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中南勘测设计研究院有限公司
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秉责 创新 卓越

Overview, Trends and Landscape of Solar PV Industry

www.msdi.cn

Speaker: Fu Meng

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1.1 Global Renewables and Solar PV Energy Market Outlook

-Net Zero Emission

Climate Change

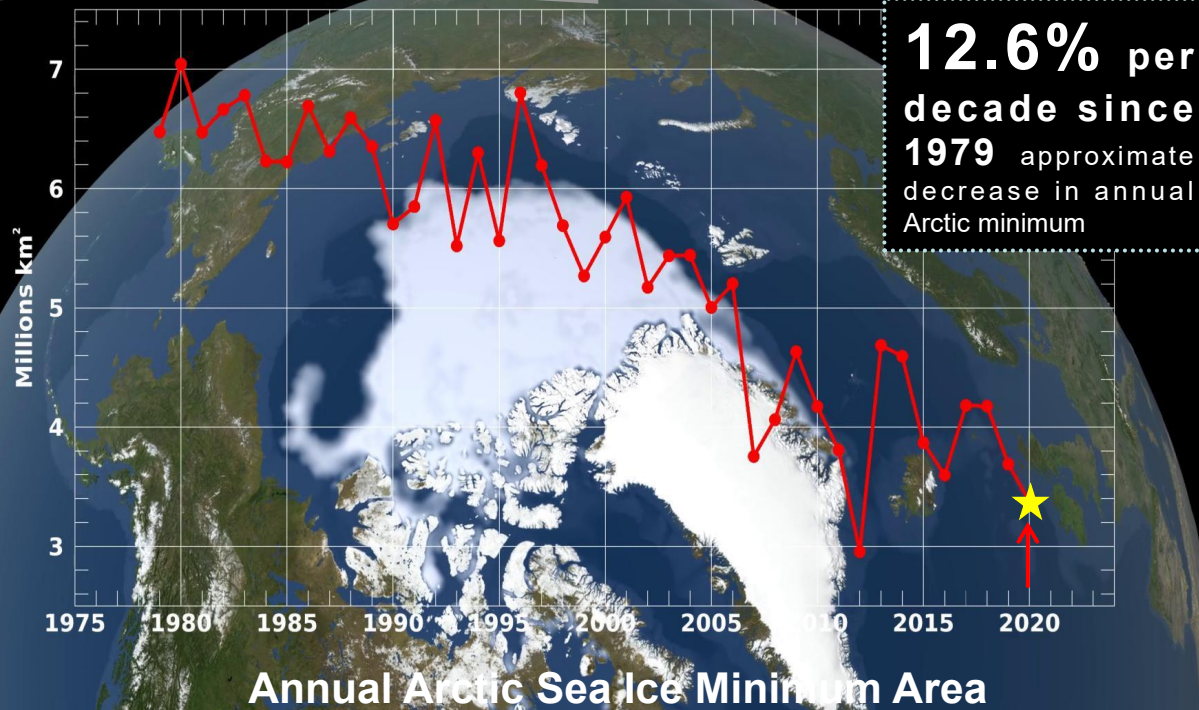
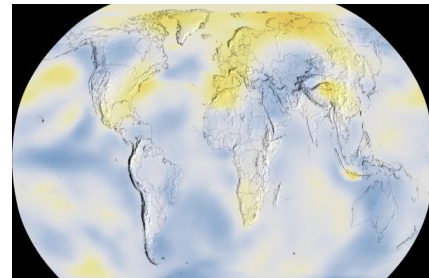
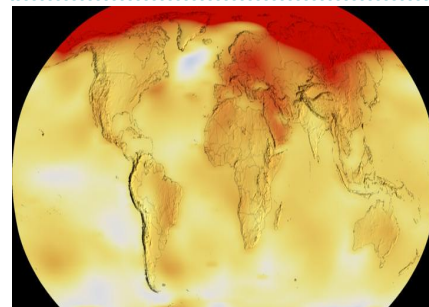


Image source: <https://climate.nasa.gov/>

1950 Earth Surface Temperature



2020 Earth Surface Temperature



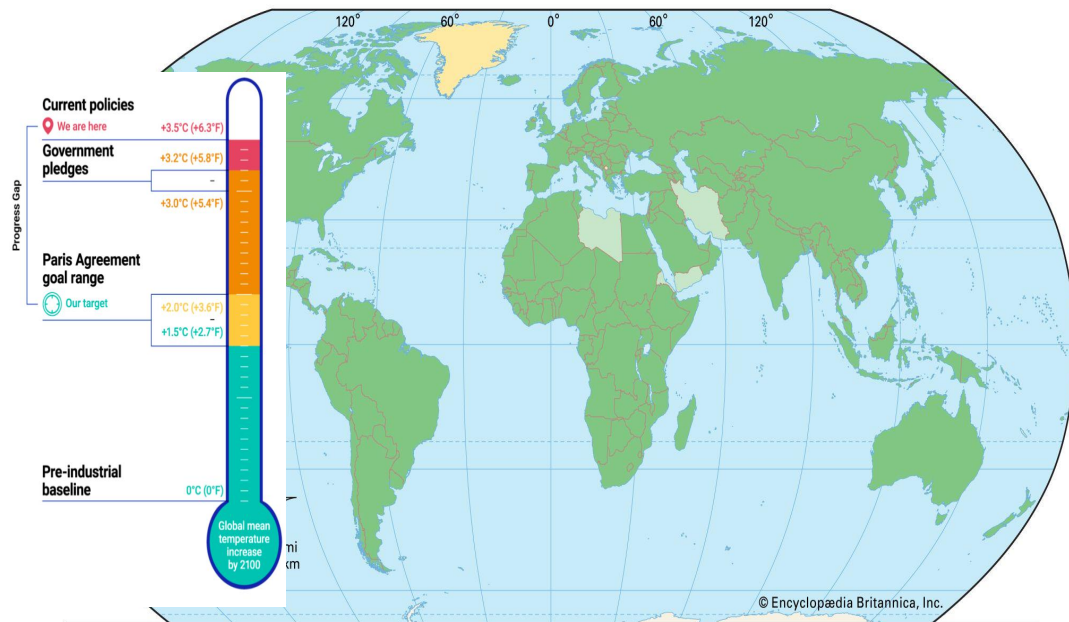
1.1 Global Renewables and Solar PV Energy Market Outlook

-Net Zero Emission

The Paris Agreement

The Paris Agreement establishes a clear goal to limit the increase of global temperature to “well below” 2 ° C, and ideally to **1.5 ° C**, compared to pre-industrial levels, by this century. To realise this climate target, a profound transformation of the global energy landscape is essential.

- Provides a durable framework guiding the global effort for decades to come.
- Marks the beginning of a shift towards a **Net-Zero Emissions** world.
- Essential for the achievement of the Sustainable Development Goals.



2015 PARIS CLIMATE AGREEMENT



Ratification (193)



Signature (195)



Neither ratified nor signed

NOTES: The United States exited the agreement formally on November 4, 2020, but rejoined on January 20, 2021.

Although Greenland remains a part of the Kingdom of Denmark, the island's home-rule government is responsible for most domestic affairs.

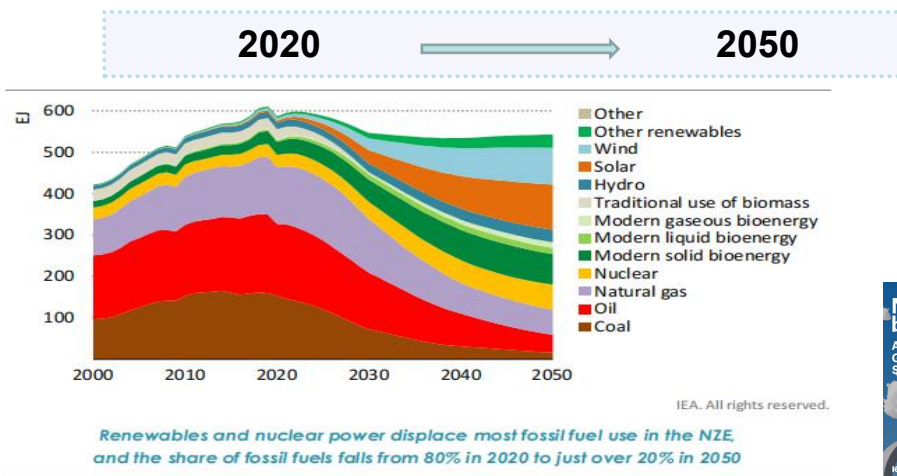
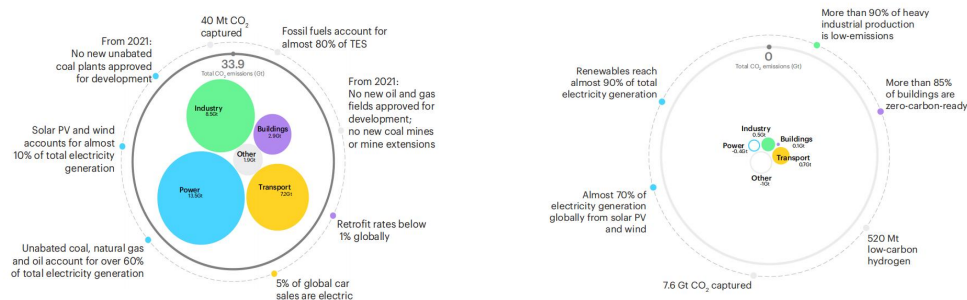
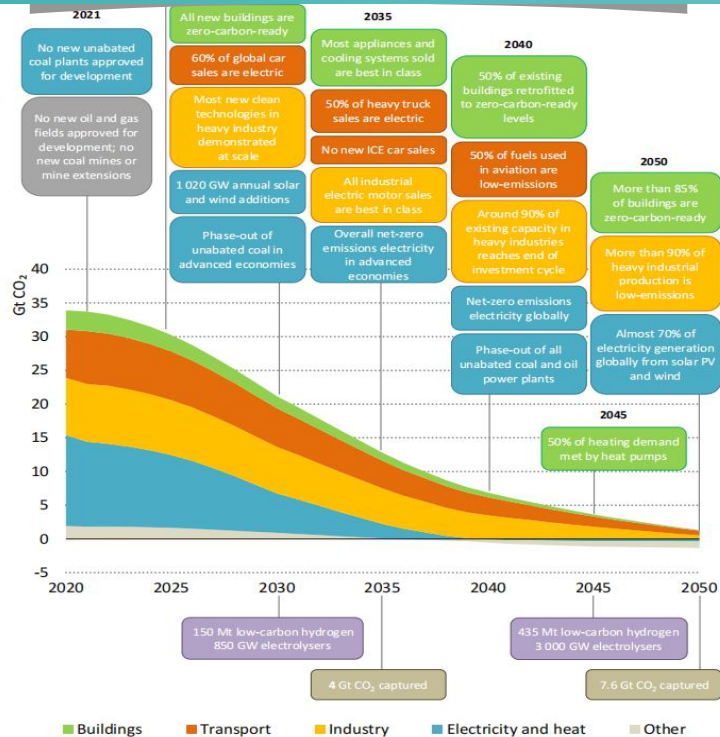
To date, Greenland has neither ratified nor signed the Paris Agreement.

As of February 2022

1.1 Global Renewables and Solar PV Energy Market Outlook

-Net Zero Emission

Net Zero Emission



Sources: Net Zero Emissions by 2050 A Roadmap for the Global Energy Sector-IEA

1.1 Global Renewables and Solar PV Energy Market Outlook

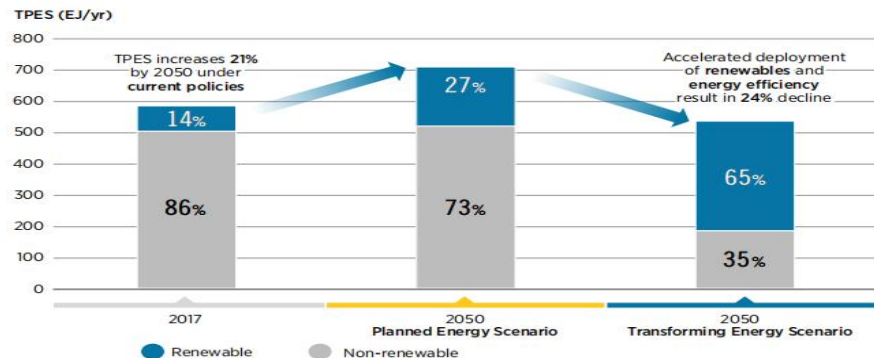
-Net Zero Emission

Climate Transformative Pathway

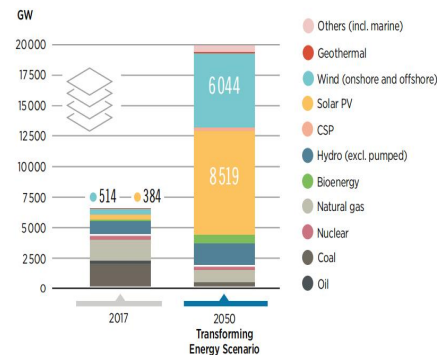
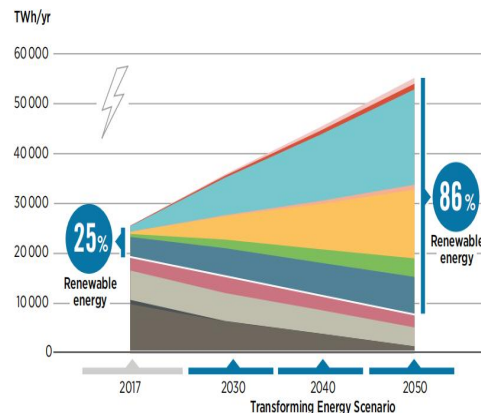
The total share of renewable energy would need to rise from around 14% of total primary energy supply (TPES) in 2017 to around 65% in 2050.

Transforming Energy Scenario:

- Achieve an 86% share for renewables by 2050.
- Wind power would be a major electricity generation source, supplying more than one-third of total electricity demand.
- Solar PV power would follow, supplying 25% of total electricity demand.
- Hydropower capacity would increase by two-thirds to 2 147 GW.



Note: PES and TES (IRENA), 2017 values based on IEA (2019b)



Sources: THE ROADMAP TO 2050-IRENA

1.1 Global Renewables and Solar PV Energy Market Outlook

-Net Zero Emission

Highest CO2 emitting countries and regions and level of ambition in NDCs

Country/region	Total GHG emissions (kt of CO2 equivalent)	Emissions target	Renewable energy target	Enhancement details from previous NDC to latest NDC
China	12,355,240	Achieve peak carbon dioxide emissions before 2030; Lower CO2 emissions per unit of GDP by more than 65% from the 2005 level	Increase the share of non-fossil fuels in primary energy consumption to around 25%	Increased emission reduction targets from 60–65% to over 65%; increased target for share of non-fossil fuel sources in primary RE consumption from 20 to 25%
United States	6,023,620	Economy-wide target of reducing net GHG emissions by 50–52% below 2005 levels in 2030	No specific renewable energy targets but does mention domestic policies and incentives that have advanced renewable energy	Almost doubled emission reduction targets (from 26–28% below 2005 levels in 2025 in the previous NDC submitted prior to re-joining Paris Agreement)
European Union	3,567,090	Net domestic reduction of at least 55% in GHG emissions by 2030 compared to 1990 levels	2030 target of at least 32% renewable energy share in final energy consumption	Increased emissions reduction target from 40% to 55%; introduced a specific renewable energy target for 2030
India	3,374,990	COP 26 pledge: 1 billion tonne reduction in CO2 emissions by 2030	COP 26 pledge: 50% share of renewables in the country's energy mix (with low-emission capacity raised from 450 GW to 500 GW)	Expected to significantly raise ambition in the forthcoming NDC update
Russian Federation	2,543,400	To reduce GHG emissions by 2030 by 'up to 70%' relative to the 1990 level	Limited mention of renewables	Russia decreased its GHG reduction target from 'up to 75%' to 'up to 70%' compared to 1990 levels from its INDC.
Japan	1,186,770	Reduce greenhouse gas emissions by 46% in 2030 compared to 2013 levels	All possible efforts in all areas including thorough energy efficiency measures, maximum introduction of renewable energy, as well as decarbonisation of public sectors and local communities	Increased emission target from 26% in the first NDC
Brazil	1,032,640	To reduce its emissions in 2030 by 43% compared with 2005 (updated to 50% at COP26)	No target; renewable energy mentioned but only in the context of previous targets	Pledged carbon neutrality by 2050 instead of 2060 (in the original NDC); slightly raised emission target at COP26 pledge
Indonesia	969,580	Unconditional: 29% reduction in GHG emissions against BAU scenario by 2030; conditional: 41% reduction by 2030, subject to availability of international support for finance, technology transfer and development, and capacity building	Refers to the National Energy Policy target of new and renewable energy share in TPES of at least 23% in 2025 and at least 31% in 2050. Presents two scenarios: a. Unconditional mitigation 19.6% of power generation will come from renewables by 2030; b. Conditional mitigation scenario: 132.74 TWh produced by renewable energy (equivalent to 21.65 GW capacity)	No change in targets or mitigation scenarios.

As of November 2021, **177 countries** (about 90% of all countries) have revealed that they are considering **net zero targets**:

1.9 have declared that they have **achieved** net zero emissions

2.16 have net zero targets **written into law**

3.59 have mentioned net zero in **policy documents**

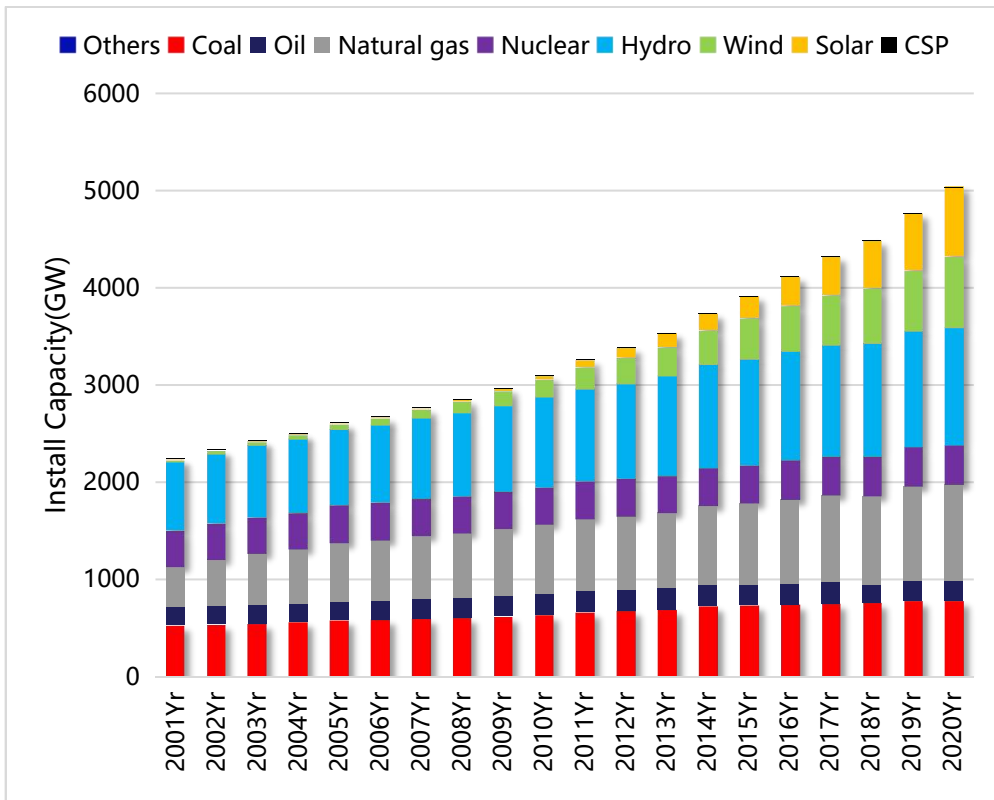
4.21 have made a **declaration or pledge** to reach net zero

5.72 have **ongoing** discussions regarding net zero targets



1.2 Global Renewables and Solar PV Energy Market Outlook

-Overview of PV Energy



Data source: International Renewable Energy Agency (IRENA)

Global Energy Capacity

Global Energy Capacity

- Total fossil fuel additions fell to 60 GW in 2020 from 64 GW the previous year highlighting a continued downward trend of fossil fuel expansion.
- 260 GW of renewable energy capacity last year, exceeding expansion in 2019 by close to 50%.
- More than 80 % of all new electricity capacity added last year was renewable, with solar and wind accounting for 91 % of new renewables.
- At the end of 2020, Global renewable generation capacity amounted to 2 799 GW with hydropower. It is 127 GW and 111 GW of new installations for solar and wind respectively.

1.2 Global Renewables and Solar PV Energy Market Outlook

-Overview of PV Energy

Solar PV Generation Play a Substantial Role

--Solar PV maintained its record-breaking streak, adding 175 GW (25%) of new capacity in 2021 to reach a cumulative total of around 942 GW.

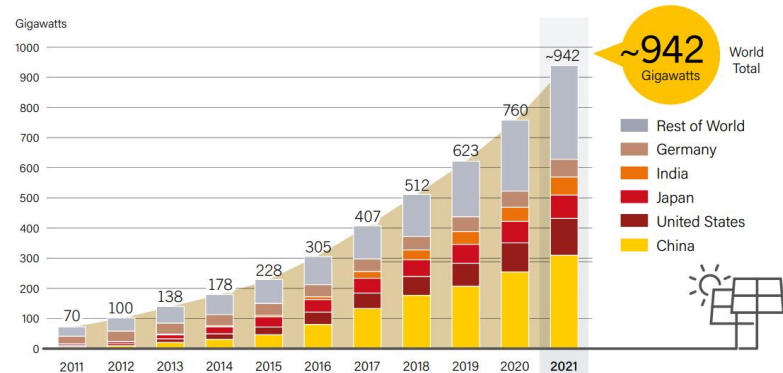
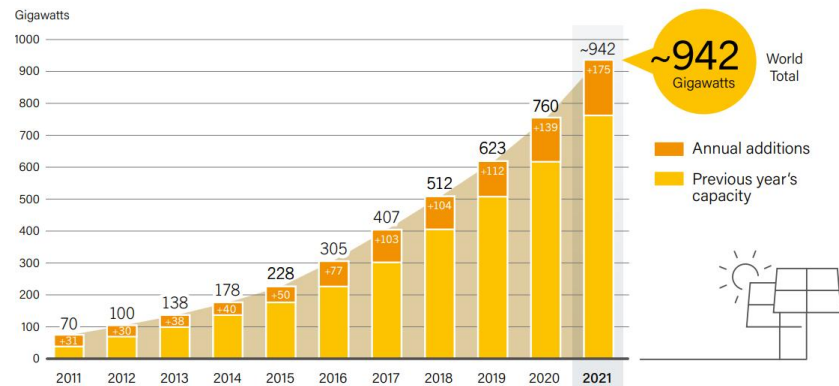
--Centralised utility-scale solar PV increased 100GW new installation, around 20%. Majority in the China, United States, India, Spain and France.

--Distributed solar PV installations rose around 25%, adding 75 GW. Majority in the China, Australia, Germany and Brazil.

--Asia dominated all other regions in new solar PV installations for nine consecutive years, representing 52% of the global added capacity in 2021.

--PV module price increased due to raw materials increased sharply.

--United States extending its import tariff and India setting unprecedently high solar import duties.



Source: Renewables 2022 Global Status Report-Ren21

1.2 Global Renewables and Solar PV Energy Market Outlook

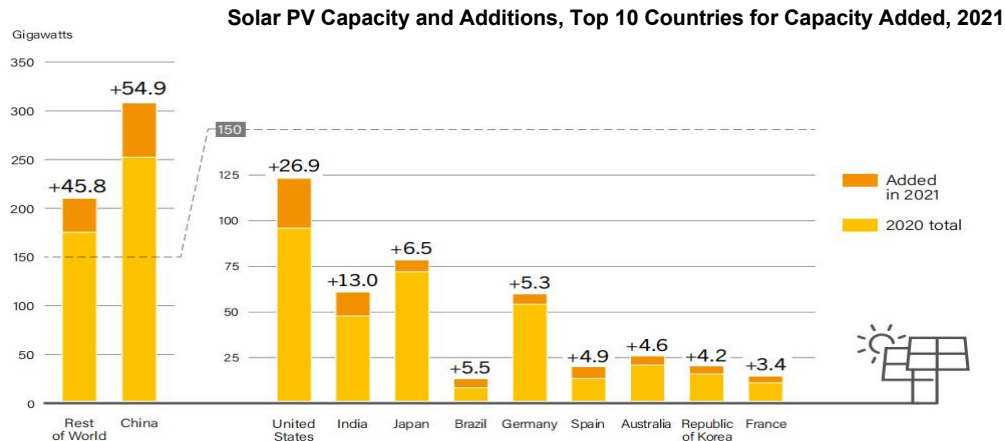
-Overview of PV Energy

China added 54.9 GW (21.5%) of solar PV capacity in 2021, of which around 29.3 GW (53%) was distributed solar PV and 25.6 GW was centralised solar PV.

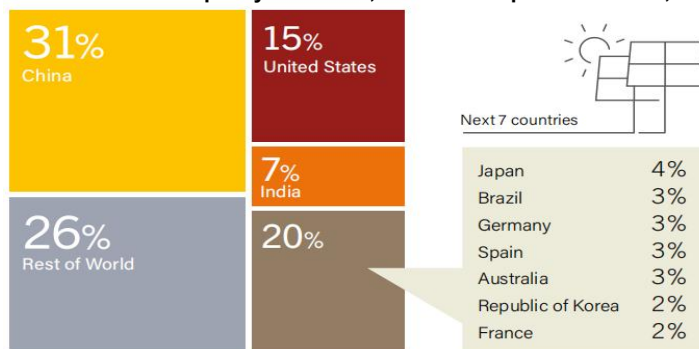
America added 26.9GW (21%), which again surpassed Europe (17%).

France was a new entrant to the top 10 solar PV installers, adding 3.4 GW of capacity; this was more than triple the amount in 2020. Total installed capacity to 14.3 GW.

India with an additional 13 GW installed, more than double the amount in 2020 setting a new record. 9 GW (63%) of utility-scale solar (large-scale, centralised systems connected to the grid) and nearly 3.4 GW (23%) of distributed generation



Solar PV Global Capacity Additions, Shares of Top 10 Countries, 2021



Source: Renewables 2022 Global Status Report-Ren21

1.2 Global Renewables and Solar PV Energy Market Outlook

-Overview of PV Energy

SOLAR RESOURCE MAP

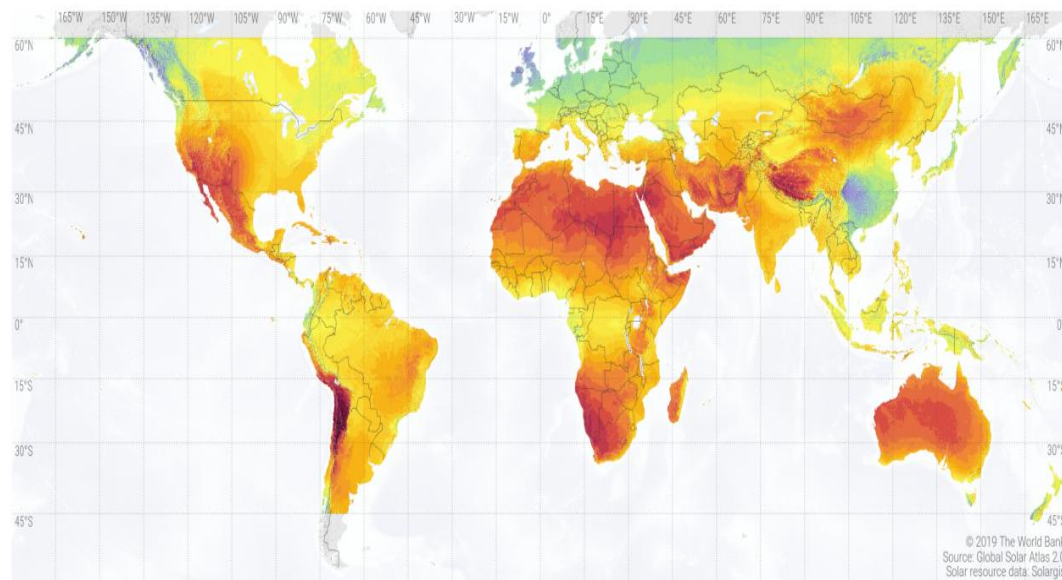
PHOTOVOLTAIC POWER POTENTIAL



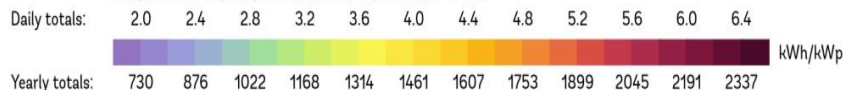
WORLD BANK GROUP

ESMAP

SOLARGIS



Long-term average of photovoltaic power potential (PVOUT)



This map is published by the World Bank Group, funded by ESMAP, and prepared by Solargis. For more information and terms of use, please visit <http://globalsolaratlas.info>

Solar Resource Distribution

The level of energy received could be affected by climate, latitude, longitude and status of geography.

--The best geographic location for harvesting solar energy include: North Africa, Middle East Region, South/West of United State, Southern Europe, Australia, South Africa. Eastern South America, West Coast, Western China, est.

Theoretical reserves (TRs)

-According to the estimation of the global horizontal irradiance data for solar energy

Technical installed potential capacity (TPIC)

-Considering the resources and various technical constraints

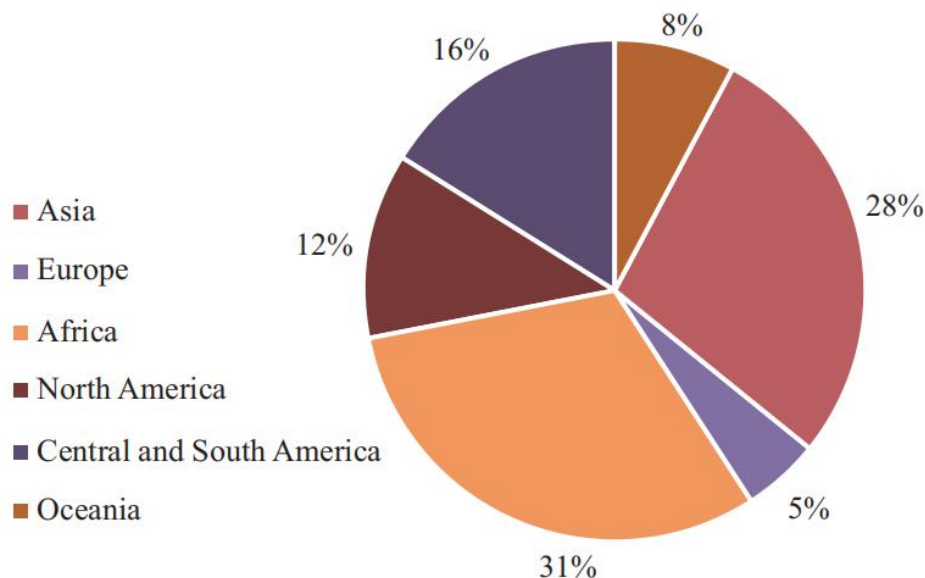
Source: Solargis

1.2 Global Renewables and Solar PV Energy Market Outlook

-Overview of PV Energy

Solar Resource Distribution

Theoretical Reserves of solar resources in each region



Source: Assessment of global solar resource development-Global Energy Interconnection by Qiong Tang

Theoretical Reserves of global solar PV resources:

--The theoretical reserves of **global** solar PV resources **total 208 EWh/a**.

-- **Africa**, accounting for **31%** of the global total, the TR of solar PV resources is 63,505.48 PWh/a, and parts of northern, southern, and eastern Africa have excellent PV resources.

-- **Asia**, accounting for **28%** of the global total, the TR of the solar PV resources is 66,617.03 PWh/a, excellent PV resources in west Asia.

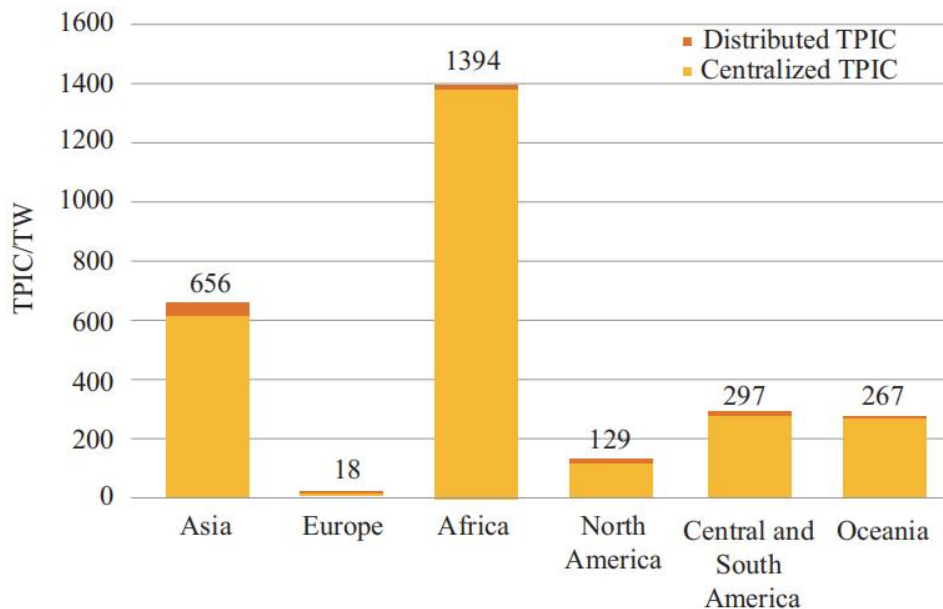
-- **European and Oceania** PV resources account for relatively small proportions of **5% and 8%**, respectively

1.2 Global Renewables and Solar PV Energy Market Outlook

-Overview of PV Energy

Solar Resource Distribution

Technical Installed Potential Capacity of solar resources in each region



Source: Assessment of global solar resource development-Global Energy Interconnection by Qiong Tang

Technical Installed Potential Capacity of global solar PV resources:

--Centralized development is approximately 2650 TW.

-- Distributed development is approximately 112 TW.

-- Africa has the best conditions for centralized development, with a total installed capacity of 1394 TW, accounting for approximately 50.5% of the world's total.

-- Considering the impact of resource endowments, land cover, terrain, conservation areas, and other factors, most of the land in Africa, except for the central part, meets the conditions for centralized development and the construction of PV plant.



2 Application Scenario for Solar Plant Development

2.1 Application Scenario for Solar Plant Development

-Development region

PV Solar
development
region

- Flat region
- Mountainous region

- Desert, gobi and desertification region
- Coal mining subsidence region
- Water surface region



2.1 Application Scenario for Solar Plant Development

-Development region

Desert, gobi and desertification region

- China's continuous effort to participate in United Nations Convention to Combat Desertification, for "Zero growth of desertification by year 2030", China had reached the goal ahead of schedule.
- In China, the first batch of renewable energy development are concentrated around Western Desert / Gobi desert, enabling generation of more than 100GW of energy from wind and solar.
- The development facilitates plantation underneath PV panel leading to a new eco-system.
- Results shown that combining renewable energy resources with anti-desertification technology offers the best prospects for the convention.
- China currently has more than 300GW solar power generating capacity made great contribution to combat desertification, and it planned to construct 450GW solar power electricity by 2030.



2.1 Application Scenario for Solar Plant Development

-Development region

Coal mining subsidence region

- Coal mining subsidence over 30 million acres in China, estimated acceleration in 1.25 million acres per annum. It has become a major challenge for local government.
- Since 2015, China had achieved an amazing result in the approach of combining a 6GW solar power plant with anti-subsidence management.
- Region suffered coal mining subsidence damage facing challenge of abandoned land with fragile eco-system, the approach of “PV+” application is adopting will be able to mitigate the problem.
- NDRC requested a national wide for “Status report for solar power development in the region of coal mining subsidence” , enforced each province to form a related strategy, which leading a promotion of abandoned land utilization.

中华人民共和国国家发展和改革委员会

关于请提供利用采煤沉陷区受损土地 发展光伏发电有关情况的函

有关省、市、自治区发展改革委：

为贯彻落实党中央、国务院关于深入推进采煤沉陷区综合治理的工作部署，研究推动采煤沉陷区受损土地综合利用，特请你委组织有关地方，提供利用采煤沉陷区受损土地发展光伏发电的有关情



2.1 Application Scenario for Solar Plant Development

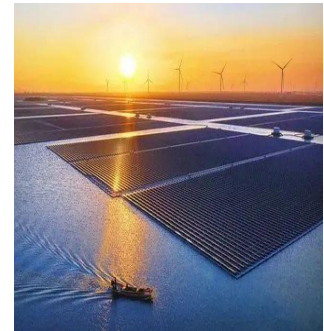
-Development region

Water surface region

- Float PV is increasingly being recognized. By World Bank Group's prediction, the total surfaces of man-make water reservoir combine can provide up to 400-4000GWp of energy, equivalent to the total PV solar energy harvested in year 2017.
- By year 2015, the total amount of energy generated by floatovoltaics worldwide were less than 100MW, reaching 2018 this power increased to more than 1GW. The world had brought great attention to floatovoltaics, causing it to grow rapidly in scale and sizes. Throughout the world, asia pacific region had kept the highest record of such development while China takes the leads.
- From the Wood Mackenzie Power & Renewables, 2019 to 2024, there will be a rapid growth up to 22% for floatovoltaics. According to DNV prediction, by the year 2030 floatovoltaics will generate more than 30GW. Therefore floatovoltaics industry has enter a period of rapid development.



Continent	Total surface area available [km ²]	No. of water bodies assessed	Total FPV capacity potential [GWp] (% of water surface used for PV installation)		
			1%	5%	10%
Africa	101,130	724	101	506	1,011
Asia*	115,621	2,041	116	578	1,156
Europe	20,424	1,082	20	102	204
N. America	126,017	2,248	126	630	1,260
Oceania	4,991	254	5	25	50
S. America	36,271	299	36	181	363
Total	404,454	6,648	404	2,022	4,044



2.2 Application Scenario for Solar Plant Development

-Dual-use PV application

Dual-use PV
application

■ “Solar PV+”agriculture
application

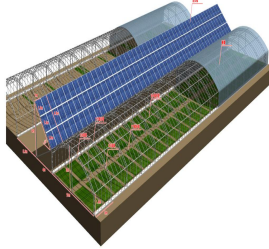


■ “Solar PV+”fishery
application



2.2 Application Scenario for Solar Plant Development

-Dual-use of PV application



“Solar PV+” agriculture application

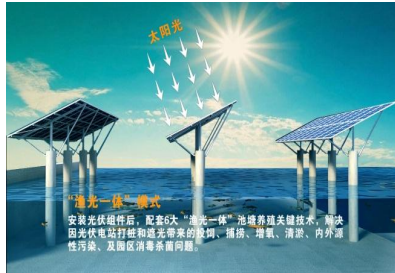
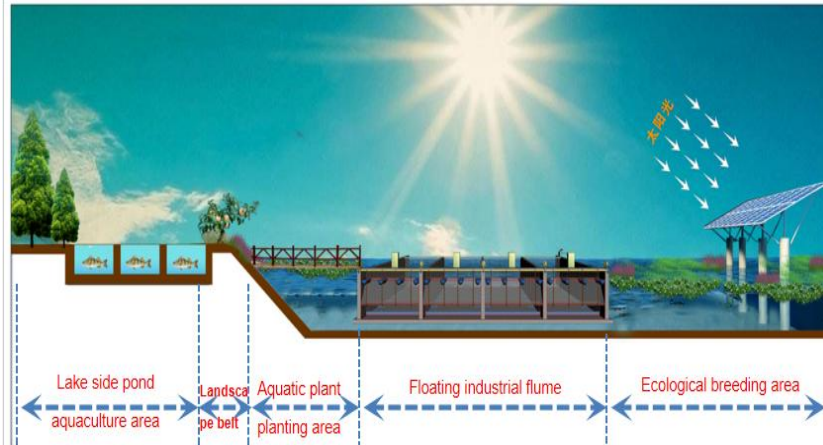
- Agrivoltaics is the combination of solar energy and farming.
- Agrivoltaics allows productive use of the land beneath solar arrays creating a perfect harmony and increases the land's profitability but decrease carbon emissions.

2.2 Application Scenario for Solar Plant Development

-Dual-use of PV application

"Solar PV+" fishery application

- "Fishery-solar hybrid system" refers to the combination of fishery and solar power generation.
- Combining Eco-Farm with "Fishery-solar hybrid system" upgrade the breeding and modern facility fishery effect which improved the standard of the aquatic product.
- Utilize the space underground and water surface, reduce the cost of electricity generation.
- "Fishery-solar hybrid system" can develop into a base for tourism, public education and fishing.



2.3 Application Scenario for Solar Plant Development

-Sustainable form of PV application

Types of PV Plant

PV Plant classification

Centralized PV plant

- Installed capacity $> 6\text{MW}$
- Full-on-grid



Distributed PV plant

- Installed capacity $\leq 6\text{MW}$
- Self-generation and self-consumption, tied on grid

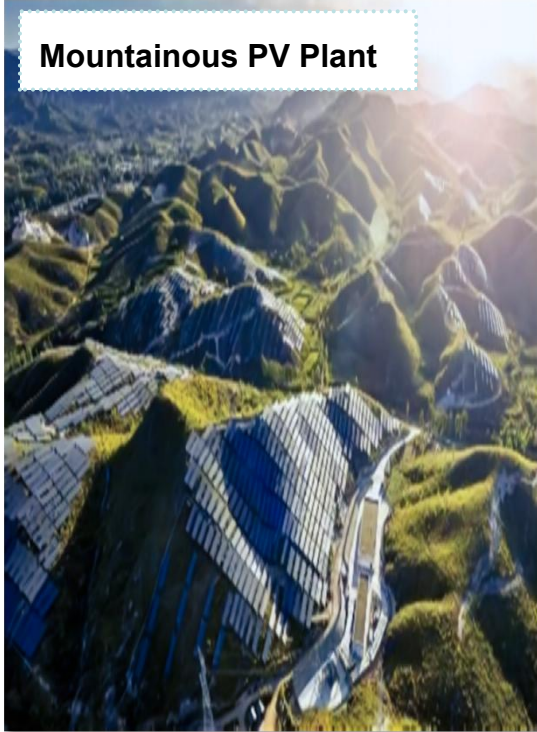


2.3 Application Scenario for Solar Plant Development

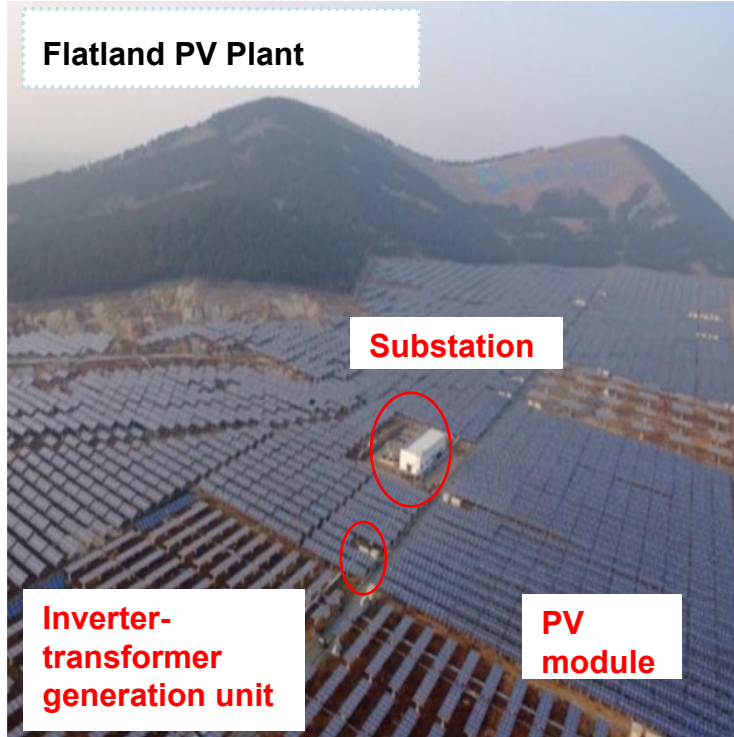
-Sustainable form of PV application

Types of PV Plant--Centralized PV Plant

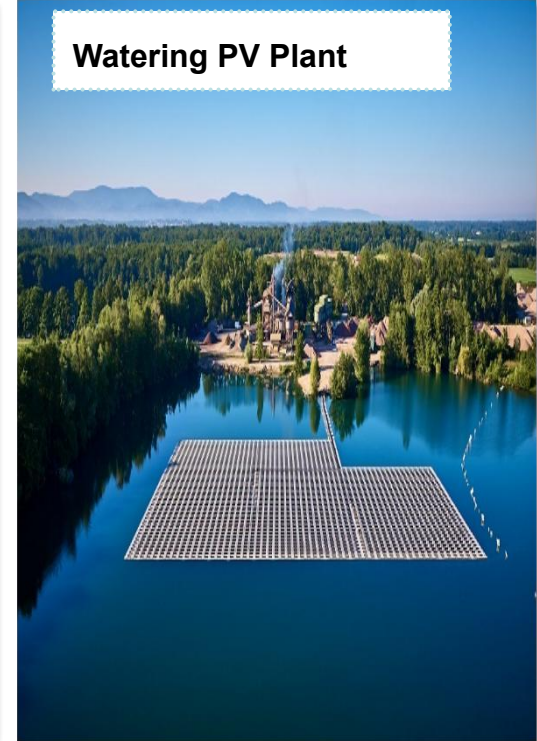
Mountainous PV Plant



Flatland PV Plant



Watering PV Plant



2.3 Application Scenario for Solar Plant Development

-Sustainable form of PV application

Types of PV Plant--Distributed PV Plant



**Residential distributed
PV station**

- Residential: The electricity generated is first provided for self-consumption, and the surplus power is connected to the grid.



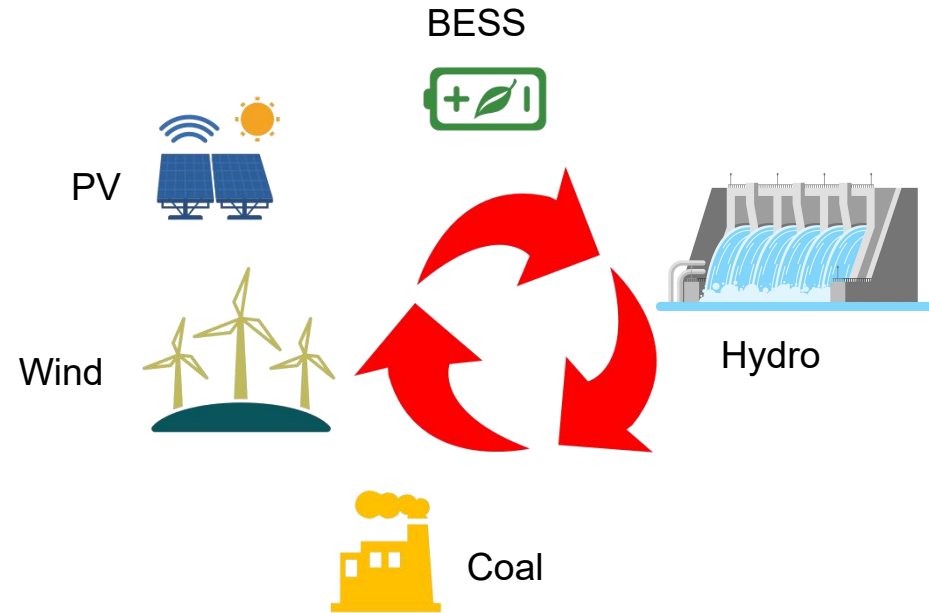
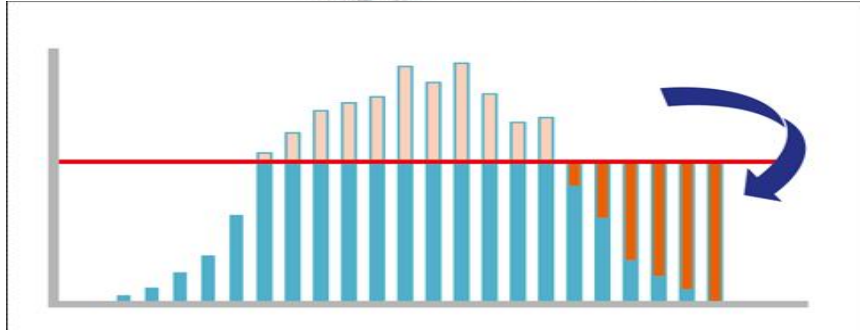
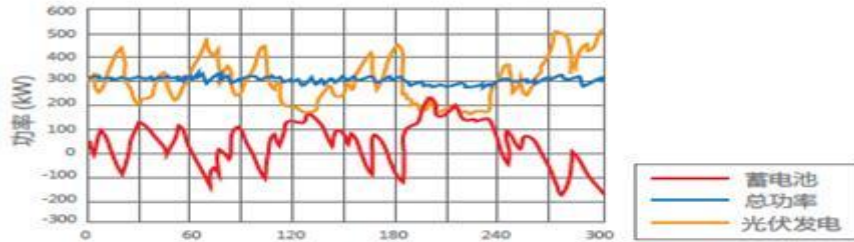
**Commercial & industrial distributed PV
station**

- Commercial & industrial: The electricity generated is first provided to the industrial plant, and the surplus is connected to the grid.

2.3 Application Scenario for Solar Plant Development

-Sustainable form of PV application

Types of PV Plant--Hybrid system



- Hybrid system: solar, wind, hydro, coal, BESS multi-energy complementary
- Grid connection: micro-grid power stations, on-grid, off-grid
- Multi-Energy Complementary Project and Source-Grid-Load-Storage Integration Project

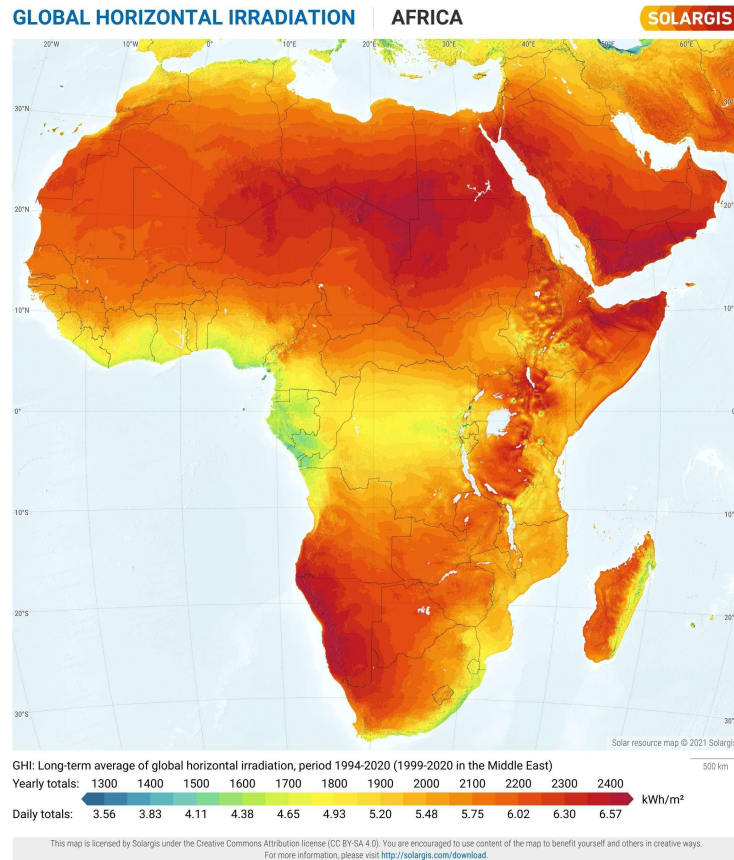


3 Overview of Solar PV in Africa

3.1 Overview of Solar PV in Africa -Solar Resource distribution

Resource distribution in Africa

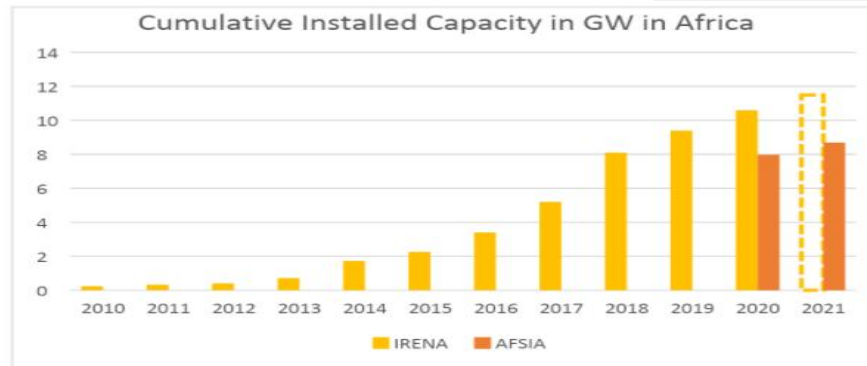
- Africa's solar resource are rich with high availability.
- The solar resource are highly concentrated in Sahara region and Ethiopian Plateau, South African Plateau.
- Coastline along Mediterranean Sea have a high solar radiation up to 1700 ~ 1900kWh/m²
- Regions across Sahara towards the east covering Sudan, Ethiopia, Somalia, Eastern of Kenya, Namibia, South Africa and Eastern of Botswana, have the richest solar resources with radiation 1800 ~ 2100kWh/m² .
- The region from middle part of western Africa has lowest irradiation. Gabon, Congo, Angola have a low solar radiation between 1200 ~ 1500kWh/m².



3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Solar PV capacity in Africa

- Based on AFSIA database, 8.7 GWp solar PV project in operation by the end of 2021. An additional 721 MWp were new installed capacity by 2021.
- In the past 7 years, Africa has experienced 2 peaks in 2014 and 2018 when it installed 2.6% and 3.1% of the global new capacity respectively. In 2021, data indicates Africa has represented only 0.5% of the new capacity globally. This is the lowest level since 2012.
- By the data from IRENA, global capacity increase by 25%, solar in Africa has grown by 9%.
- Africa is yet to suited for massive large scale plants compared to other parts of the world.
- Lack of demand for electricity, and not able to absorb significant quantities of solar.



		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
IRENA	WORLD	ANNUAL INSTALLED											
		CUMULATIVE											
		41.6	32.3	30.1	37	39	47.7	71.9	94.9	94.2	101.3	126	191
		41.6	73.9	104	141	180	227.7	299.6	394.5	488.7	590	716	907
AFRICA	WORLD	ANNUAL INSTALLED											
		CUMULATIVE											
		0.09	0.08	0.31	1.01	0.53	1.14	1.8	2.9	1.3	1.2	0.90	
		0.24	0.33	0.41	0.72	1.73	2.26	3.4	5.2	8.1	9.4	10.6	11.5
	%	INSTALLED VS. WORLD											
		0.3%	0.3%	0.8%	2.6%	1.1%	1.6%	1.9%	3.1%	1.3%	1.0%	0.5%	
		CUMULATIVE VS. WORLD											
		0.4%	0.4%	0.5%	1.0%	1.0%	1.1%	1.3%	1.7%	1.6%	1.5%	1.3%	

3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Africa PV solar - Large scale

- The large scale PV Solar segment has continued growth with an additional 552 MWp. A 7.7% increase of the historically installed capacity for large scale projects in Africa.
- South Africa is leading the charge, contributed to 2/3 of this new capacity. But some new countries have joined the group, such as Malawi, Togo, Somaliland, Burundi and Somalia.
- These notable developments are currently taking place in Algeria, Morocco, Angola, Namibia, Botswana to cite a few. These countries anticipation of join the “Gigawatt Club” in the near future.
- Significant progress has been made in Namibia and Botswana, where a \$9B project hosting a total of 5 GW is being planned.
- In Algeria, the long-awaited 4 GW program has moved to the next stage in 2021 through the recent release of the tender for the 1st phase of 1 GW.

SHS UNITS SOLD	2017	2018	2019	2020	2021	TOTAL
EAST AFRICA	2,499,103	2,743,877	4,129,014	3,738,100	3,879,078*	16,989,172
WEST AFRICA	706,142	540,084	714,035	773,000	947,662*	3,680,923
CENTRAL AFRICA	321,486	179,112	192,143	286,000	302,000*	1,280,741
SOUTHERN AFRICA	59,625	50,672	32,873	n/a	n/a	143,170
	3,586,356	3,513,745	5,068,065	4,797,100	5,128,740*	22,094,006
CUMULATIVE	3,586,356	7,100,101	12,168,166	16,965,266	22,094,006	
GROWTH vs. CUMULATIVE	-	98%	71%	39%	30%	

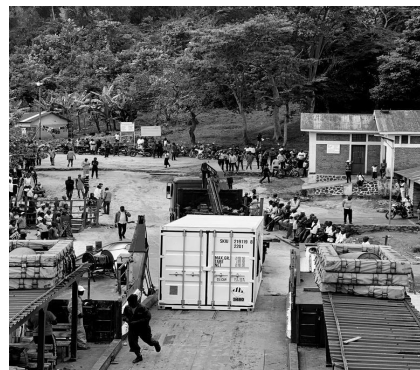
- Angola had only an estimated 13MW of grid connected solar capacity a year ago, news broke this year of plans for another 405MW.

3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Africa PV solar - SHS

- Solar Home Systems (SHS) providers continue to rival with ingenuity to come up with better, cheaper and more diversified solutions to reach the 600 million people who still lack access to electricity in Africa
- The SHS (“Solar Home Systems”) segment has experienced another sweet and sour year in 2021. Among all solar segments, SHS indeed is among the segments that were most impacted by the COVID crisis.
- East Africa remains by far the leader of SHS in Africa, with Kenya being the undisputed leader in terms of units sold. But West and Central Africa are also growing strongly and could soon catch up with East Africa. Southern Africa remains at very humble levels.

SHS UNITS SOLD	2017	2018	2019	2020	2021	TOTAL
EAST AFRICA	2,499,103	2,743,877	4,129,014	3,738,100	3,879,078*	16,989,172
WEST AFRICA	706,142	540,084	714,035	773,000	947,662*	3,680,923
CENTRAL AFRICA	321,486	179,112	192,143	286,000	302,000*	1,280,741
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3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Africa PV solar - C&I

- A final reason to be optimistic is the boom of solar for Commercial and Industrial (C&I) users.
- Based on info collected by AFSIA, operational C&I installations across Africa now account for 717 MWp, an increase of 138 MWp from 2020, which represents a 24% growth.
- This installed capacity is still very far from the 7.7 GWp of large-scale projects. But it is to be noted that while C&I represents only 8% of the current total installed capacity in Africa, it represented 19% of the newly installed capacity in 2021.
- This growth of the C&I segment should experience an additional boost in the months to come, driven by 2 major factors: the new 100 MW threshold for self generation in South Africa and the appetite for solar from the mining industry.

C&I IN AFRICA	2021	HISTORICAL
MWp C&I	137.8	716.9
MWp all solar	721.4	8,693.6
Share of C&I	19.1%	8.2%
Growth C&I	23.8%	
Growth all solar	9.0%	
Average C&I MWp	1.150	0.273
Median C&I MWp	0.225	0.050

3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Africa PV solar - mini grid

- The African mini-grid segment has made great progress this year with AFSIA numbers indicating an increase of 16% of historical installed capacity in 2021.
- In absolute terms however, this increase remains relatively small: at the end of 2021, there was 49.5 MWp of capacity installed at mini-grids throughout the continent (0.6% of all installed solar capacity in Africa).
- Uganda, Sierra Leone and Nigeria have been particularly active on the mini-grid front this year.
- Mozambique took big steps toward embracing the rural electrification benefits of off-grid solar in 2021, with a tender for five solar-plus-storage mini-grids followed by much-needed supporting legislation.



3.2 Overview of Solar PV in Africa -Solar PV plant distribution

Recommendation for Africa PV solar

Simultaneous development centralized & distributed PV Plant

1. Centralized grid-connected PV power plant are introduced in desert, gobi region
2. Distributed generation power plant will be introduced to weak grid area. Providing solar, wind and Diesel helps residents to stabilize electricity.

Pluralistic co-development Mode

1. Solar power will continue to grow synergy with different type of energy. Apart from Solar energy storage system, other combination such as hydro, wind and solar grid system or solar, wind, hydro energy storage system, will continue to expand in its development.
2. In integration development, solar and renewables energy will continue to combine with agriculture, fishery and other industry as ecosystem.

Localization of PV industry

1. Localization of photovoltaics manufacturing, attract business investment for factory or plant that produce spare parts, inverter, etc. As such, ensured cost control as well as job security for the region.
2. Localization of design and construction work. Advocate local construction company and design firm to actively engage in photovoltaic project, promote regional growth of photovoltaic development.

Financial & policy incentives

Deployment policies and related measures are required to support market creation; these typically include fiscal and financial incentives (e.g. tax incentives, import duty exemptions and grants), regulatory and pricing policies and tradable certificates.



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谢谢！
Thank you!