SOLAR POWER GENERATION WORLDWIDE

INDUSTRY ANALYSIS AND FORECAST

MAY 2023

INTRODUCTION

Solar power continues to see substantial year-over-year growth. The Compound Annual Growth Rate (CAGR) of photovoltaic (PV) installations was 32% between 2010 and 2022.

China dominates every stage of the solar panel industry accounting for almost 80% of all Polysilicon manufacturing and 75% of solar (PV) modules.

China also leads in both capacity additions and generation throughout the forecast period. The US is a distant 2nd.

The cost of solar PV has fallen by about 90% over the last 10 years and is expected to continue to decline. The cost of battery packs dropped from over $700 USD/kWh in 2013 to about $150 today. Incorrys expects prices to continue falling and approach $100 USD/kWh by 2026.

Incorrys forecasts global solar capacity to more than triple between 2022-2030 from 1190 GW to 3800 GW with solar power generation increasing from 1250 TWh to 7200 TWh over the same period.

Solar power intermittency remains the largest hurdle, with load factors averaging about 25%.

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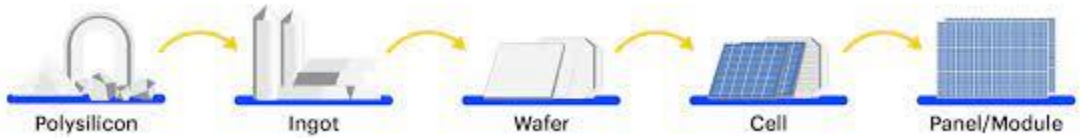
PV TECHNOLOGIES AND SOLAR PANEL SUPPLY CHAIN

Photovoltaics (PV) is the conversion of light into electricity.

Two technologies currently dominate global solar PV markets and supply chains: crystalline silicon (c-Si) modules account for over 95% while cadmium telluride (CdTe) thin-film PV technology makes up the remaining 5%.

Polysilicon is a key material for c-Si technology and currently the bottleneck for the industry.

Main steps in the process of making solar panels:

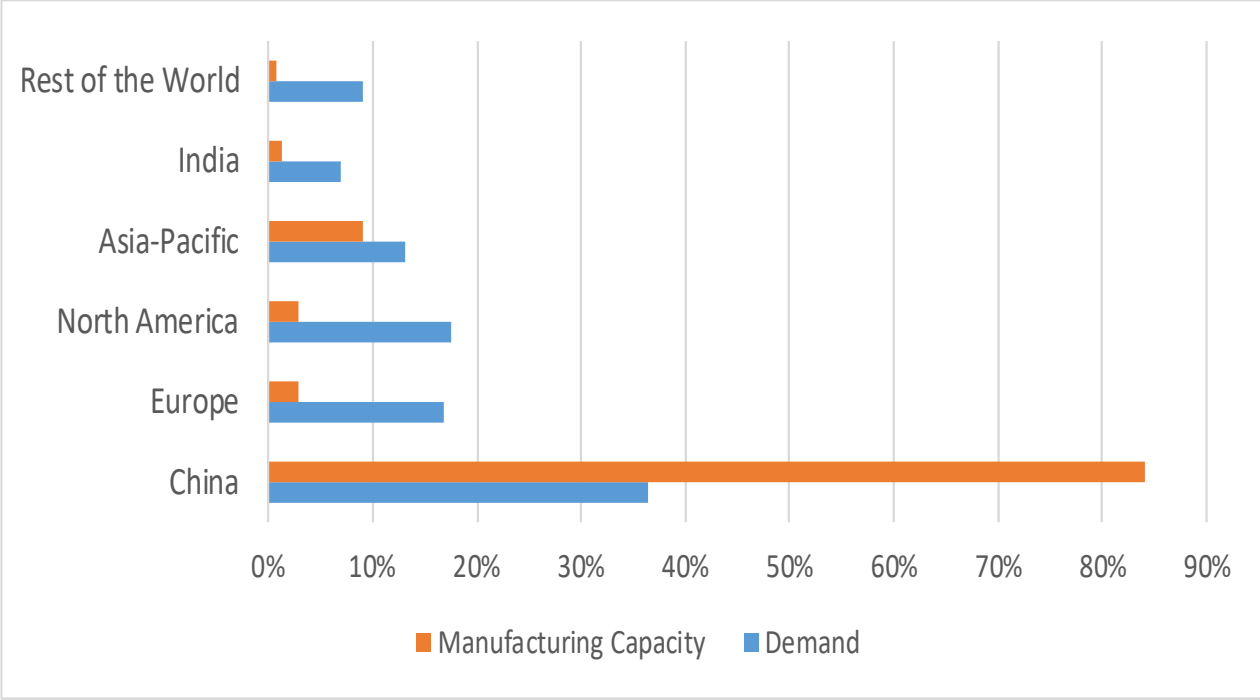


China accounts for almost 80% of all Polysilicon manufacturing and 75% of solar photovoltaic modules.

India ranks second with just 3% of solar module manufacturing and 1% of cell manufacturing although their PV module manufacturing capacity more than doubled from 18 GW in 2022 to 38 GW in 2023.

When comparing manufacturing capacity to demand, there is a clear imbalance on a country-by-country basis.

China has considerably more capacity than it requires while the reverse is true for most other countries.



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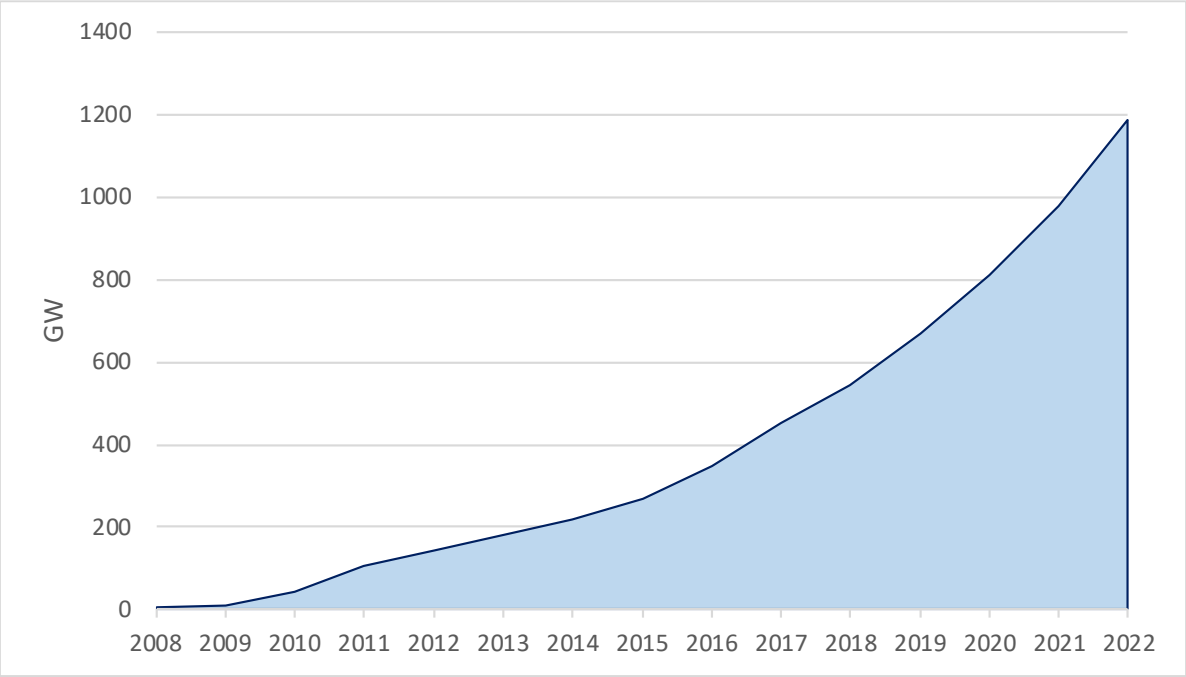
SOLAR POWER GENERATION CAPACITY



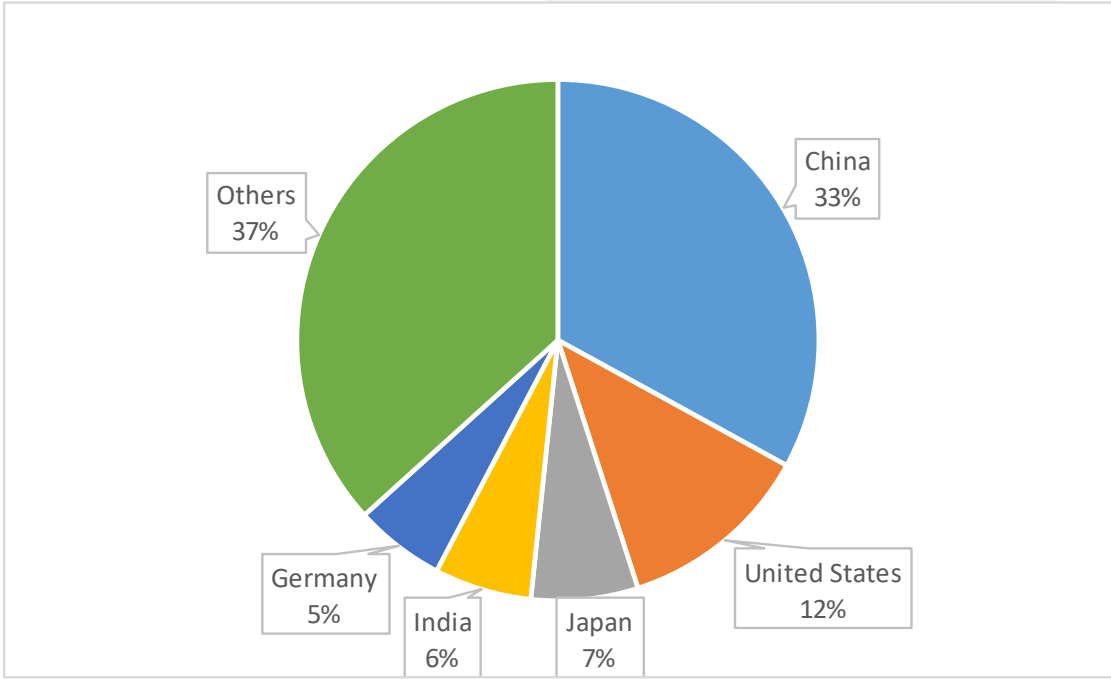
Capacity has been increasing year-over-year from just 6 GW in 2008 to almost 1200 GW in 2022 with about 70% being installed over the last 6 years and a 20% growth rate over the past 2 years.

In 2021 and 2022 total global grid-connected capacities were about 168 GW and 212 GW, respectively.

In 2022, of the 1200 GW of global capacity, China accounted for 33% (almost 400 GW) while the US represented about 12% (about 150 GW).

Rounding out the top 5 are: Japan (7% / 80 GW), India (6% / 70 GW) and Germany (5% / 65 GW).

The rest of the world combined accounted for 37% (440 GW).



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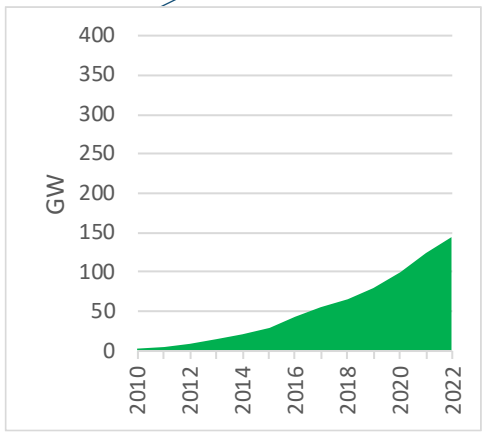
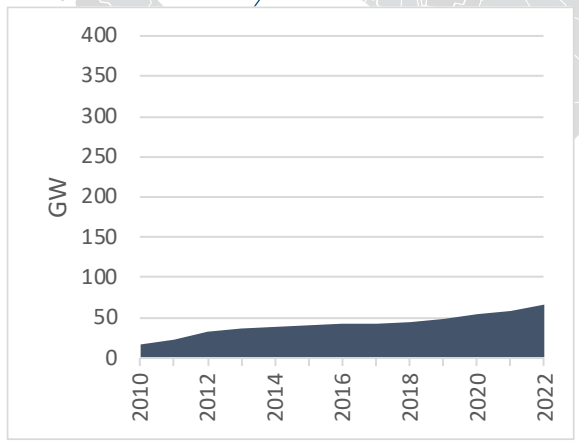
CUMULATIVE PV CAPACITY BY COUNTRY (GW) 2010-2022

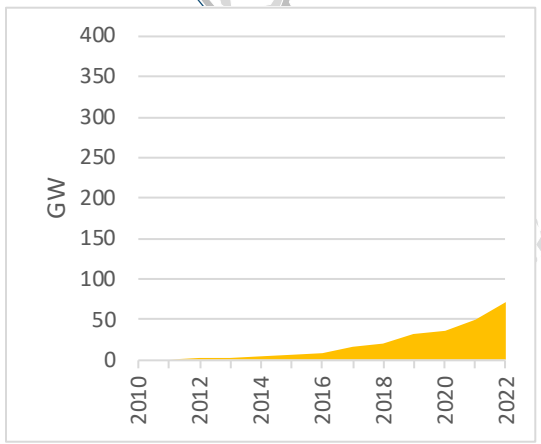
US



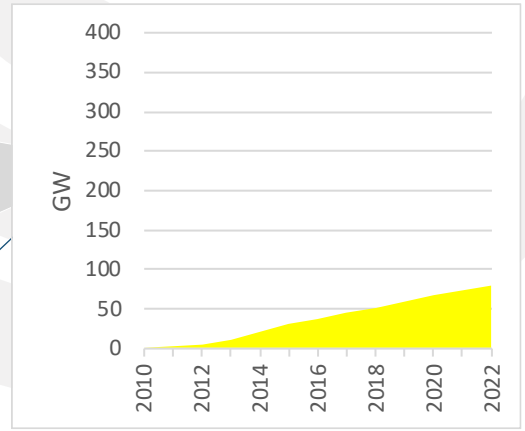
GERMANY



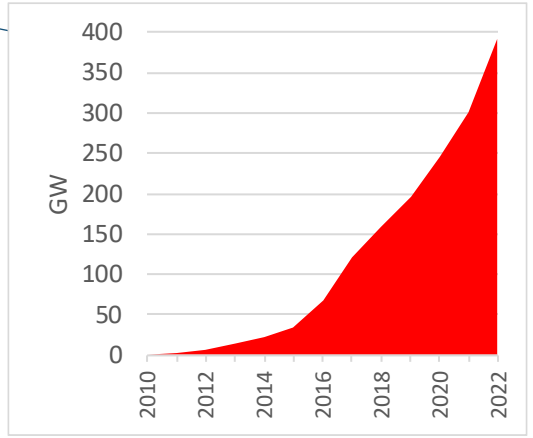
INDIA



JAPAN

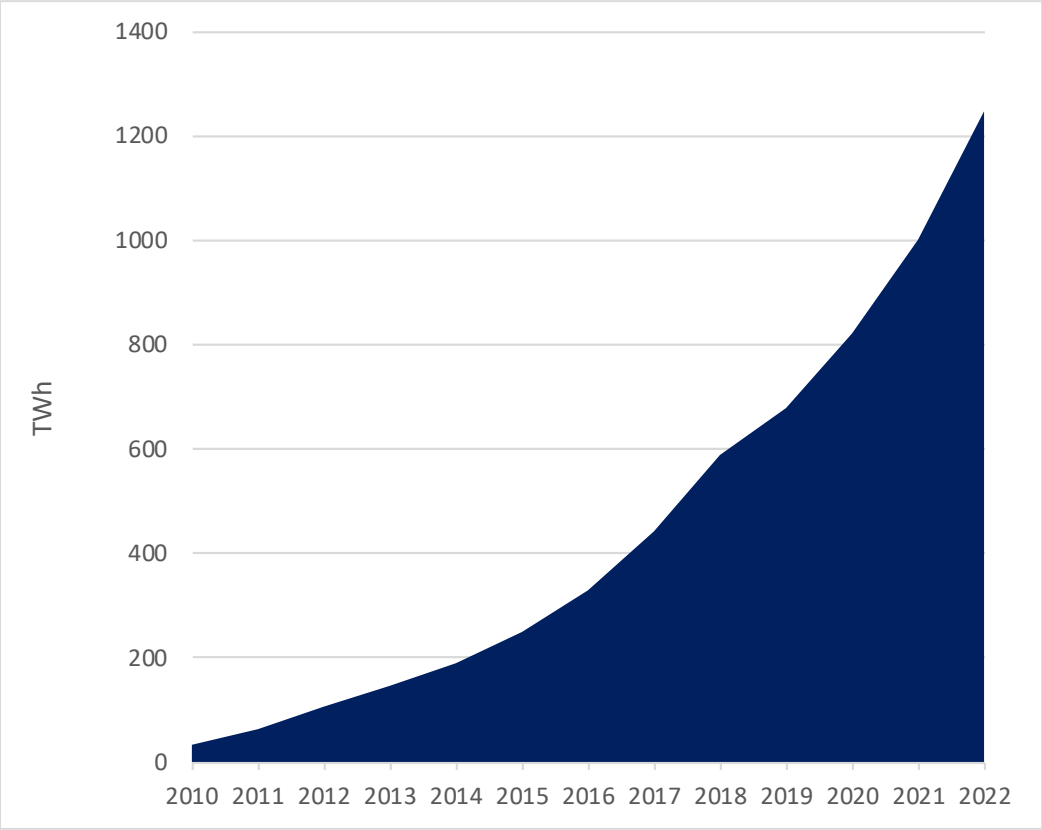


CHINA



All regions have shown significant year-over-year capacity growth rates; except for Germany.

SOLAR POWER GENERATION



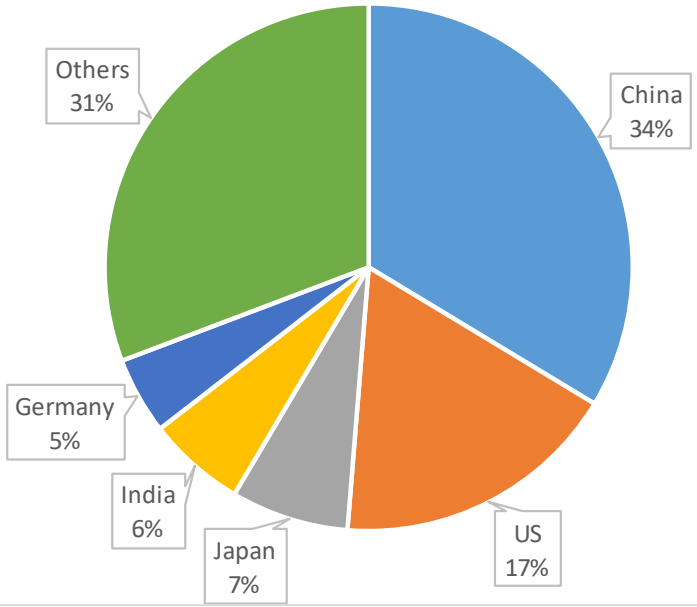
Global solar generation increased from just 32 TWh in 2010 to 1250 TWh in 2022.

Solar generation has grown over 20% annually since 2020 increasing from 180 TWh to 245 TWh.

In 2022, of the 1250 TWh of global solar generation, China accounted for 34% (almost 420 TWh) while the US represented about 17% (about 220 TWh).

Rounding out the top 5 are: Japan (7% / 90 TWh), India (6% / 75 TWh) and Germany (5% / 60 TWh).

The rest of the world combined accounted for 31% (380 TWh).



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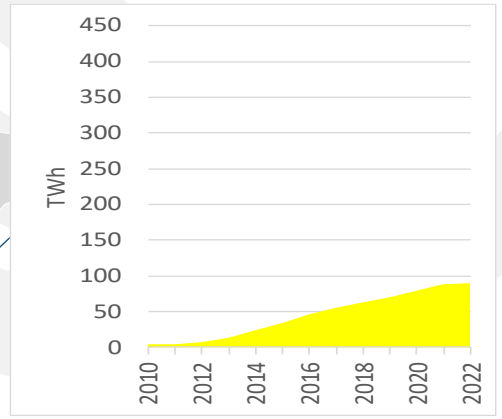
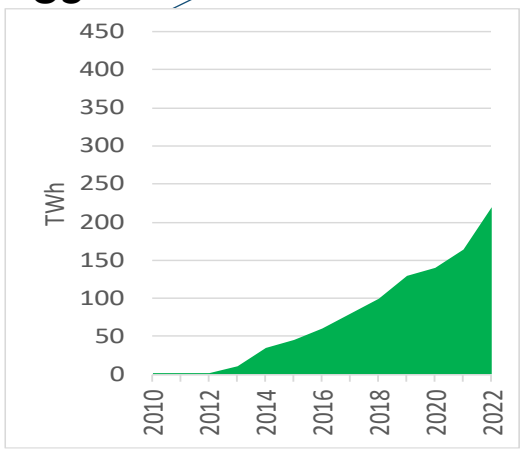
SOLAR POWER GENERATION BY COUNTRY (TWH) 2010-2022

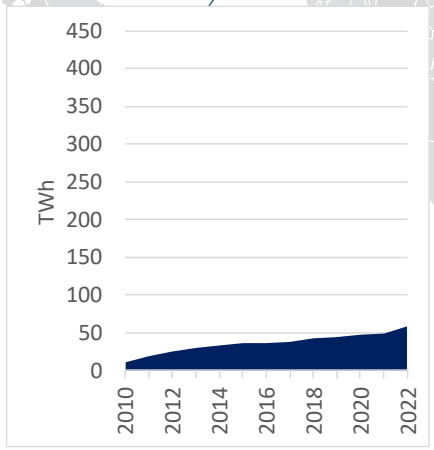
JAPAN



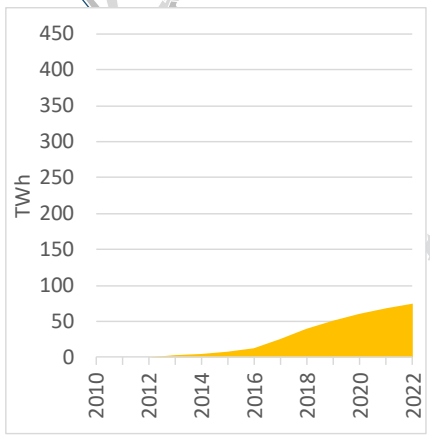
US



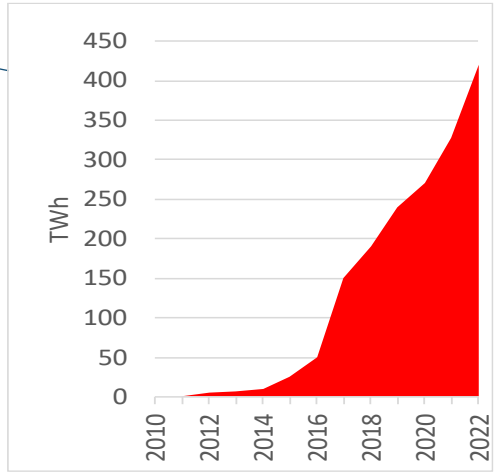
GERMANY



INDIA



CHINA



All regions have shown significant year-over-year generation growth rates, except for Germany.

LARGEST SOLAR PROJECTS 2022

Six large solar energy construction projects began in 2022, two of which are in India.

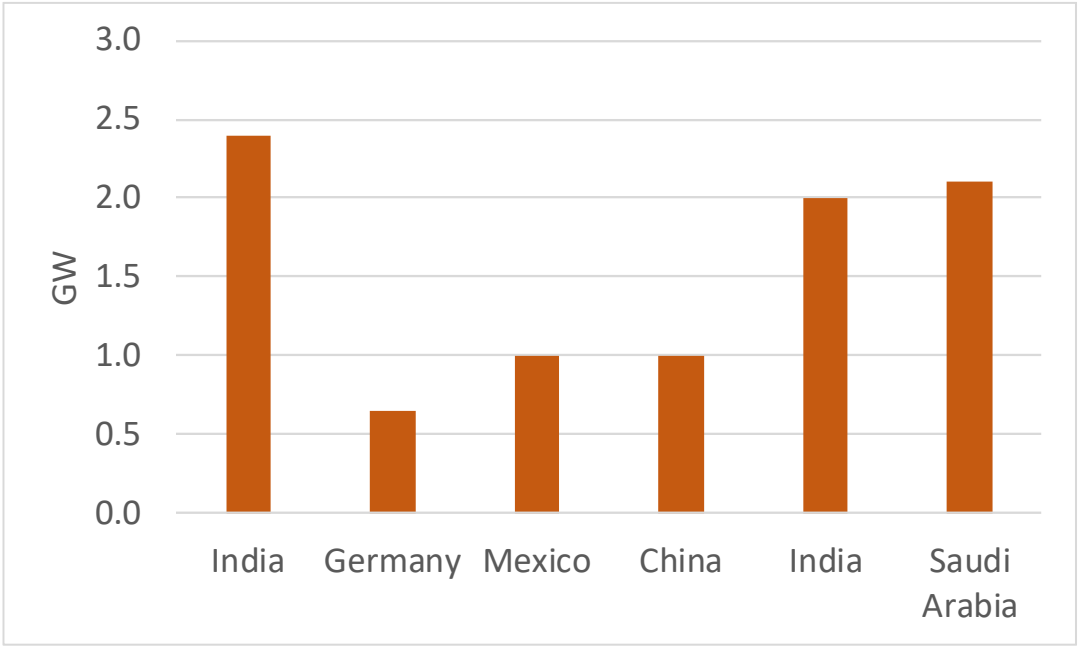
India recently announced plans to add 250 GW of renewable capacity over the next five years to meet its target of 500 GW of clean energy by 2030.

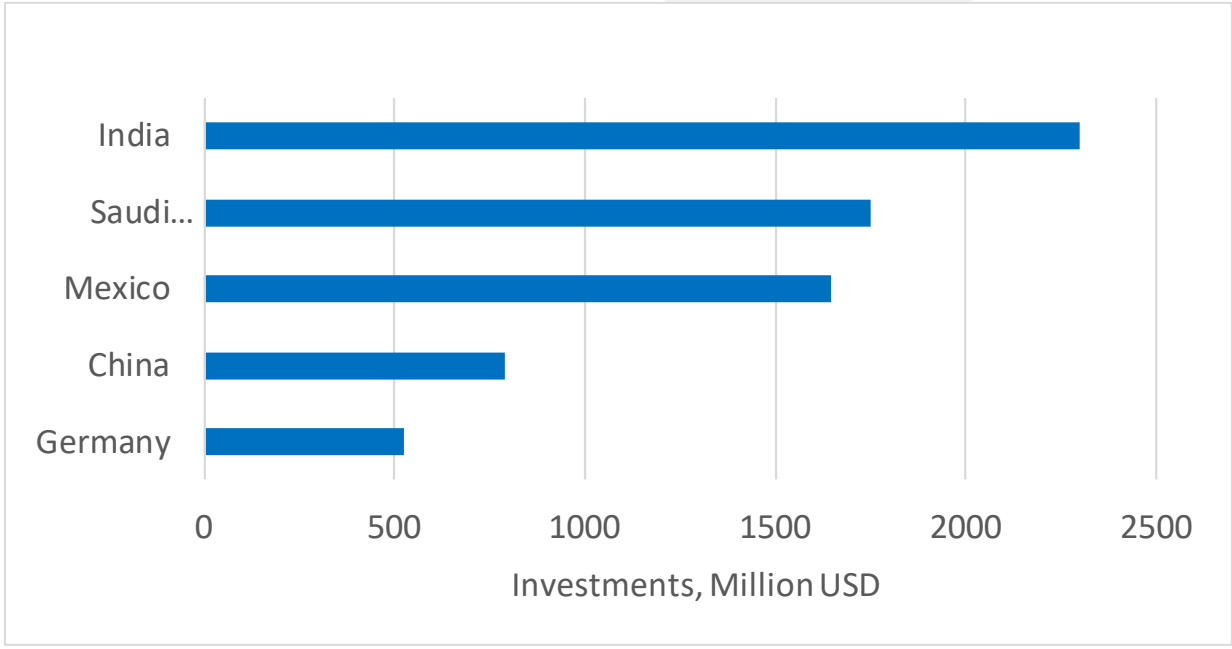
Saudi Arabia is also making big investments in solar power with plans to build the world's largest single-site solar power plant in Mecca province. The facility is expected to start operations by end of 2025, with a capacity of 2060 MW.

The total investment in these six large solar projects is USD $7 billion.

India represents one third of the total, investing USD $2.3 billion.

Combined, Saudi Arabia and Mexico account for half of the total at about USD $1.7 billion.





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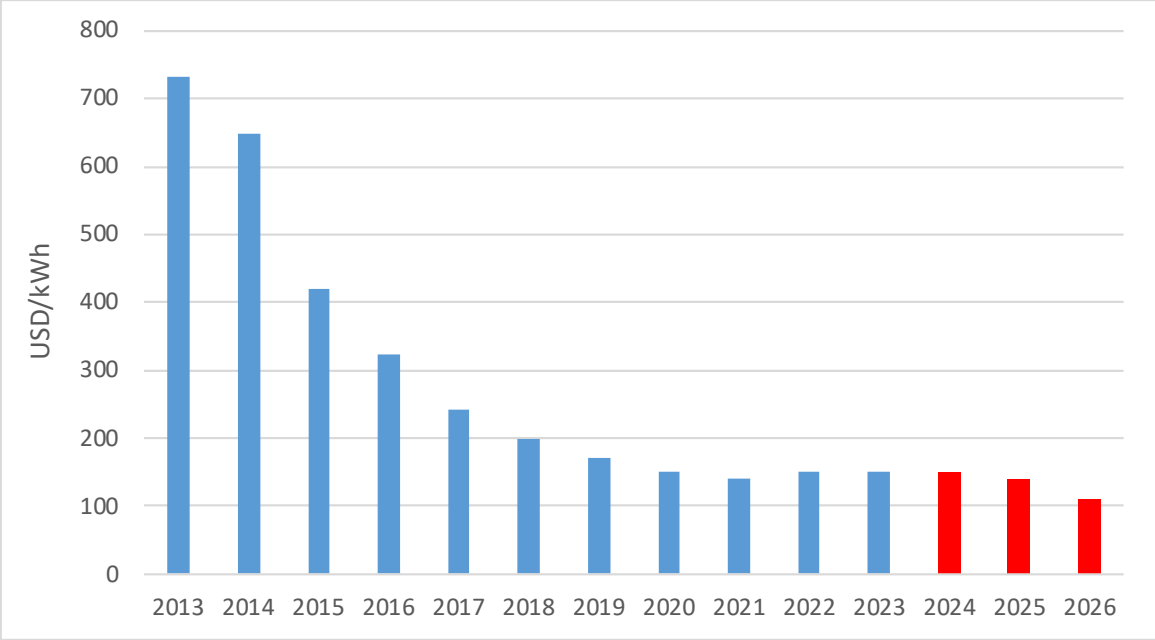
LITHIUM-ION BATTERY PRICE DYNAMICS AND FORECAST



Source: Bloomberg NEF and Incorrys Analysis

Lithium-ion batteries are used for energy storage, including solar energy.

While lead-acid batteries dominated the market for many years, the use of lithium-ion and lithium iron phosphate (LiFePO4) batteries is increasing in solar-plus-storage commercial applications. This is mainly due to their:

- high energy density
- low maintenance
- stability under high temperatures
- high efficiency
- longer lifespan
- declining prices

Average lithium-ion battery pack prices have been declining rapidly; down from over $700 USD/kWh in 2013 to just $140 in 2021. However, rising raw material and battery component prices, coupled with soaring inflation, led to the first ever year-over-year increase in lithium-ion battery pack prices in 2022, up 7% to about $150.

On a regional basis, battery pack prices were cheapest in China at $127 USD/kWh, while in the US and Europe prices were about 24% ($157) and 33% ($169) higher, respectively. Although prices for key battery metals like lithium, nickel and cobalt have moderated in recent months, Incorrys expects 2023 prices to remain relatively unchanged.

Global Lithium-ion Battery Capacity

Cumulative capacity of top 15 battery manufacturers reached 600 GWh in 2021 and 700 GWh in 2022 with a further 3000 GWh of capacity under construction or in the planning stage with many expected to be in operation by 2025. This leads to more extraction and refining capacity which, in turn, will ease lithium prices. Incorrys expects battery prices to begin declining again in 2025 and forecasts average battery prices to drop below $110/kWh by 2026.

Global cumulative lithium-ion battery capacity could reach 5500 GWh by 2030; Incorrys expects battery pack prices to continue to fall through 2030 and could drop well below $100/kWh.

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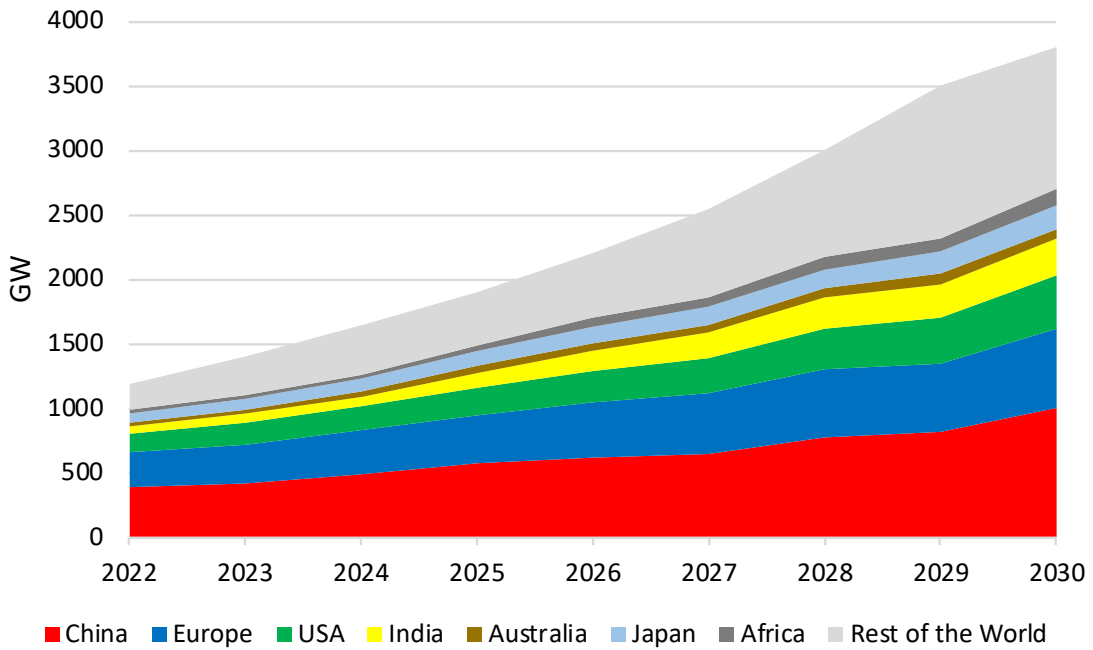
SOLAR POWER CAPACITY FORECAST 2022-2030



Incorrys expects solar capacity to more than triple from about 1200 GW in 2022 to 3800 GW in 2030.

China accounts for the most capacity in all years increasing from 400 GW in 2022 to 1000 GW in 2030.

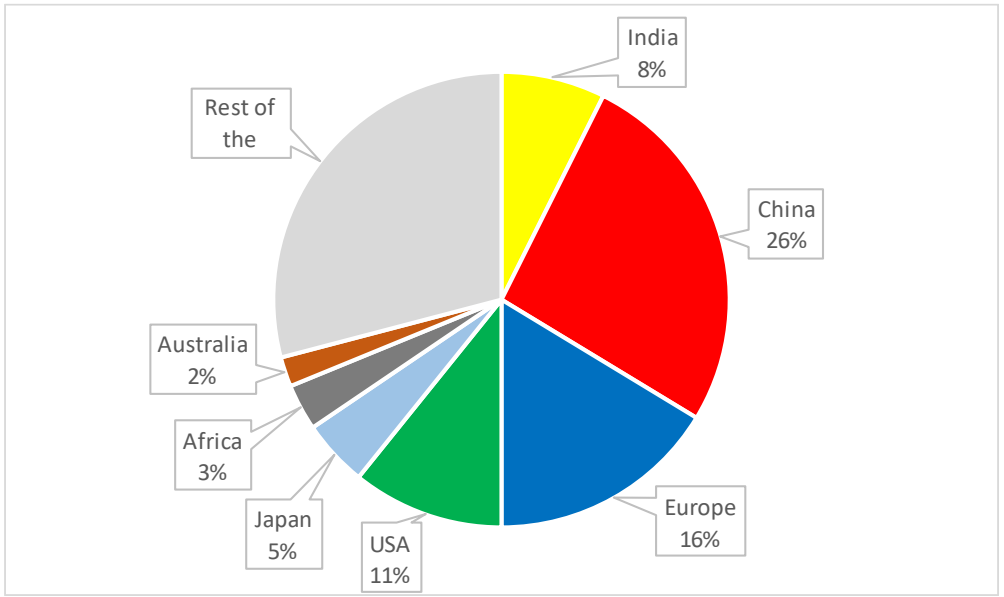
Europe ranks second increasing from 260 GW to 620 GW over the same time period and the US third (140 GW to 410 GW).

In 2030, China maintains the largest market share of solar capacity, although it does decline from 32% in 2022 to 26% in 2030. Both Europe and the US also see their market share drop over the forecast period. The remainder of the countries shown here remain about the same.

Offsetting these declines in market share is the many countries and regions making up the rest of the world which increases its market share from 18% in 20212 to 29% in 2030.

Each countries trade policies will be a large factor going forward. Since China is the dominant supplier of PV components, if countries were to limit imports and favor domestically produced PV products, China would be forced to scale back their PV production.

2030 Capacity Market Share



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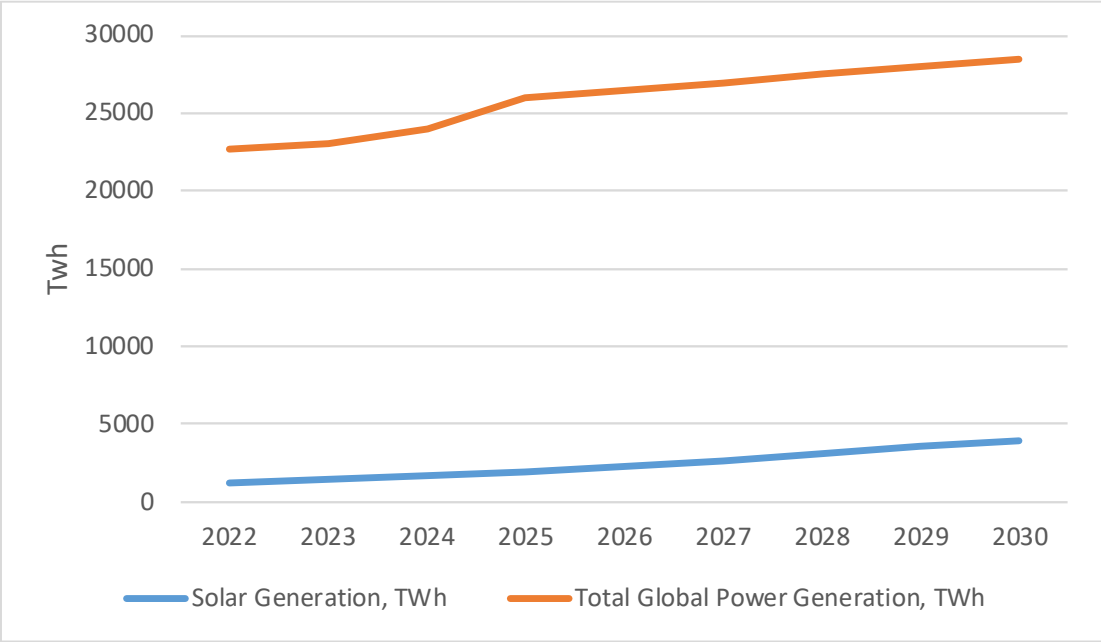
SOLAR POWER GENERATION FORECAST 2022-2030



• Global electricity demand declined slightly in 2021 due to the Covid pandemic and has rebounded slowly into 2023. The growth is expected to accelerate going forward and will be met more by renewables, including solar. Total global generation reaches 28500 TWh in 2030 – up 24% from 2023.

• China will account for a third of global electricity demand in 2030 and, combined with strong growth in other parts of Asia, this region will make up more than half of global electricity demand. Europe and North America will also grow steadily although their share of demand will decline as Asia's expands.

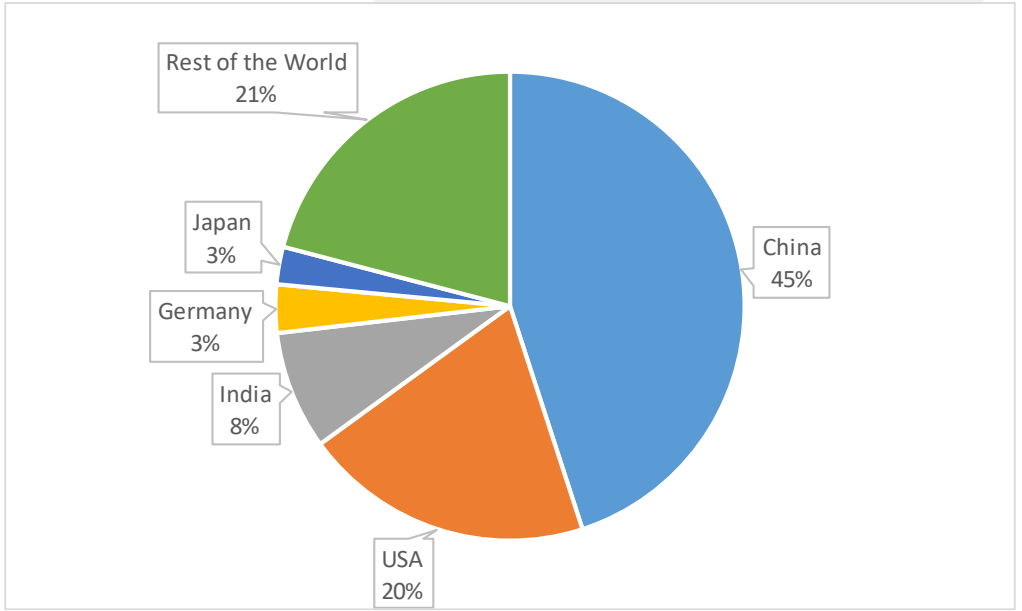
• Incorrys forecasts solar generation to more than triple from 1250 TWh in 2022 to 3900 TWh in 2030 and will represent 14% of global electric generation.

•Incorrys expects China to maintain its top position in solar power generation in 2030 reaching 3200 TWh. This will see China's market share increase to 45%.

• The US 2030 market share is also expected to increase slightly to 20%, 2nd highest. India, at 8%, surpasses Japan and claims 3rd in 2030, potentially reaching 10%.

• Germany and Japan could see a decrease in market share below 5% (Incorrys is forecasting just 3%).

2030 Solar Generation Market Share



Solar Generation Methodology: Solar capacity (based on announced projects) coupled with the global 3-year average load factor.

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WHY INCORRYS INFORMATION SYSTEM

COMPREHENSIVE DATA

Incorrys constantly collects huge amounts of data from multiple sources world-wide

ADVANCED ANALYTICS

Incorrys performs data analysis to ensure quality and consistency among different industries and jurisdictions

ACCURATE FORECASTS

Incorrys employs proprietary forecasting methodologies to ensure accurate forecasts of trends in different industries.

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