positive signs of growth, enabling increased penetration of solar energy, especially in rural areas and in developing and underdeveloped countries that lack access to reliable power supply from the grid
- The end-of-life stage in solar value chain is an upcoming area of work to ensure circularity within the whole solar PV eco-system by following the principles of 3Rs. It has been estimated that recycling or repurposing solar PV panels at the end of their roughly 30-year lifetime can unlock an estimated stock of 78 million tonnes of raw materials and other valuable components globally by 2050, holding immense potential for new economic activities
- Adoption of innovative tools such as green bonds, dedicated climate funds, blockchain, dedicated credit lines, etc. is gaining momentum across countries and can provide the much-needed push to accelerate solar adoption across the globe by mobilizing funds from large private players, institutional investors, and banks.

These findings provide a holistic picture of solar energy investments on a broader scale and working on them can help in speeding up solar transition globally.

CONTACT US
International Solar Alliance Secretariat
Surya Bhawan, National Institute of Solar
Energy Campus Gwal Pahari,
Faridabad-Gurugram Road, Gurugram,
Haryana – 122003, India
Email: info@isolaralliance.org