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Assessment of Distributed Solar PV potential in BRI Countries

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Outline

1. The great significance of promoting distributed PV in the BRI countries
2. Evaluation methods and results of distributed PV potential
3. Typical application scenarios of distributed PV
4. Conclusion and recommendations

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The great significance of promoting distributed PV in the "Belt and Road" countries

Basic information of the “Belt and Road” countries (as of Nov. 2021)

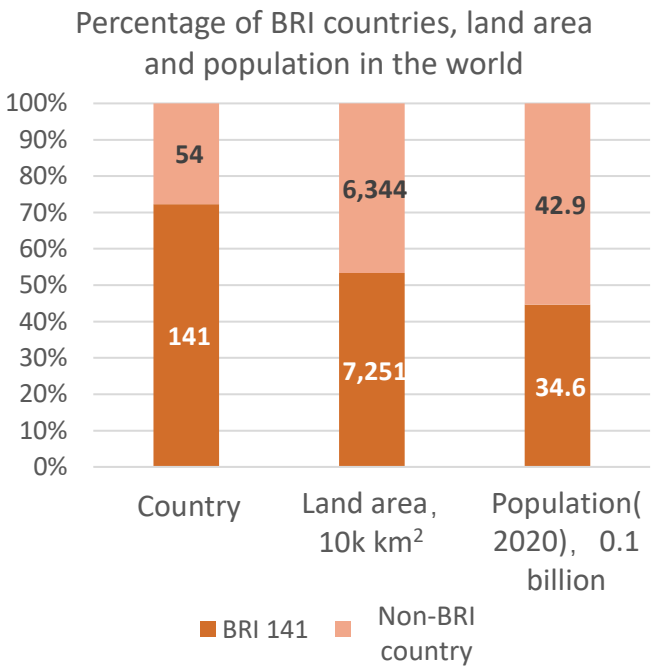
Geographical distribution

Regional groupings according to the UN Millennium Development Goals：

- Eastern Asia: 2 countries
- Southeast Asia: 11 countries
- Southern Asia: 7 countries
- Western Asia: 10 countries
- Caucasus and Central Asia: 7 countries
- North Africa: 5 countries
- Sub-Saharan Africa: 42 countries
- Latin America and the Caribbean: 19 countries
- Oceania: 10 countries
- Developed regions: 28 countries

Percentage in the world

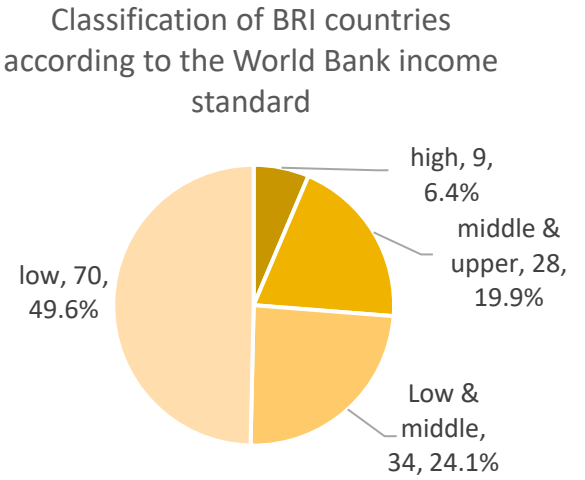
- Number of countries: 141, 72%
- Land area: 72.51 million km^2, 53%
- Population: 3.46 billion, 45%



Economic development

Level of national economic development：

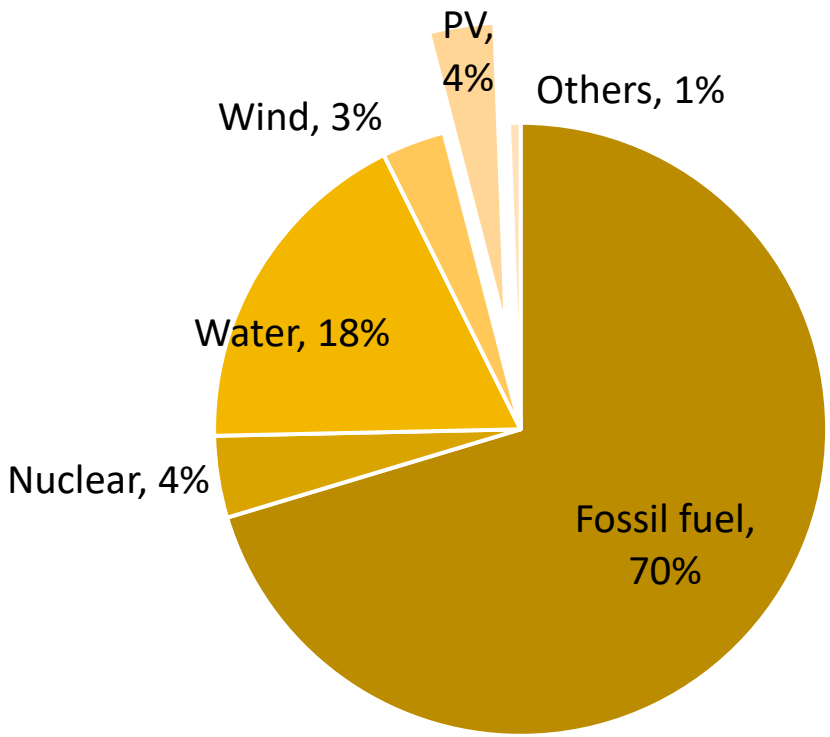
- Nearly 3/4 of the BRI countries belong to low- and middle-income countries
- Per capita GDP of the 141 BRI countries in 2020 was $5,037, about 50% of the global per capita GDP in the same year



https://zh.wikipedia.org/wiki/%E4%B8%80%E5%B8%A6%E4%B8%80%E8%B7%AF

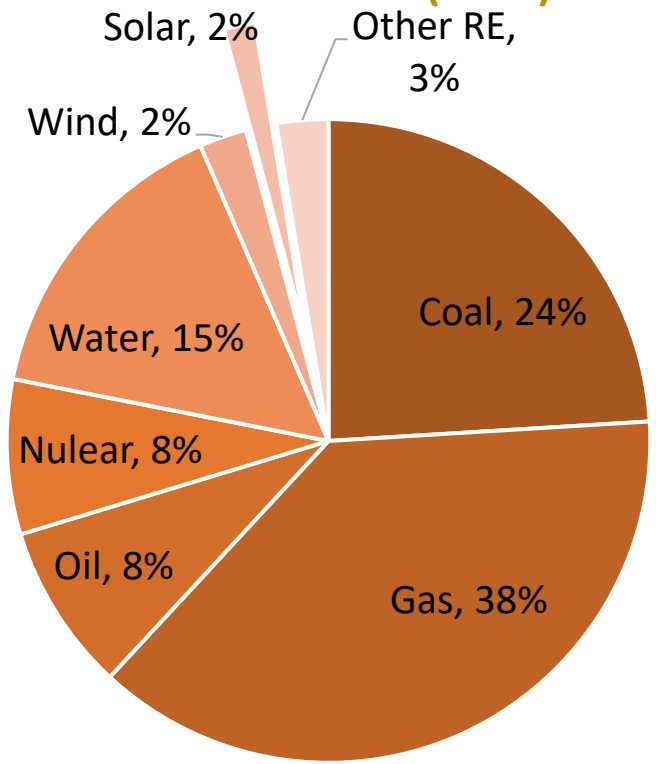
Status quo of power sector in the BRI countries

Power installation of the 141 BRI countries (2018)



- Total installation: the 141 BRI countries have a total installation capacity of 1898 GW, accounting for about 27% of the global installation capacity.
- Installation composition: the 141 BRI countries have a higher proportion of fossil fuel installation than the global average.

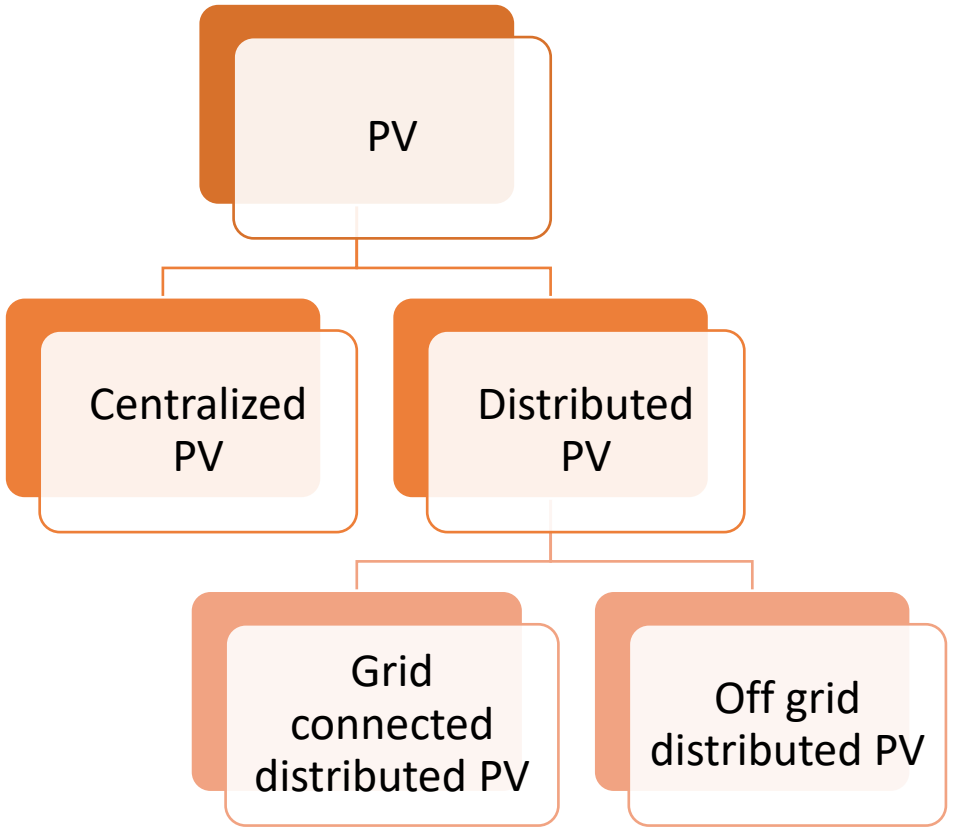
Power generation of the 141 BRI countries (2019)



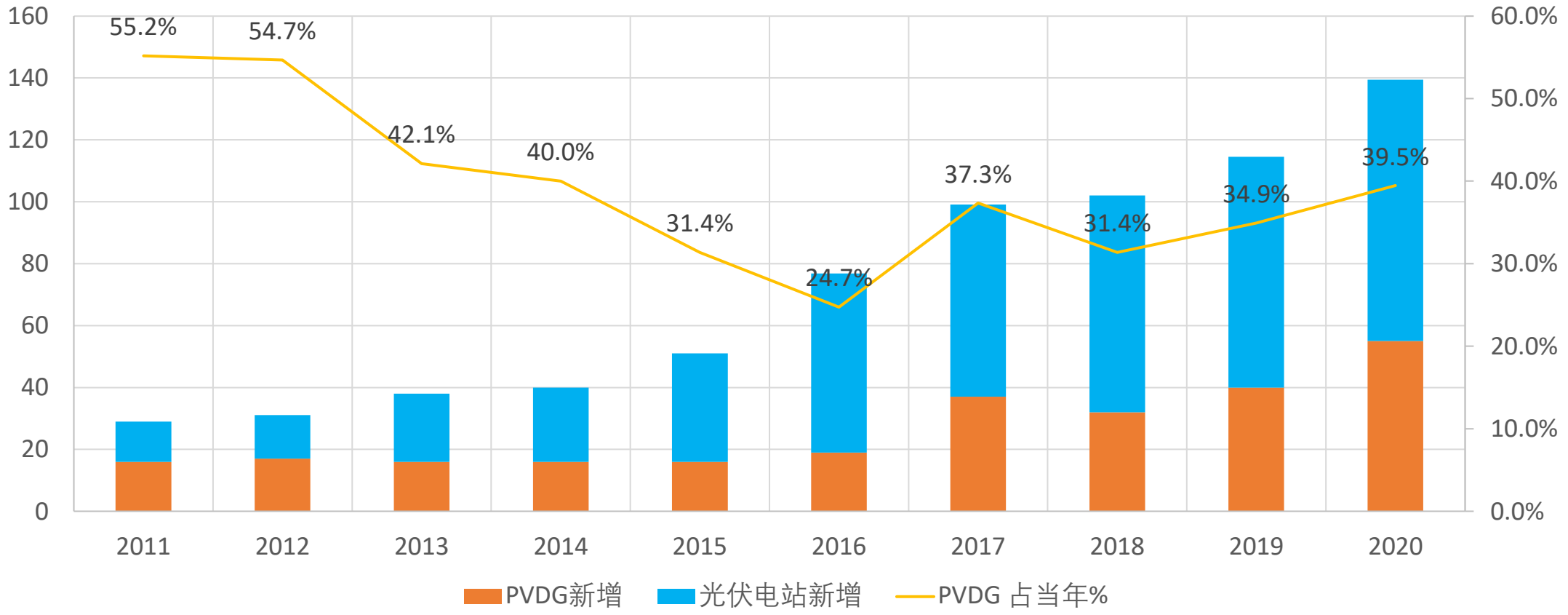
- Total power generation: the 141 BRI countries had generated 6934 TWh of all energy sources in 2019, accounting for about 27% of the global electricity generation.
- Power composition : fossil fuel accounts for about 70% of the 141 BRI countries' total power generation.

The importance of developing distributed PV in the BRI countries

- PV cost has dropped significantly and will continue to drop in the future
- Short construction period of distributed PV system
- Provide power for areas beyond the reach of power grid
- Improve resilience of power system



Globally, the share of distributed PV is increasing



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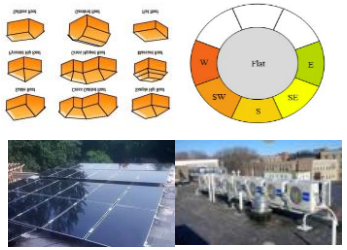
Methodology and results of distributed PV potential assessment

Methodology Overview

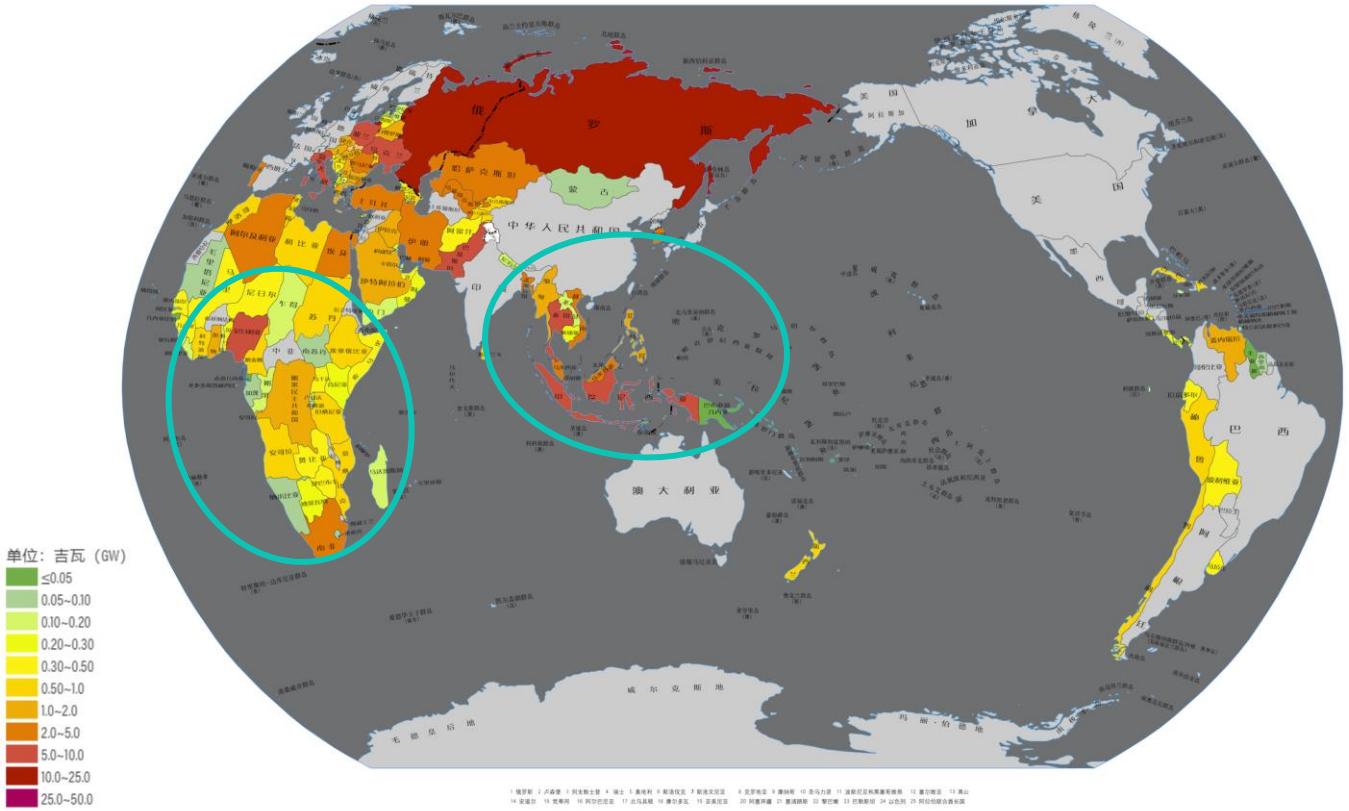
Category	Name	Brief description	
Direct method	Aerial photography method	Providing visual information for rooftop PV installation locations through aerial photography and computers, and then manually calculating.	
	GIS method	The most reliable way to estimate suitable roof area at scale is based on modeling from orthophotography or light detection and ranging (LiDAR) data and geographic information systems (GIS).	
	Built-up area method	Estimates are made using data from built-up areas (projected roof areas of buildings) provided by statistical agencies, taking into account a variety of influencing factors.	Resource side
	Statistical method of land occupation of classified buildings	Estimate with statistics of classified building area. The premise of this method is to understand the proportion of different types of buildings in the land area, and then conduct evaluation and calculation.	
Indirect method	Assessment by national development stage	Based on the close relationship between electricity demand and economic growth, the potential of distributed PV can be evaluated with the needs and goals of different stages of the distributed development of renewable energy in a country.	
	Unit demand method	The future installed capacity potential of PV can be calculated by combining the per capita photovoltaic ownership of a country with the total population in the country, and the total demand can also be estimated by combining the demand of population or household units (people, households) with the number of people or households.	Demand side
	Data reference method from international authorities	Direct reference to data published by international authorities can also be used to verify various assessments and predictions.	

Source: Table complied by Author.

Resource side: assessment of rooftop areas

Collecting	Estimating	Assessment	Evaluating	Calculating
historical data on built-up areas	built-up area (2030)	of external development conditions	effective roof utilization	installed capacity
Built-up area (1975, 1990, 2000, 2014)	Calculating CAGR to estimate the projected roof area in 2030	Comprehensively considering the stage of socio-economic development of BRI countries, power grid conditions and other factors	Comprehensively considering structure, orientation, shelter and other limiting factors of roof	Installation factor: 100W/m^2
	$CAGR = \sqrt[m]{(A_1/A_0)} - 1$			
Assumed parameters	/	*1.77% ~2.19%*	*5 ~ 10%*	*10%*	/

Resource side: assessment results of rooftop distributed PV potential (2030)

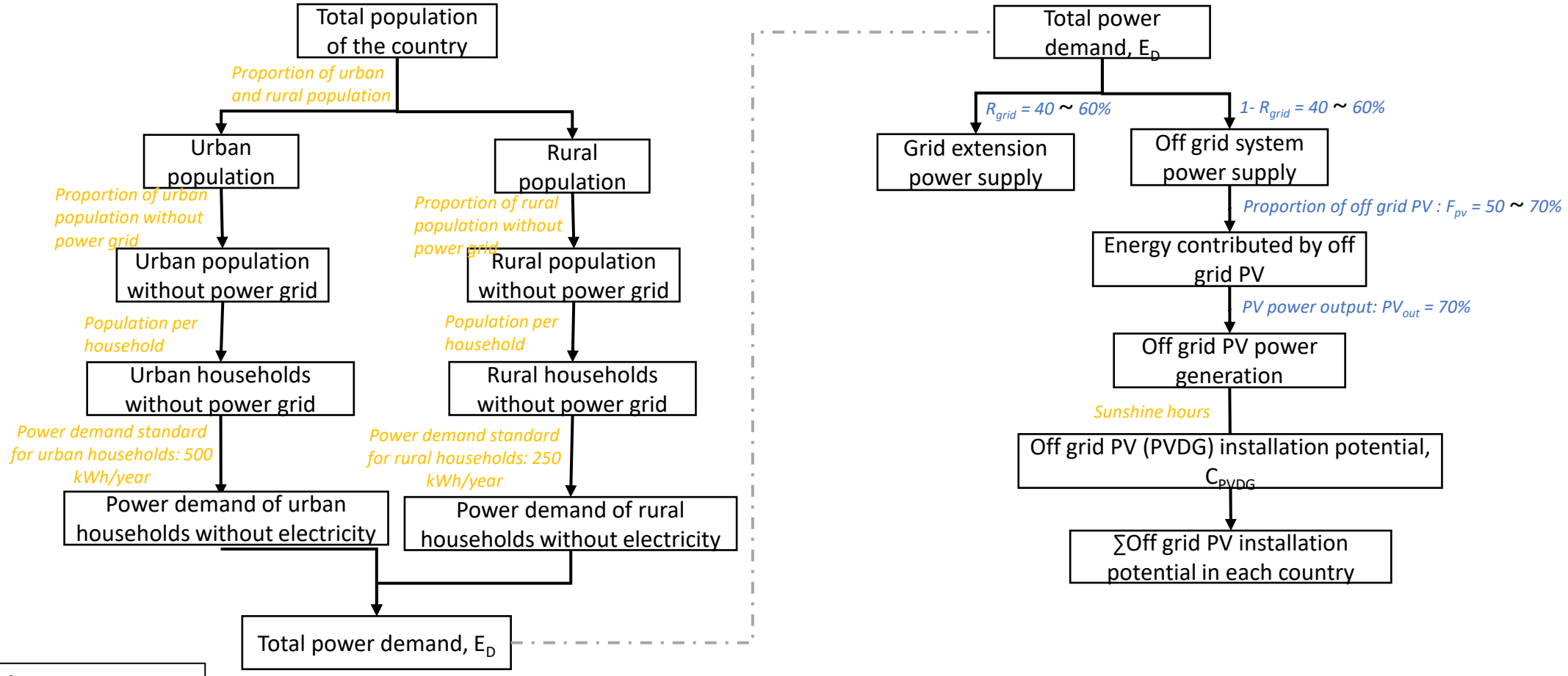


Rooftop distributed PV capacity potential of the 141 BRI countries– Basic scenario

The basic scenario model assumes that the roof area in the built-up area is CAGR=1.77%, the roof installed distributed PV will account for 5% in 2030, the roof area utilization rate is 10%, and the installation factor is 100W/m^2.

UN MDGs (Number of countries)	Installed capacity potential-Basic Scenario (GW)	Installed capacity potential-Positive Scenario (GW)
Eastern Asia (2)	3.13	6.68
Southeast Asia (11)	**22.95**	**49.06**
Southern Asia (7)	14.79	31.62
Western Asia (10)	9.07	19.39
North Africa (5)	6.66	14.24
Caucasus and Central Asia (7)	8.18	17.48
Sub-Saharan Africa (42)	**20.87**	**44.60**
Latin America and the Caribbean (19)	6.66	14.23
Oceania (10)	0.03	0.07
Developed regions (28)	69.38	148.28
Total	***162***	***346***

Demand side: evaluation method of distributed PV potential in areas without power access

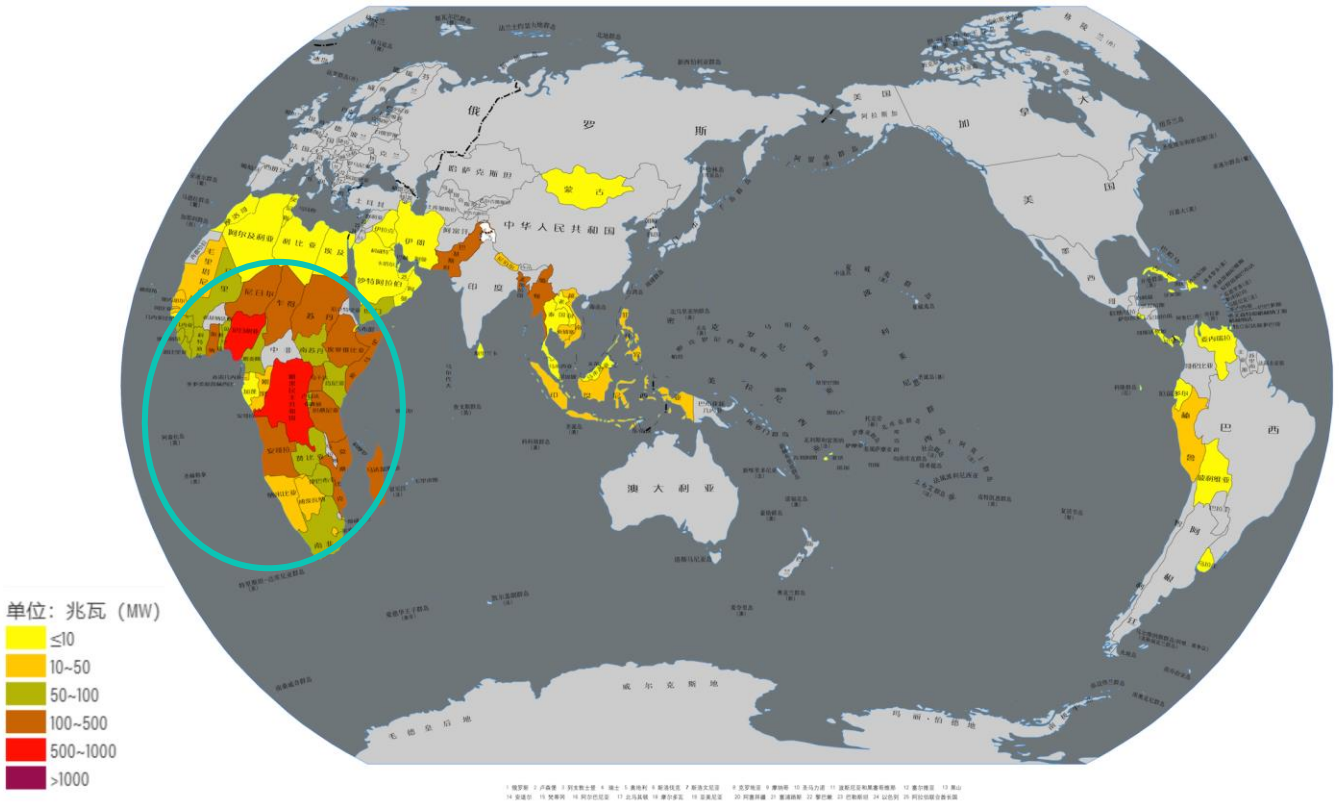


Graphic
Yellow: Published data
Blue: Assumption data

High proportion of PV installation ： $C_{\text{pv-high}} = E_D \times (1 - U_{\text{grid-low}} - U_d) \times F_{\text{pv-high}} / PV_{\text{Actual power generation}}$ (GWh/GW)

Low proportion of PV installation ： $C_{\text{pv-low}} = E_D \times (1 - U_{\text{grid-high}} - U_d) \times F_{\text{pv-low}} / PV_{\text{Actual power generation}}$ (GWh/GW)

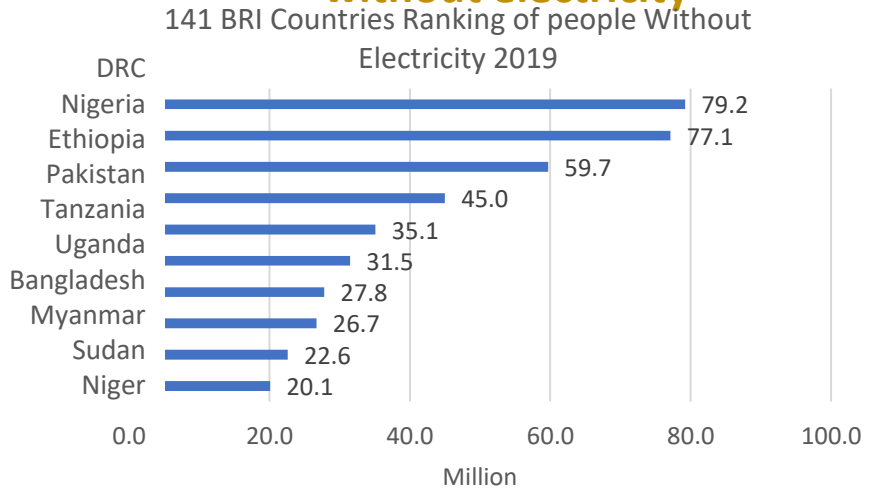
Demand side: assessment results of distributed PV potential in areas without power access (2030)

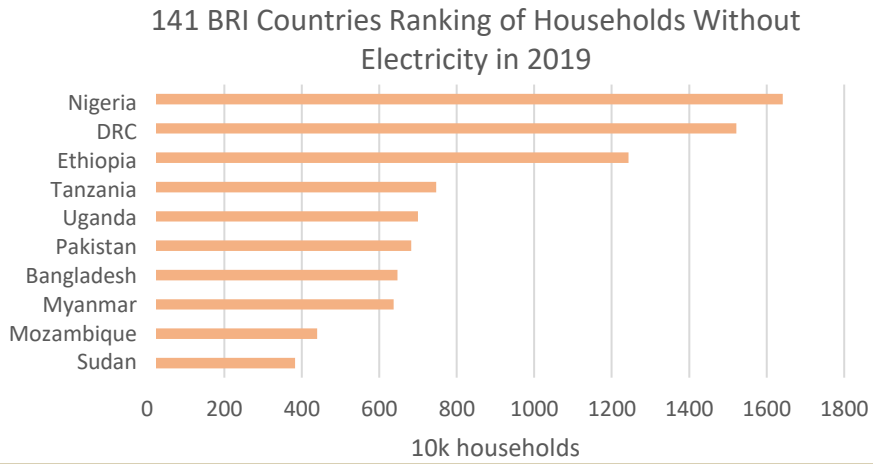


The 141 BRI potential installed capacity of distributed PV for people without electricity - basic scenario

The basic scenario model assumes that the extended energization rate of the grid is 60%, the distributed PV installed capacity accounts for 50% of the total installed capacity of the off-grid system, and the PV power output is 70%.

People and households without electricity





Ethiopia

Country profiles

- Geographical location : Northeast Africa
- Population: 112 million (2019)
- Electrification rate: 47%
- Primary energy: biomass and waste account for about 88% of energy supply
- Resource endowment: rich in water resources

Potential assessment

Rooftop distributed PV

- Basic scenario: CAGR=5.25%, the installed capacity of rooftop distributed PV is expected to be 560MW in 2030
- Positive scenario: CAGR=6.7%, The installed capacity of rooftop distributed PV is expected to be 1394MW in 2030

Distributed PV provide electricity to areas without electricity

- Status: There are 59.7 million people without electricity, and 198,000 urban and 12.23 million households in rural areas without electricity
- Scenario with low PV proportion: In 2030, the installed capacity of off-grid photovoltaics for the electrification of the population without electricity is expected to be 460MW
- Scenario with high PV proportion: In 2030, the installed capacity of off-grid photovoltaics for the electrification of people without electricity is expected to be 1012MW

Application of distributed PV

- **Industrial and commercial field**

Rooftops of industrial plants/parks covered with photovoltaic panels can provide clean electricity, act as thermal insulation and reduce expenses such as cooling electricity

- **Transportation field**

Motorcycles are the main means of transportation at this stage, and electric motorcycles are promoted and charged with clean electricity

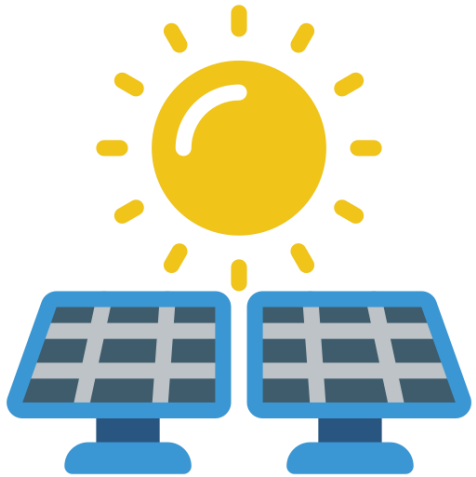
- **Health and medical field**

In response to COVID-19, PV + clinic, PV + refrigeration and other application models can refrigerate vaccines to extend their service life

Application of photovoltaic + refrigerator in Africa

https://zh.wikipedia.org/wiki/File:Ethiopia_in_Africa.svg

Typical application scenarios of distributed PV



PV home system

PV + animal husbandry

PV + forestry

PV + fishery

Application of distributed PV in the field of transportation

Distributed PV applications in industrial and commercial

Solar Empowers Family

Solar Battery

1.Lighting

2.Reading lamp

3.TV

4.Phone

5. Radio

6. Fan

7. Anti-mosquito lamp

Basic Model

8. Computer

9. Refrigerator

10. Electric bicycles

11. Motorcycles

12. Cooking

Upgraded Model

	Lighting	Reading Lamp	TV	Phone	Radio	Fan	Anti-mosquito Lamp	Total
Capacity	2.5 W	5 W	12 W	10 W	5 W	10 W	5 W	
Number	3	1	1	2	1	1	2	
Duration	6h	4h	6h	2.5h	6h	6h	6h	
Total (Wh/d)	45	20	72	50	30	60	60	337

Basic Model: 337 Wh/day

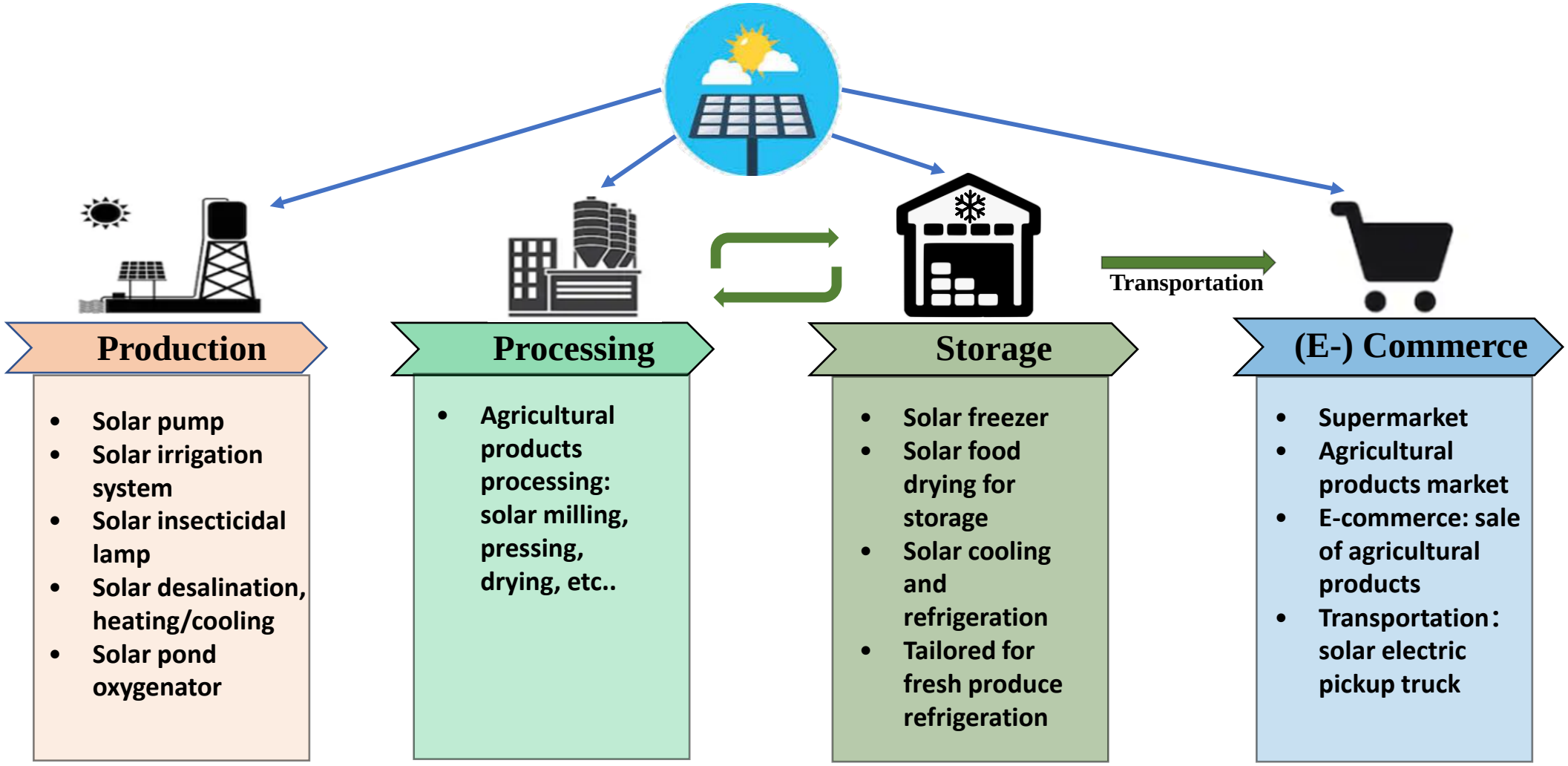
Two solar panels can support a family's daily life !

	Computer	Refrigerator	E-bicycle	Motorcycle	Basic Model	Total
Capacity	60W	300	250W	300W		
Number	1	1	1	1		
Duration	5h		1h	1h		
Total (Wh/d)	300	300	250	300	337	1187-1237

Upgraded Model: 1187-1237 Wh/day

Eight solar panels guarantee a family's modern life!

Solar Power Agricultural Facilities and Extended Value Chain



Source： Author and Shutterstock

- ❖ The use of solar energy in agricultural production, agricultural product processing and storage has extended the agricultural value chain.
- ❖ The e-commerce of agricultural products further extends the value chain which goes beyond space constraint.

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Conclusion and recommendations

Main conclusions

Forecast in this report

This report forecasts that the 141 BRI countries in 2030 will:

Rooftop distributed PV in built-up areas

- newly install capacity of 150~334GW, increasing the total distributed PV capacity to 162~346GW on the basis of the existing 12GW
- transform the developed countries, Southeast Asia and sub-Saharan Africa into important rooftop distributed PV market, with the acceleration of urbanization and the maturity of renewable energy conditions

Distributed PV are used to electrify areas without electricity

- increase the installed capacity to 6.4~14GW
- The installed capacity mainly reflects the distribution of electricity demand among people without electricity, with sub-Saharan Africa being the main market

Accumulated investment

- The cost of PV system is expected to decrease further, and the accumulated investment amount is still 306.6-681.4 billion dollars to achieve the above forecasted installed capacity

Typical countries

Assessment of Ethiopia's distributed PV potential in 2030:

	Forecast of distributed PV potential in 2030	Basic Scenario GW	Positive Scenario GW
Ethiopia	Installed capacity of rooftop PV in built-up areas	0.56	1.39
	Installed capacity of PV electrification in areas without electricity	0.460	1.012

Assessment of Indonesia's distributed PV potential in 2030:

	Forecast of distributed PV potential in 2030	Basic Scenario GW	Positive Scenario GW
Indonesia	Installed capacity of rooftop PV in built-up areas	9.7	23.5
	Installed capacity of PV electrification in areas without electricity	0.023	0.050

Recommendations

Incorporate distributed photovoltaic into the energy planning of BRI countries, formulate progressive development goals, and issue supporting policies.

It is recommended that the host country put forward a distributed photovoltaic project development model and economic, social and environmental benefit analysis in line with its national conditions on the basis of in-depth research, so as to promote the project while helping the host country to build capacity.

Strengthen information communication among stakeholders, explore integrated solutions, reduce transaction costs, and leverage private sector investment with de-risking tools for public and multilateral funds.

Make the best of the resources and advantages of institutions in the identification, incubation and assistance investment of distributed photovoltaic projects, connect with the demand for power in BRI countries, explore multi-party cooperation models, and jointly participate in the development, construction and operation of distributed photovoltaic projects in areas without electricity.

Strengthen the practice sharing of China's promotion of distributed photovoltaics in terms of policies, technologies and business models, so that China's experience can contribute to the green energy transformation of BRI countries.

Thanks for Attention