Global Trends in Solar Power

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Knowledge provider

INTERNATIONAL SOLAR ALLIANCE

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Contents

1 Executive Summary

In response to an unprecedented health crisis, countries had hoped to seize the post Covid-19 opportunity for a green and sustainable recovery. Renewable energy sector experienced record growth in power capacity in 2022 due to the newly installed PV systems, overall rise in electricity demand, government incentives and growing awareness of need to transition to clean energy sources.

The solar PV market maintained its record-breaking streak, with new capacity installations totalling to approximately 191 GW in 2022 (IRENA, 2023). This was the largest annual capacity increase ever recorded and brought the cumulative global solar PV capacity to 1,133 GW. The solar PV market continued its steady growth despite disruptions across the solar value chain, mainly due to sharp increases in the costs of raw materials and shipping. In 2022, 114 ISA countries (members and signatories) represented approximately 489 GW (43%) of the global solar PV capacity. Europe & others region account for 56% of the total installed solar capacity among the ISA members followed by the Asia-Pacific (36%), Latin America & Caribbean and Africa regions contributing to approximately 7% and 1% respectively.

In addition to the increase in solar capacity installations, 135 countries had included renewable energy components in their NDCs globally. The latest/revised renewable energy target in ISA Member countries are discussed in further sections of this report. The number of countries with renewable energy policies increased in 2022, continuing the multi-year trend seen in 2021 and 2020. Most countries support renewables with policy instruments that often vary depending on the technology, scale or other features of installation (e.g., centralised or decentralised).

Innovation and cost trends are being increasingly seen across a broad range of technologies. The emergence of new cell architectures has enabled higher efficiency levels. In particular, the most important market shift in cell architecture has resulted from bifacial cells and modules. Other technology improvements of solar such as solar trees, solar carports and floating solar are also discussed in this report. Solar PV cost trends emphasise on the major drivers for reduction in the cost of solar PV in 2023 and the decline in costs of solar PV module and other components. Major factors contributing to declining module costs included polysilicon availability and decline in the shipping costs and raw materials.

The section on Solar Market Trends describes the 'Distributed Renewables for Energy Access' (DREA) systems, which are a key solution for fulfilling the modern energy needs and also improving the livelihoods of hundreds of millions of people presently lacking access to electricity/clean cooking solutions. It specifically holds the key in cases where development of electric grid to deliver electricity up to the last mile is commercially not viable. Further, the report captures the market trends covering solar infrastructure and electricity access rates in ISA Member countries.

Global investment in renewables reached USD 0.5 Tn in 2022 due to the global rise in solar PV installations. Solar PV dominated investment in 2022, accounting for 64% of the renewable energy investment. The overall snapshot of the investment trends across Asia-Pacific, Africa, Europe & others and Latin America & Caribbean regions are captured in the solar PV investment trends section of this report.

This report is intended to educate the reader to understand the ongoing trends in the solar space across the world in terms of technology, policy, employment etc. and could bring out positive change in the lives of people and the planet.

2 Introduction

To avert the deleterious effects of climate change, the world is undergoing a major transition in the energy sector to achieve net-zero targets. Renewable energy occupies a central role in energy transition, and it is evident from the increasing trend of capacity additions, employments, and increasing solar energy investments. The major drivers for the increased penetration of solar deployment are described below,

- *Strong policy support for solar PV is driving the acceleration in capacity growth* - Policy support remains a principal driver of solar PV deployment across the globe.
- *Solar PV is the major renewable technology of choice in the private sector* **-** Companies investing in solar PV installations on their own premises are responsible for 30% of total installed PV capacity as of 2021.
- *Companies entering into corporate PPAs* – signing direct contracts with solar PV operators for the purchase of generated electricity. Solar PV plants dominate renewables PPAs, with a share of almost 75% in 2020.
- *Net zero ambitions of corporate* - Many corporates had set their ambition to be a net zero company. Getting to net zero requires tremendous, rapid change and large-scale technology deployment across industries.

International Solar Alliance (ISA) aims to provide a dedicated platform for cooperation among solar-resource-rich countries, through which the global community (governments, bilateral/multilateral organizations, corporates, industry and the stakeholders) can contribute to help achieve the common goal of increasing the use and quality of solar energy. Further, ISA seeks to meet the energy needs of its prospective member countries in a safe, convenient, affordable, equitable and sustainable manner.

ISA has conceptualized the Ease of Doing Solar ("EoDS") report for its member countries to capture and develop a holistic view of a country's solar ecosystem. The Global trends in Solar Power report, as a part of the EoDS initiative, is envisaged to present key trends in the global solar market with a focus on ISA member countries. The objective of the report is to capture the best practices and trends in the area of policy, technology, market eco-system , supply chain and investment/ employment in the industry globally with a focus on ISA member countries.

About International Solar Alliance (ISA)

International Solar Alliance was launched on November 30, 2015 by India and France and ISA's framework agreement came into force on December 7, 2017.

Headquartered in India, the alliance of 114 countries works to address energy needs and challenges in Member Countries and scale up solar through multiple flagship interventions.

As part of its Ease of Doing Solar (EoDS) initiative which provides data on renewable energy with a focus on solar for individual Member Countries, ISA also publishes the Global trends in Solar Power report which provides an overview of trends in the Solar Sector.

Glossary

Abbreviation	Definition
APV	Agrophotovoltaic
BoS	Balance of System
Bn	Billion
CAGR	Compound Annual Growth Rate
CMERI	Central Mechanical Engineering Research Institute
CSIR	Council of Scientific and Industrial Research
CSP	Concentrated Solar Power
DREA	Distributed Renewables for energy access
EPC	Engineering, procurement and construction
EU	European Union
EV	Electric Vehicle
FIP	Feed-in premium
FIT	Feed In Tariff
GW	Gigawatt
GWh	Gigawatt-hour
Km	Kilometre
kWh	Kilowatt-hour
LCOE	Levelized cost of electricity
LNOB	Leave no one behind
Mn	Million
MU	Million Units
MVA	Million Volt Ampere

Abbreviation	Definition
MW	Megawatt
MWh	Megawatt-hour
MWp	Megawatt peak
NDC	Nationally Determined Contribution
OGS	Off-Grid Solutions
O&M	Operation and Maintenance
PLI	Production-linked incentive
PPA	Power purchasing agreement
PV	Photovoltaic
P2P	Peer-to-peer
RE	Renewable Energy
REC	Renewable Energy Certificate
RPS	Renewable Portfolio Standards
SDG	Sustainable Development Goals
SHS	Solar Home Systems
STEM	Science, Technology, Engineering and Mathematics
Tn	Trillion
TWh	Terawatt-hour
UN	United Nations
USD	United States Dollar

Global Trends in Renewables & Solar

135 countries have notified net zero target, covering 88% of global emissions

135 countries have notified renewable power targets, and 17 countries have solar specific targets

At the 2021 UN climate summit, countries agreed to a phase-down of unabated coal power

3,372 GW of global installed renewable power capacity in 2022

1,053 GW of global installed solar energy capacity in 2022

USD 0.5 Trillion in renewables and USD 308 Billion invested in solar in 2022

12.7 Million Worldwide employment in renewable energy in 2021

4.3 Million jobs in solar PV, caters one third of the total renewable energy workforce in 2021

Fossil fuel subsidies reached USD 532 Billion in 2021

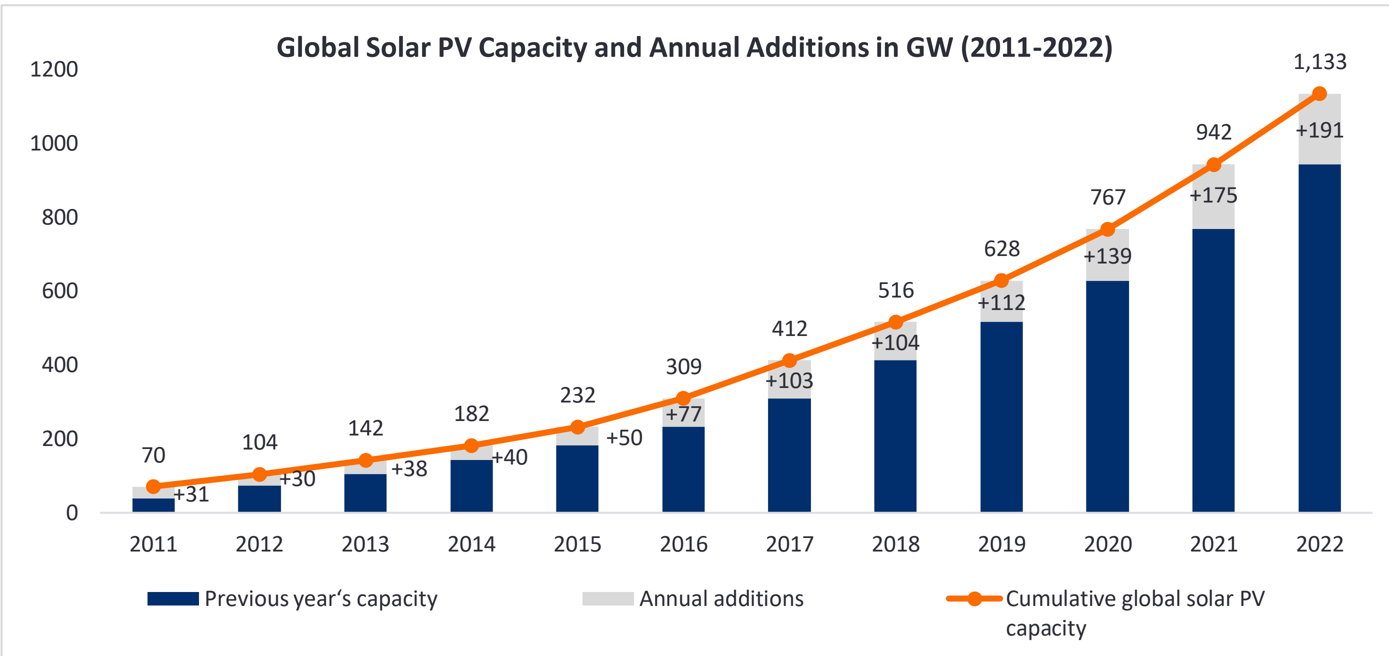
Source: REN 21, IEA, IRENA; 2022

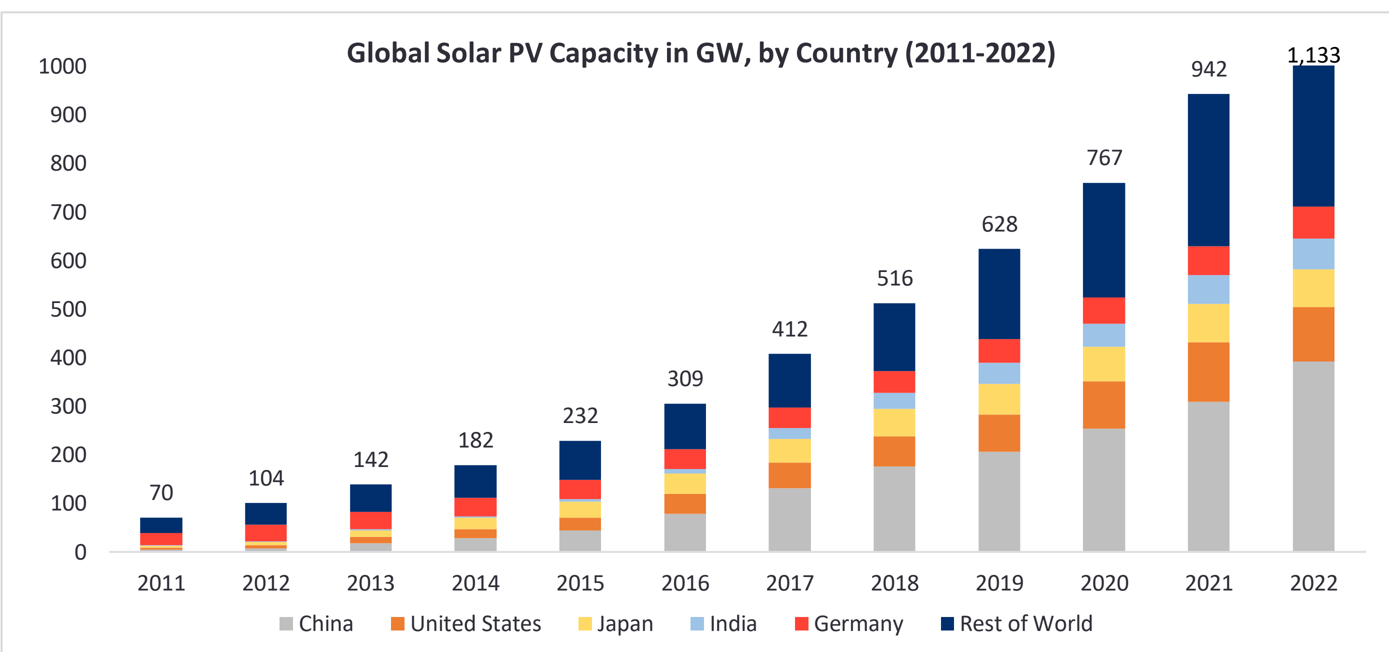
3 Global Solar Overview

3 Global Solar Market

A renewable-based economy is a game changer for a more secure, low-cost and sustainable energy future. Development of renewable energy is at the core of energy transition. Globally renewables are expected to become the new baseload accounting for 50% of the power mix by 2030 and 85% by 2050 (IRENA, 2022). Global renewable installed capacity growth accelerated in 2022 adding up to 295 GW [1]. The growth in renewable energy penetration was largely based on newly installed PV systems, overall rise in electricity demand, government incentives and growing awareness of need to transition to clean energy sources.

Solar sector is gaining traction in recent years and is becoming a dominant force in renewable energy domain. The solar PV market maintained its record-breaking streak with new capacity installations totalling approximately 191 GW in 2022[1]. The graph below, depicts the cumulative global solar PV capacity in the last decade. Countries like China, the United States, Japan, India and Germany have made some of the significant contributions to global solar PV capacity.





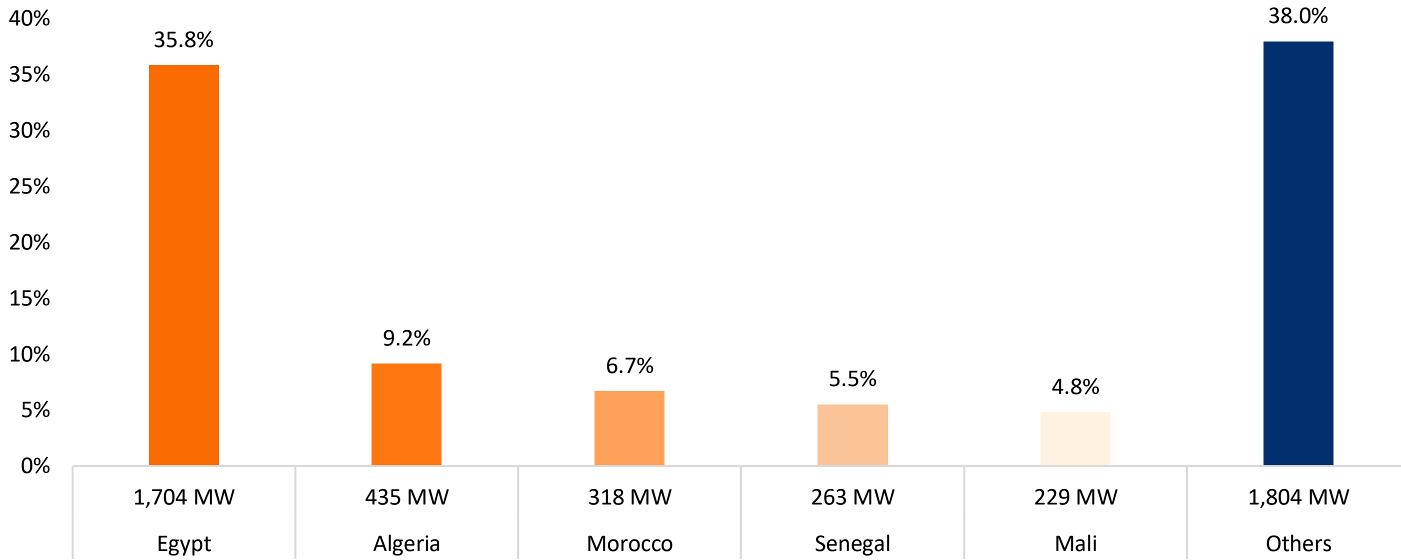
Source: REN 21, IRENA; 2022

[1] REN21, 2022

Regional Insights

Africa

Top 5 ISA Member Countries by Solar PV Installation, 2022 (Total: 2,949 MW)



Source: IRENA, 2022

The market leaders in the African region in terms of total solar installed capacity are Egypt, Algeria, Morocco, Senegal, and Mali with 2,949 MW capacity contributing 62% of the total installed solar capacity in Africa. Owing to higher levels of solar irradiations in the region, countries in Africa are bestowed with large solar potential and technological feasibility. **Significantly low levels of access to electricity in some countries present a significant opportunity for off-grid solar technologies.**

Egypt

The total installed capacity of solar PV in **Egypt** has reached 1,704 MW in 2022 from 160 MW in 2017, grown at a CAGR of 60%. The country is targeting renewable energy capacity to reach electric power contribution target of 42% by 2035 as per Egypt's Integrated Sustainable Energy Strategy 2035.

Algeria

Algeria constitutes a 9.2% share in the total installed capacity of solar PV in the African region. The total installed capacity has reached 435 MW in 2022 from 400 MW in 2017, grown at a CAGR of 2%. By 2030, it aspires to the deployment of solar photovoltaic and wind power as well as thermal solar energy on a large scale. It also aims to reach the target that 27% of the electricity produced nationally is derived from renewable sources of energy by 2030.

Morocco

Morocco accounts for 6.7% share in the total installed solar PV capacity in Africa. The total installed capacity has reached 318 MW in 2022 from 24 MW in 2017, grown at a CAGR of 68%. Morocco is targeting to achieve a 52% RE share (20% from solar energy, 20% from wind energy and 12% from hydraulic energy) in generation mix by 2030.

Senegal

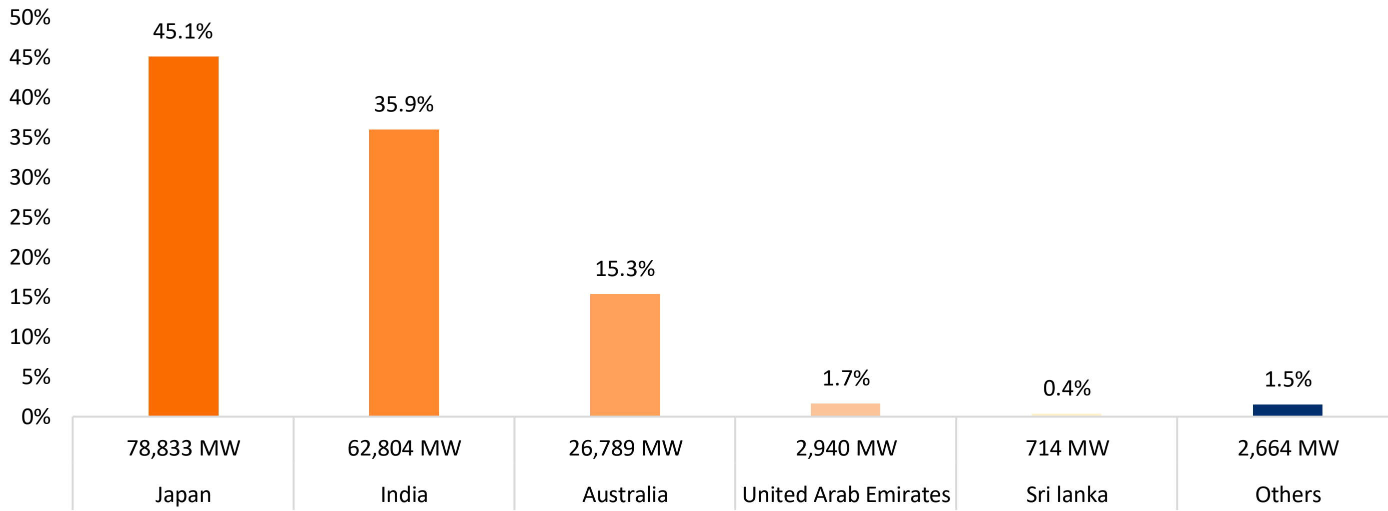
Senegal accounts for 5.5% share in the total installed capacity of solar PV in the African region. Owing to the government target to increase the share of RE in the generation mix and favourable policies for the RE sector, the total installed capacity has reached 263 MW in 2022 from 107 MW in 2017, grown at a CAGR of 20%.

Mali

Mali constitutes a 4.8% share in the total installed capacity of solar PV in the African region. The total installed capacity has reached 229 MW in 2022 from 19 MW in 2017, grown at a CAGR of 64%. Namibia's efforts in renewables contributed to a 30% reduction in electricity imported in 2018 which resulted in 330 MW of solar PV generation per annum until 2030.

Asia Pacific

Top 5 ISA Member Countries by Solar Installation, 2022 (Total: 172 GW)



Source: IRENA, 2022

Japan, India and Australia have the major installations accounting for 96.4% of total capacity in the region. The Asia and Pacific region comprise a diverse and dynamic region of the globe, with 4.4 Bn people living in 58 markets, ranging from the small island economies that are among the most vulnerable to the impact of the climate change to the world's largest energy consumer. Along with the vast renewable energy potential, the region already possesses significant knowledge and expertise on renewables.

Japan

Japan is the market leader in Asia and Pacific region with 78,833 MW of solar PV capacity installed in 2022 from 49,500 MW in 2017, grown at a CAGR of 10%. The Japanese government developed a set of measures to expand solar PV, which include requiring 60% of new residential buildings to include rooftop PV and deregulating land zoning to allow PV installations on agricultural land.

India

India has shown tremendous growth over the recent years with the total solar PV installed capacity reaching 62,804 MW in 2022 from 17,923 MW in 2017, grown at a CAGR of 29%. Market expansion was driven mainly by the focus on local manufacturing. The country is targeting to achieve 50% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030.

Australia

For **Australia**, the total installed capacity of solar PV in the country has reached 26,789 MW in 2022 from 7,352 MW in 2017, grown at a CAGR of 30%. In 2021, Australia set a new global record of 1 kW of installed solar PV per capita, which was 31% higher than in the runner-up country the Netherlands (0.765 kW per capita).

UAE

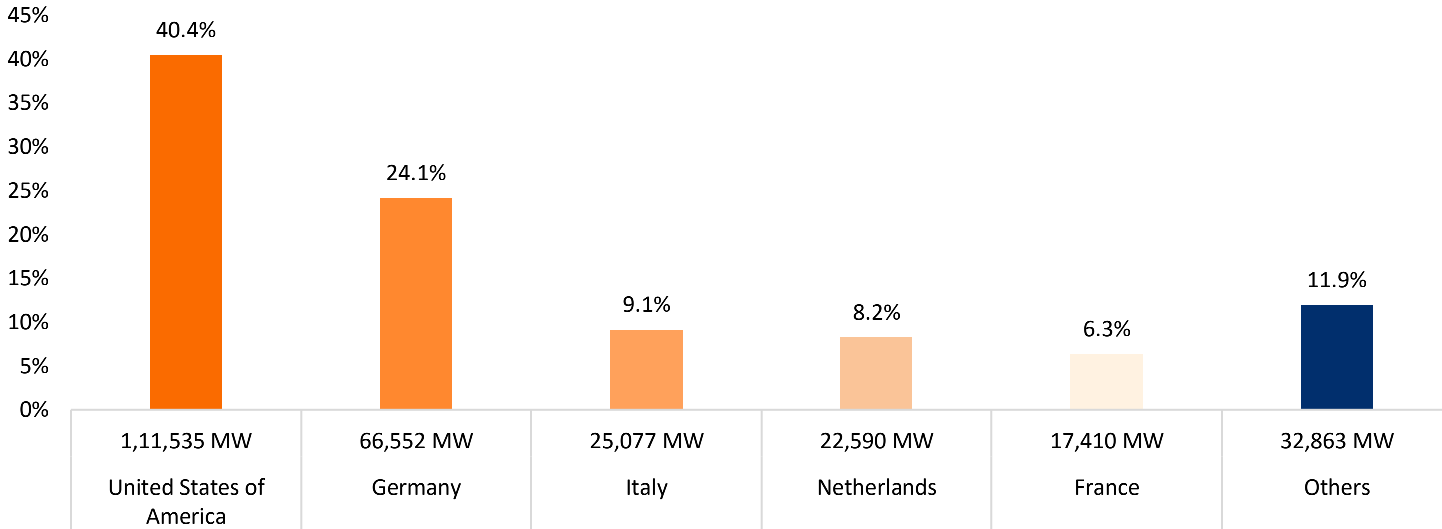
The total installed capacity of solar PV in the country has reached 2,940 MW in 2022 from 255 MW in 2017, grown at a CAGR of 63%. **UAE's** National Energy Strategy 2050 envisages a 50% share of clean energy (renewables and nuclear) in the installed power capacity mix by 2050.

Sri Lanka

Sri Lanka's installed capacity of solar PV reached 714 MW in 2022 from 131 MW in 2017, grown at a CAGR of 40%. The country committed to achieve 70% renewable energy in electricity generation by 2030 as part of its latest NDC.

Europe and others*

Top 5 ISA Member Countries by Solar Installation, 2022 (Total: 243 GW)



Source: IRENA, 2022

The market leaders in the region are United States of America, Germany, Italy, Netherlands and France with 243 GW capacity contributing 88.1% of the total installed solar capacity in the region. The EU has been a front-runner in the spread of solar energy. The European Green Deal and the REPowerEU plan have turned solar energy into a building block of the EU's transition towards clean energy. The accelerated deployment of solar energy contributes to reducing the EU's dependence on imported fossil fuels.

USA

United States of America is the top market leader in Europe & others region and the total solar PV installed capacity has reached 1,11,535 MW in 2022 from 41,357 MW in 2017, grown at a CAGR of 22%. With increased consumer demand, the residential sector broke records with rooftop installations of 4.2 GW – up 30% from 2020 and the highest annual growth rate since 2015 – to reach a total capacity of 23.1 GW.

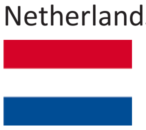
Germany

Germany is the second market leader in the Europe region and the total solar PV installed capacity has reached 66,552 MW in 2022 from 42,291 MW in 2017, grown at a CAGR of 9%. The country has committed to increase renewable energy in final energy consumption to reach at least 32% by 2030.

Italy

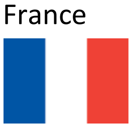
The total installed capacity in **Italy** has reached 25,077 MW in 2022 from 19,682 MW in 2017, grown at a CAGR of 5%. Italy has committed to increase renewable energy in final energy consumption to reach at least 32% by 2030.

Netherlands



Netherlands installed capacity of solar PV has reached 22,590 MW in 2022 from 2,903 MW in 2017, grown at a CAGR of 51%. The increase in the share of solar was due to three factors: a higher number of PV installations that went online during the year, falling electricity demand, and an exceptional number of sunny hours.

France

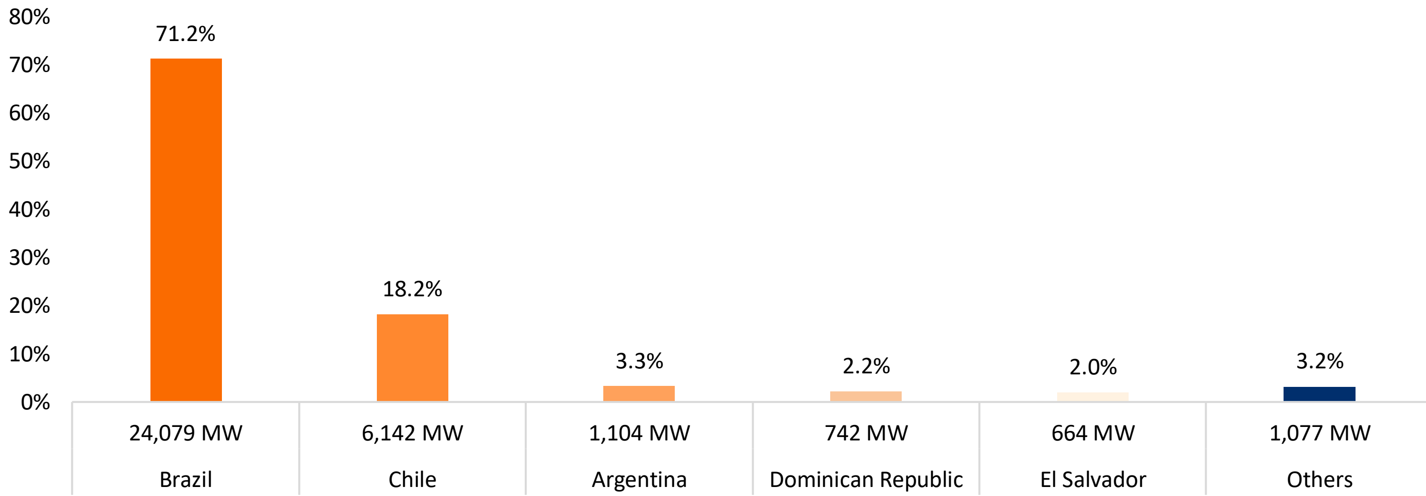


The total installed capacity of solar PV in **France** has reached 17,410 MW in 2022 from 8,610 MW in 2017, grown at a CAGR of 15%. France targets to reduce the share of nuclear from 70% to 50% in its electricity mix by 2035 and close its coal plants by 2022. The government is seeking to accelerate progress in solar by streamlining permits, promoting flagship initiatives, and aligning regional and national ambitions.

**USA has been included in the Europe and Others region as per ISA's regional classification of member countries.*

Latin America and Caribbean

Top 5 ISA Member Countries by Solar Installation, 2022 (Total: 33 GW)



Source: IRENA, 2022

Major markets in the LAC region are Brazil, Chile, Argentina, Dominican Republic and El Salvador having total installed capacity of 32,731 MW in 2022, accounting for 96.8% of total capacity in the region. Latin America comprises some of the most dynamic renewable energy markets in the world, with more than a quarter of the primary energy (twice the global average) coming from renewable energy sources. The maturing technologies and renewable energy policy reforms offer an unprecedented opportunity to further tap the vast renewable energy potential in the region.

Brazil

The total installed capacity of solar PV in **Brazil** has reached 24,079 MW in 2022 from 1,104 MW in 2017, grown at a CAGR of 85%. The distributed solar installation led Brazil's market for newly added capacity, with 4 GW, driven by soaring electricity prices due to a hydropower crisis and by a national net metering regulation.

Chile

For **Chile**, the total installed capacity of solar PV in the country has reached 6,142 MW in 2022 from 1,809 MW in 2017, grown at a CAGR of 28%. Chile is home to one of the highest irradiation regions in the world, the desert of Atacama, with "around 60 to 70% of solar PV" capacity installed in the regions of Atacama.

Argentina

The total installed capacity of solar PV in **Argentina** has reached 1,104 MW in 2022 from 8.8 MW in 2017, grown at a CAGR of 163%. Among the several initiatives to increase the power generation, the Argentinian government has launched the RenovAr Programme to develop the Argentina's renewable energy sector.

Dominican Republic

Dominican Republic's installed capacity of solar PV reached 742 MW in 2022 from 106 MW in 2017, grown at a CAGR of 48%. The country plans for the displacement of the private vehicles fleet by 75% EVs and 25% hybrids by 2030 with recharging from renewable sources at an estimated cost of USD 5 Mn.

El Salvador

The total installed capacity of solar PV in **El Salvador** has reached 664 MW in 2022 from 120.5 MW in 2017, grown at a CAGR of 41%. El Salvador is in the process of implementing a new long-term national energy policy 2020 – 2050, which aims to reduce electricity tariffs in the country by prioritising renewables over fuel imports and facilitating the removal of electricity subsidies.

Per Capita Electricity Demand

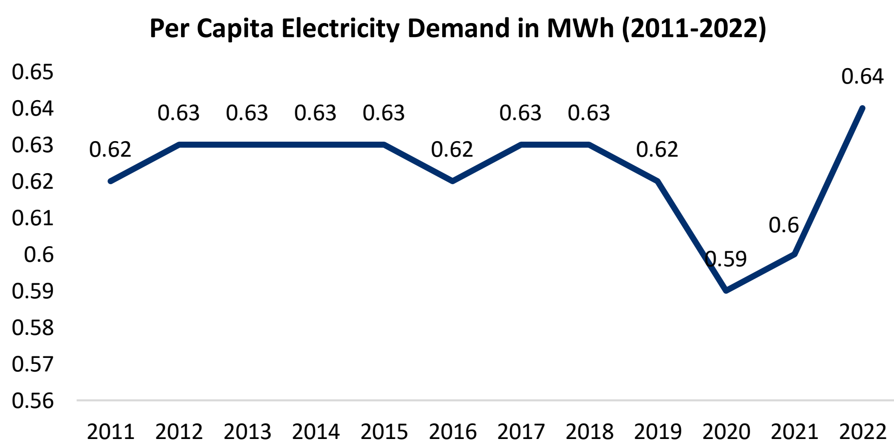
In 2022, Global electricity demand reached a record high of 28,510 TWh. Major economies were responsible for the magnitude of this demand: China for 8,840 TWh (31%), India for 1,836 TWh (6%), United States for 4,335 TWh (15%), the European Union for 2,794 TWh (10%), Japan for 968 TWh (3%) and Russia for 1,102 TWh (4%).

At a global level, the average per capita electricity demand reached **3.6 MWh** in 2022, with major countries above the global per capita average (United States 13 MWh, South Korea 12 MWh, China 6.2 MWh) and other countries such as India 1.3 MWh and Bangladesh 0.6 MWh far below.

Wind and solar met the majority of demand growth: In 2022, growth in wind and solar met 80% of the increase in electricity demand, while renewables together met 92% of the growth. In China, wind and solar met 69% of the electricity demand in 2022. In India, wind and solar met 23% of the demand growth. In the United States, wind and solar met 68% of the demand growth.

The figure below shows the electricity demand per capita across the 4 geographical regions ('Africa', 'Asia & Pacific', 'Europe and others', 'Latin America & Caribbean'),

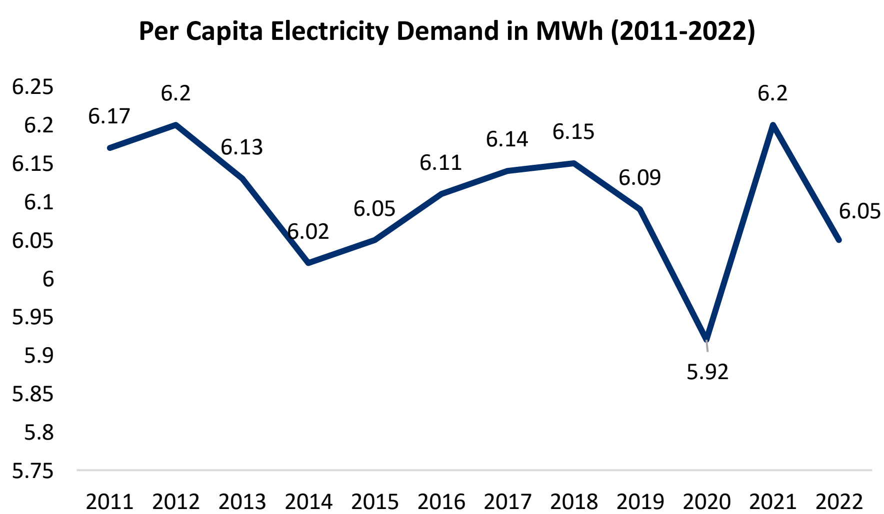
Africa



Source: EMBER, 2022

- The African region's electricity demand per capita of 0.6 MWh is significantly lower than the world average of 3.6 MWh in 2022.
- Africa's proportion of electricity demand growth met by clean energy sources roughly doubled, from 23% during 2008-2015 to 61% during 2015-2022.

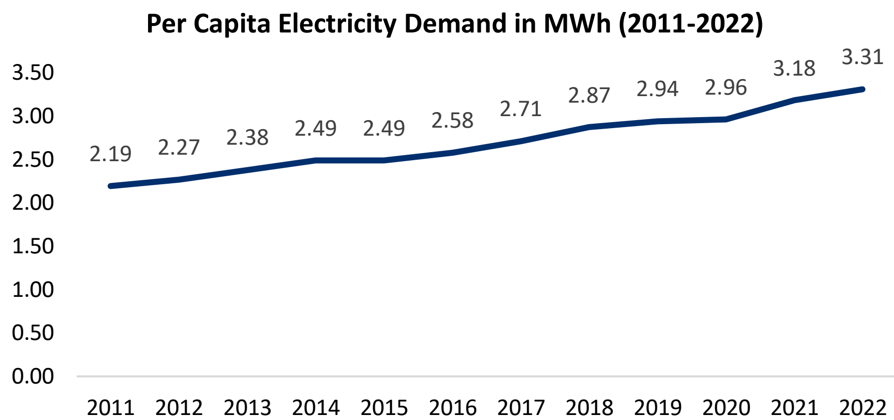
Europe and others



Source: EMBER, 2022

- The Europe region's electricity demand per capita of 6.05 MWh is significantly higher than the world average of 3.6 MWh in 2022.
- Since 2015, electricity demand in the region has been broadly unchanged and the growth in clean power reduced fossil generation.
- EU's electricity demand declined from 6.2 MWh to 6.05 MWh in 2022 due to the mild weather, alongside demand reduction measures driven in part by high electricity prices across the region.

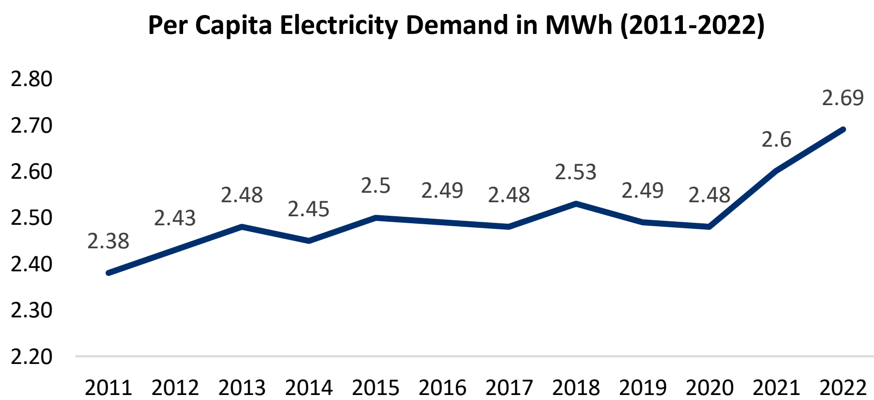
Asia Pacific



Source: EMBER, 2022

- The Asia Pacific region's electricity demand per capita of 3.3 MWh is relatively lower than the world average of 3.6 MWh in 2022.
- Over half of the electricity demand increase in Asia (52%) was met with clean electricity over the last few years from 2015 to 2022.

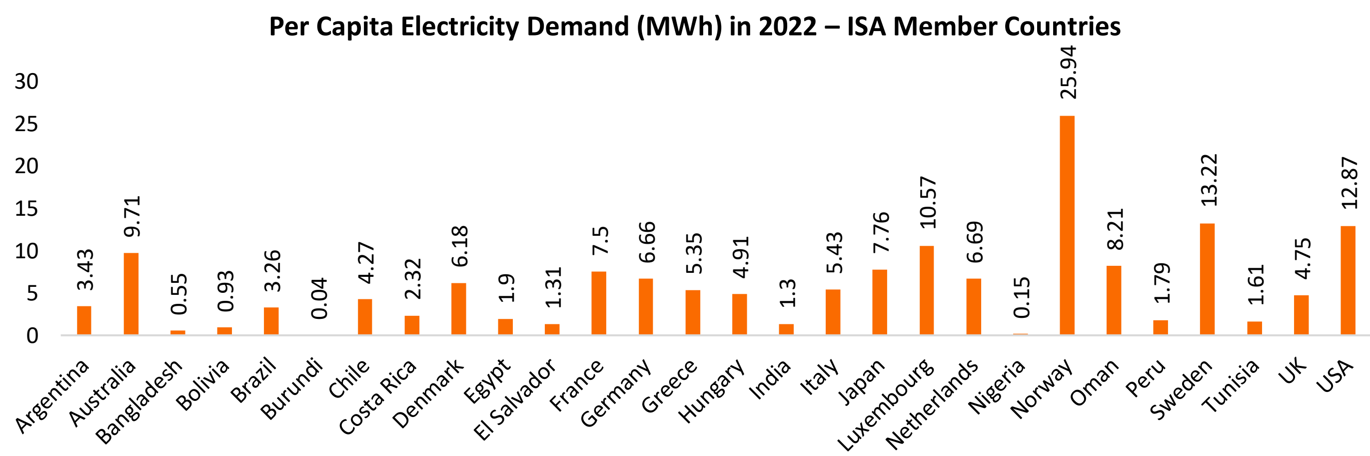
Latin America and Caribbean



Source: EMBER, 2022

- The Latin America and Caribbean region's electricity demand per capita of 2.7 MWh is relatively lower than the world average of 3.6 MWh in 2022.
- This region effectively increased the clean power over the last few years to meet the rising electricity demand and to reduce fossil generation.

Based on the data availability from the secondary data sources, the electricity consumption per capita of ISA Member countries are captured below,



Source: EMBER, 2022

From the above figure, it can be noted that the Norway has the highest electricity demand per capita of 25.94 MWh followed by Sweden (13.22 MWh) and USA (12.87 MWh) in 2022. USA's electricity demand per capita reached 12.87 MWh, more than three times the world average of 3.6 MWh. Increased demand has been primarily met by solar and wind replacing gas generation and retiring coal plants. Thus, the United States transition to wind and solar is happening faster than the global average. Europe's electricity demand per capita of 6.05 MWh is higher than the world average of 3.6 MWh. European Union is a critical region in the global transition to clean power and its efforts to reduce emissions through wind, solar and other clean electricity sources will have a significant impact to achieve net zero by 2050.

4

Trends in Solar PV

4.1 NDCs and Renewable Energy Trends

The section presents an overview of the latest updates in the NDC focusing on the renewable energy targets of ISA member countries. Renewable energy is one of the key components of the energy transition, but not all countries have included targets for their deployment in their NDCs. Based on the data availability from the secondary data sources, the revised/latest renewable energy targets of 34 ISA Member countries are captured below:

Country	Description	Country	Description
Algeria	27% of the electricity produced nationally to be derived from renewable sources of energy by 2030; 4% achieved (2020)	Dominica	100% renewable energy usage by 2030, principally from the harnessing of geothermal resources; 25% achieved (2020)
Antigua & Barbuda	86% renewable energy generation from local resources in the electricity sector by 2030; 7% achieved (2020)	Dominican Republic	Installation of 479 MW of solar PV power by 2030 at an estimated cost of USD 407.15 Mn; 66% achieved (2019)
Bahrain	Renewables will cover 5% of peak capacity in 2025 and 10% in 2035; 1% achieved (2020) against 2025 targets	Egypt	Installing renewable energy capacities to reach electric power contribution target of 42% by 2035; 26% achieved (2020)
Barbados	95% share of renewable energy in the electricity mix by 2030; 7% achieved (2020)	EU	At least 32% renewable energy share in final energy consumption by 2030.
Belize	75% gross generation of electricity from renewable energy sources by 2030 through hydro, solar, wind and biomass; 56% achieved (2020)	Grenada	Incorporation of 15 MW of renewable energy to the existing feeder line network by 2030; 23% achieved (2020)
Bolivia	By 2030, 19% of the energy consumed will come from power plants based on alternative energies (biomass, solar, wind and geothermal); 209% achieved (2020)	Cuba	24% of electricity generation based on renewable energy sources in Cuban electricity matrix by 2030 (biomass – 14%; wind + solar PV – 10%); 89% achieved (2020)
Cambodia	25% of the renewable energy in the energy mix (solar, wind, hydro, biomass) by 2030; 218% achieved (2020)	Guyana	100% renewable electricity by 2025; 13% achieved (2020)
Cameroon	To increase the share of renewable energies in the electricity mix to 25% by 2035; 263% achieved (2020)	Guinea-Bissau	Increase the share of renewable energies in the electricity mix to 58% by 2030, from hydro (40%) and rest from solar PV and wind; 0% achieved (2020)
Cape Verde	30% renewable energy share in the electricity supply in 2025 and up to 50% in 2030; 54% achieved (2020)	India	To achieve about 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030; 40% achieved (2020)

Country	Description	Country	Description
Israel	To increase the share of renewable power generation to 20% in 2025 and 30% in 2030; 27% achieved (2020) against 2025 targets	Saudi Arabia	To increase the share of renewable energy to reach approximately 50% of the energy mix by 2030; 0.1% achieved (2020)
Mauritius	60% of energy needs to be produced from green sources by 2030; 35% achieved (2020)	Seychelles	To increase the renewable energy share in the electricity supply to 15% in 2030 using mainly wind and solar PV; 78% achieved (2020)
Morocco	52% of the installed electric power from renewable sources, including 20% from solar energy, 20% from wind energy and 12% from hydraulic energy by 2030; 35% achieved (2020)	Sao Tome & Principe	To increase the use of renewable energy sources up to 49 MW, mainly from solar (32.4 MW), hydroelectric (14 MW) and biomass (2.5 MW); 6% achieved (2019)
Myanmar	To increase the total share of renewable energy (solar and wind) to 53.5% by 2030,; 90% achieved (2020)	Sri Lanka	To achieve 70% renewable energy in electricity generation by 2030; 55% achieved (2020)
Nicaragua	To increase the percentage of electricity generation through renewable energy sources such as solar, wind and biomass to 60% by 2030, with respect to the year 2007; 91% achieved (2020)	Suriname	To maintain a share of electricity from renewable sources above 35% by 2030; 146% achieved (2020)
Oman	To raise the penetration of renewable energy in the energy mix to 20% in 2030; 2% achieved (2020)	Tonga	70% of electricity generated from renewable sources by 2030 through combination of solar, wind and battery storage; 20% achieved (2020)
Papua New Guinea	To increase levels of renewables in the energy mix for on-grid connection through increasing the share of installed capacity of renewable energy from 30% in 2015 to 78% in 2030; 35% achieved (2020)	United Arab Emirates	National Energy Strategy 2050 envisages a 50% share of clean energy (renewables and nuclear) in the installed power capacity mix by 2050; 9% achieved (2020)
Samoa	To reach 100% renewable electricity generation by 2025; 38% achieved (2020)	Vanuatu	To reach approximately 100% renewable energy in the electricity sector by 2030; 29% achieved (2020)

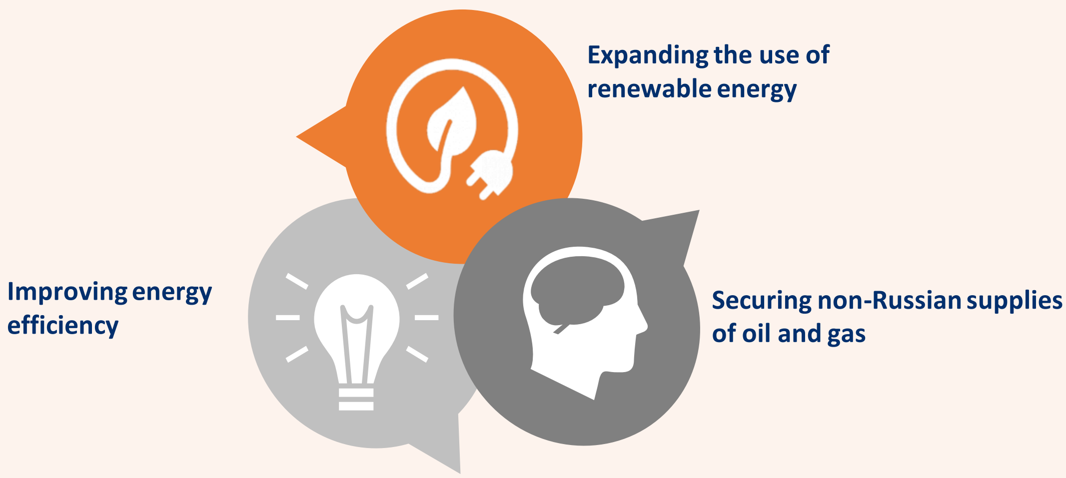
Source: UNFCCC NDC registry

Box 1

Increase in ambition of Renewable Energy Targets In the European Union - REPowerEU

Until 2022, Europe relied on the Russian Federation for 40% of its fossil gas and 27% of its imported oil valued at around EUR 400 Bn a year. The conflict and resulting sanctions have raised concerns regarding energy security and energy costs that have put extremely high financial pressure on consumers and businesses.

In response, the European Commission announced its REPowerEU strategy in March 2022 with the goal of reducing Russian gas imports by two-thirds by the end of 2022 and entirely by 2030. The strategy focuses on three key topics,



If the proposal is adopted, the European Union's 2030 target for renewables would increase from the current 32% to 45% of the energy mix. The REPowerEU plan would bring total renewable energy generation capacity to 1,236 GW by 2030 (including 600 GW solar PV and 510 GW wind), 15% higher than the 1,067 GW envisaged under Fit for 55.

Source: IRENA, 2022

4.2 Policy and Regulatory Trends

As in 2020, the power sector continued to receive the renewable energy policy attention in 2021. Policies to support renewables in the power sector include: renewable portfolio standards (RPS), feed-in policies (tariffs and premiums), auctions and tenders, renewable energy certificates (RECs), net metering and other policies to encourage self-consumption, as well as fiscal and financial incentives (such as grants, rebates and tax credits).

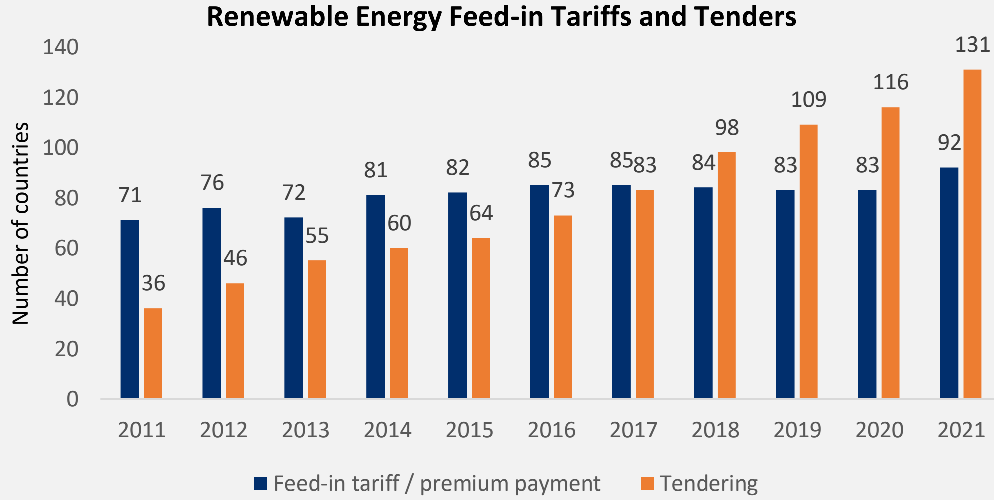
The major policy and regulatory trends to support solar energy deployment are described below,

<table>
<tr><th>Key policies</th><th>Description</th></tr>
<tr><td>Feed-in Tariff (FIT)/ Feed in Premiums Policy</td><td>

FITs and FIPs, are used to promote centralised and decentralised renewable power generation, and they remain among the most widely used policy mechanisms for supporting renewable power.
Ireland, which had removed its FIT in 2015, re-introduced it to boost citizen and community participation in the energy transition.
Trinidad and Tobago introduced a FIT to support solar PV rooftop systems.
India's introduction of time-of-day (ToD) tariffs to incentivize solar power generation during peak demand periods.
Australia's solar feed-in tariff (FIT) program is transitioning to competitive tenders, promoting cost-effective solar energy deployment. Developers now submit tariff proposals, and contracts are awarded to projects with the most competitive rates.

</td></tr>
<tr><td>Renewable energy auctions or tenders</td><td>

It is a competitive process to procure low cost Auctions for renewable energy offer a competitive way to buy cheap power from renewable sources. In 2021, a number of nations held national or subnational renewable energy auctions or tenders, as shown in the figure below:

Renewable Energy Feed-in Tariffs and Tenders


Source: REN21, 2022

Auction-based solar projects promote competition among developers, leading to cost reductions, increased efficiency, and better value for money.
It opens opportunities for price discovery, ensuring selection of the most economically competitive projects as well as lessens the subsidy burden on the government for deployment of large scale solar energy projects.

</td></tr>
</table>

Key policies	Description
Net metering	▪ Net metering continued to be a popular policy instrument to support renewable energy i.e. for rooftop solar segment ▪ Net metering is a regulated arrangement in which electricity generators can receive credits for excess generation, which can be applied to offset consumption in other billing periods. Under net metering, customers receive credit at the level of retail electricity price. ▪ In India, Kerala introduced a new net metering rooftop programme with a goal of installing solar panels on 75,000 homes and West Bengal introduced net metering for household rooftop solar PV between 1 kW and 5 kW. ▪ Malaysia introduced a new programme that allows residential customers to export surplus solar generation to the grid.
Financial/ fiscal policies (grants, rebates and tax credits)	▪ At a global level, approximately 17 countries introduced new financial or fiscal policies in 2021, including Denmark, France, Italy, Australia and New Zealand. ▪ In Europe, Croatia implemented an USD 8.4 bn rebate programme for rooftop solar PV installations for businesses and households. ▪ Sweden made available USD 28.7 Mn in rebates for households who install solar PV.
Renewable portfolio standards (RPS)	▪ RPS mandates requiring utility to install/ use a certain share of renewable energy. ▪ As of 2021, 31 US states and the District of Columbia had legally binding RPS. ▪ Colombia introduced an obligation for utilities operating in the wholesale energy market to ensure that 10% of the electricity they distribute is generated by renewable technologies as of 2022.
Renewable energy certificate (REC)	A certificate awarded to certify the generation of renewable energy (typically 1 MWh of electricity). RECs are preferred instrument to meet renewable energy obligations.

■ Existing policies /schemes

□ Absence of policies/schemes

Key Solar Policies in ISA Member Countries

S No	Countries	FIT	RPS	REC
	Africa			
1	Algeria	■	□	□
2	Benin	□	□	□
3	Botswana	□	□	□
4	Burkina Faso	□	□	□
5	Burundi	□	□	□
6	Cameroon	□	□	□
7	Cape Verde	□	□	□
8	Chad	□	□	□
9	Comoros	■	□	□
10	DR Congo	■	□	□
11	Cote d'Ivoire	■	□	■
12	Djibouti	□	□	□
13	Egypt	■	□	□
14	Equatorial Guinea	□	□	□
15	Eritrea	□	□	□
16	Ethiopia	□	□	□
17	Gabon	□	□	□
18	Gambia	■	□	□
19	Ghana	■	■	■
20	Guinea	■	□	□
21	Guinea-Bissau	□	□	□
22	Liberia	□	□	□
23	Madagascar	■	□	□
24	Malawi	□	□	□
25	Mali	□	□	□
26	Mauritius	□	□	□
27	Morocco	□	□	□
28	Mozambique	■	□	□
29	Namibia	□	□	□
30	Niger	□	□	□
31	Nigeria	■	■	□
32	Rwanda	■	□	□
33	Sao Tome Principe	□	□	□
34	Senegal	■	■	□
35	Seychelles	□	□	□
36	Somalia	□	□	□
37	South Sudan	□	□	□
38	Sudan	□	□	□
39	Tanzania	■	□	□
40	Togolese Republic	□	□	□
41	Tunisia	□	□	□
42	Uganda	■	□	□
43	Zambia	■	□	□
44	Zimbabwe	□	□	□
	Asia-Pacific			
45	Australia	■	■	■
46	Bahrain	■	□	■
47	Bangladesh	□	□	□
48	Cambodia	□	□	□
49	Fiji	□	□	□
50	India	■	■	■
51	Japan	■	□	■
52	Kiribati	□	□	□
53	Maldives	■	□	□
54	Marshall islands	□	□	□
55	Myanmar	□	□	□
56	Nauru	□	□	□
57	Nepal	■	□	■
58	Oman	□	□	□
59	Palau	□	■	□
60	Papua New Guinea	□	□	□
61	Samoa	□	□	□
62	Saudi Arabia	■	□	□
63	Sri Lanka	■	■	□
64	Syria	■	□	□
65	Tonga	□	□	□

Note: FIT - Feed-in Tariff; RPS - Renewable portfolio standards; REC - Renewable Energy Certificate

Existing policies /schemes

Absence of policies/schemes

Key Solar Policies in ISA Member Countries

S No	Countries	FIT	RPS	REC
66	Tuvalu	Absent	Absent	Absent
67	United Arab Emirates	Absent	Existing	Absent
68	Vanuatu	Existing	Absent	Absent
69	Yemen	Existing	Absent	Absent
Europe & others				
70	Denmark	Existing	Absent	Existing
71	France	Existing	Absent	Existing
72	Germany	Existing	Absent	Existing
73	Greece	Existing	Existing	Existing
74	Hungary	Existing	Absent	Absent
75	Israel	Existing	Existing	Absent
76	Italy	Existing	Absent	Absent
77	Luxembourg	Existing	Absent	Absent
78	Netherlands	Existing	Absent	Existing
79	Norway	Absent	Existing	Existing
80	Sweden	Absent	Existing	Existing
81	UK	Existing	Existing	Existing
82	USA	Existing	Existing	Existing
Latin America & Caribbean				
83	Antigua and Barbuda	Absent	Absent	Absent
84	Argentina	Existing	Existing	Absent
85	Barbados	Absent	Absent	Absent
86	Belize	Absent	Absent	Absent
87	Bolivia	Existing	Existing	Absent
88	Brazil	Absent	Absent	Absent
89	Chile	Existing	Existing	Existing
90	Costa Rica	Absent	Absent	Absent
91	Cuba	Absent	Absent	Absent
92	Dominica	Absent	Absent	Absent
93	Dominican Republic	Absent	Absent	Absent
94	El Salvador	Absent	Absent	Absent
95	Grenada	Absent	Absent	Absent
96	Guyana	Absent	Absent	Absent
97	Haiti	Absent	Absent	Absent
98	Jamaica	Absent	Absent	Absent
99	Nicaragua	Existing	Absent	Absent
100	Paraguay	Absent	Absent	Absent
101	Peru	Existing	Existing	Absent
102	Saint Kitts and Nevis	Absent	Absent	Absent
103	Saint Vincent and the Grenadines	Absent	Absent	Absent
104	Saint Lucia	Absent	Absent	Absent
105	Suriname	Absent	Absent	Absent
106	Trinidad and Tobago	Absent	Absent	Absent
107	Venezuela	Absent	Absent	Absent

Note: FIT - Feed-in Tariff; RPS - Renewable portfolio standards; REC - Renewable Energy Certificate; Source: REN21, 2022

Major Policy gaps and Challenges

1. Facilitate permitting for utility-scale systems - Lengthy and complicated permitting processes are one of the major challenges to the faster deployment of utility-scale solar PV plants in many parts of the world, especially in Europe. Developing clear rules and pathways for developers applying for a construction permit, determining strict timeframes for application processing, and public engagement in the identification of land suitable for investment could significantly accelerate solar PV deployment.

2. Establish a balanced policy environment for distributed PV - Appropriate policies are needed to attract investment into distributed solar PV while also securing sufficient revenue to pay for fixed network assets and ensuring that the cost burden is allocated fairly among all consumers.

Box 2

A Renewable Policy Transition in China

China has shifted its renewable energy pricing policy from a premium FIT model to a “grid parity” model where renewable and coal plants sell electricity at the same price. The National Energy Administration stopped approving FITs for renewable energy projects in 2018, which was followed by a decision to phase out FIT schemes. The move was driven by delay in FIT payments and by the plunging cost of PV modules.

The policy transition resulted annual solar PV installations to fall approximately 30% in 2019. However, as prosumers sought to benefit from the final years of FIT, the market grew 60% in 2020, to reach 55 GW of new installations in 2021.

In 2021, China announced its 14th Five-Year-Plan, puts a continued focus on wind and solar PV power as well as energy integration and energy storage, aiming for a 20% non-fossil fuel share in the energy mix by 2025. China’s recently announced targets for carbon neutrality by 2060 have also driven demand for renewables.

Source: REN21, 2022

Box 3

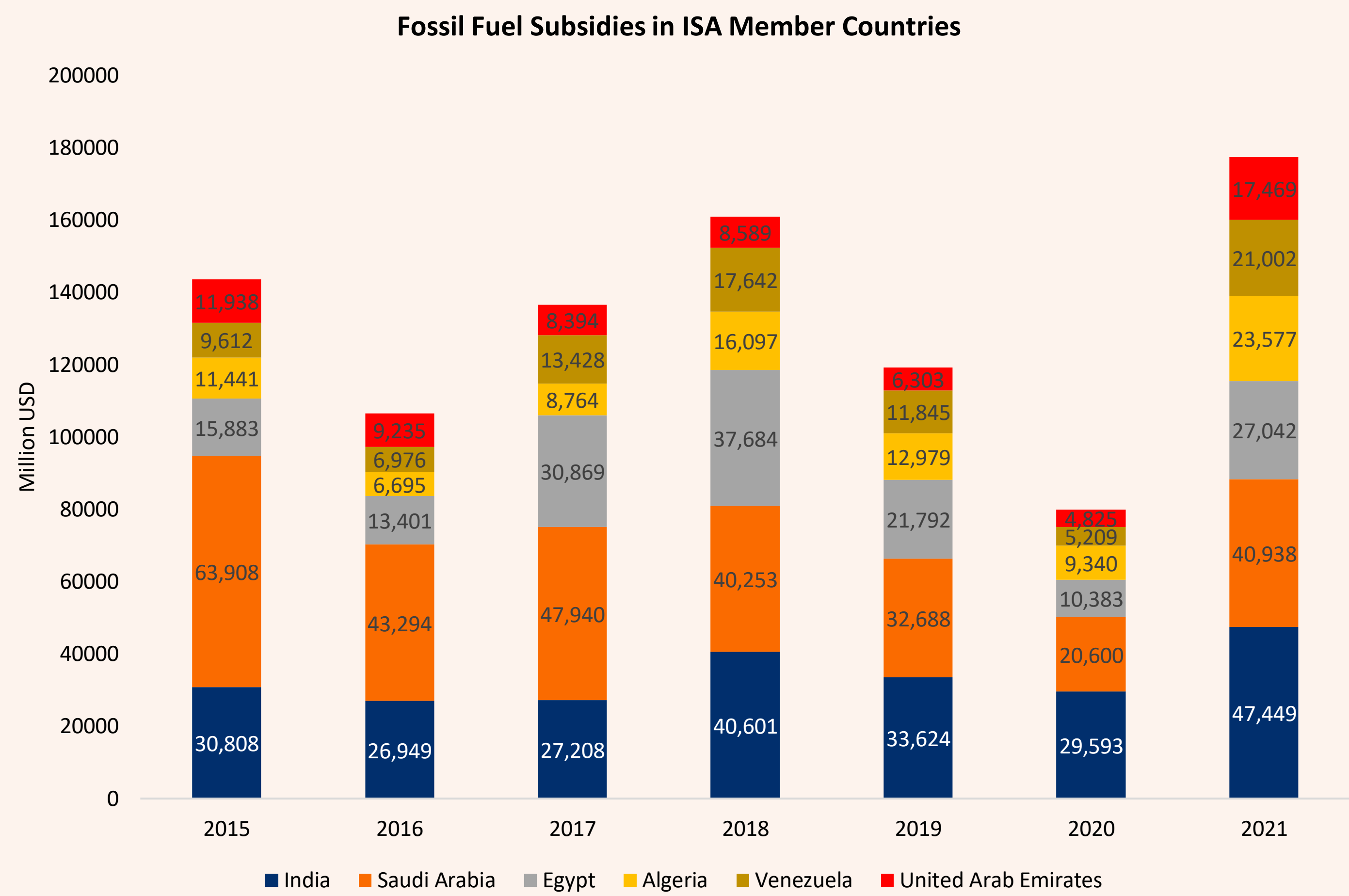
Fossil Fuel Subsidies are back on the rise – Global Scenario

According to IEA, energy subsidies have been rising since 2021 after a noticeable dip in 2020 due to the Covid pandemic. In 2021, rebounding fossil fuel prices and energy had already lifted fossil fuel consumption subsidies to USD 532 billion, around 20% above 2019’s pre-pandemic levels.

At a global level, Russia was the largest single provider of fossil fuel subsidy payments, followed by Iran and China in 2021. According to the IEA, subsidies for the use of fossil fuels increased to more than USD 1 Tn in 2022, by far the highest yearly value ever recorded.

In 2022, the cost of fossil fuels experienced significant fluctuations and reached exceptionally high levels due to geopolitical tensions affecting energy markets. Various policy measures were implemented to shield consumers from skyrocketing prices. However, these interventions had an unintended consequence of maintaining the artificial competitiveness of fossil fuels compared to low-emission alternatives.

Source: IEA, 2022



Source: IEA, 2022

- Phasing out fossil fuel subsidies is a crucial element for successful clean energy transitions, as highlighted in the Glasgow Climate Pact.
- Fossil fuel consumption is subsidized due to end-user prices being high enough to cover the market value of the fuel.
- During an energy crisis, governments prioritize shielding consumers from price impacts rather than committing to phasing out subsidies.
- This approach led to a significant increase in fossil fuel consumption subsidies in 2022 and the implementation of measures to mitigate the impact on energy bills.
- While this provided temporary relief, it reduced the incentive for consumers to save or transition to cleaner energy sources, thus delaying a sustainable resolution of the crisis.
- Moreover, these subsidies depleted public funds that could have been allocated to other areas, including clean energy transitions.

4.3 Solar PV Technology Trends

Taking advantage of the growing solar PV capacity across the globe, several countries are underway to stimulate future market growth, exploring innovative solar technologies from bifacial solar cells and floating solar farms to the energy harvesting trees. The major developments are as follows.

Technologies	Description
Bifacial solar cells	▪ Key features: Bifacial solar panels can **generate up to 30% more energy than monofacial panels**. Bifacial modules have also lower Balance of Systems (BOS) costs as fewer modules are needed to produce the same amount of energy as traditional modules. ▪ Worldwide demand of bifacial modules has also raised, with countries such as the United States, Brazil and the United Kingdom increasingly use these modules for utility scale Photovoltaic plants. ▪ Based on the present market trend, bifacial solar modules are extending their geographical reach from Japan, Europe to the emerging markets across the globe. Bifacial solar modules have attracted a lot of market attention in the recent years. ▪ The International Technology Roadmap for Photovoltaic (ITRPV) predicts that after having a minimal presence in 2017, the bifacial concept is expected to capture approximately 10% of the market share in 2018, increase to 15% by 2020, and potentially reach 40% within the next decade (IRENA, 2019).
Solar trees	▪ In solar tree, the solar modules are planted on a single pillar, which resembles like a tree trunk. Solar tree serves the dual purpose of being an energy generator as well as an artwork. ▪ Solar trees serve as a complementary option to rooftop solar, offering ergonomic advantages over traditional solar panels. They require around 100 times less space compared to horizontal solar plants while generating an equivalent amount of electricity. This makes solar trees a viable solution for economies facing challenges of limited land and space availability. **Box 4** **India develops World's largest Solar Tree**  The Council of Scientific and Industrial Research - Central Mechanical Engineering Research Institute (CSIR-CMERI) residential colony in Durgapur is now home to the world's largest solar tree, developed by CSIR-CMERI. With an installed capacity of 11.5 kW, this solar tree can generate an annual clean power output of approximately 12,000-14,000 units. The design of the solar tree ensures maximum sunlight exposure for each of its approximately 35 solar PV panels, minimizing shadow areas below. Unlike rooftop solar facilities, the solar tree's arms holding the panels are flexible and adjustable according to specific needs, providing an additional advantage. Source: CSIR-CMERI Website

Technology	Description
	The energy generation data from the solar tree can be monitored either real-time/ on daily basis. The Solar Tree can also have certain customizable features for application at diverse sites. The Solar Trees are designed in a manner to ensure minimum Shadow Area, thus potentially making it available for widespread usage in the agricultural activities such as, e-Tractors and e-Power Tillers and High Capacity Pumps. Solar Trees can be aligned with Agriculture for substituting price-volatile fossil fuels. Each Solar Tree has the potential to save 10-12 tonnes of CO_2 emissions being released into the atmosphere as GHG when compared with fossil fuel fired energy generation. Besides, the surplus generated power can be incorporated into the energy grid. This Agricultural Model can provide a constant economic return and support the farmers to counter the effects of the uncertain variation in agriculture related activities, thus creating farming an Economic & Energy Sustainable practice. The solar tree has the capability to include IOT based features, i.e. round-the-clock CCTV surveillance in agricultural fields, wind speed, rainfall prediction, real-time humidity, and soil analytics sensors. Source: Ministry of Science and Technology (India), 2016
Solar carports	▪ Solar carports are ground-mounted solar panels that are installed in the vehicle parking lots. Home driveways can also be laid underneath to form a carport. ▪ Solar Carports are very popular alternative and supplement to the classic rooftop systems, with the benefit that the solar carports can be installed entirely independent of the roof angle, shape and orientation of the house. ▪ Besides providing the shade to the vehicles parked underneath, they can efficiently generate electricity and offers a number of benefits. If solar carports are coupled with a well-designed charging system, the electricity produced can be used for EV charging thus reducing the costs of running the vehicle. ▪ An elevated solar carport track the sun throughout the day, can generate 50-70% more energy than fixed solar carport systems of similar size and they are becoming a strong and attractive economic proposition in a growing number of markets. ▪ Finally, space saving is another important aspect, as carports make better utilisation of land which is already in use for the vehicle parking rather than using an open land. **Box 5**  **Tata Motors and Tata Power inaugurate India's largest Solar Carport at its Car Plant in Pune** Tata Motors and Tata Power jointly inaugurated India's largest grid-synchronized solar carport at the Tata Motors car plant in Chikhali, Pune. The 6.2 MW solar carport deployed by Tata Power will generate 86.4 lakh kWh of electricity per year and is estimated to decrease 7,000 tonnes of carbon emissions annually and 1.6 lakh tonnes over its lifecycle.

Technology	Description
	Spanning over to 30,000 square meters, the solar carport will not only generate green power, but will also provide covered parking for cars in the plant. Also, Tata Power Solar commissioned solar carport with 2.67 MW of capacity at Cochin International Airport. The project comprised of 8,472 solar panels on 27 carports spread over 20,289 square meter of area. Benefits**:** Offsets 1,868 tonnes of CO_2 at Cochin International Airport per annum, equivalent to 46,700 tonnes of CO_2 offset in 25 years. The plant generates 11,000 units of electricity daily. Source: Tata Power Website
Floating solar farms/ floatovoltaics	▪ Floatovoltaics refer to the photovoltaic solar power systems that float on dams, reservoirs and other water bodies. ▪ These floating photovoltaic panels generate large amount of electricity, and the best part is, that they don't use any space on real estate/ land. ▪ Due to the cooling effect of water, these floating solar cells generate **more power by up to 10%**. However, floating solar PV also faces some challenges such as feasible site selection, rusting due to moisture and high cost as compared to conventional solar plants. ▪ Besides producing electricity, these 'floatovoltaics' are also beneficial in water management by reducing water loss due to evaporation. **Box 6**  **Hybrid Hydropower and Floating Solar PV systems in China** The development of the grid connected hybrid systems that combine floating solar photovoltaic and hydropower technologies is still at an early stage. Only a small system of 218 kWp has been deployed in Portugal. In 1989, the Longyangxia hydropower plant was commissioned with the four turbines of 320 MW each 1,280 MW in total. It serves as the frequency regulation and major load peaking power plant in China's northwest power grid. The associated Gonghe solar plant is 30 kms away from the Longyangxia hydropower plant. The initial phase was built & commissioned in 2013 with a nameplate capacity of 320 MW. An additional 530 MWp was completed in 2015. The Photovoltaic plant is directly connected through a reserved 330 kV transmission line to the hydropower substation. The hybrid system is operated so that the energy generation of the hydro and Floating Solar Photovoltaic components complement each other. After the solar Photovoltaic was included, the grid operator began to issue a higher power dispatch set point during the day.

Technology	Description
	As expected, on a typical day the output from the hydro facility is now decreased, especially from 11 a.m. to 4 p.m., when solar Photovoltaic generation is high. The saved energy is requested by the operator to be utilised during the early morning and late night hours. Although the daily generation pattern of the hydropower has varied, the daily reservoir water balance could be maintained at the same level as before to meet the water requirements of the other downstream reservoirs. All power produced by the hybrid system is fully absorbed by the grid, without any reduction. This system shows that hydro turbines can provide adequate response to demand. Source: World Bank, 2018
Agrophotovoltaic (APV)	▪ APV technology aligns with sustainable agriculture practices by utilizing land efficiently and promoting renewable energy generation in rural areas. ▪ APV systems can help farmers diversify income streams by generating electricity and potentially accessing additional revenue streams through renewable energy incentives. ▪ Research efforts are focused on understanding the agronomic impacts of APV systems, exploring compatible crop combinations, and assessing the long-term sustainability of this integrated approach. The "Agrophotovoltaics – Resource-Efficient Land Use (APV-RESOLA)" project, situated in Germany near Lake Constance, has successfully demonstrated the APV concept. The project involved a 194 kW solar system mounted on a 5-meter-high structure above land used for cultivating celery, clover, potatoes, and winter wheat. The findings confirmed earlier research, with land use efficiency reaching 160% in 2017 and 186% in 2018 (IRENA, 2019). Italy included USD 1.24 Bn in support for agrovoltaics in its post-COVID recovery plan. Farmers are beginning to gain wider awareness of the benefits of agricultural PV – including higher crop yields. **Box 7** **Fiji Agrophotovoltaic Project in Ovalau** In order to reduce Fiji's reliance on hydropower, the electricity output is becoming increasingly volatile owing to irregular annual rainfall, this project aims to develop a 4 MW solar PV power generation system that will boost local agricultural production, and to combine it with a 5 MW battery storage system. The total project value is USD 10 million, including Green climate fund's loan of USD 3.9 Mn and a USD 1.1 Mn grant. Source: IRENA, 2022

Technology	Description
Solar energy storage	Solar energy storage systems stores solar energy during the day to utilise at night/ during periods of low sunlight, reducing the need for grid electricity. There are several benefits of solar storage, including storing excess energy for use during periods of high demand, reducing reliance on the grid, and providing backup power in case of an outage. **Box 8**  **Maryland, U.S - Solar and Battery Storage for Customer and Ancillary Services** Solar Grid Storage LLC provided 500 kW AC storage comprising about 300 kWh of lithium-ion batteries and inverter combination to the headquarters of Konterra in Maryland. The storage and inverter system are connected to the solar PV panels with 400 kW capacity. The key objective of the Solar Grid Storage LLC is to provide both the customer and the grid with multiple benefits. This includes ***fast-power balancing support*** to the local grid, ***backup emergency power during grid outages*** and ***reduced system cost.*** The battery storage systems are connected to the local utility and can thus provide a range of ancillary services when required by the utility or grid operator through normal dispatch. Solar Grid Storage LLC's standard service is to provide the inverter and storage system at a very low cost. Solar Grid recovers these costs plus a profit margin through ancillary services provided to the grid and paid by the grid operator. Thus, Solar Grid Storage LLC business model effectively utilises solar battery storage to capitalise on the regulatory markets for ancillary services in the United States. Source: IRENA, 2022
Building-integrated photovoltaics (BIPV)	Building-integrated photovoltaics are photovoltaic materials that are used to replace conventional building materials in parts of the building envelope such as the roof, skylights, or facades. BIPV serves dual-purpose: they serve as both the outer layer of a structure and generate electricity for on-site use or export to the grid. The key benefits are : ▪ No unoccupied area required ▪ Decreased heat-transmittance ▪ Decreased harmful irradiance Some of the constraints include: ▪ Higher capital cost for installation ▪ Difficult and expensive to retrofit older buildings ▪ More complex and requires high labour charges than normal PV modules installation

4.4 Solar Supply Chain Trends

This section focuses on the trends in the solar PV supply chain, bottlenecks and measures to build a more secure supply chain. For the solar PV technology, the main segments of the value chain include manufacturing of equipment, construction and installation, and O&M, plus a range of support services, enabling functions and governance aspects.

Solar Supply Chain - Overview

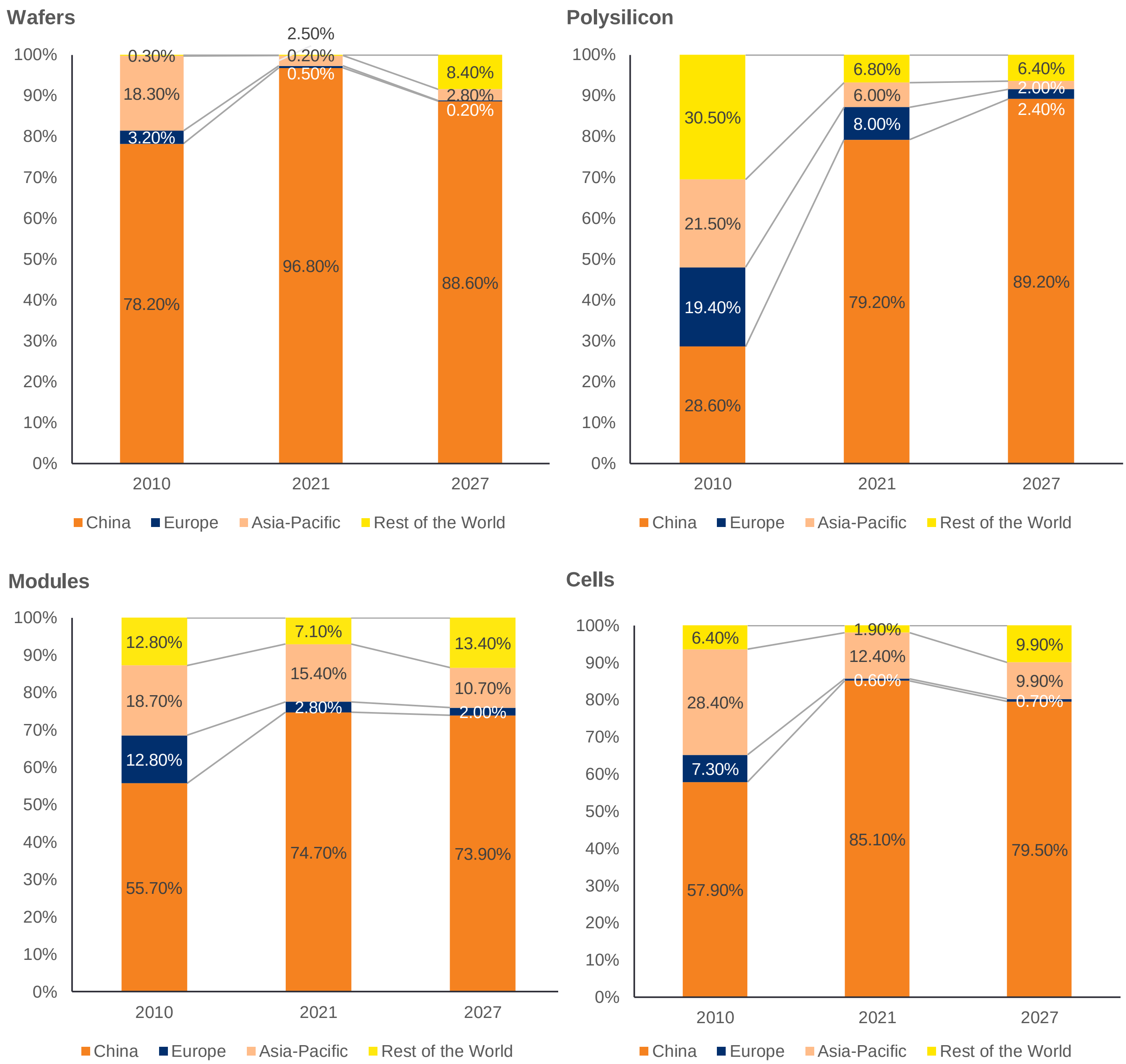
Source: IRENA, 2022

The solar PV manufacturing capacity shifted from Europe, the United States to China over the last decade. In 2022, China dominates the global solar PV supply chains. The global manufacturing capacity of solar PV jumped from approximately 25 GW (2010) to 220 GW (2022), with China accounting for 97% of the production. In addition, 300 GW of manufacturing capabilities have already been announced, underlying the willingness to prevent other actors from gaining significant shares of the market.

The Chinese market dominance reflects the ability of local companies to gain benefit from the economies of scale, and the government support which has set strategic long-term goals in the industry.

Between 2017 and 2021, around half of the total Chinese production of PV modules has been delivered to Asia-Pacific regions and India while the other half delivered to Europe, with smaller amounts directed to Latin America and Caribbean and the rest of the world.

Based on the IEA Data and Statistics (2022), the previous, and expected solar PV manufacturing capacity based on different technologies by region for the FY 2010, FY 2021 and 2027 provided below,



Source: IEA, 2022

The skewed geographical concentration in solar PV supply chain has led the European Union, India and the United States to introduce policy incentives to support domestic solar PV production. However, diversifying solar PV manufacturing will be possible only if the production costs reduce to ensure competitiveness with the lowest- cost producers (like China) in both short and long term.

China has infrastructure and industrial policies that built an integrated supply chain with large economies of scale. Low labour cost is also a key enabler. China’s industrial policies focusing on solar PV have enabled economies of scale and enabled continuous innovation throughout the supply chain.

In 2021, Thailand, Vietnam and Malaysia have become manufacturing and assembly hubs, together representing approximately 9% of cell and module production. Further Japan, India and Singapore account for 10.5% of cell and 7.6% of module production.

In the past year, rising global commodity prices have led to higher material costs for solar PV manufacturing. Today, China and ASEAN countries (Viet Nam, Thailand and Malaysia) have the lowest solar PV module manufacturing costs for all segments of the supply chain. Economies of scale, supply chain integration, relatively low energy costs and labour productivity make China the most competitive solar module manufacturer worldwide. Higher investment costs in India are the primary reason for the cost differential with China, while higher overhead and labour costs makes US PV manufacturing not as competitive.

In Europe, rising energy prices following Russia's invasion of Ukraine widened the cost gap with China. Today, EU industrial energy prices are more than triple those of China, India and the United States.

Key Trends in Solar PV Manufacturing

China

- Manufacturing activities accounted for 1.6 Mn of the PV jobs; construction and installation accounted for almost 1 Mn jobs, with O&M accounting for 0.8 million jobs.
- China's dominant role in solar PV employment reflects its strong position as both the dominant manufacturer of equipment and its commanding position in capacity installations.
- Supported by industrial policy measures, China is home to the bulk of the global PV supply chain. Approximately 72% of global polysilicon production takes place in China, with massive expansion of capacity under construction or planned.

India

- The Indian government imposed import duties of 40% on all modules and 25% on all cells effective April 2022.
- The country also introduced a production-linked incentive (PLI) scheme to boost domestic manufacturing of high-efficiency modules. This offers financial support for project developers who commit to setting up production facilities along the supply chain.
- In 2021, the rising costs in China had knock-on effect on module prices. Indian PV imports sank to a low of approximately USD 500 Mn, down from almost USD 4 Bn in 2018.

USA

- The Inflation Reduction Act, passed in August 2022, embraces elements of a broader industrial policy.
- It includes manufacturing credits for clean energy, in addition to a long-term extension of existing solar and wind tax credits and many other climate and health provisions.
- A clean manufacturing tax credit alone could trigger approximately 1,15,000 job-years (direct, indirect and induced jobs), and tax credits for solar, wind and battery manufacturing could create another 5,61,000 jobs.

The solar PV manufacturing supply chain is influenced by factors such as land, energy, capital, and labor. However, government industrial policies play a critical role in shaping viable supply chains. Polysilicon production requires significant capital investments and skilled labor. Solar cell manufacturing relies on access to modern production equipment and skilled machine operators. Module production, focused on assembly, requires less technical skill compared to cell fabrication.

Diversifying solar PV supply chains requires addressing key challenges - The cost competitiveness of existing solar PV manufacturing is a key challenge to diversify supply chains. China is the most cost-competitive country to manufacture components of the solar PV supply chain. Costs in China are 20% lower than in the United States, 10% lower than in India and 35% lower than in Europe. Large variations in labour, and investment explain these variations. In the absence of manufacturing support and financial incentives, the bankability of manufacturing projects remains limited outside China and few countries in Southeast Asia.

Low-cost electricity is a key enabler for the competitiveness of the solar PV supply chain. Electricity accounts for over 40% of production costs for polysilicon and 20% for ingots/wafers. Solar panel manufacturers can also use their own renewable electricity on site, thereby reducing both electricity bills and emissions.

Government policies are vital to build a more secure solar PV supply chain - High commodity prices and supply chain bottlenecks resulted in the increase of 20% in solar panel prices over the last year. Globally, policies to support solar PV have focused mostly on increasing demand and lowering costs.

However, sustainable and resilient supply chains are needed to ensure timely and cost-effective delivery of solar panels. Governments need to turn their attention to ensuring the security of solar PV supplies as an integral part of clean energy transition.

Solar PV Cost Trends

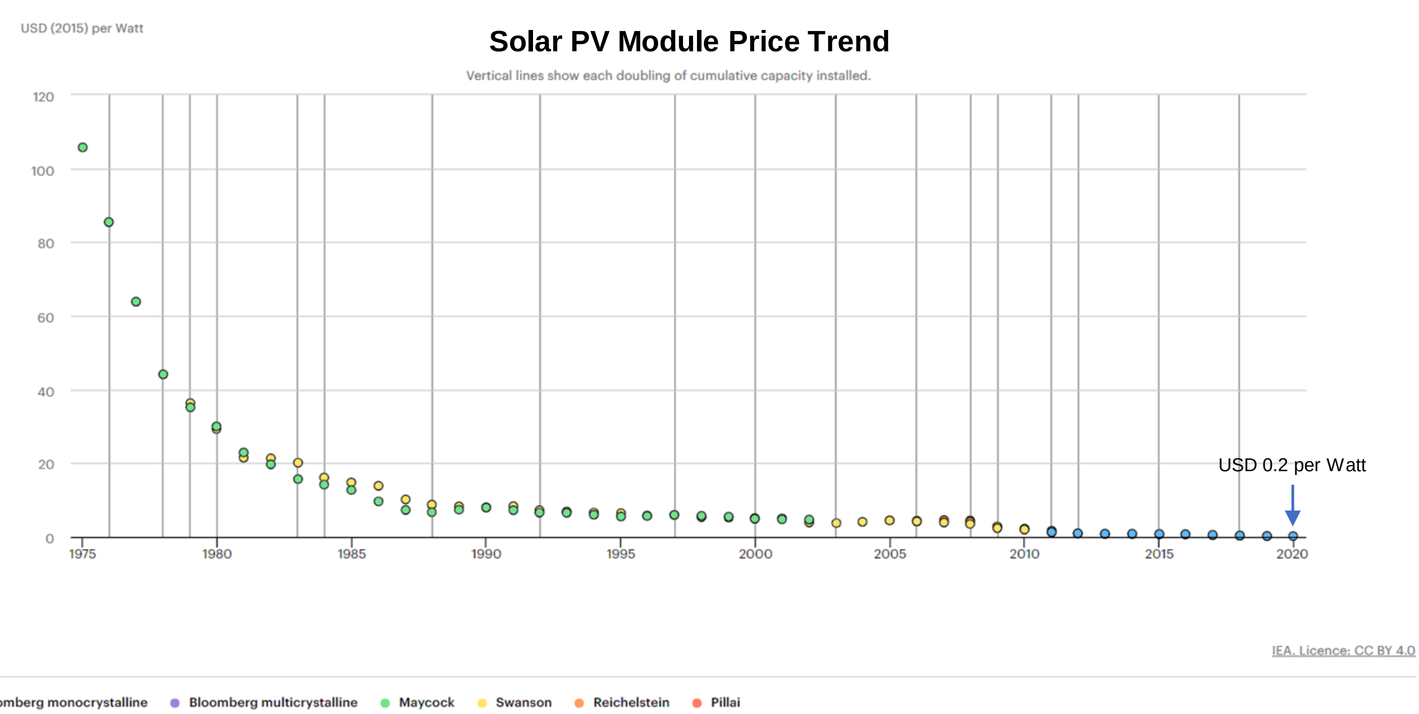
One of the key trends in the solar PV industry in 2023 is the continued decline in the cost of components required for solar panel installations, such as solar cells and inverters. This is due to the increased manufacturing efficiency, advances in technology and economies of scale. Manufacturers have become more efficient in their solar PV production processes, leading to produce solar panels at a much faster pace. Advances in technology have led to manufacturing of solar cells and inverters at a lower cost. The economies of scale have resulted in the cost-effective production of solar panels in larger quantities. The figure below depicts the key drivers involved in reducing the price of solar panels,

Technology improvements that have reduced system losses have played a vital role. The recent adoption towards an increased use of bifacial modules has increased the performance of the solar panel by generating more energy (than mono-facial panels).

Further, solar PV module prices return to the downward curve they were following prior to the covid-19 pandemic, as polysilicon supply becomes more abundant. The raw material and shipping costs decline in 2023 also has a direct impact on solar component prices.

Key factors influencing price of Solar PV Modules

- **Technological advancements:** The continuous improvement in solar cell efficiency, manufacturing processes, and material utilization has led to cost reductions and increased module output, resulting in lower prices.
- **Scale of production:** As the solar industry expanded and production volumes increased, economies of scale kicked in. Larger manufacturing capacities allowed for bulk purchasing of raw materials and equipment, reducing production costs, and driving down module prices.
- **Policies and incentives:** Various policies, such as feed-in tariffs, tax credits, and subsidies, have played a significant role in driving demand for solar PV installations. These incentives have stimulated market growth, increased competition, and ultimately led to price reductions.
- **Reduction in manufacturing costs:** Over time, manufacturers have optimized production processes, improved yield rates, and reduced manufacturing costs. Factors such as automation, economies of scale, and increased competition among manufacturers have contributed to cost savings and subsequently lower module prices.
- **Supply and demand dynamics:** Fluctuations in supply and demand have influenced module prices. Increased demand has strained the supply chain at times, resulting in temporary price spikes. Conversely, oversupply situations have led to price declines.
- **Raw material prices:** The prices of key raw materials used in solar PV modules, such as silicon, silver, and aluminium, have experienced fluctuations. Changes in these material costs can impact module prices, although technological advancements and manufacturing efficiencies have helped mitigate the impact.
- **Trade policies and tariffs:** Trade policies, including import duties and tariffs, have affected the price of solar PV modules. Imposition of tariffs on module imports has disrupted the supply chain and increased prices in some instances.
- **Balance of system costs:** The components beyond the module itself, such as inverters, mounting structures, and installation costs, it has an indirect impact on module prices. As the balance of system costs decreased due to technological advancements and market competition, it created downward pressure on overall system prices, including modules.
- **Research and development (R&D) investments:** Investments in solar PV research and development have driven technological advancements and innovation. R&D initiatives have led to the discovery of new materials, manufacturing techniques, and cell designs, all of which have contributed to price reductions over time.
- **Global market dynamics:** Changes in the global solar PV market, including the emergence of new markets, regional variations in demand, and geopolitical factors, have influenced module prices. Market dynamics impact the balance of supply and demand, which in turn affects prices.

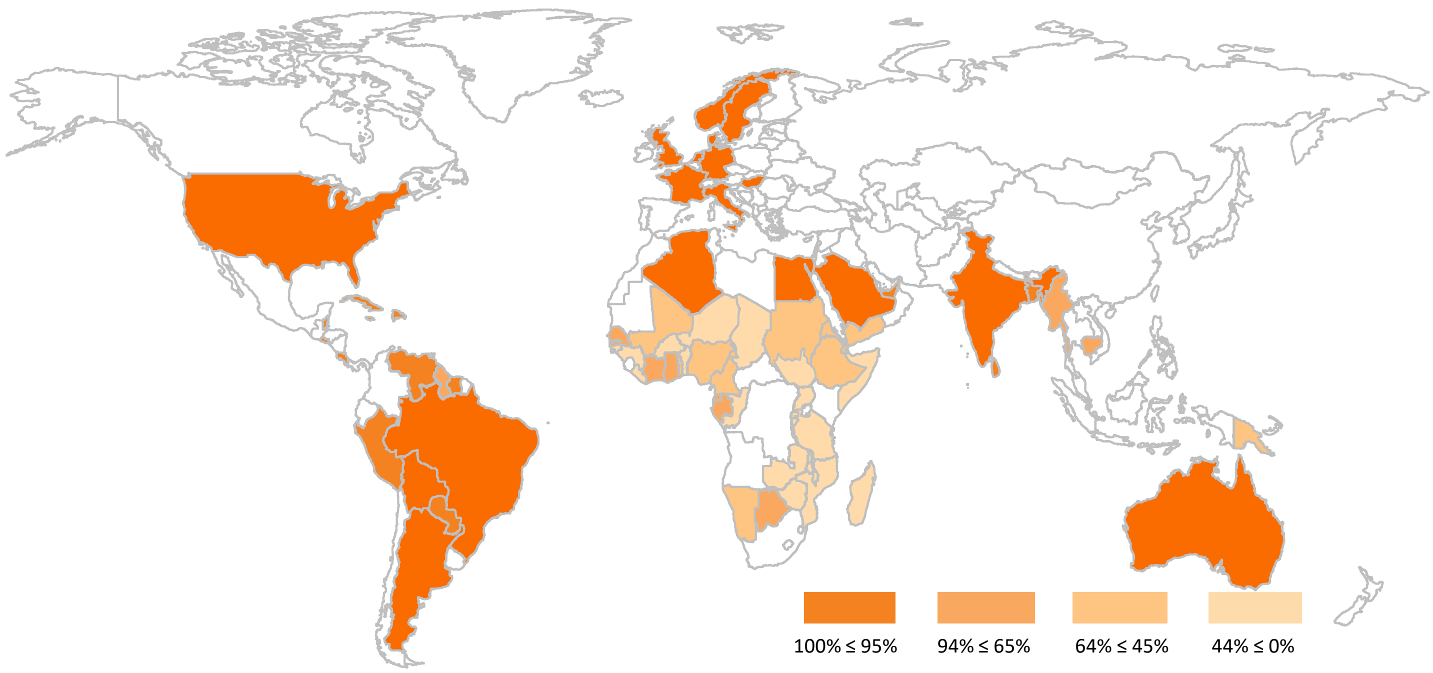


Source: IEA, 2020

4.5 Solar Market Trends

The rise of increasingly cost-effective energy storage combined with greater demand-side flexibility and the expansion of transmission infrastructure is making it possible for regions to transition to fully renewable-based power systems. Another factor enabling the transition to solar-based energy systems is the improvement in the electricity access rates, especially in the off-grid areas. The figure below highlights the share of the population with access to electricity in 2020 across ISA Member Countries,

Status of Access to Electricity (%) – ISA Member Countries



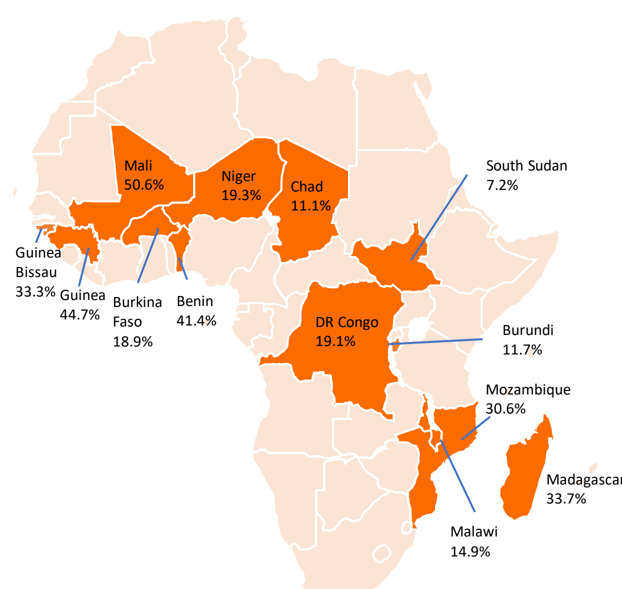
Source: World Bank, 2020

By the end of 2020, 91%[2] of the global population had access to electricity. In Asia & Pacific, access to electricity reached 92.9% in 2020, Europe and others (100%), Latin America (96.4%).

In Africa, access to electricity rates almost tripled from approximately 8 Mn between 2000 and 2013 to 24 Mn people between 2014 and 2019. The population without electricity access, peaked at 613 Mn in 2013, declined progressively to 572 Mn in 2019. Much of this transition came from countries such as Kenya, Senegal, Rwanda, Ghana and Ethiopia, while more than 40% of Sub-Saharan African countries do not yet have official electricity access targets.

Most of the gap in electricity access can be attributed to the countries where population growth has outpaced the electrification rate, such as Burundi, Chad, Malawi and Democratic republic of Congo. These countries should effectively utilise the natural solar potential to improve the electricity access rates. The figure below highlights the solar radiation availability across ISA Member countries,

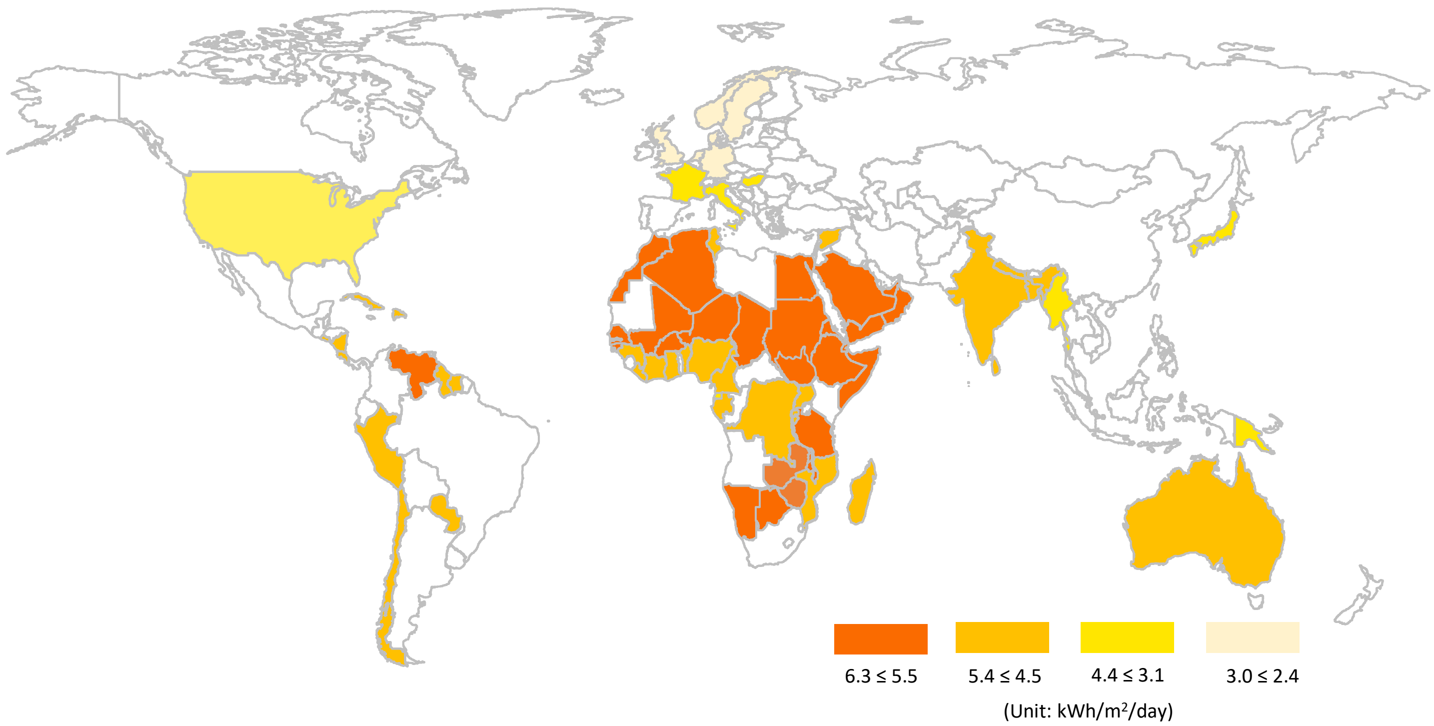
ISA Member Countries with lowest Electricity Access (%)– Africa



Source: World Bank, 2020

[2] IRENA, 2022

Global Horizontal Irradiation (GHI) in kWh/m²/day – ISA Member Countries



Source: Global Solar Atlas, 2020

The figures from the Global Solar Atlas from World Bank reveal the average potential of solar energy around the world and this infographic shows the solar advantage of African countries many of which are ISA Member Countries. The reality is that most of these nations have not yet taken action to utilise this advantage. Approximately, 20% of the global population living in 70 countries possess excellent conditions for solar.

A significant quantum of solar energy potential in Africa is still untapped and represents a unique opportunity to provide affordable, reliable, and sustainable electricity services to a large share of population where improved economic opportunities and quality of life are the most needed.

Further, to improve the electricity access rates across Africa and other such regions with lower access rates, Distributed Renewables for Energy Access (DREA) could be a possible solution.

Distributed Renewables for Energy Access

Distributed Renewables for Energy Access (DREA) systems are renewable-based systems (stand-alone off-grid systems) that can generate and distribute energy independently of a centralised electricity grid. DREA systems provide a wide range of services including cooking, lighting, space heating and cooling in the urban and rural areas of the developing world.

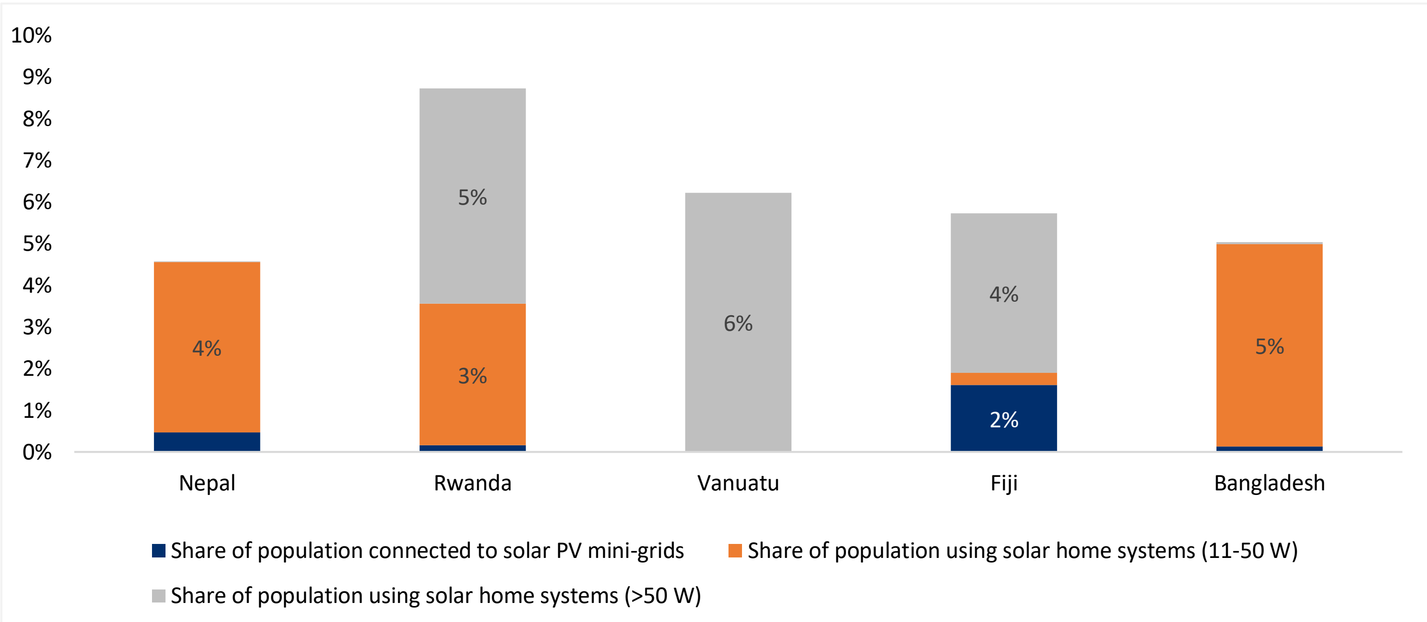
DREA system represents an essential solution for fulfilling modern energy needs and also improving the livelihoods of hundreds of millions of people presently lacking access to electricity/clean cooking solutions.

Stand-alone systems and Mini-grids are considered as the least cost option for providing access to electricity to nearly half of the population in Sub-Saharan Africa by 2030.

In Benin, Burkina Faso, Fiji, Papua New Guinea, Rwanda, Samoa, Tanzania and Vanuatu – at least 9% of the population has benefited from off-grid solar lighting systems.

The figure below shows the top 5 ISA Member countries with highest electricity access rate from off-grid solar solutions (solar home systems and mini-grids) in 2019.

Top 5 ISA Member Countries with highest Electricity Access (%) from Distributed Renewable Energy Solutions, 2022

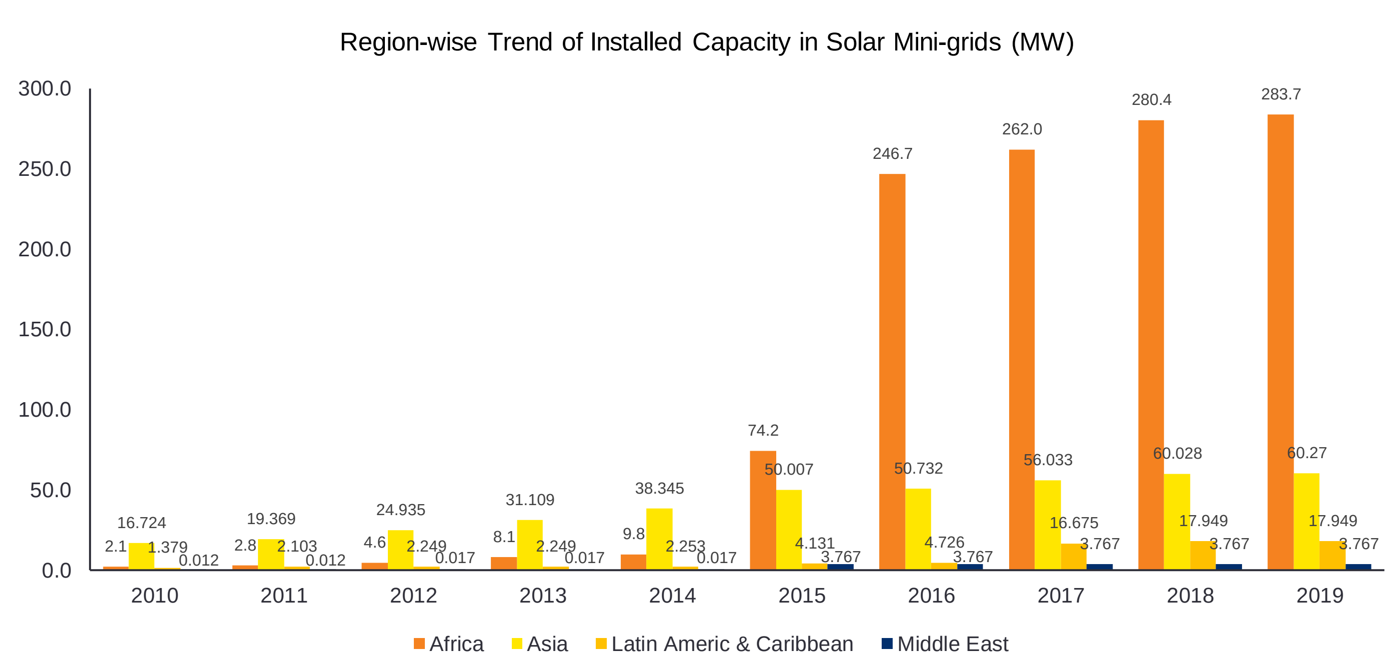


Source: REN21, 2022

1. Solar Micro grids/Mini grids

For distributed renewable energy systems for energy access, Micro-grid typically refers to an independent grid network operating on a scale of less than 10 kW power, while the mini grids are designed to generate 10 kW or more power using renewable energy that distributes electricity to a limited number of customers. Unlike traditional grid systems, microgrids are decentralized and located close to the area they serve. Microgrids can serve as a supplement to a larger, connected grid system or as a stand-alone power source.

Solar PV mini-grids are the preferred technology for providing electricity access across Africa and Asia. The global installed capacity of solar mini-grids totalled 365 MW in 2019. The graph below shows the region-wise trend of total installed capacity of mini-grids in ISA Member countries,



Source: IRENA, 2021

In West Africa, *Nigeria* has one of the world's largest mini-grid support programmes under the Nigeria Electrification Project (NEP) and aims to electrify 300,000 households and 30,000 local enterprises through private sector-driven solar-hybrid mini-grids by 2023.

Nigeria's Rural Electrification Authority commissioned several installations in 2020, including two solar-hybrid mini-grids (totalling 135 kW) developed by Renewvia Energy and a 234 kW solar-hybrid mini-grid installed by a local developer to power nearly 2,000 households. In 2021, the Authority signed agreements with Husk Power to build seven mini grids providing over 5,000 new connections.

Box 9

Energy Access in the Health Sector - Nigeria

Renewable energy solutions have supported the provision of health care and other essential services, especially since the start of the COVID-19 pandemic. Solutions range from small-scale off-grid installations for unelectrified rural clinics, to larger, steady power delivery services for urban clinics that house crucial medical devices but are subject to unreliable grids. During the pandemic, there has been a particular focus on cold chains to keep COVID-19 vaccines chilled from production to delivery. These cold storage facilities require a 24/7 power supply, which has come from hybrid solar/diesel, battery/inverter systems or direct-drive solar refrigerators.

During 2020 and 2021, a variety of initiatives included mini grids and microgrids in the health sector:

- Nigeria's Rural Electrification Agency developed several solar mini-grids for use at hospitals and other healthcare facilities as an emergency response to COVID-19. Health facilities also were a focus of several other donor-driven mini-grid initiatives.
- Power Africa, funded by the US Agency for International Development, directed USD 4.1 million in grants to off grid companies in 2020 to electrify health clinics in rural and peri-urban areas through mini-grids.

Source: REN21, 2022

Box 10

Solar PV for Electricity Access - Chad

At a global level, Chad has one of the lowest electricity access rates. As of 2019, approximately 8% of the population in the country had electricity access, with a significant gap between urban (20%) and rural (1%) areas.

Apart from 1 MW wind power plant in the country, electricity is supplied only by generators, which break down regularly. The energy situation affects quality of life and hinders socio-economic development, especially in Chad's second largest city, Abéché. With 80,000 inhabitants, the city remains unconnected to the national grid and has struggled to develop its infrastructure because of security challenges.

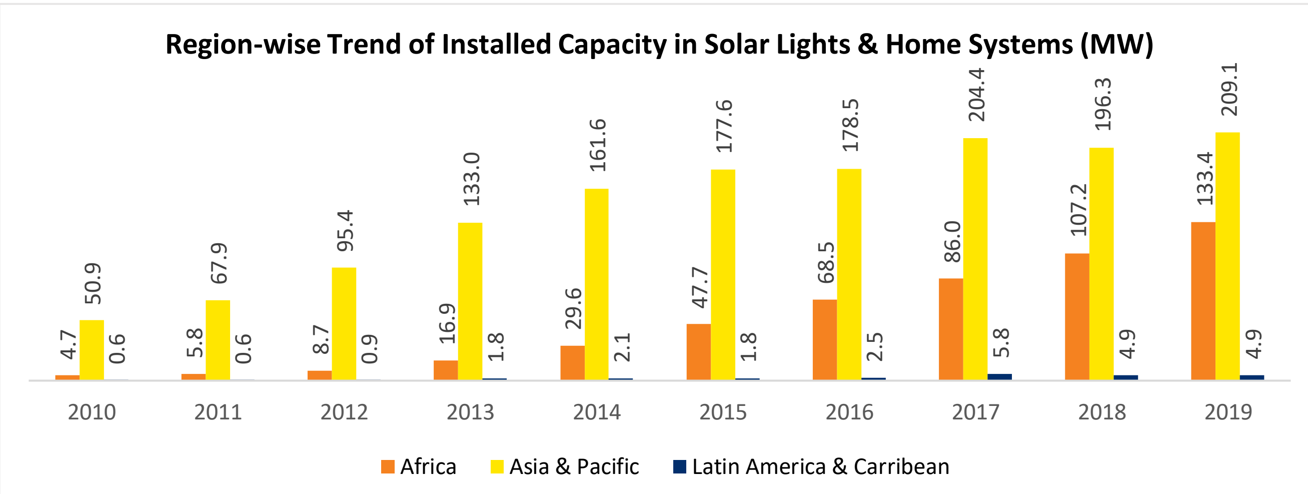
InnoVent, the French renewable energy firm has developed Chad's first solar power plant in Abéché. The pilot phase of the plant (1 MW) was built between 2020 and November 2021, with soldiers providing security for both personnel and equipment. In 2021, the first electricity was delivered to the national grid in the country.

Source: REN21, 2022

2. Solar Lights and Solar Home Systems (SHS)

The Solar home systems are off-grid solar systems, rated at 11 watts (W) and above, that can be used for lighting and to power small electrical appliances. As of 2020, 100 Mn people had gained access to basic residential electricity services through the use of solar lighting and solar home systems.
In 2019, SHS supplied electricity to approximately 8 Mn people in Bangladesh, 4.4 Mn people in India and 3.4 Mn people in Kenya.

In Asia & Pacific, the installed capacity of solar lights and SHS increased from 51 MW in 2010 to 209 MW in 2019, followed by Africa with 4.6 MW in 2010 to reach 133.4 MW in 2019 and Latin America & Caribbean with only 0.6 MW in 2010 to reach 4.9 MW in 2019. The graph below shows the region-wise trend of total installed solar lights and home systems.



Source: IRENA, 2021

Box 11

Nigeria supports 5 Million SHS/Mini grid connections serving upto 25 Million customers under the Solar Power Naija Initiative

To help the economic recovery in response to the COVID-19 pandemic, the Nigerian government has launched an initiative as part of the Economic Sustainability Plan to achieve the roll-out of 5 Million new solar based connections in the communities that are not grid connected. The Solar Connection Intervention Facility will supplement the government's effort for providing affordable power to underserved rural communities through the provision of long term low-interest credit facilities to the Nigerian Electrification Project NEP, assemblers/manufacturers of solar components and off-grid energy retailers in the country. The 5 Million Solar Power Naija connection scheme is a Federal government initiative that aims to,

i. Expand energy access to 25 Mn individuals (5 million new connections) through the provision of solar home systems/ connection to the mini-grid

ii. Increase local content in the off-grid solar value chain and also facilitate the growth of the local manufacturing industry.

iii. Incentivize the formation of 250,000 new jobs in the energy sector.

Source: Rural Electrification Agency of Nigeria Website

Box 12

Solar Home Systems with Micro Credits in Bangladesh

Rural electrification through solar PV technology is becoming more popular day by day in Bangladesh. Solar Home Systems are decentralized and are particularly suitable for inaccessible and remote areas.

Under the "Rural Electrification Program" of the Government of Bangladesh, about 3 Mn SHS have been installed in the last 16 years. Of these 3 Mn, around 1.5 Mn were installed by the Grameen Shakti since 1996.

Grameen Shakti focuses on the off-grid rural areas. Grameen Shakti is also promoting the small Solar Home System to target the low-income rural households.

Solar Home System can be used to light up shops, homes and fishing boats etc. It can also be used to charge cellular phones as well as to run radios, televisions, and cassette players. Solar Home Systems have become increasingly popular among users because they present an attractive alternative to conventional electricity.
Advantages include no monthly bills, no fuel costs, very low repair and maintenance costs, easy installation anywhere, etc. Solar Home Systems installed by the Grameen Shakti has had a beneficial impact on rural households.

Grameen Shakti has introduced a micro utility model to reach the poorer people in rural areas who cannot afford SHS separately. More than 1.5 Mn SHS have been installed in Bangladesh through the microcredit system provided by the Grameen Shakti. Making it possible to charge mobile phones with SHS provides new access to more reliable telecommunication in off-grid areas.

Around 10 Mn people are getting benefits from the systems, and several tonnes of CO_2 are abated each year as one Solar Home System saves 0.2 tonne of CO_2/year from avoided kerosene use.

Source: International Network for Sustainable Energy Website

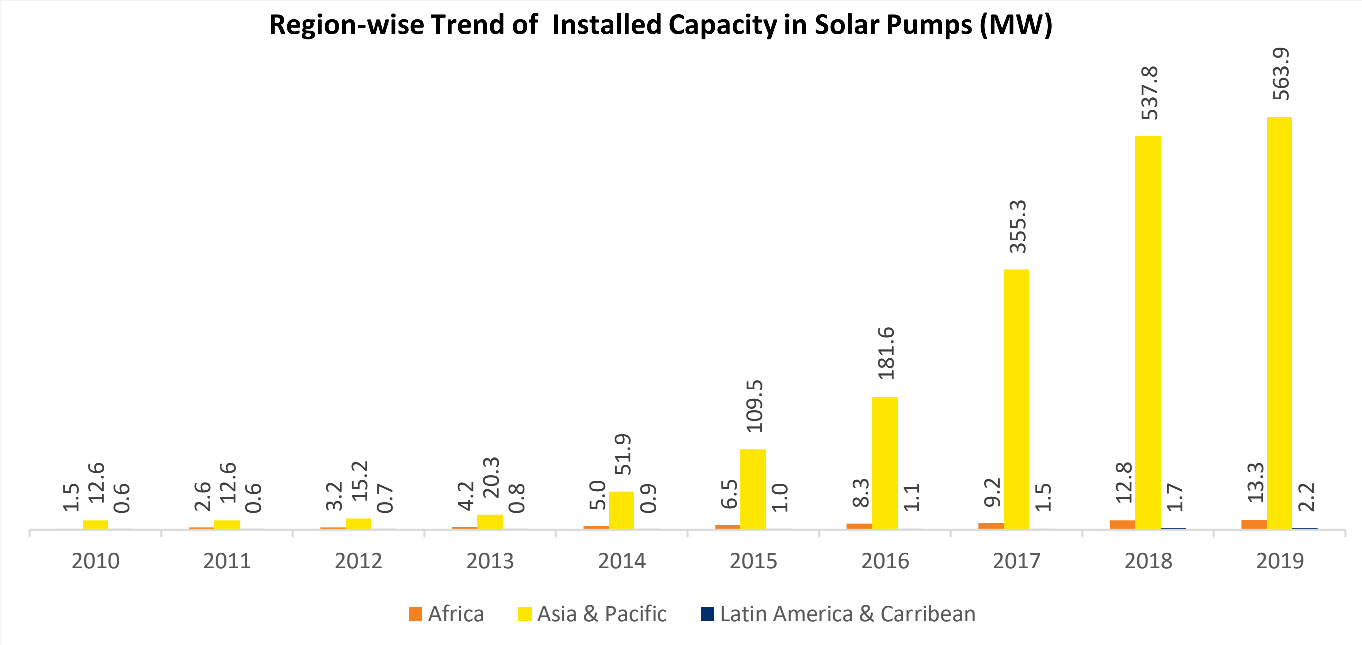
3. Solar Pumps

In developing countries, most of the population depends on agriculture for living and the agricultural sector contributes a significant share of the GDP. Unavailability of water for irrigation due to dependence on rain and absence of affordable water pumps due to unavailability of electricity is a major challenge this sector is facing.

Solar Pump is one of the proven technologies that aim to increase the yield of agricultural lands by making water supply available in areas where the grid is not available.

Bangladesh targets to deploy 50,000 solar pumps by 2025 and Morocco, 100,000 by 2022. India also targeted to achieve a solar capacity of 30.8 GW by 2022 under the Kusum Solar Pump Scheme.

The graph below shows the region-wise trend of total installed capacity of solar pumps till 2019, considering only ISA Member countries.



Source: IRENA, 2021

In Asia & Pacific, the installed capacity of solar pumps increased from 12.6 MW in 2010 and reached 564 MW in 2019, followed by Africa with 1.5 MW in 2010 to reach 13.3 MW in 2019 and Latin America & Caribbean with 0.6 MW in 2010 to reach 2.2 MW in 2019.

Box 13

Reducing Production Costs using Solar Pumps: India

Nearly 70% of India's salt is made in the 'Rann of Kutch' in Gujarat. The majority of 43,000 salt pan farmers utilise inefficient diesel powered water pumps for extracting brine from ground as part of salt harvesting process. The diesel accounts for a significant proportion of farmers production costs. In fact, farmers spend up to 40% of their annual revenue buying diesel for the next production season, thus reducing disposable income.
Two pilot projects, carried out by the Self Employed Women's Association, have demonstrated that powering pumps with solar energy can decrease production costs, increase reliability, efficiency and salt harvest outputs, resulting in the improved rural livelihoods.

Annual savings for a farmer rose to INR 83,000 - a 161% raise when compared to those using diesel-powered pumps with additional benefits including reduced air pollution. Across the Kutch, replacing diesel water pumps with solar and hybrid solar/diesel ones could potentially reduce CO_2 emissions by 115,000 tonnes.

The multi-functional nature of solar panels also increases its value, particularly for the off-grid villages, enabling complementary uses such as powering the households. Interestingly, some salt traders - who usually loan salt-pan-worker money to purchase diesel for irrigation, have now acquired the solar pumps and are leasing them out to salt pan workers on an annual basis.

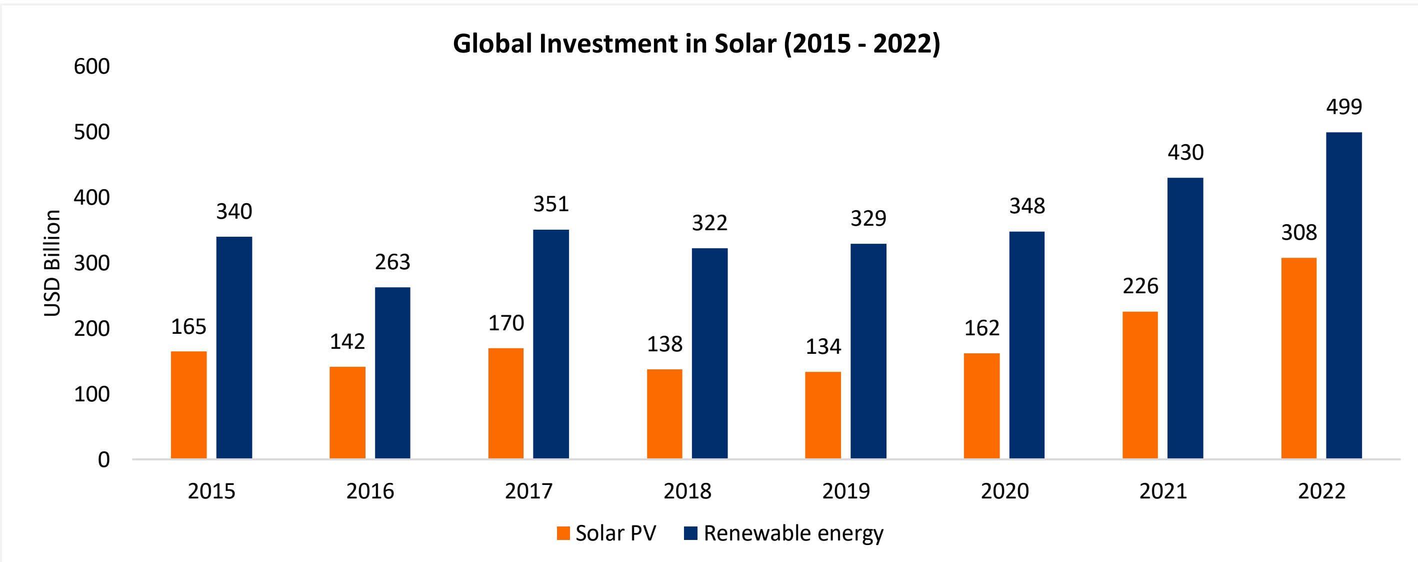
In this manner, they are able to recover their investment in three years, while making the technology accessible for salt pan workers who now need not incur the capital costs of the system.

Source: NRDC, 2018

4.6 Solar PV Investment Trends

The annual investments in renewable energy continued a positive trend in 2022. Global investment in renewables reached USD 430 Bn in 2021 and in 2022 they further increased by 16% reaching almost USD 0.5 Tn.

Solar PV continued to dominate investment in 2022, accounting for 64% of the renewable energy investment. The strong growth in solar PV investment in 2021 expanded further in 2022, to reach approximately USD 308 Bn. Increased maturity and declining costs attracted investments in solar technologies, particularly in solar PV deployment, which accounts for approximately 90% of total solar investments between 2013 - 2020. The figure below represents the global investment trends across renewable energy and solar,



Source: IRENA, 2022

The increase in renewable energy investments has been driven by, 1) Policy makers growing awareness of the importance of renewable energy in fighting climate change, strengthening energy security and reducing dependence on volatile energy sources; 2) Investors appetite for alternatives to balance out the volatility and risks of investments in fossil fuels.

Regional Highlights

The overall snapshot of the investment trends across renewables on regional basis is summarised below,

Europe and others

Europe attracted USD 54 Bn in 2019 and USD 67 Bn in 2020 (16% and 19% of the global total, respectively). As per IRENA, the investments reached USD 77 Bn in 2021, but dropped to USD 61 Bn in 2022. In 2020, investments in the region grew by 24% compared to 2019, driven primarily by an threefold increase in the Netherlands and a fourfold increase in investments in the United Kingdom.

In Europe, the European Commission presented a Green Deal Industrial Plan, which would provide investment aid and tax breaks towards technological development, manufacturing, production and installation of net-zero products in green sectors including renewables and hydrogen. The plan looks to mobilise EUR 225 Bn in loans from its existing Recovery and Resilience Facility, and an additional EUR 20 Bn in grants.

United States consistently attracted the majority of solar investments since 2013. In the United States, the 2022 Inflation Reduction Act – encompassing new tax credits, USD 30 Bn in grants and loans for clean energy generation and storage, and USD 60 Bn in support of manufacturing of low-carbon components – is expected to attract **USD 114 Bn** investment by 2031.

Africa

African region remains the major destination for off-grid renewables investment - Between 2010-2021, the region attracted USD 2.2 Bn, more than 70% of global off-grid investments. Within Africa, the countries such as Kenya, the United Republic of Tanzania and Rwanda attracted higher investments.

Investment in these countries benefited from the existing mobile money ecosystem, which was leveraged by the pay-as-you-go (PAYGO) business model. Approximately 78% of the total commitments in off-grid renewables between 2010-2021 involved the funding of projects using PAYGO, with East Africa accounting for USD 917 Mn.

Asia and Pacific

Asia and Pacific region continues to attract the majority of global renewable energy investment of USD 170 Bn in 2020.

Investment in renewable energy has grown significantly in Viet Nam, which overtook Japan to become the second-largest destination in 2020, largely due to expiring of FIT policy. From 2013 to 2020, investment grew by an average of 219% per year, rising from USD 47 Mn to USD 18.7 Bn. However, after the expiration of FIT, investments declined quickly from USD 18.7 Bn in 2020 to USD 9.7 Bn in 2021 to less than USD 4.7 Bn in 2022.

The region attracted USD 137 Mn in off-grid renewable energy investments in 2019, led primarily by Myanmar. During 2020-2021, investments plummeted to USD 3 Mn, likely due to the pandemic and political developments.

Latin America and Caribbean

Latin America and Caribbean region attracted 4.9% of global investments in 2020, followed by Asia and Africa. During 2018-2021, Latin America and Caribbean attracted USD 21 Mn, equivalent to less than 1.5% of cumulative commitments over that period.

The region has electricity access rates of more than 90%. With smaller shares of the population living in off-grid locations, these regions represent relatively small markets for decentralised energy systems.

Box 14

Investment Trends in Vietnam and Thailand

Vietnam's rapid industrialisation has prompted a surge in energy demand. Much of this industrial growth has been fuelled by foreign direct investment, as companies look to diversify their supply chains away from China. Rooftop solar installations in industrial parks have grown to meet these companies requirement for renewable energy (and more climate-friendly products). The country has incentivised the growth of renewable energy generation via FiTs in the solar industry. Tariffs for onshore and offshore wind were made more generous in 2018 after poor initial uptake. Coal is still the primary source of electricity production in the country, though slow development of new plants led the government to pivot to solar (and later wind) along with gas to meet its rising energy needs (Government of Vietnam, 2016).

In contrast, investment in neighbouring Thailand has been anaemic. This can be partly explained by differences in the two countries' stages of economic growth, and energy mixes, among other factors. While endowed with similar natural resources, economic growth in the 1990s helped Thailand set up a well functioning and robust power supply. A subsequent decline in economic growth rates slowed energy demand significantly, and Thailand's demand now lags that of its rapidly industrialising neighbour.

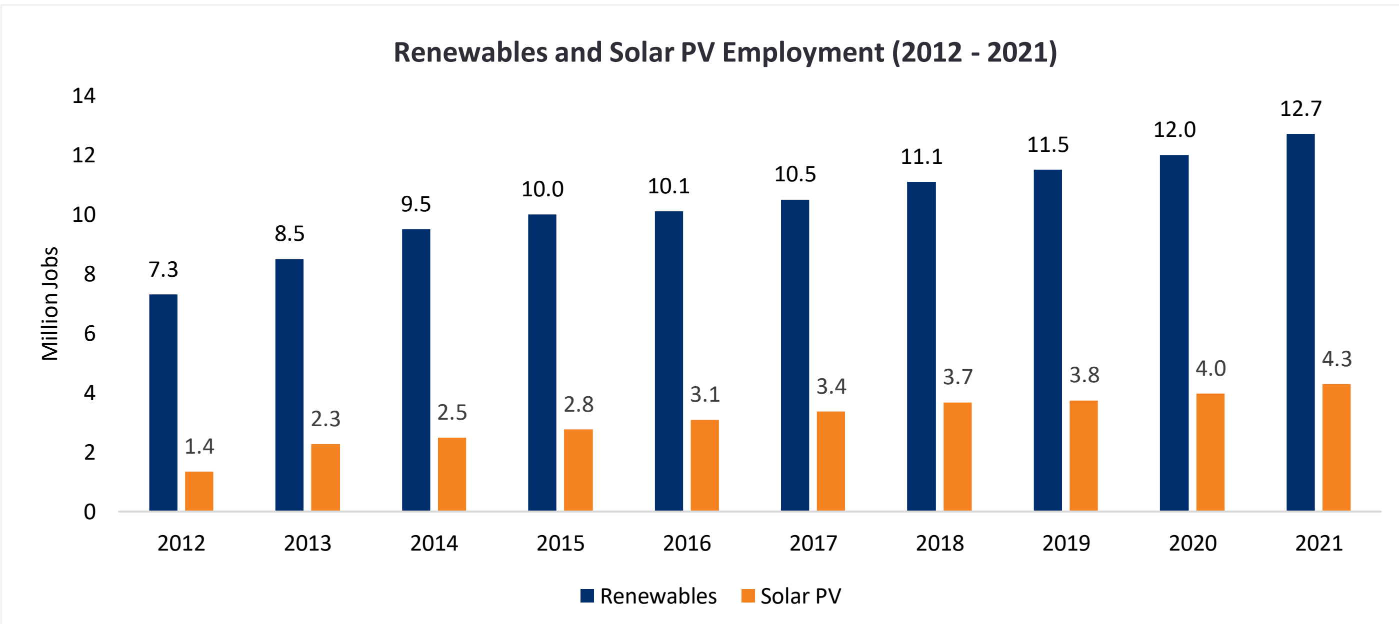
Thailand's Power Development Plan aims for a 10 GW expansion in solar PV capacity by 2037, whereas Vietnam has targeted an additional 18 GW of solar PV capacity by 2030 and another 18 GW from wind power. With renewable energy growth in Thailand remaining tepid for the foreseeable future, private energy giants such as Super Energy Corp have been increasingly turning to foreign markets, including Vietnam, to fuel growth.

Both Vietnam and Thailand have used generous FiTs to help grow the supply of renewable energy. However, Vietnam's high energy demand and ambitious renewable energy targets have made FiTs a more effective policy tool.

Source: IRENA, 2023

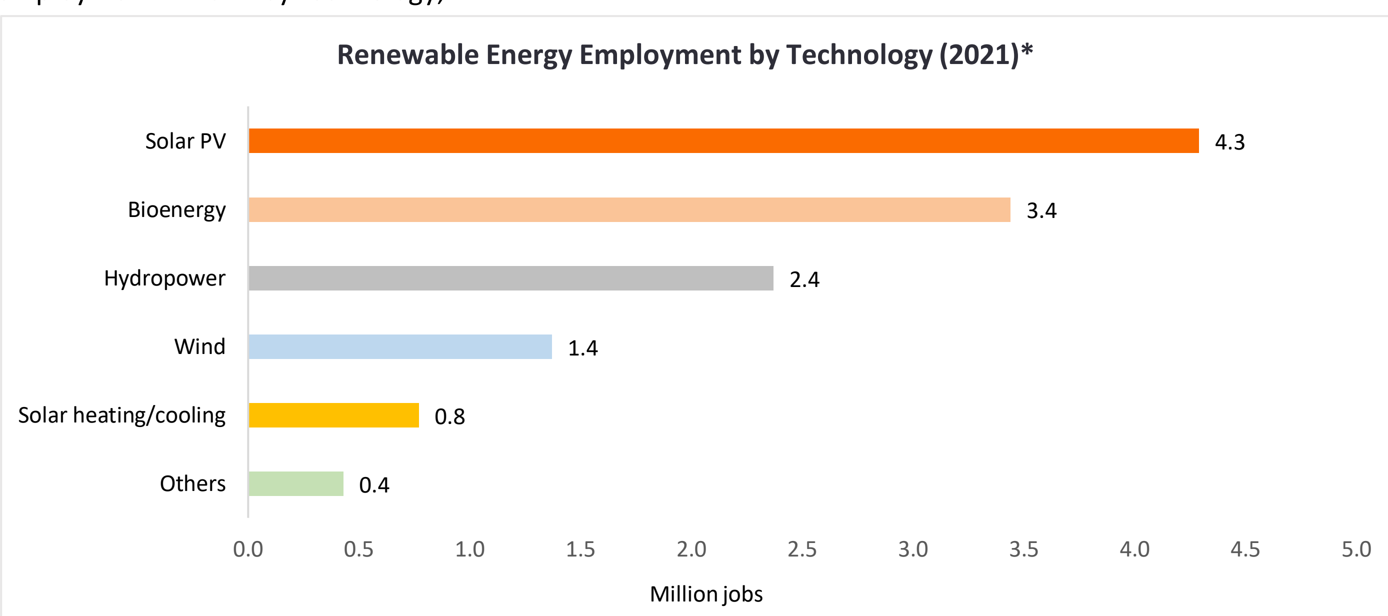
4.7 Solar PV Employment Trends

The renewable energy sector employed 12.7 Mn people, directly and indirectly, in 2021. About two-thirds of all jobs are in Asia, and China accounts for 42% of the global total. It is followed by the European Union and Brazil with 10% each, and the United States and India with 7% each. The number continued to grow worldwide over the past decade, with most jobs in the solar PV, bioenergy, hydropower and wind power industries. In 2021, solar PV employed 4.3 Mn jobs, the fastest-growing sector, accounting for more than a third of the total renewable energy workforce. The figure below shows the Global Renewable energy employment trends by solar across 2012-2021,



Source: IRENA, 2022

These employment trends are shaped by a multitude of factors, including investments, new and cumulative capacities, and by a broad array of policy measures to enable renewable energy deployment, generate viable supply chains and create a skilled workforce. The figure below highlights the Global renewable energy employment in 2021 by technology,



Source: IRENA; 2022 *Others includes geothermal energy, CSP and Ocean energy

In 2021, Solar PV contributed to the highest number of jobs globally, followed by Bioenergy with 3.4 Mn jobs, Hydropower (2.4 Mn jobs), Wind (1.4 Mn jobs), Solar heating/cooling (0.8 Mn jobs). Considering solar PV employment, China alone accounts for 63% of PV jobs[3] in 2021.

[3] IRENA, 2022

Based on the secondary data sources, solar PV employment (2021) in ISA Member Countries are captured below,

Solar PV Employment in 2021: ISA Member Countries

S No	Countries	Number of jobs (in thousand)
1	United States of America	255
2	India	217
3	Japan	150.5
4	Bangladesh	120
5	Brazil	115.2
6	Germany	51.3
7	Australia	35
8	Nigeria	34.2
9	Uganda	23.79
10	Netherlands	20.1
11	France	17.634
12	Italy	14.98
13	Chile	12.2
14	Ethiopia	12.18
15	United Kingdom	6.4
16	United Arab Emirates	5.1
17	Israel	5
18	Greece	3.668
19	Denmark	3.35
20	Sweden	3.1
21	Egypt	1.9
22	Mali	1.9
23	Argentina	1.39
24	Ghana	1.234
25	Zambia	1.2
26	Rwanda	1.075
27	Guinea	1
28	Morocco	1
29	Hungary	0.729
30	Algeria	0.5
31	Namibia	0.46
32	Peru	0.38
33	Luxembourg	0.23
34	Norway	0.22
35	Nicaragua	0.2
36	Tunisia	0.2

Source: IRENA, 2022

From the above table, it can be seen that the United States of America is the top performer among ISA Member countries in providing the solar PV employment to 255,000 workers followed by India and Japan. At a Global level, China accounted for about 2.7 Mn jobs (i.e. 63% of PV employment worldwide). Asia Pacific countries host 79% of the world's PV jobs, reflecting the region's continued dominance of manufacturing and strong presence in installations. The remaining jobs were in the Americas (7.7% of all jobs), Europe (6.8%) and the rest of the world (4.9%)[4].

[4] IRENA, 2022

Box 15

Renewable Energy Employment landscape in Vietnam & Australia

Vietnam is a major manufacturer, exporter and installer of PV cells and modules. Solar cell production rose from just 37 MW in 2014 to 3.75 GW; module output increased from 1.2 GW to 8.5 GW in 2021 (Wood Mackenzie, 2022a). The breakneck expansion of domestic solar installations, triggered by high FITs, brought total capacity from 105 MW in 2018 to 17 GW in 2020.

As a result, the country's electricity grid became severely overloaded, leading to curtailments. Despite some grid improvements, the domestic solar PV expansion came to an abrupt halt in 2021, and emphasis shifted to off-grid rooftop deployment.

The unprecedented installations in 2020 resulted in significant economic activity and job creation. More than a hundred new installation companies were set up in south-central Ninh Thuan province, which was home to around 2.5 GW of installations in 2021.

As installations shot up, Vietnam's solar PV workforce rose to 1,26,300 jobs in 2020. In 2021, the lack of installations apart from the rooftop additions has resulted in reduction of the workforce.

In the Pacific, ***Australia*** completed some of its largest solar projects in 2021, according to the Clean Energy Council (2022). New capacity additions included 3.3 GW of small-scale solar and 1.2 GW of large-scale solar.

The Clean Energy Council reports another 9.3 GW worth of renewable energy projects under construction or financially committed at the end of 2021, representing over 35,000 jobs, including almost 21,000 in New South Wales. Meanwhile, the ***federal government's bioenergy roadmap*** created some 26,200 full-time jobs. The government committed about AUD 464 Mn to the construction of seven regional hydrogen hubs, which might create 1,30,000 jobs by 2030 (Clean Energy Council, 2022).

Source: IRENA, 2022

5

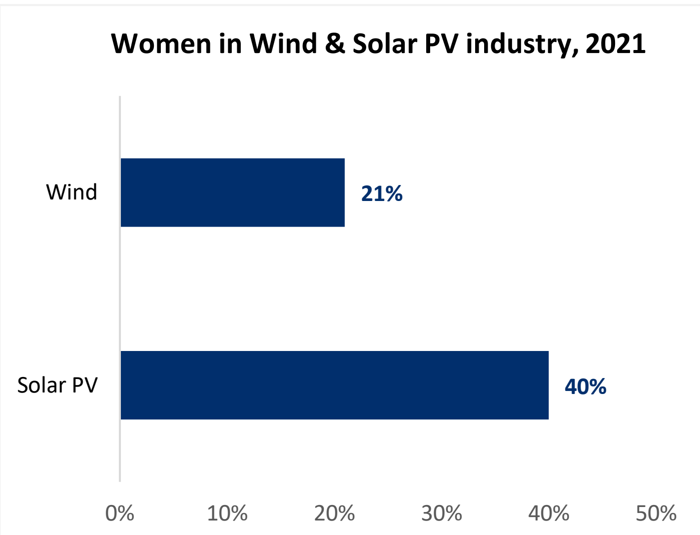
Solar & Equity

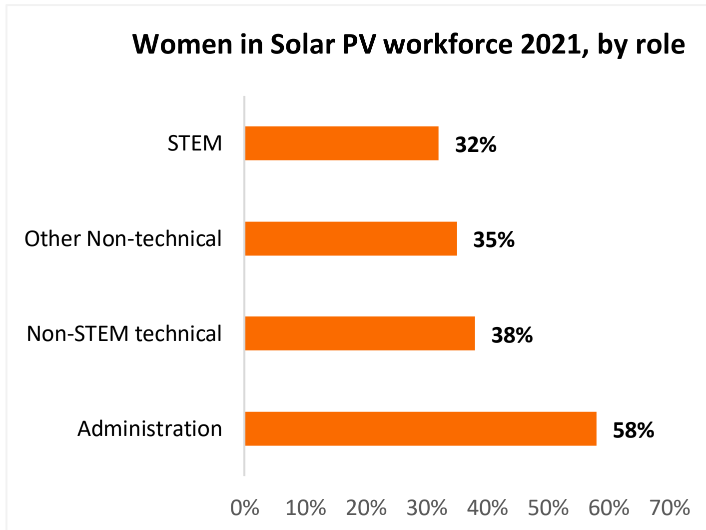
5 Solar & Gender Equity

The inclusion of women in renewable energy weaves together SDG 5 on gender equality and women's empowerment whereas SDG 7 on affordable and clean energy. Gender equity refers to 'the provision of fairness and justice in distribution of benefits and responsibilities between women and men'.

The energy industry has long been known for its male-dominated culture and unequal opportunities for women's career advancement.

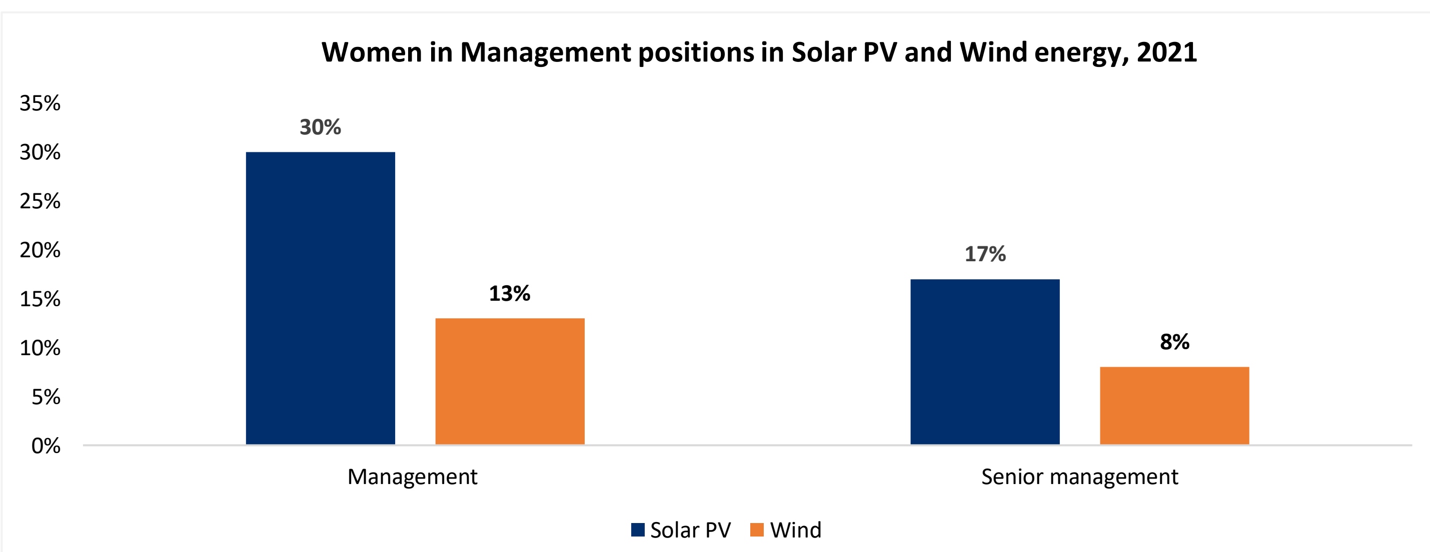
At a Global scenario, the share of women working full time in the solar PV industry is 40%, the highest share of any renewable energy sub-sector.





Source: IRENA, 2022

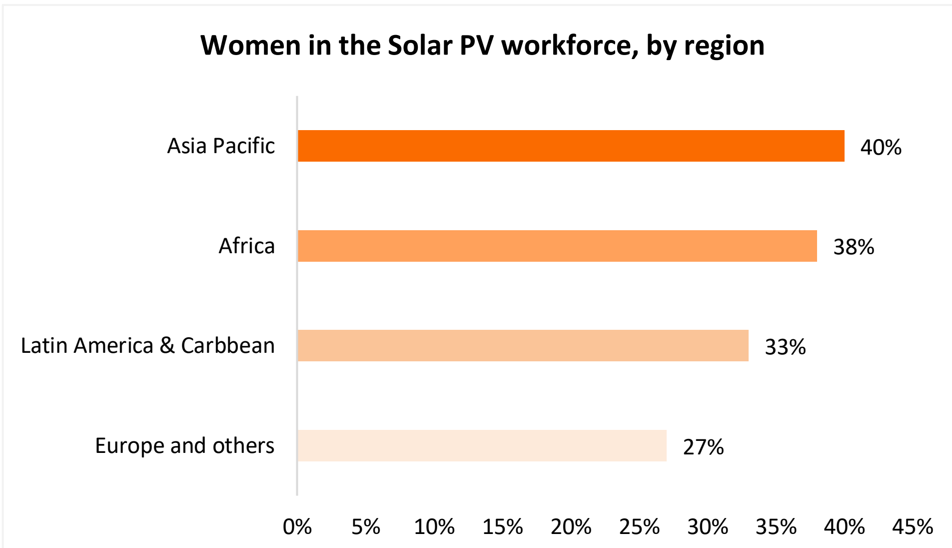
Most women in solar PV hold administrative jobs (58%), followed by non-STEM (science, technology, engineering and mathematics) technical positions (38%). It is well reported that across the economy, in policy making and governance, women's presence on company boards and in senior management positions is low. According to IRENA's solar PV survey, women hold barely 30% of managerial jobs and 17% of senior management positions, faring better in solar PV compared to the wind power.



Source: IRENA, 2022

Therefore, while women are better represented in solar PV management than in other technologies and sectors, substantial efforts are needed to enable greater participation of women at all levels and to expand the skills and talents needed to drive the transformation.

Women's share of solar PV employment is smaller in Europe and others, Latin America and the Caribbean than in the Asia-Pacific and Africa regions. In the solar PV sector, women are represented in administrative positions across the globe. The spread between women's shares in administration and in all other roles is most pronounced in companies in the Asia-Pacific region.



Source: IRENA, 2022

Box 16

Solar Sister Is Addressing Gender Equity and Climate Change - Africa

Solar Sister, a network of women entrepreneurs operating in multiple African countries, has enabled 3 million individuals to access clean energy as of 2022. What sets it apart is its dedication to empowering women in establishing sustainable enterprises within their communities.

The initiative recruits, trains, and supports female entrepreneurs, equipping them with off-grid solar products like solar lighting. Solar Sister's efforts benefit rural communities by providing assistance, generating income for women entrepreneurs, and expanding the availability of clean energy sources.

Since its establishment in 2010, Solar Sister has assisted over 7,000 entrepreneurs, distributed more than 647,250 clean energy products, and impacted 3 million people.

Energy equity is a crucial aspect of Solar Sister's mission. By offering economic opportunities to women, the program has facilitated the creation of clean energy businesses for over 6,800 entrepreneurs. A significant 86% of these businesses focus primarily on supporting women, although men are also involved to some extent.

The products sold by Solar Sister entrepreneurs have successfully prevented the emission of over 946,763 metric tonnes of CO_2.

Source: Solar Sister Website

Financing for Women in Solar

Victoria (Australia) launched a USD 11 Mn plan to subsidise 50% of the cost of apprenticeships, professional mentoring and ongoing education for women entering the renewables industry as electricians, plumbers and solar installers, etc.

In Africa, the state-owned Ethiopia Electric Utility looks to employ 30% women by 2030 by providing scholarships and internships in STEM (science, technology, engineering and math) fields.

Efforts towards Gender Equity

Belize

In order to adhere to the overarching principle of global sustainable development, which emphasizes the inclusion of all individuals, it is imperative that the climate finance strategy ensures equitable representation of various aspects such as gender, indigenous communities, people with disabilities, and youth.

Barbados

Alongside providing social assistance, the Barbadian government prioritizes the facilitation and support of women's entrepreneurship and business development as a means to address the increasing levels of unemployment, layoffs, and contribute to the economic recovery efforts.

Bolivia

Bolivia is committed to integrating a gender perspective into its Plurinational Policy for Climate Change in order to address inequality gaps in various dimensions. This recognition stems from the understanding that climate change impacts women and men differently and acknowledges the crucial role that women play in areas such as water management, agricultural production, food and energy security, and community resilience. Therefore, Bolivia is dedicated to incorporating a gender and intergenerational approach into its climate policy to ensure inclusivity and equality.

Cambodia

Cambodia upholds four key measures: promoting gender equality, fostering innovation, ensuring inclusivity, and empowering women.

Cape Verde

Implement the Gender and Energy Action Plan and provide support for the growth of local enterprises while actively encouraging economic opportunities for women, with a specific focus on the renewable energy sector.

India

The Ministry of New & Renewable Energy (MNRE) has been actively promoting the involvement of women in the renewable energy sector. Recently "Women in Renewable Energy (RE): Call for Action" was organized to recognize the contributions of women entrepreneurs and leaders in the RE sector and to chart a path for the future. To expedite this initiative, MNRE has established an empowered committee consisting of government officials, experts, and industry associations.

Barriers to Women's inclusion in the Solar Sector

Multiple barriers limit women's ability to access energy technologies and participate in solar projects and programs. A variety of pervasive factors interact at the individual, institutional, and societal levels that directly limit women's inclusion in the sector, including:

- **Gender and Social Norms -** Gender norms and intrahousehold dynamics inhibit women's access to energy technologies. In addition, men are the main purchasers of energy products, even when women are the primary end users; this results in skewed consumer data and products that do not always reflect the needs or preferences of women. As in other sectors, gender norms and bias, as well as broader systemic barriers, limit women's ability to enter the workforce and obtain funding.

- **Lack of appropriate financing for women-owned and led businesses -** Although financial institutions increasingly design gender-neutral policies and services, these tend to reflect the preferences of men. Research shows that women's businesses may, for example, need a combination of financial and nonfinancial products and services, including training, mentoring, networking, and other advisory services. Specifically, for early-stage off-grid energy enterprises, financing for women to grow and sustain their businesses is limited. Microfinance and traditional rural village savings and loan associations and cooperatives are the most common financing options available to women.

- **Lack of policies that address gender inequality in the solar sector -** Gender discrimination in laws, policies, and regulations prohibit and inhibit women from accessing the benefits of energy services and from actively participating in the sector. The 2021 Women, Business and the Law (World Bank, 2021) reports that 75 countries limit women's property rights in some form, and various legal barriers prevent women from working in specific sectors and occupations. Renewable energy policies and frameworks can be catalytic in introducing labor conditions that are conducive to women's active participation in the sector, although even when energy frameworks include some gender considerations, women are mostly characterized as potential beneficiaries rather than as agents of change.

Solar & Energy Equity

- Energy equity aims to ensure that disadvantaged communities have equal access to clean energy and are not disproportionately affected by pollution. It requires fair and distribution of benefits in the energy system through intentional design of systems, technology, procedures and policies.

- Committing to equity in clean energy programs, policies, and investments can improve and expand clean energy services and technologies for marginalized groups while creating more just processes, outcomes, and systems.

- Clean energy services can reduce energy costs, create jobs, and promote the health, safety, and well-being of residents.

- Policymakers, utilities and other decision makers can address these energy burden disparities through clean energy policies and programs.

- Equitable energy policies often improve energy access and affordability, procedural justice, economic participation and community ownership, and health and environmental impacts.

6 Way Forward

Despite the ongoing expansion of renewables around the world, significant challenges remain which include:

- Certain renewable power markets follow a boom-bust cycle due to short-term, unpredictable policy making, as evidenced in 2021 by the surge in offshore wind power in China to meet a feed-in tariff deadline and by the collapse of Vietnam's solar PV market after two years of generous incentives.

- Transmission bottlenecks and network expansion in some countries have held back the deployment of renewables.

- Unstable supply chains (related to a concentration of technology suppliers in few countries) can delay projects and raise costs, leading to unpredictable price rises that put pressure on the economic validity of projects.

- Local capacity and knowledge gaps remain a challenge during the construction and operation phases in emerging markets and remote locations.

Efforts towards addressing the development of solar sector as mentioned above, should be addressed at a faster pace, to facilitate the deployment of solar energy and to achieve the transition to a net-zero economy.

Future editions of the "Global trends in Solar power" report will aim towards capturing the global and regional level insights related to the solar sector which are quintessential in further reinforcing the analysis for ISA Member countries. Also, in the upcoming editions, greater emphasis will be given to include the best and emerging practices in the area of policy, technology and market eco-system in the ISA member countries.

Inclusion & analysis of new chapters pertaining to the Solar market ecosystem, desired key trends in the global solar market related to digital and emerging technologies etc are some other additional initiatives to enhance the outcomes and outreach of Global trends in Solar Power.

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