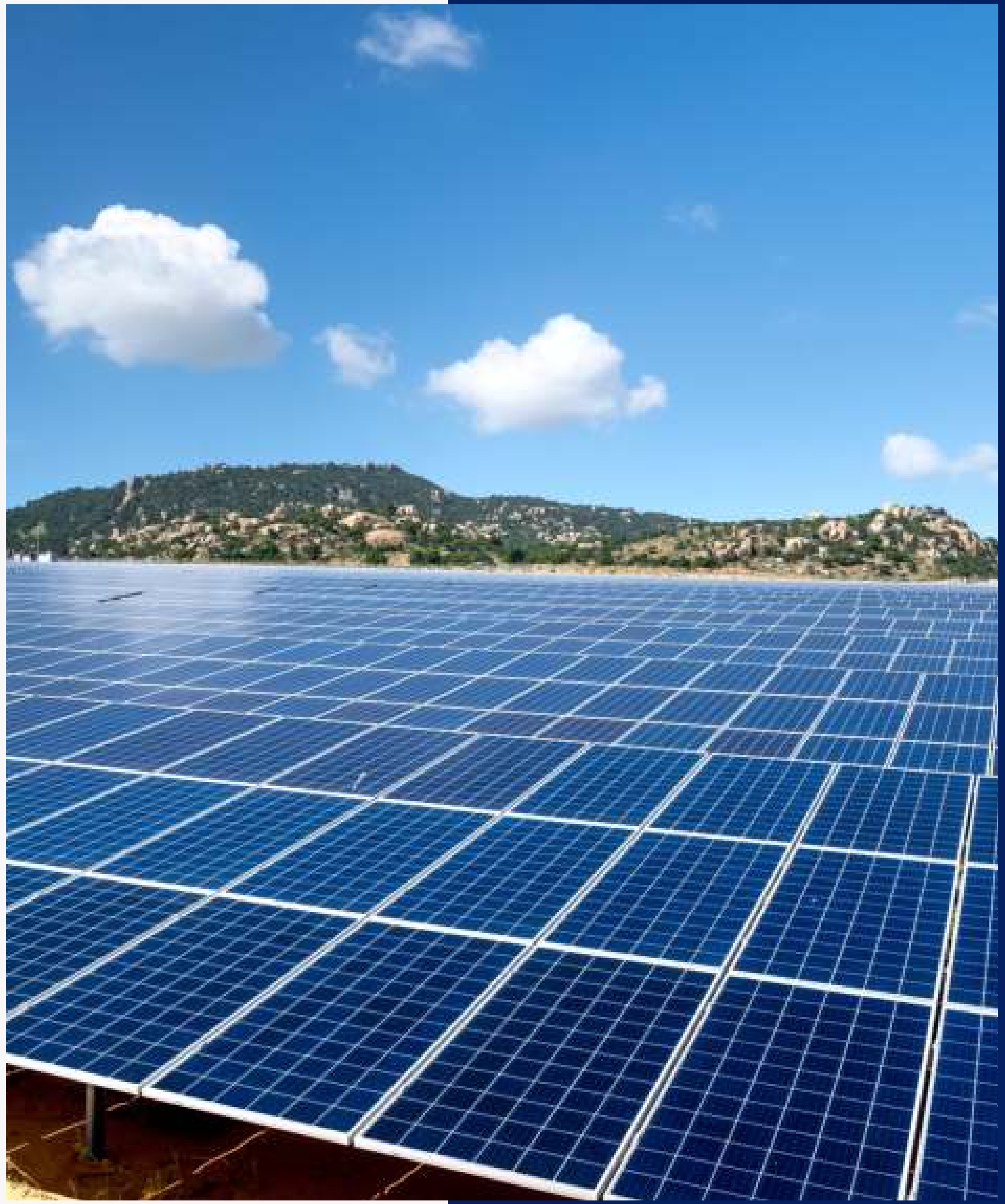
SOLAR ENERGY FOR A BRIGHTER FUTURE

Clean. Affordable. Sustainable. Powering tomorrow with today's sunlight.



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PLAN

SOLAR ENERGY :

GENERAL OVERVIEW

- **Definition:**

Solar energy is the energy derived from sunlight and converted into electricity or heat

- The Earth receives **10,000 times more solar energy** than humanity consumes daily.

- **Three main technologies:**

- Clean, renewable, and adaptable to both small-scale and large-scale applications.

Photovoltaic (PV)

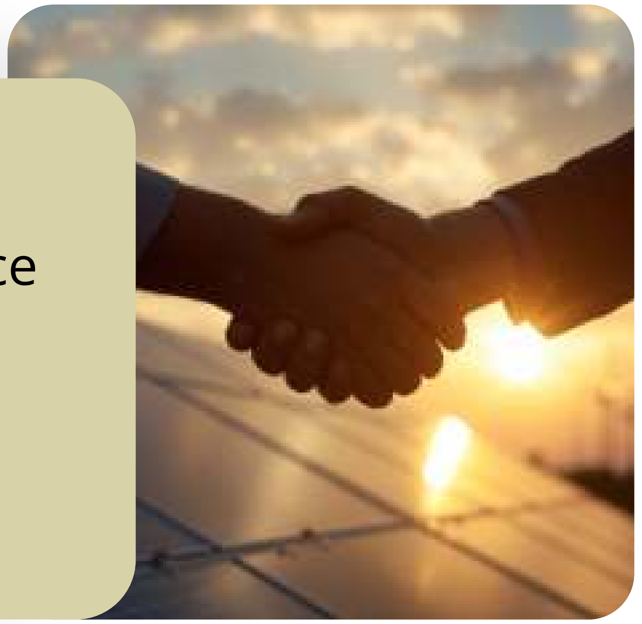
- Uses sunlight to directly generate electricity through semiconductor cells.
- Ideal for rooftops, homes, and decentralized systems.
- Low maintenance and fast installation.

Solar Thermal

- Uses sunlight to produce heat, usually for water heating, buildings, or industrial processes.
- Efficient for heating needs and cost-effective on a small scale.

Concentrated Solar Power (CSP)

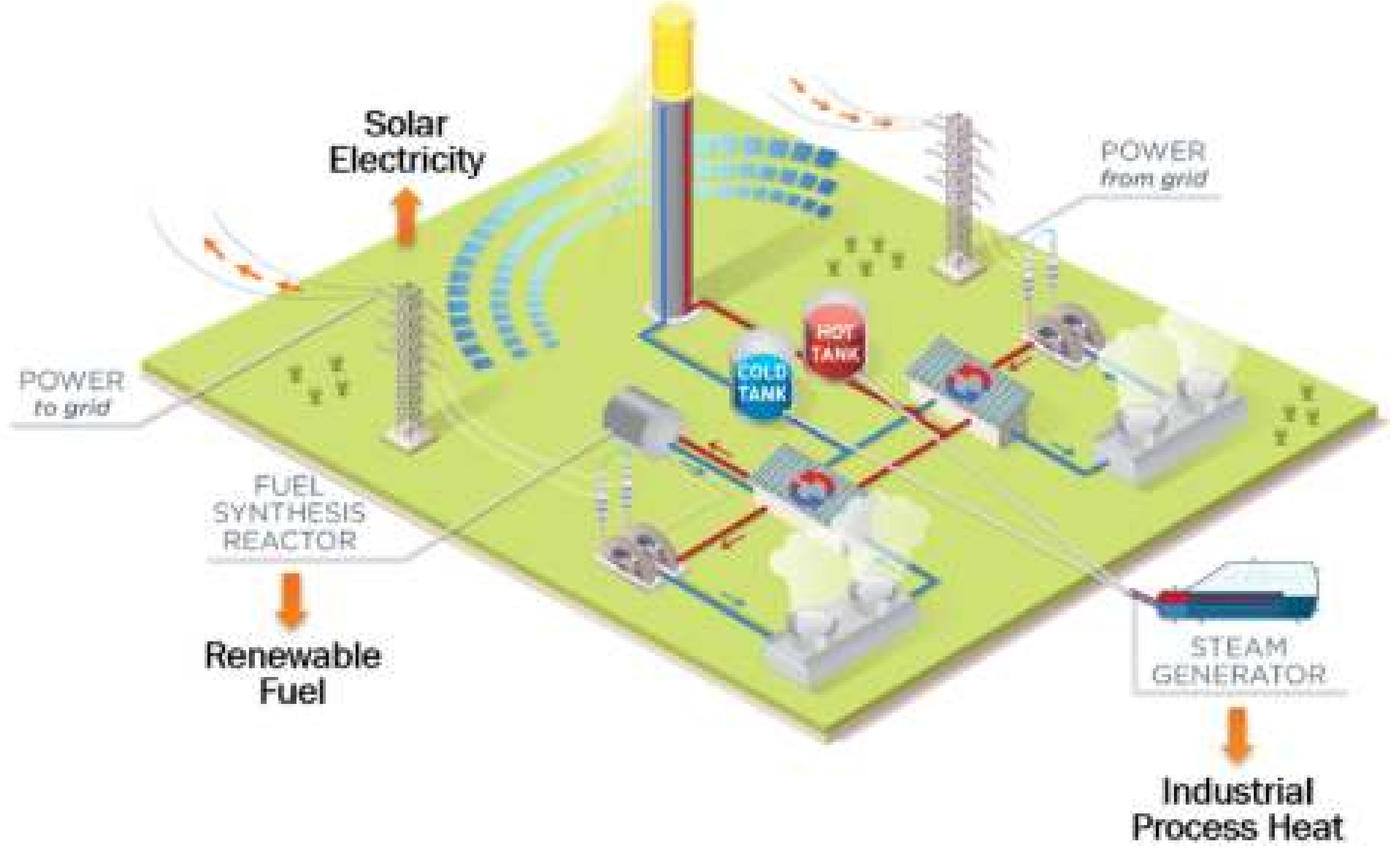
- UUses mirrors to concentrate sunlight and produce high-temperature heat.
- Generates electricity using steam turbines and includes thermal storage for night operation.
- Suitable for large-scale power plants.



Comparative Table: PV vs Solar Thermal vs CSP

Criteria	Photovoltaic (PV)	Solar Thermal	Concentrated Solar Power (CSP)
Main Output	Electricity	Heat (hot water / heating)	Electricity + high-temperature heat
How it Works	Converts sunlight into electricity using semiconductor cells	Converts sunlight into electricity using semiconductor cells	Uses mirrors to concentrate sunlight and generate steam
Best For	Homes, rooftops, small to medium installations	Domestic water heating, industrial heat	Utility-scale power plants in sunny regions
Storage	Needs batteries for storage	Water tanks (simple and low-cost)	Thermal storage in molten salts (long duration)
Cost	Low and decreasing	Very low	High initial cost
Efficiency	Moderate (15–22%)	High for heating (60–80%)	High when combined with thermal storage
Operation at Night	No (unless batteries)	Limited (if tank is hot)	Yes, thanks to thermal storage
Advantages	Cheap, modular, low maintenance	Very efficient for heat production, cheap	Provides stable electricity, works day & night
Disadvantages	Intermittent, needs storage	Only produces heat	Expensive, needs a lot of land
Best Choice When?	You need electricity	You need heat	You need large-scale, dispatchable electricity

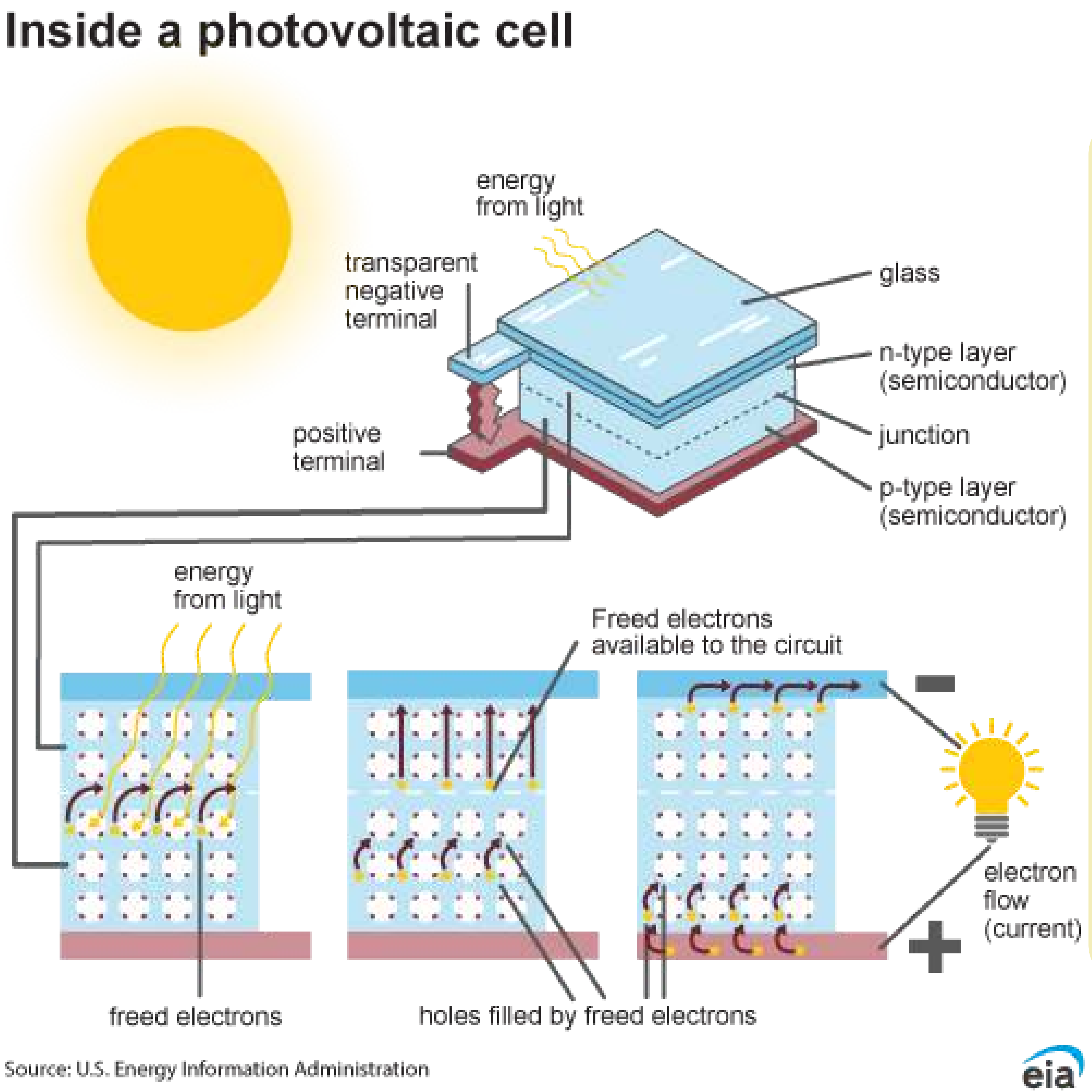
Solar Thermal: Concentrated Solar Power (CSP)



"CSP tower plant with thermal storage producing electricity, industrial heat, and renewable fuel."

- **Uses thousands of mirrors (heliostats) to concentrate sunlight onto a central tower.**
- **The receiver heats a working fluid (often molten salts).**
- **Heat is stored in hot and cold tanks to ensure continuous operation, even without sunlight.**
- **The stored heat generates steam → drives a turbine → produces solar electricity.**
- **Excess thermal energy can supply industrial process heat.**
- **Some CSP systems can also power a fuel synthesis reactor to produce renewable fuels.**
- **Electricity can be sent to the grid or used on-site.**

How a Photovoltaic Cell Generates Electricity



- **Sunlight hits the solar cell and transfers energy to electrons in the semiconductor.**
- **The cell is made of two layers:**

1. **N-type (extra electrons)**
2. **P-type (missing electrons / "holes")**

- **The junction between these layers creates an electric field.**
- **Light frees electrons → they move toward the N-type layer, leaving holes in the P-type layer.**
- **The electric field forces electrons to move in one direction → this creates current.**
- **When the cell is connected to a circuit, electrons flow and power a device (lamp, battery, etc.).**

Jinko Solar: Company Overview

Jinko Solar is a globally recognized leader in the solar photovoltaic (PV) industry. The company is renowned for its vertical integration, covering the entire solar industry value chain from silicon wafers to complete solar power solutions.

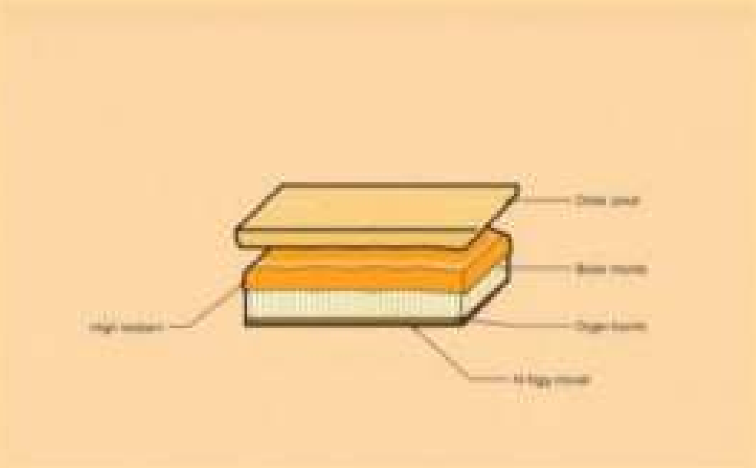
Global Leadership

- One of the world's largest solar module manufacturers by shipments.
- Extensive global sales and marketing network across Europe, Asia, North America, and more.
- Known for high-efficiency solar cells and modules, driving innovation in the sector.

Core Business

- Research and development of PV technologies.
- Manufacturing of mono and multi-crystalline PV panels.
- Development of commercial and utility-scale solar power projects.

Factors Influencing Installation Costs



Technological Advancements

Innovations in cell efficiency mean more power can be generated per panel, reducing the number of modules and land area needed.

Economies of Scale

As the world's largest manufacturer, China benefits from massive production volumes, which significantly lowers the per-unit cost of solar panels and components.

Government Policies & & Subsidies

Initial government feed-in tariffs and tax incentives spurred rapid growth. While direct subsidies have decreased, policy support for renewable energy targets remains strong.

Supply Chain Efficiency Efficiency

A highly developed domestic supply chain for raw materials like polysilicon, glass, and aluminum reduces transportation costs and logistical complexities.

Financial Metric	Value (Illustrative)	Description
Project Size	100 MW	Utility-scale solar farm
Modules Used	Jinko Solar Tiger Neo	High-efficiency N-type modules
Project ROI (25-year lifespan)	~15-20%	The total return on investment over the project's
Initial Investment (CAPEX)	$40 Million USD	Includes panels, land, construction, and grid co
Annual Revenue	$5.5 Million USD	From selling electricity via a Power Purchase Ag (PPA).
Annual OPEX	$0.5 Million USD	Covers maintenance, insurance, and administra costs.
Annual Gross Profit	$5.0 Million USD	Revenue minus operating expenses.
Payback Period	~8 Years	The time required to recoup the initial investme

Economic Benefits of Solar Energy

Beyond environmental advantages, the widespread adoption of solar energy brings substantial economic rewards to a nation's economy.

Energy Independence

Reduces reliance on imported fossil fuels, leading to improved national energy security and less exposure to volatile global energy prices.

Job Creation

Creates a wide range of jobs in manufacturing, R&D, project development, installation, and long-term operations and maintenance.

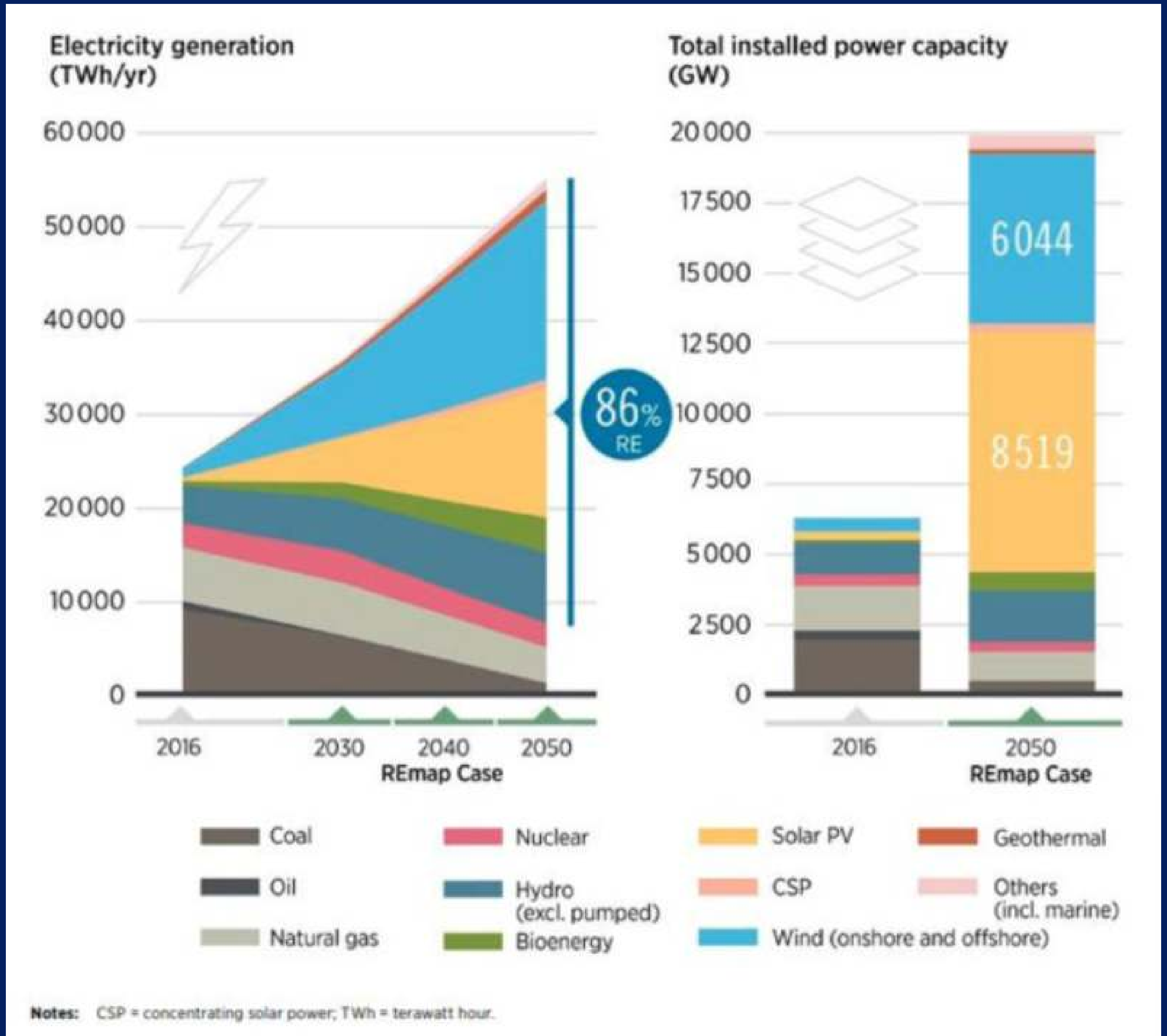
Lower Energy Costs

Solar power is now one of the cheapest sources of new electricity generation, lowering utility costs for industries and residential consumers.

ENERGY TRANSITION: Solar Energy

The global energy transition represents a fundamental shift toward renewable and sustainable energy sources. Solar energy stands at the forefront of this transformation, offering a clean, abundant, and increasingly cost-effective alternative to fossil fuels.

Goal: Combat climate change by reducing GHGs emissions and ensuring it by diversifying the energy mix.



Why to opte now for solar energy?

Solar + Storage = Energy Security

Adding a battery ensures uninterrupted power during blackouts.aragraph text

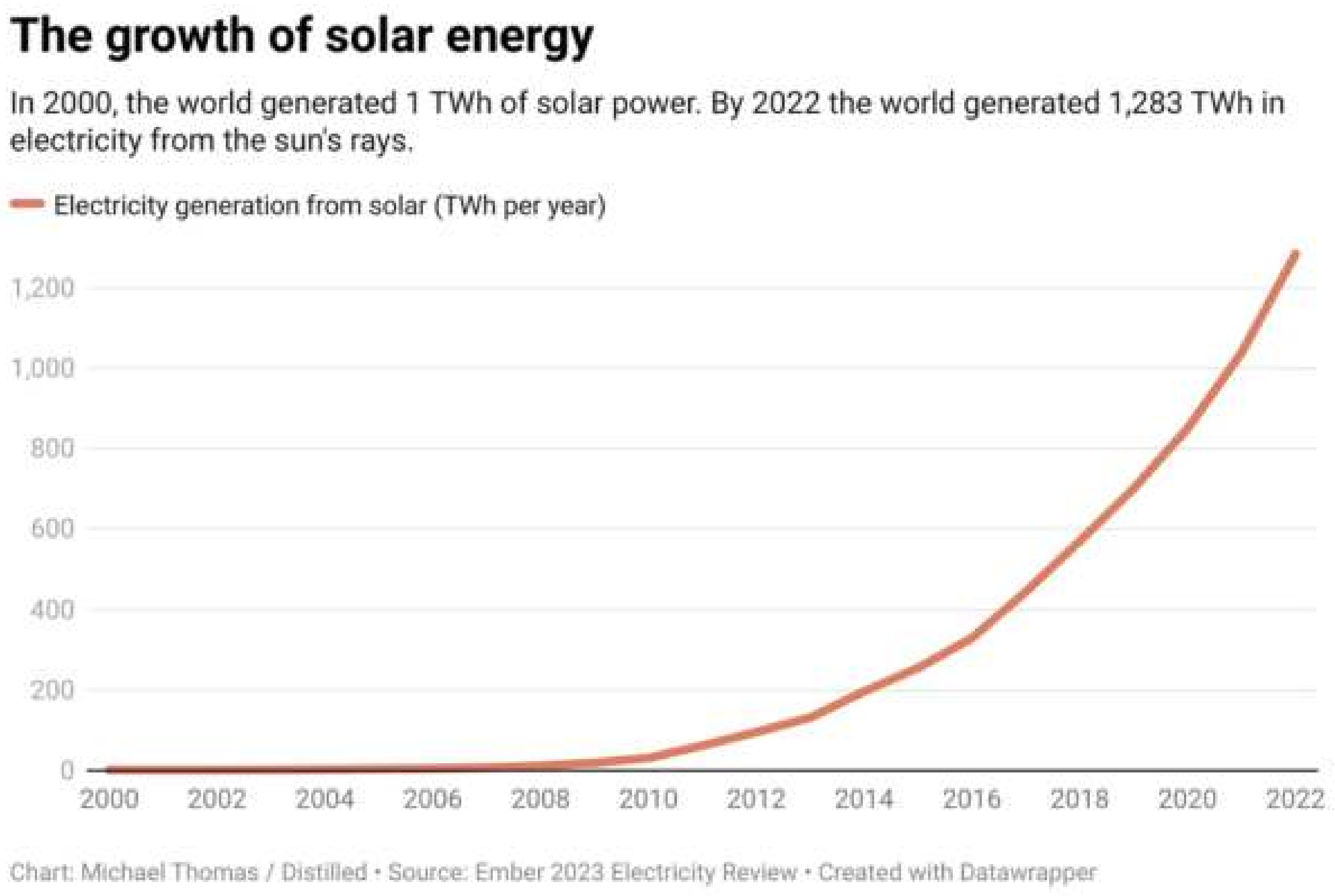
Direct Environmental Impact

- Every 1 kW of solar installed offsets about 1.5 tons of CO_2 per year.
- A 5 kW system offsets the equivalent of planting ~200 trees annually.
- Reduces strain on fossil-fuel-based grids and helps meet national climate targets

Recycling & Circular Economy Growth

- End-of-life solar recycling infrastructure is now expanding globally.
- 95% of a solar panel’s materials (glass, aluminum, silicon) are recyclable — making it a sustainable long-term choice.

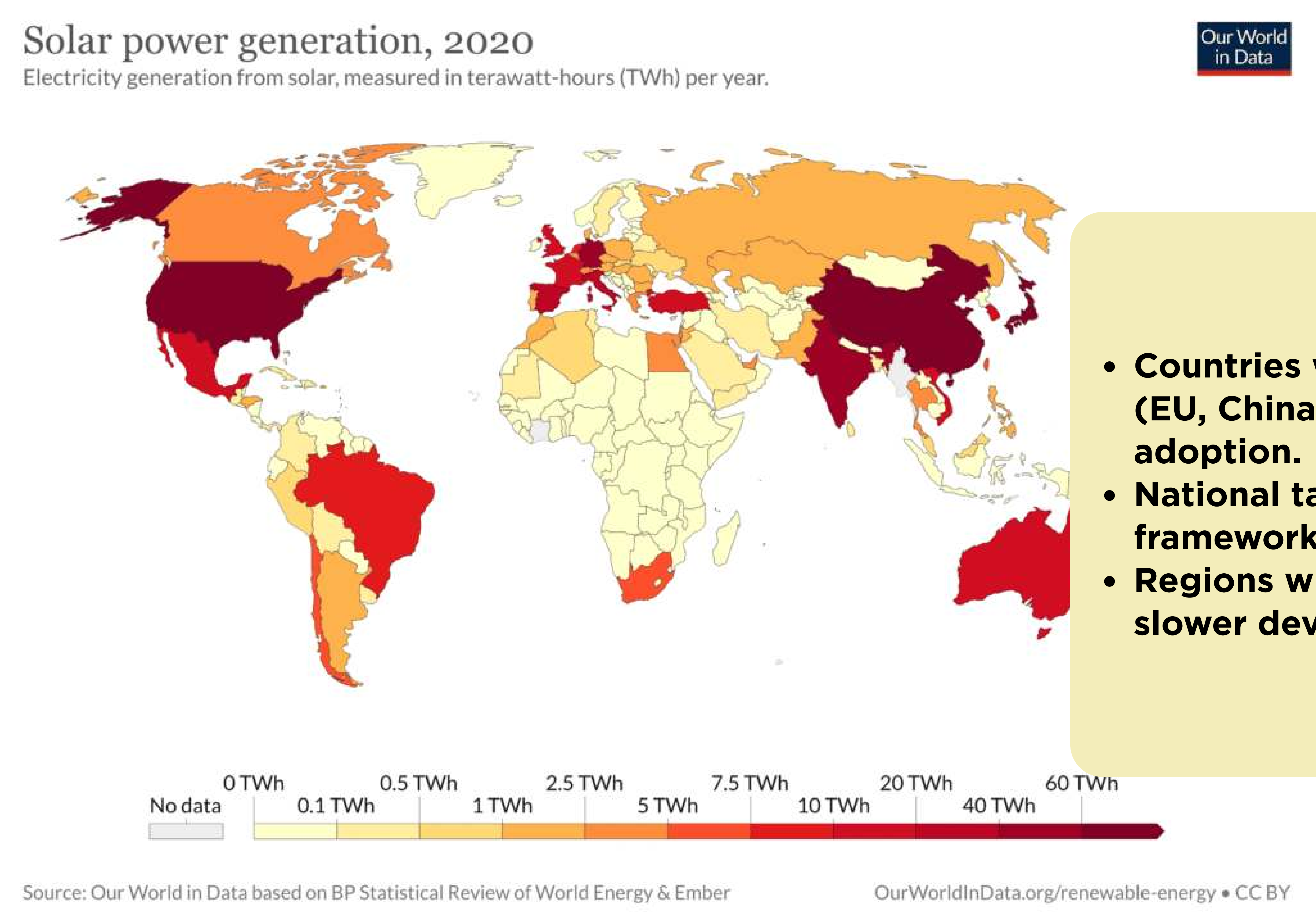
Impact of Support Policies on Solar Growth



Growth of Solar Energy over Time (TWh generated) — Distilled.Earth chart

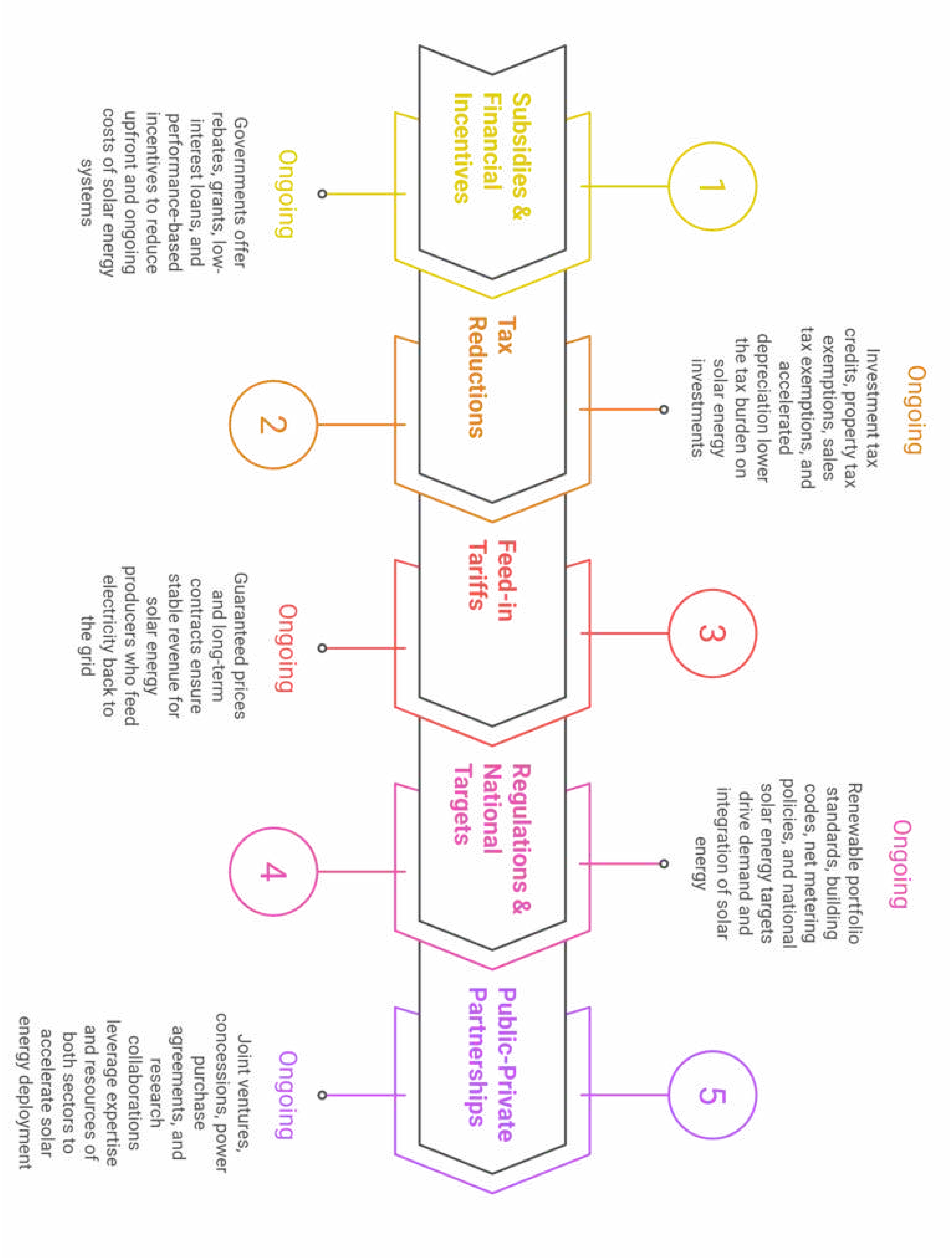
- **Global solar capacity has increased rapidly thanks to subsidies, tax incentives, and feed-in tariffs.**
- **Government policies lowered installation costs and encouraged households and companies to invest.**
- **This strong growth demonstrates how effective public measures are in accelerating the energy transition.**

Differences in Solar Development Across Countries



- **Countries with strong and ambitious policies (EU, China, USA) show the highest solar adoption.**
- **National targets, incentives, and regulatory frameworks directly shape solar deployment.**
- **Regions with weak support programs show slower development.**

Key Drivers Behind Solar Energy Adoption



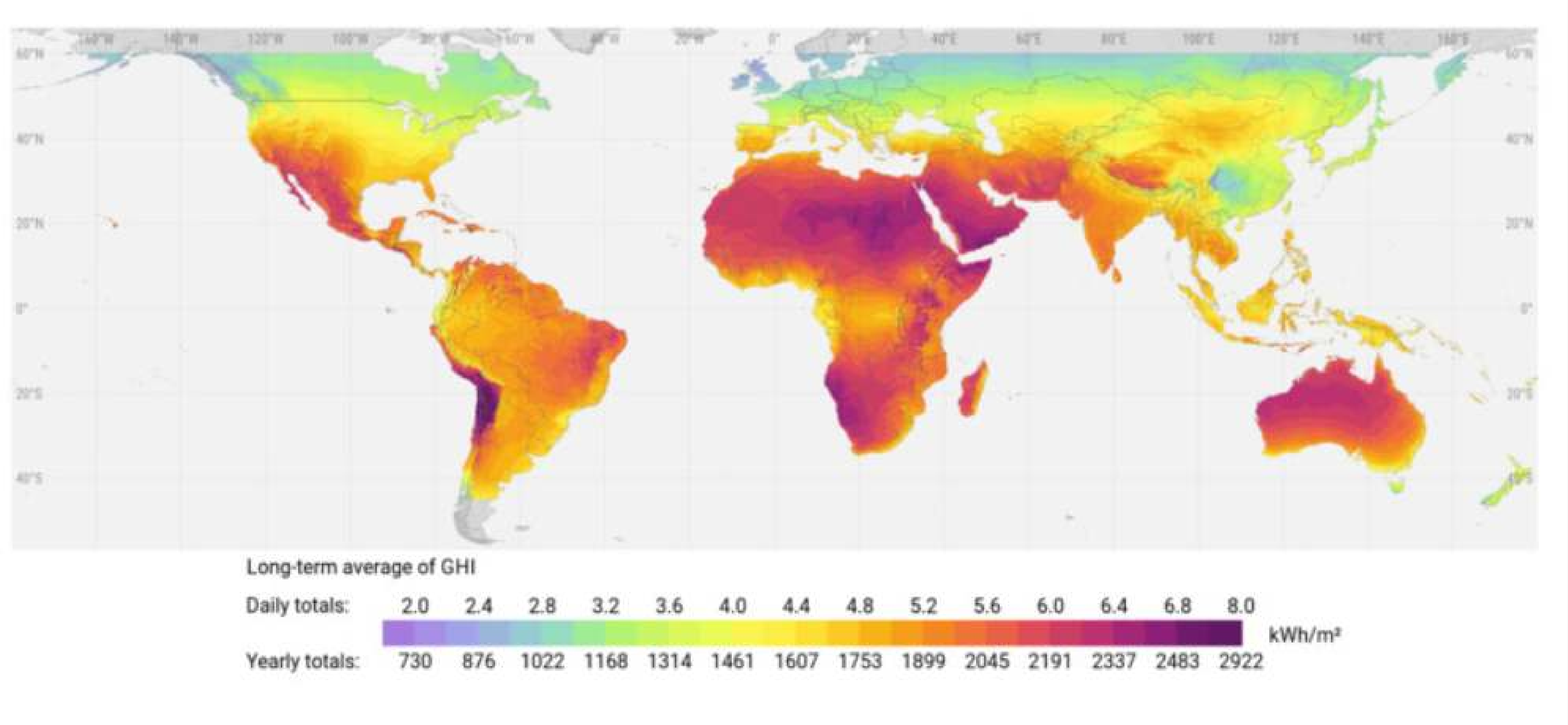
Solar Energy Storage Systems and Battery Types

Battery Type	Description	Advantages	Disadvantages	Best Use Cases
Lead-Acid (AGM / GEL)	Traditional, low-cost batteries	Cheap- Reliable- Easy to recycle	Short lifespan (3–5 yrs)- Heavy- Low depth of discharge (50%)	Small systems, low-budget solar, rural areas
Lithium-Ion (Li-ion)	Modern, high-performance batteries	Long lifespan (8–15 yrs)- High discharge (80–95%)- Fast charging- Lightweight	Higher cost- Sensitive to heat	Homes, businesses, off-grid systems
Lithium Iron Phosphate ($LiFePO_4$ / LFP)	Best lithium technology for solar	Very long lifespan (3000–6000 cycles)- Very safe- Performs well in hot climates- Deep discharge (90%+)	Higher initial cost	Best for homes, enterprises, long-term storage
Sodium-Ion (Na-ion)	New, low-cost alternative to lithium	Low cost- Good heat resistance- Good lifespan	Less available- Lower energy density	Budget systems, hot climates (future use)
Supercapacitors	Fast charge/discharge storage	Ultra-long lifespan- Rapid charging	Very low energy capacity	Specialized applications, not home storage
Thermal Storage (Molten Salt)	Stores solar energy as heat	Large-scale storage- Very efficient for power plants	Not for small installations	Industrial solar farms, CSP plants

SOLAR SYSTEM INSTALLATION

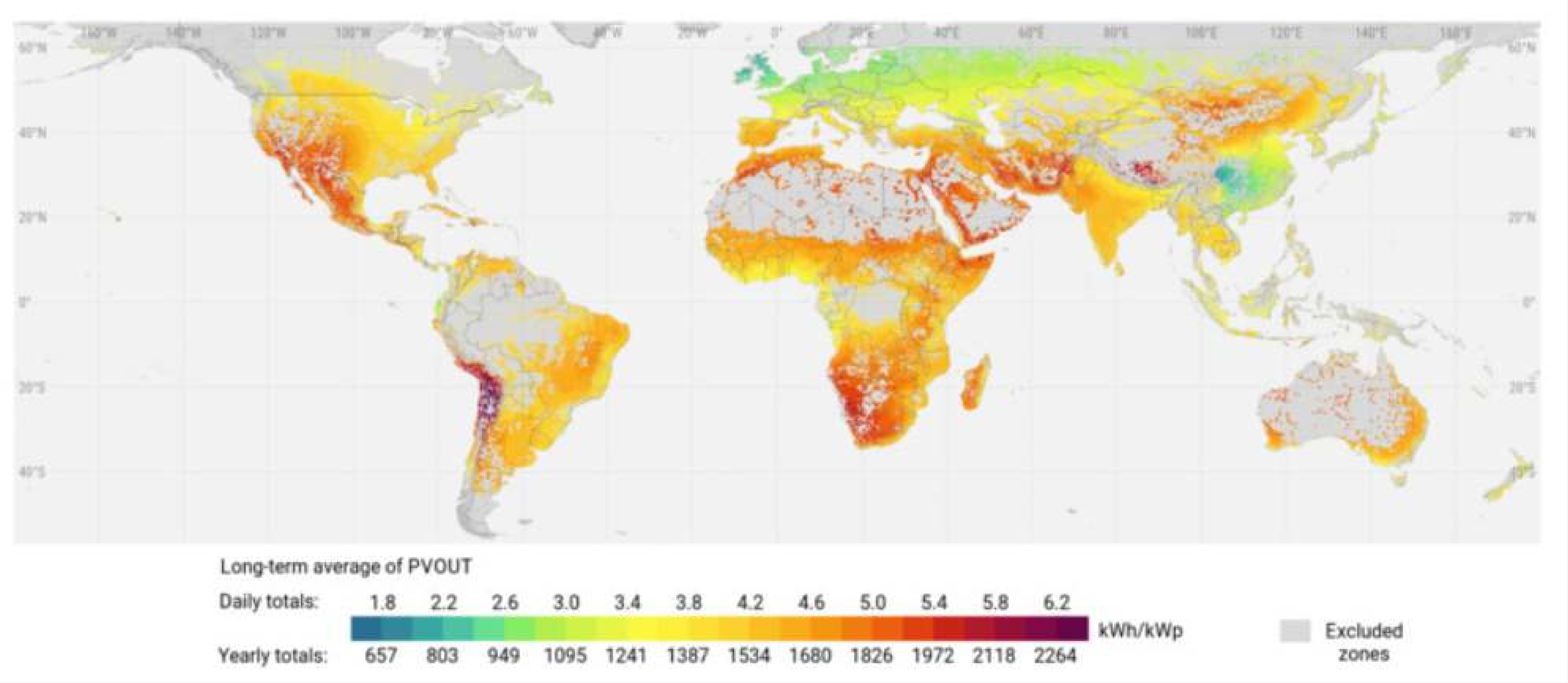
DETERMINATION OF FAVORABLE AREAS

We characterize the long-term energy availability of solar resource at any location, the **theoretical potentia**l. This potential is illustrated by the physical variable of **global horizontal irradiation (GHI)**, which is the sum of direct and diffuse irradiation components received by a horizontal surface.



The pillar of this study is the evaluation of the **practical PV potential**, which means the power output achievable by a configuration taking into account **theoretical potential**, air temperature, topography, land-use constraints.
This study describes 03 levels of practical potential:

- **Level 0:** disregards any limitations to the development and operation of solar power plants.
- **Level 1:** exclude areas due to physical/technical constraints, such as rugged terrain, presence of urbanized/industrial areas, forests, and areas that are too distant from the centers of human activity.
- **Level 2:** consider “soft” constraints, such as unsuitable areas due to regulations imposed by national or regional authorities (eg : nature conservation).



PVOUT represents the amount of power generated per unit of the installed PV capacity over the long-term

Site & environmental considerations

Roof/ground suitability

Check strength, material, slope, orientation, and available space

Shading

Avoid obstacles like trees, buildings
shading reduces efficiency significantly.

Sunlight availability

Assess average daily solar irradiance and seasonal variations

Environmental factors

Wind loads, snow, hail, dust, or salt corrosion (coastal areas)

Solar resource assessment

- **Solar irradiance (kWh/m²/day)**

the amount of sunlight available for energy generation

- **Weather patterns**

consider clouds, rain, and seasonal sunlight fluctuations.

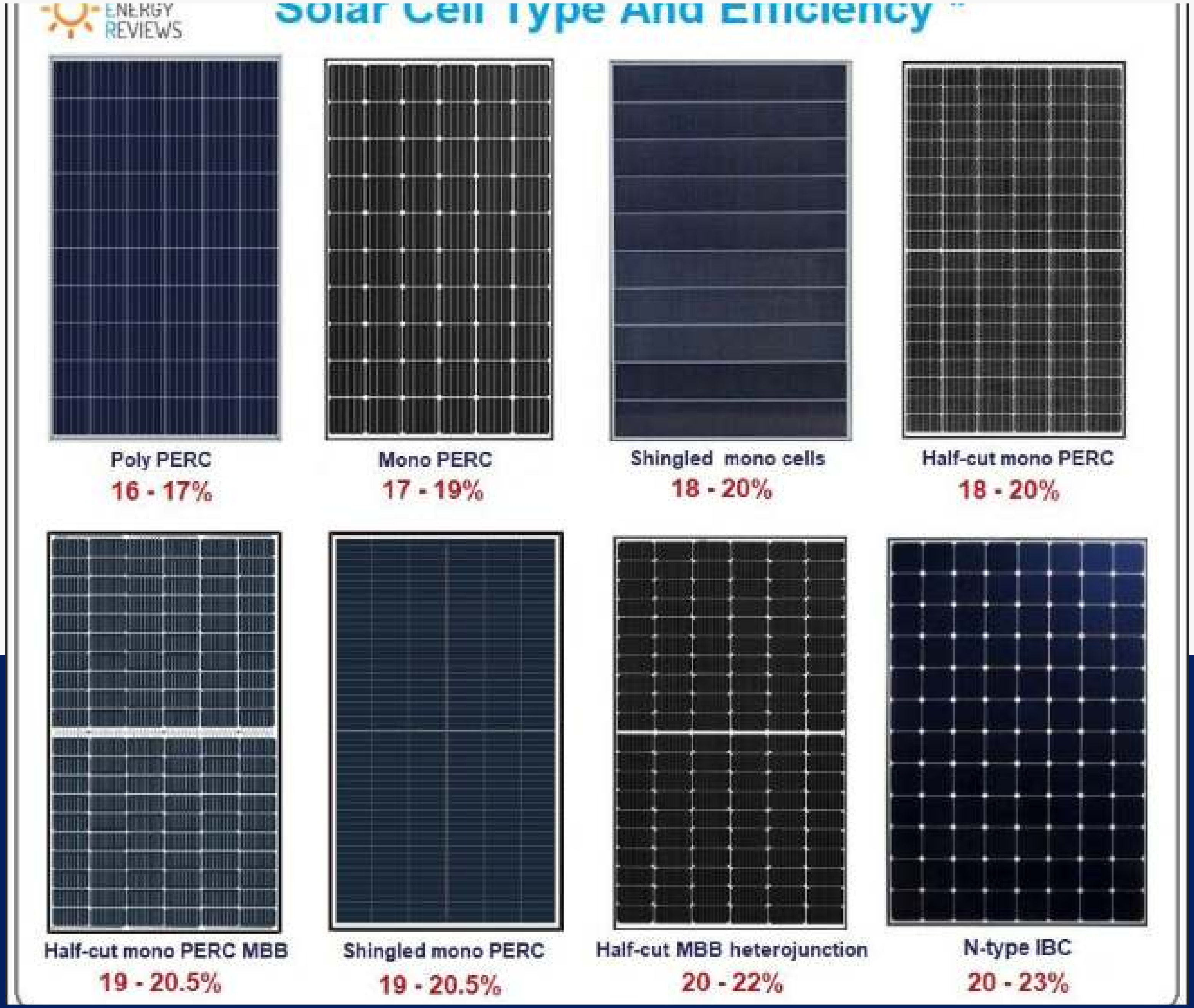
- **Temperature effects**

higher temperatures reduce panel efficiency slightly.

Panel type and technology

- **Monocrystalline vs polycrystalline vs thin-film**

affects efficiency, cost, and performance in low light



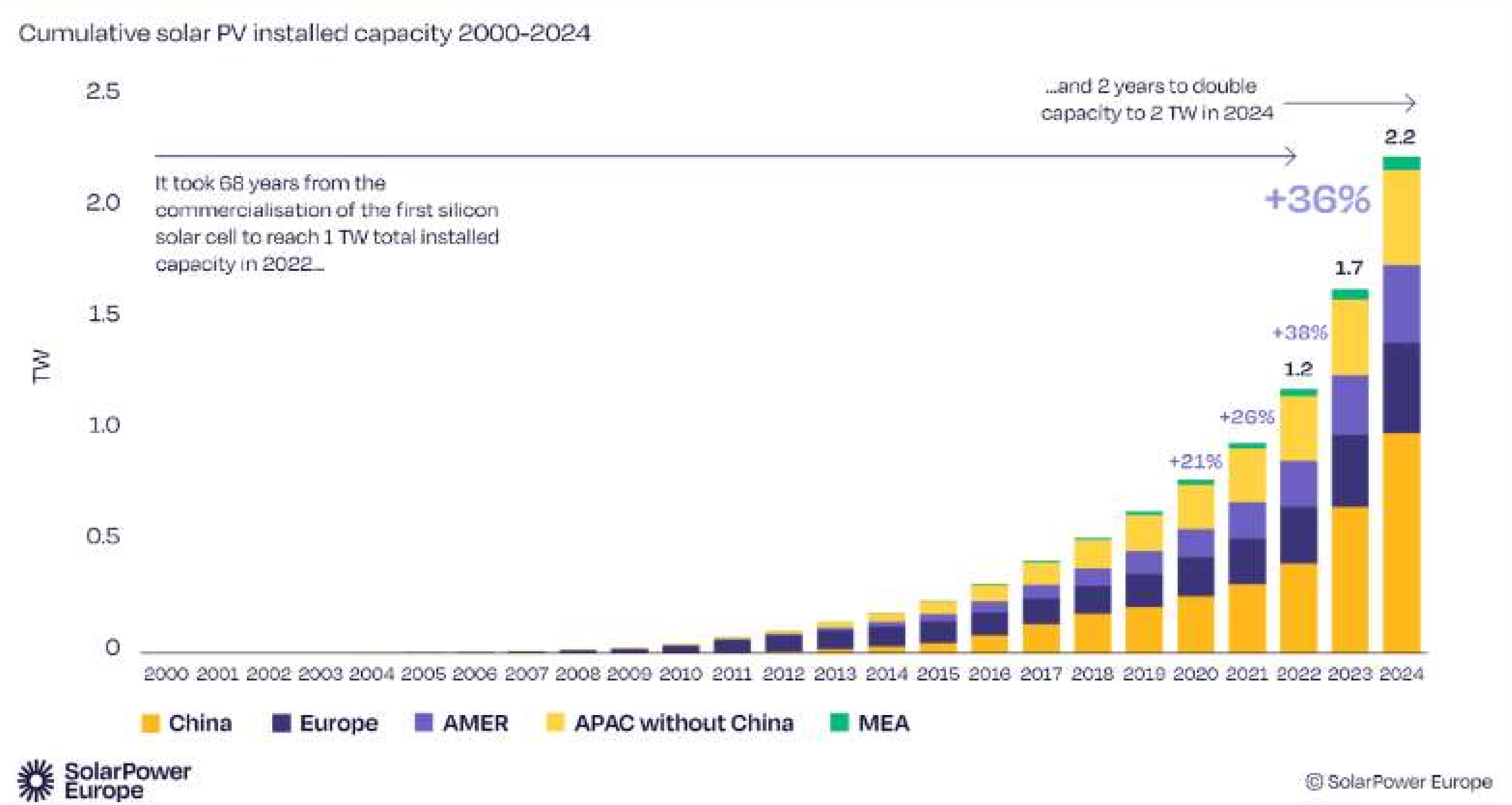
- **Durability and warranty**

panels should last 25-30 years.

- **Degradation rate**

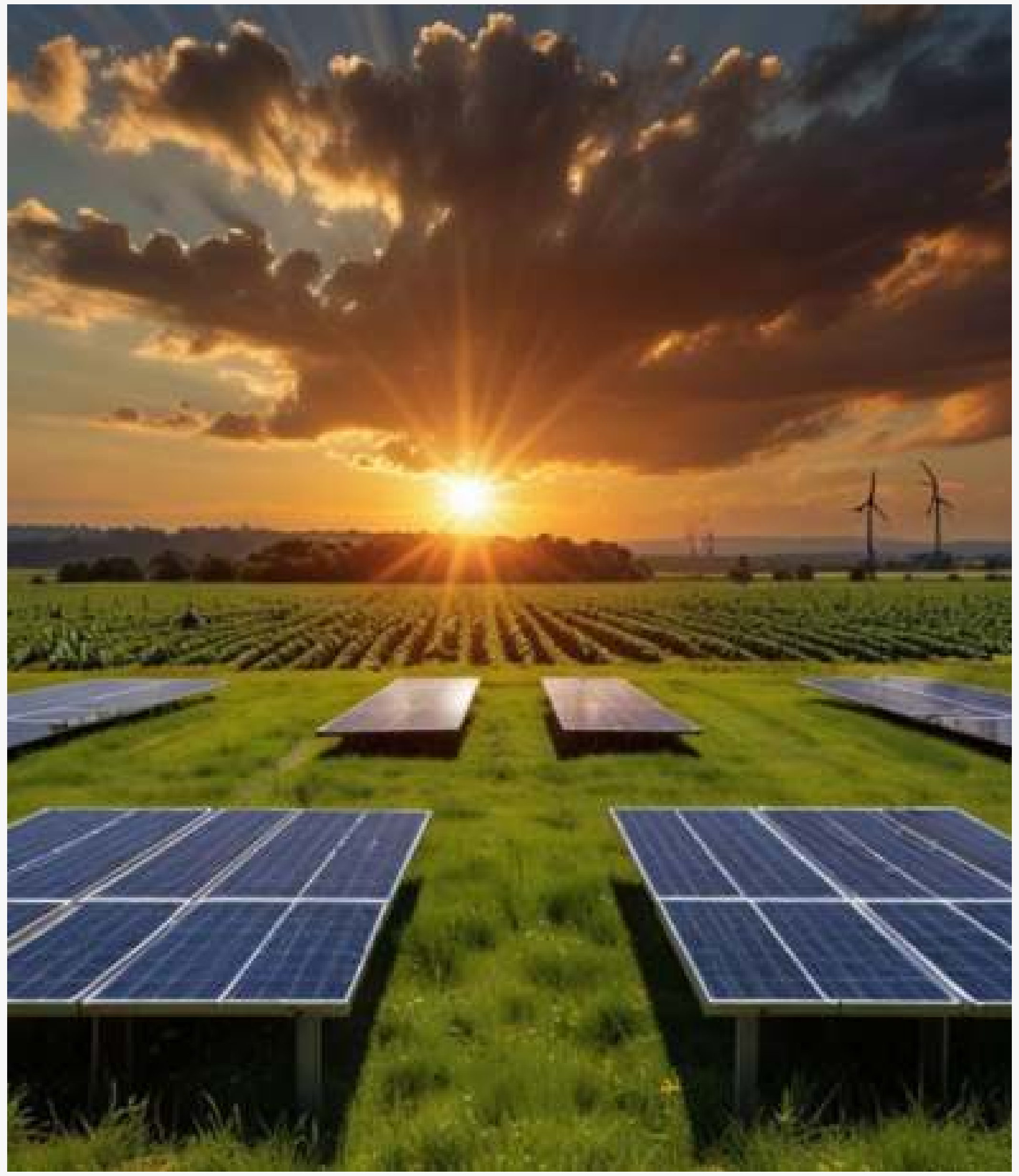
how performance declines over time.

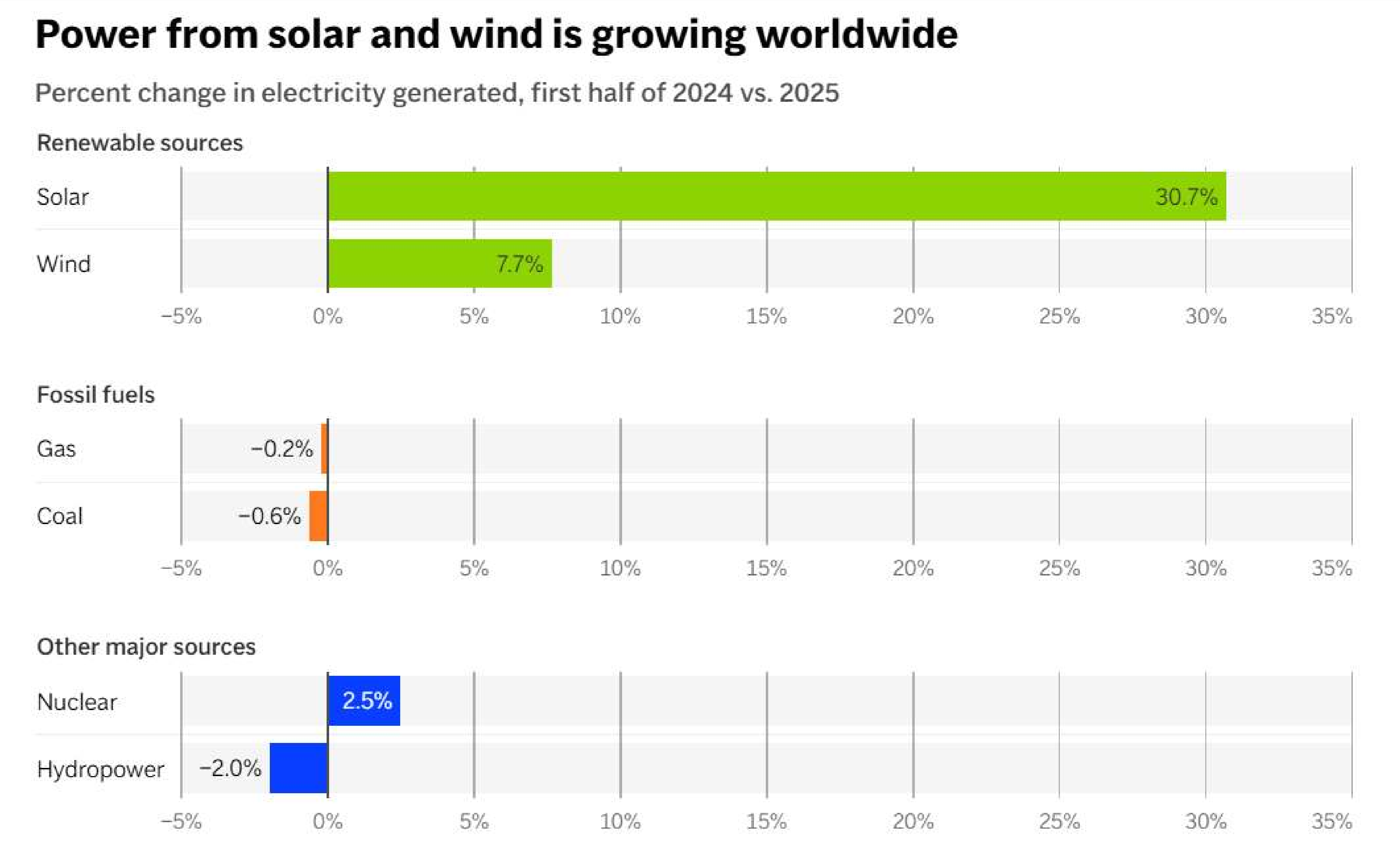
It took nearly 70 years from the first commercialisation of solar cells in 1954 to install the first solar TW, and only 2 years to double the solar fleet to 2 TW.



GLOBAL DEVELOPMENT LEVEL

Worldwide solar and wind power generation has outpaced electricity demand this year, and for the first time on record, The year 2024 was a true landmark year for solar power. Global solar installations reached nearly 600 GW an impressive 33% increase over the previous year setting yet another record. Solar accounted for 81% of all new renewable energy capacity added worldwide.





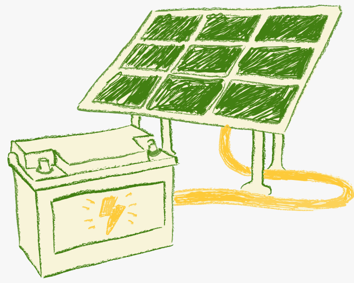
CHALLENGES OF SOLAR ENERGY

High Initial Costs

Installing solar panels and equipment can be expensive at first, even though they save money in the long run.

Space Requirements

Large solar systems need a lot of space to capture enough sunlight, which can be difficult in crowded areas.



Energy Storage and Battery Costs

Batteries used for storing solar energy are still quite expensive and not 100% efficient ,some energy is always lost in the process

Weather Dependency

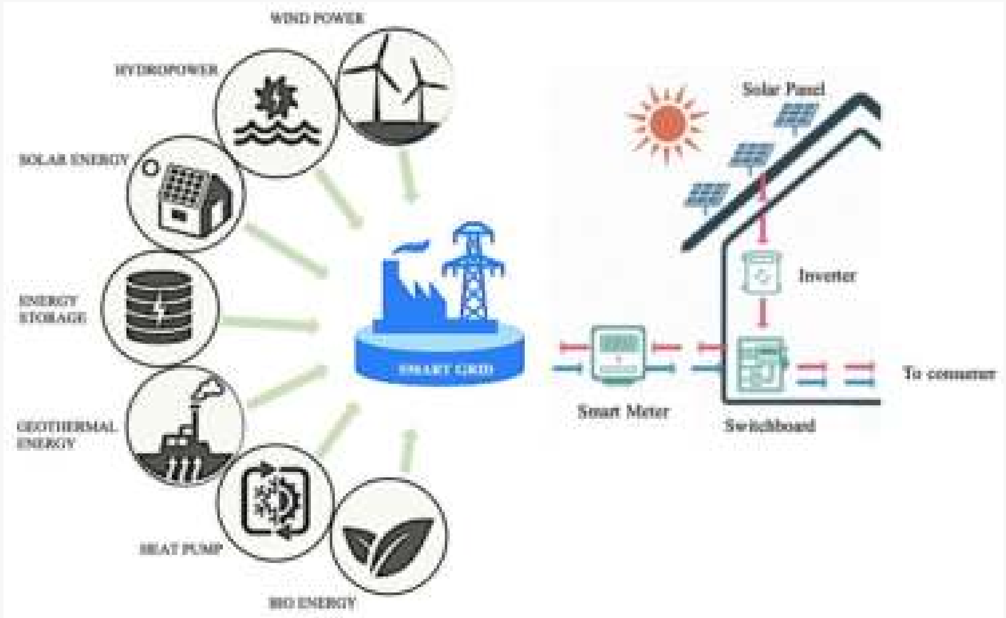
Solar panels work best on sunny days. Cloudy or rainy weather reduces how much electricity they can produce.

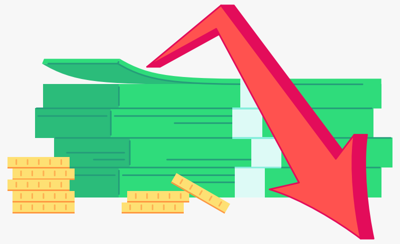
Efficiency Concerns

Solar panels don’t convert all the sunlight they receive into electricity, most panels only convert around 15–25%. This means a lot of sunlight energy is wasted, and more panels are needed to produce enough power.

Government incentives and policies: inclusion of subsidies like tax credits to encourage solar adoption. The Renewable Energy Development Agency (IREDA) offers financial support for solar installations.

Integration with Smart Grids: Combining solar energy with smart grids and advanced battery storage solutions can ensure a stable and efficient power supply.





Falling costs of solar pannels: Over the past decade, the cost of solar photovoltaic (PV) panels has dropped by over 80%,

Growing interest from corporations and industries:
Large corporations such as Apple, Google, and Amazon have committed to 100% renewable energy, heavily investing in solar power to meet sustainability goals.:

Solar energy is taking a tremendous part in the production of clean energy worldwidly .
In a vision of Zero-net Carbon emission and a 1.5°C we have as extrapolation of the use of solar energy:

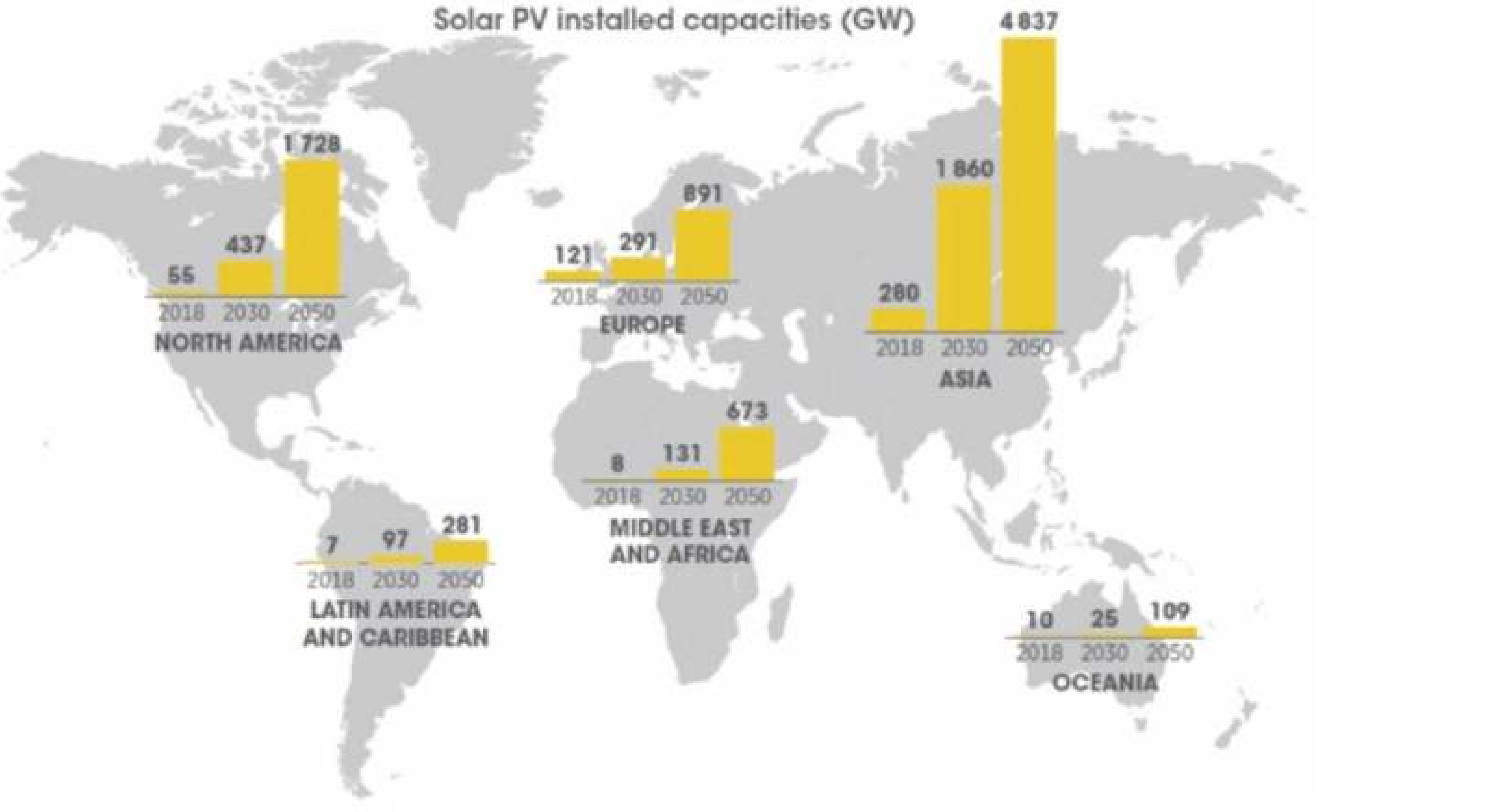


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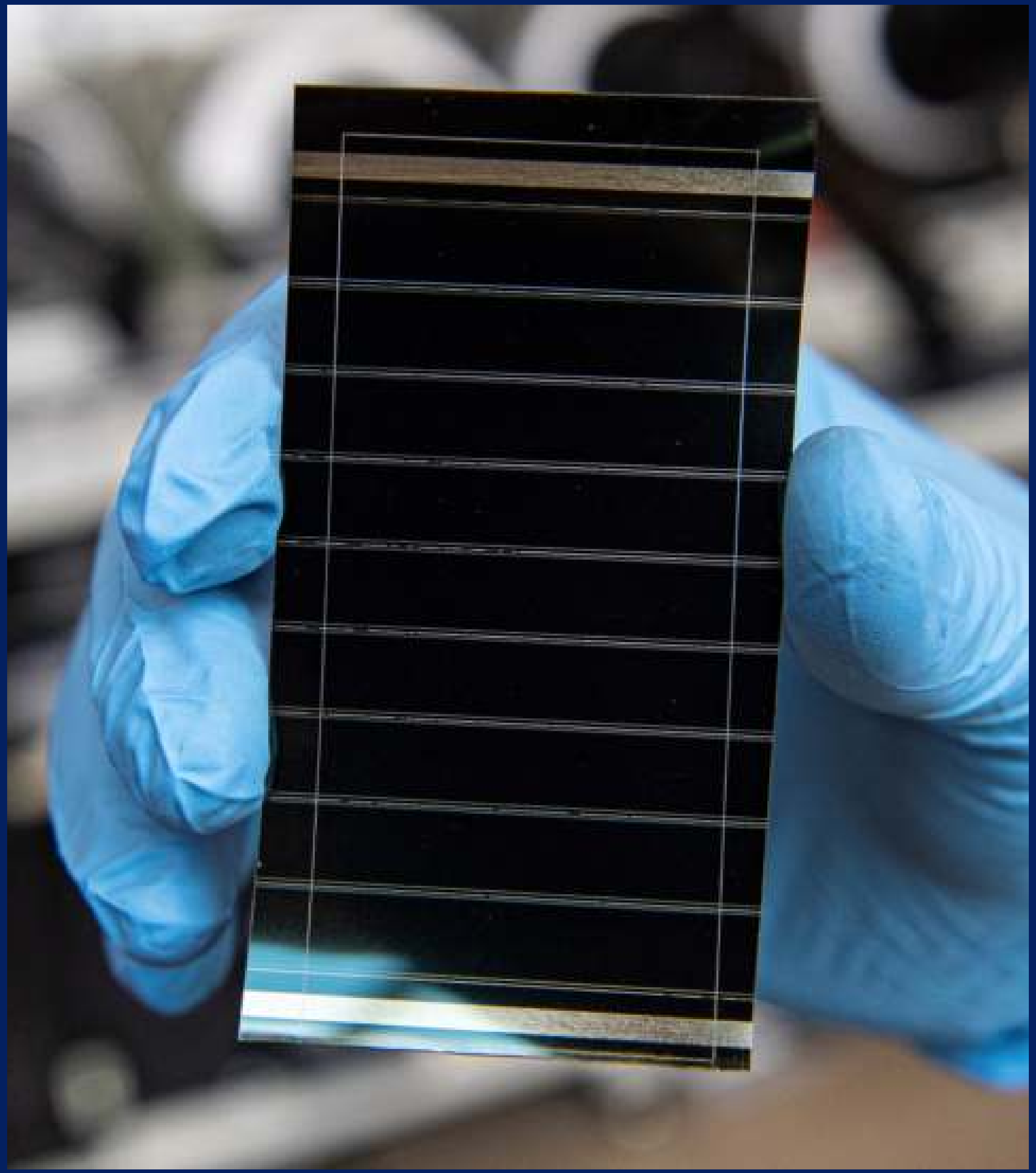
Fig. 2. The world solar PV installed capacity by 2050 (IRENA, 2019a).

Prospects of solar energy

Innovations in solar technologies are taking a turning point facing its limitations and expanding its potential.

Advancements in solar efficiency: development of more efficient photovoltaic cells for example **perovskite solar cells** , which has shown promising results by increasing conversion rates.



Perovskite solar cell

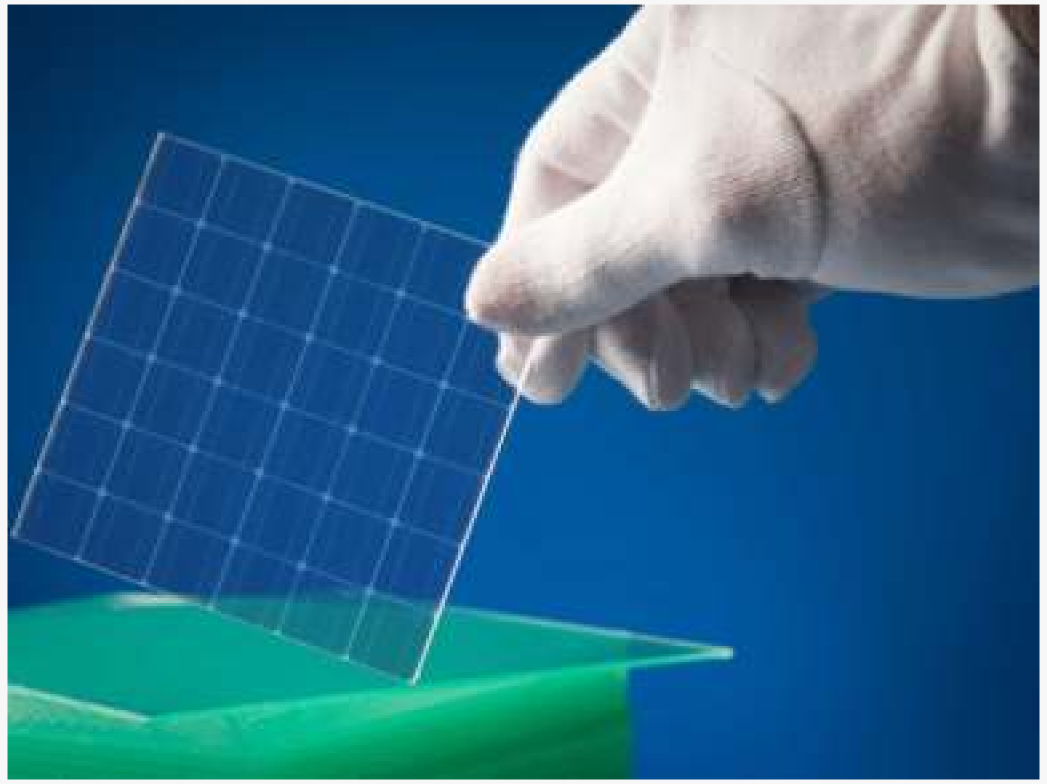
Emerging technologies: New solar innovations are paving the way for widespread adoption. For example:

Thin-films solar panel

These are made by placing very thin layers of solar material on glass or plastic. They're lightweight, flexible, and cheaper to make, but usually less efficient than traditional panels

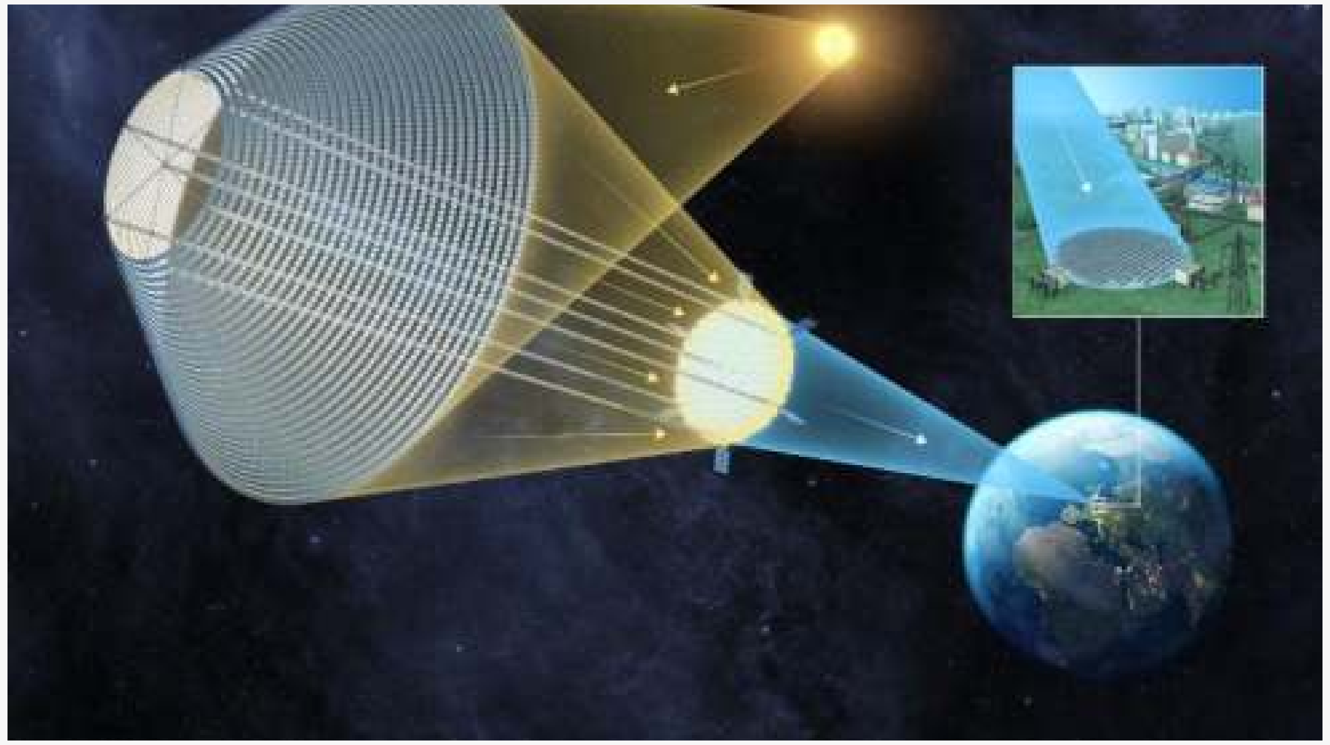
Floating solar farms

These are solar panels installed on bodies of water like lakes or reservoirs. They save land space, reduce water evaporation, and can produce energy efficiently because the water helps keep the panels cool.



Transparents solar panel

These special panels can let light pass through while still generating electricity. They can be used on windows or glass surfaces, turning buildings into power producers.



Spatial solar farms

These are futuristic systems designed to collect solar energy in space, where sunlight is constant and stronger, and then send the energy back to Earth using microwaves or lasers.

Top Solar Technology in 2025

01 Bifacial Solar Panels

Unlike traditional panels that capture sunlight on only one side, bifacial panels are designed to capture sunlight from both the front and back

02 Perovskite Solar Cells

These cells are made from a unique class of materials called perovskites, which have a distinctive crystal structure that makes them highly efficient at converting sunlight into electricity.

03 Solar Roof Tiles

These tiles function as both roofing materials and solar panels, offering a seamless and aesthetically pleasing solution for residential and commercial properties.

04 Artificial Intelligence and Machine Learning

These technologies help optimize energy production, predict system failures, and enhance energy management.

5 Floating Solar Systems

These systems are designed to float on bodies of water, such as lakes, reservoirs, and even oceans, providing a new space for solar panel installation.

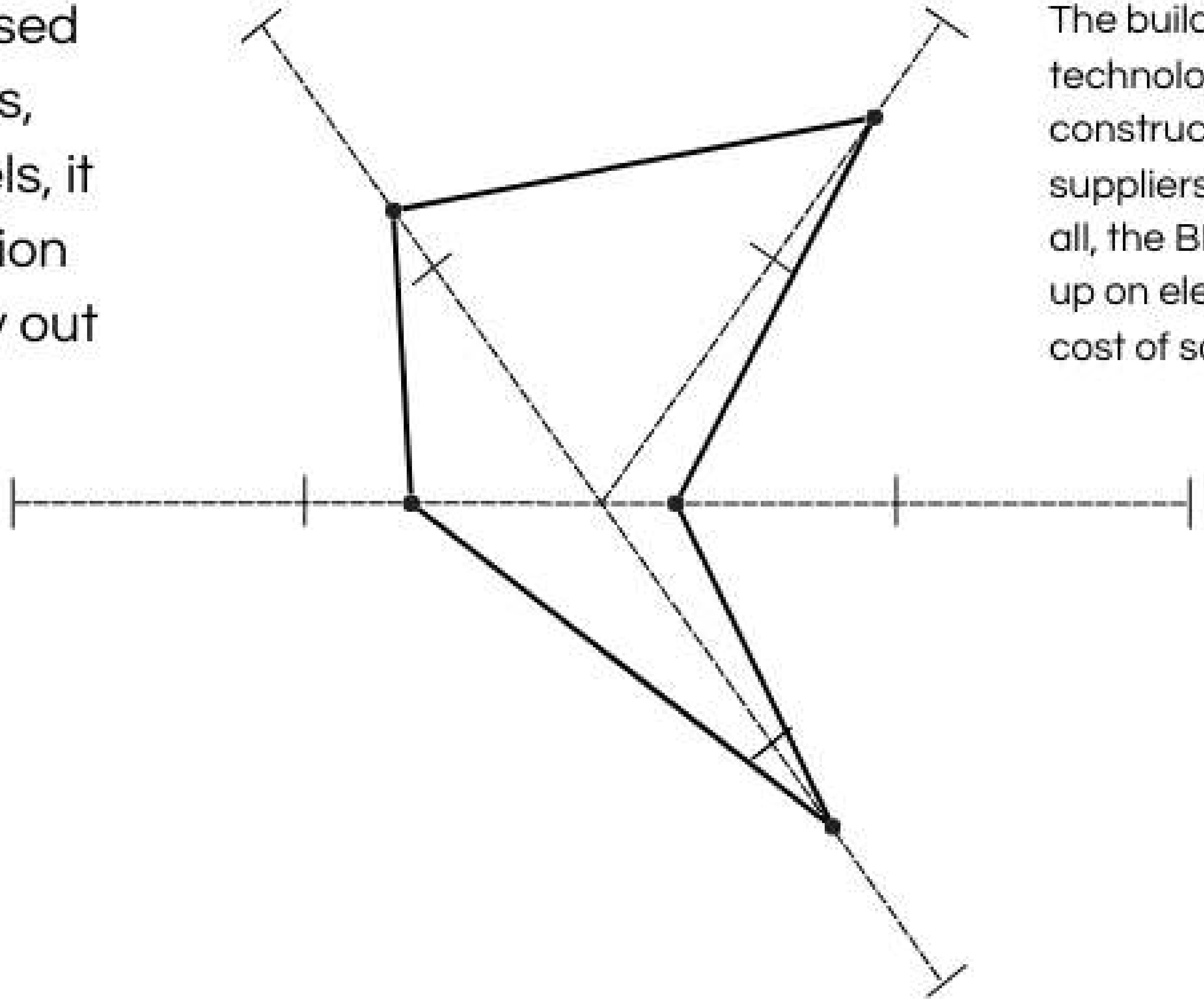
TOP SOLAR INNOVATION IN 2025

⁕ SOLAR FABRIC

- Solar fabric can be used to make clothes, tents, curtains: just as panels, it captures solar radiation and makes electricity out of it.

⁕ BIPV SOLAR TECHNOLOGY

The building-integrated photovoltaics (BIPV) technology aims to use solar elements as construction parts that will become power suppliers for a future office or a house. All in all, the BIPV technology lets the owner save up on electric power costs and later on the cost of solar panel mounting systems.



⁕SOLAR SKINS

solar skins give you an option to monitor the performance of your modules

THE DOWNSIDE IS THE COST: FOR A SOLAR THIN-FILM SKIN, YOU'LL HAVE TO PAY 10% MORE ON TOP OF THE PRICE OF A SOLAR PANEL.

⁕ FLOATING SOLAR FARMS

- The main advantage of floating solar farms is that they can be installed on almost any water body. The cost of floating photovoltaic panels is comparable to a land installation of a similar size

Solar plants in the world

Solar PV installations have surged with the domination of China in the market. In 2024,the world added a record 597 GW of new capacity and brought the global total to 2.2TW. More and more, solar plants are being implant in many areas allowing a optimized exploitation of the solar energy. The 03 main solar plants are:

Bhadla solar park

one of the largest solar power plants in the world, located in India covers more than 14.000 acres,with a staggering capacity of 2,245 Megawatts

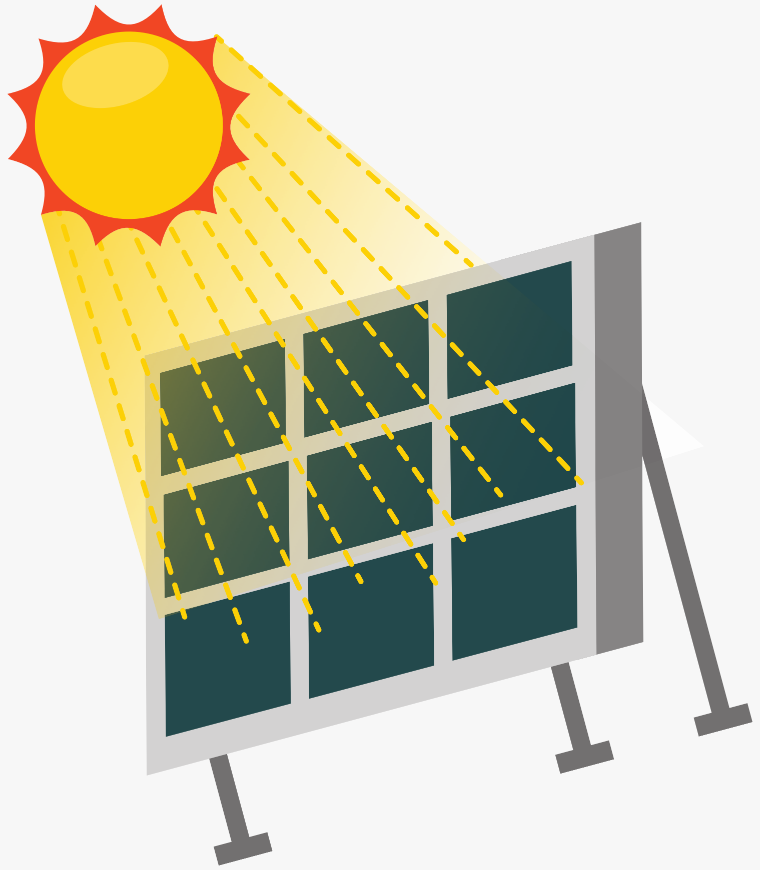
1 acre=0.4047 hectare

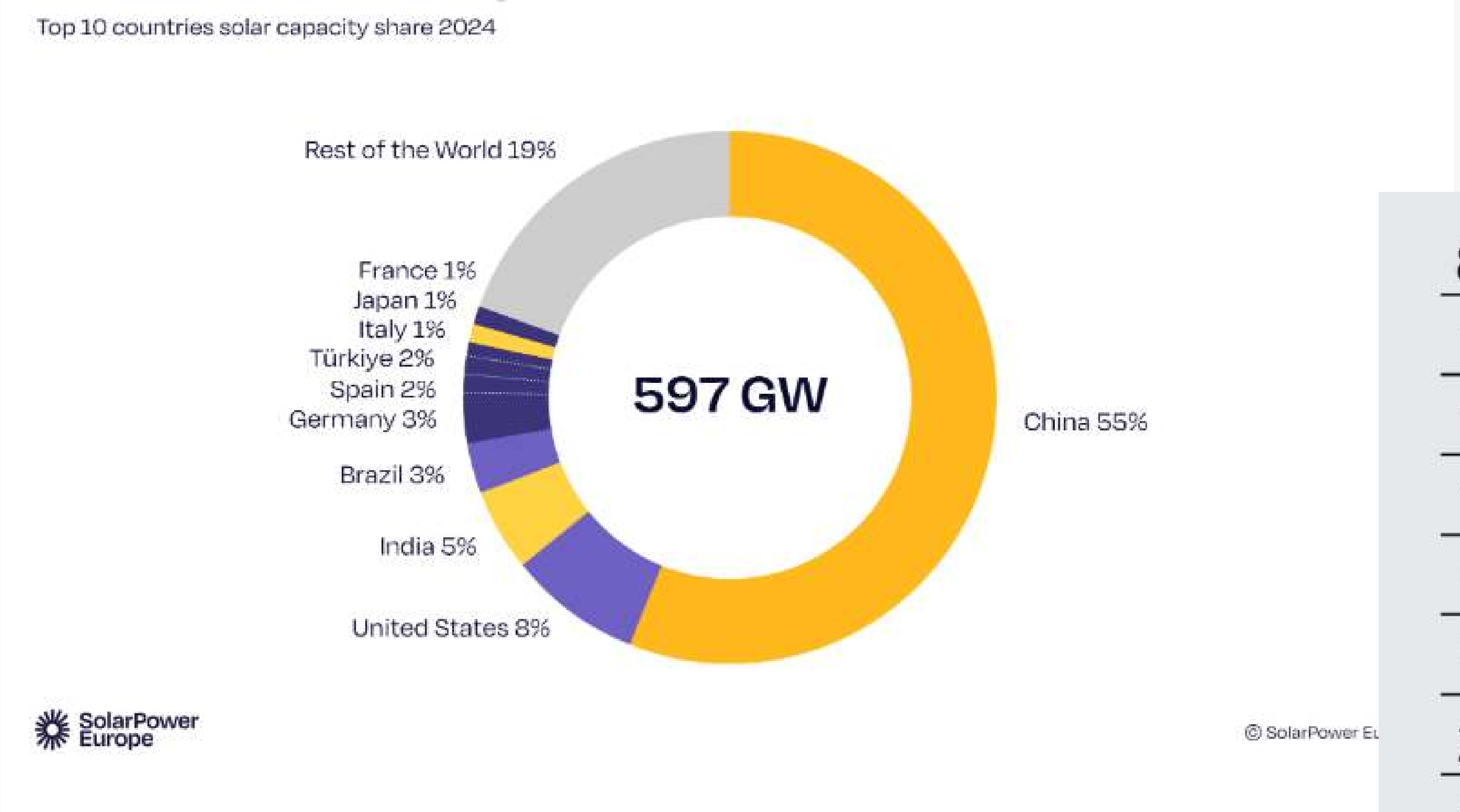
Tengger desert solar park

A huge solar power station located in the Tengger desert in China. It covers around 43 km2 with a capacity of over 1.500 MW often called **"Great Wall of Solar"**

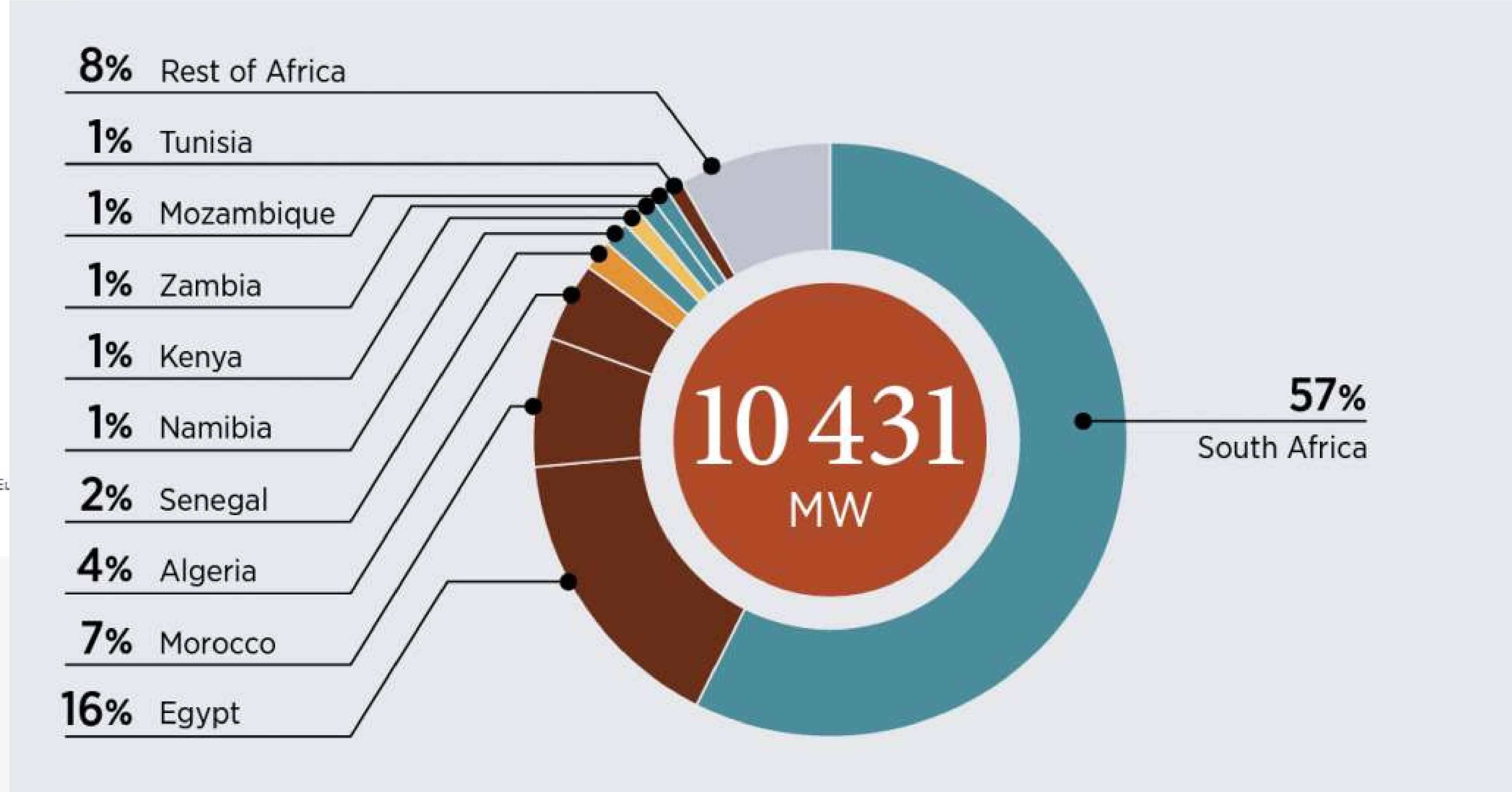
Gonghe Talatan Solar Park (China)

The largest solar power plant currently in operation is the Gonghe Talatan Solar Park in Qinghai Province, China. It has a capacity of about 15,600 megawatts (MW).





The top 10 markets install around 81% of global solar energy.



The repartiton of the total solar energy in Africa
South Africa dominates solar energy production in Africa around 57%*10431=5.945 GW

ADVANTAGES OF SOLAR ENERGY

- **It's a renewable and clean energy**

  It converts a natural and constant resource (sun lightning) directly into energy and reduces carbon footprint

- **Independance**

  Installing solar power makes you a producer and reduces electricity you get from local utility

- **Low operating costs**

  Solar panels require very low maintenance

- **Abundance and availability**

  Using solar panels is viable anywhere

- **Versatile Usage**

  it's a polyvalent energy

- **reduce dependance to fossil fuels**

  preserves natural resources of the planet

DISADVANTAGES OF SOLAR ENERGY

Efficiency

It converts only a small percentage of the sunlight into electricity (at most 22%)

High Upfront costs

It includes panels, batteries, wiring and the installation itself. Today they're around 20 000 USD

Not the best environmentally friendly option

It's about building PV cells, batteries the transportation, and management of wastes.

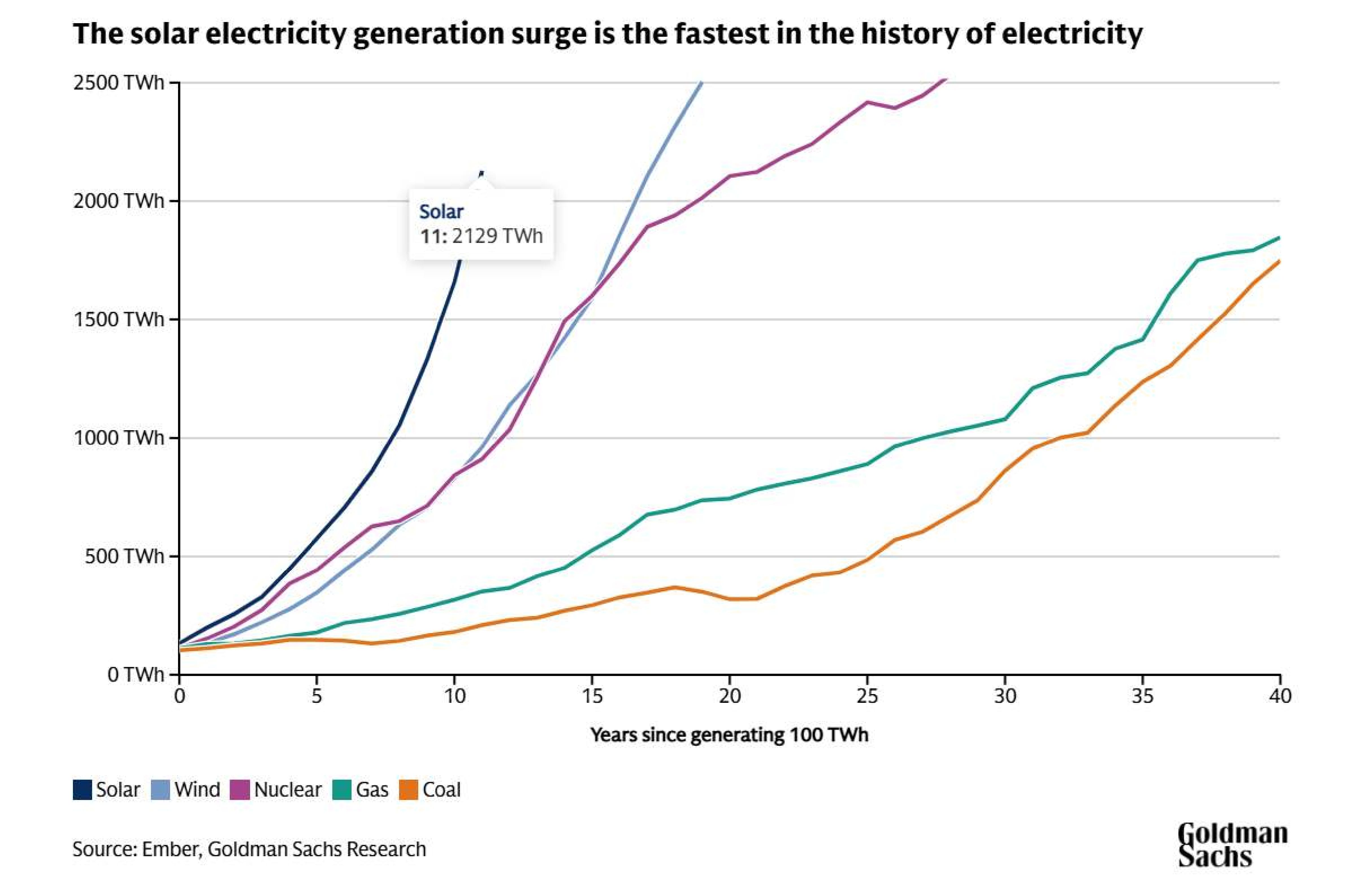
Weather, time dependency

Solar panels don't function at night and are less efficient during cloudy days or seasons (winter for example)

Space Requirements

To provide electricity to 1000 homes, a solar plant would require 12.95 ha of Land

COMPETITIVENESS COMPARED TO OTHER SOURCES OF ENERGY

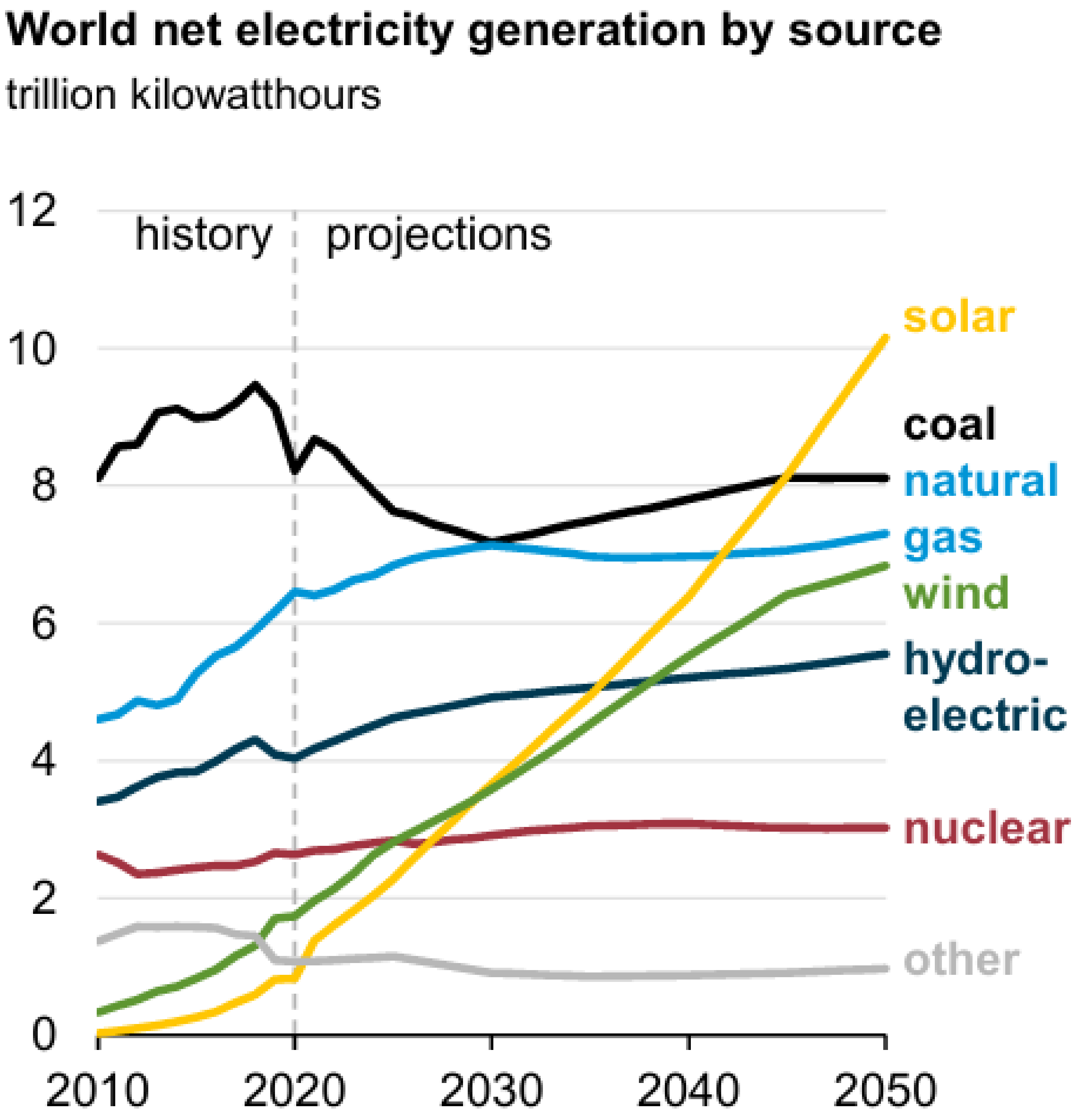


" The rise in solar generation is the fastest in the history of electricity"

Daan Struyven, *co-head of global commodities research at Goldman Sachs Research*

COMPETITIVENESS COMPARED TO OTHER SOURCES OF ENERGY

In the list of the advantages of solar energy, price is an important point. In its World Energy Outlook 2020 report, the International Energy Agency (IEA) confirmed that solar power schemes now offer the cheapest electricity in history. In its 2021 report, the Agency predicted that by 2050, renewable energy generation will keep growing, with solar power production skyrocketing and becoming the world's primary source of electricity.



https://www.eia.gov/outlooks/ieo/pdf/IEO2021_ReleasePresentation.pdf

COMPETITIVENESS COMPARED TO OTHER SOURCES OF ENERGY *IN ELECTRICITY PRODUCTION*

Compared to other renewables:

Criteria	Solar Energy	Wind Energy	Hydropower	Biomass Energy
Efficiency	High, with modern panels achieving over 20%	Variable, depending on turbine design and location	Moderate, reliant on consistent water flow	Low, generally below 19%
Environmental Impact	Low, no emissions and minimal maintenance	Low, but can affect bird populations	Moderate, significant ecological disruption from dam construction	Moderate, involves emissions and land use for biomass growth
Cost	Decreasing, due to innovation and scale	Stable, with high maintenance costs	High initial cost, lower operation and maintenance costs	Variable, depending on biomass production and transport costs

https://www.tenmenelectrical.com/comparing-solar-energy-to-other-renewable-energy-sources/

COMPETITIVENESS COMPARED TO OTHER SOURCES OF ENERGY IN *ELECTRICITY PRODUCTION*

Compared to other sources (fossil fuels)

Category	Solar Energy	Fossil Fuels
Generation method	Converts sunlight into electricity using photovoltaic cells	Burns coal, oil, or natural gas to create steam or pressure that drives turbines
Average cost of new electricity (LCOE)	\$0.038–\$0.078 per kWh (PV Magazine USA, 2025)	\$0.048–\$0.109 per kWh for new natural gas plants (Scientific American, 2025)
Average cost of new electricity (LCOE)	About 46 g CO_2-eq/kWh (Community Power Magazine, 2025)	490–820 g CO_2-eq/kWh depending on fuel type
Average cost of new electricity (LCOE)	20–30% depending on sunlight and location	80–90%, can operate continuously
Average cost of new electricity (LCOE)	Minimal, no fuel required	High due to fuel, maintenance, and regulatory costs
Average cost of new electricity (LCOE)	Clean, renewable, no air pollution	Emits carbon dioxide, sulfur dioxide, and other pollutants
Average cost of new electricity (LCOE)	Few weeks to months depending on project size	Several years for large-scale power plants

https://www.sunhub.com/blog/solar-vs-fossil-fuels-energy-2025/

ENVIRONMENTAL AND SOCIAL IMPACT

I-Social Impact

- **Job Creation and economic growth**

The need for a skilled workforce for manufacturing, installation an maintenance of solar panels stimulates job opportunities

- **Energy independence and security**

Producing energy locally reduces dependance to foreigners. And solar energy system can provide reliable power in case of natural disaster or grid failure

- **Educational opportunities and awareness**

Many *schools* and *universities* include solar in their curricula. Public awareness is also raised through **campaigns**

ENVIRONMENTAL AND SOCIAL IMPACT

I- Social Impact

- **Technological innovation and advancement**

  New technologies due to the research of efficiency

- **Health Benefits**

  Reduction of respiratory illnesses due to reduction of air pollution

II- Environmental Impact

- **Reduction of Green House Gas Emissions**

  Even if solar panels manufacturing produces CO2, it's unsignificant when we compare it to emitted CO2 from fossil fuels.

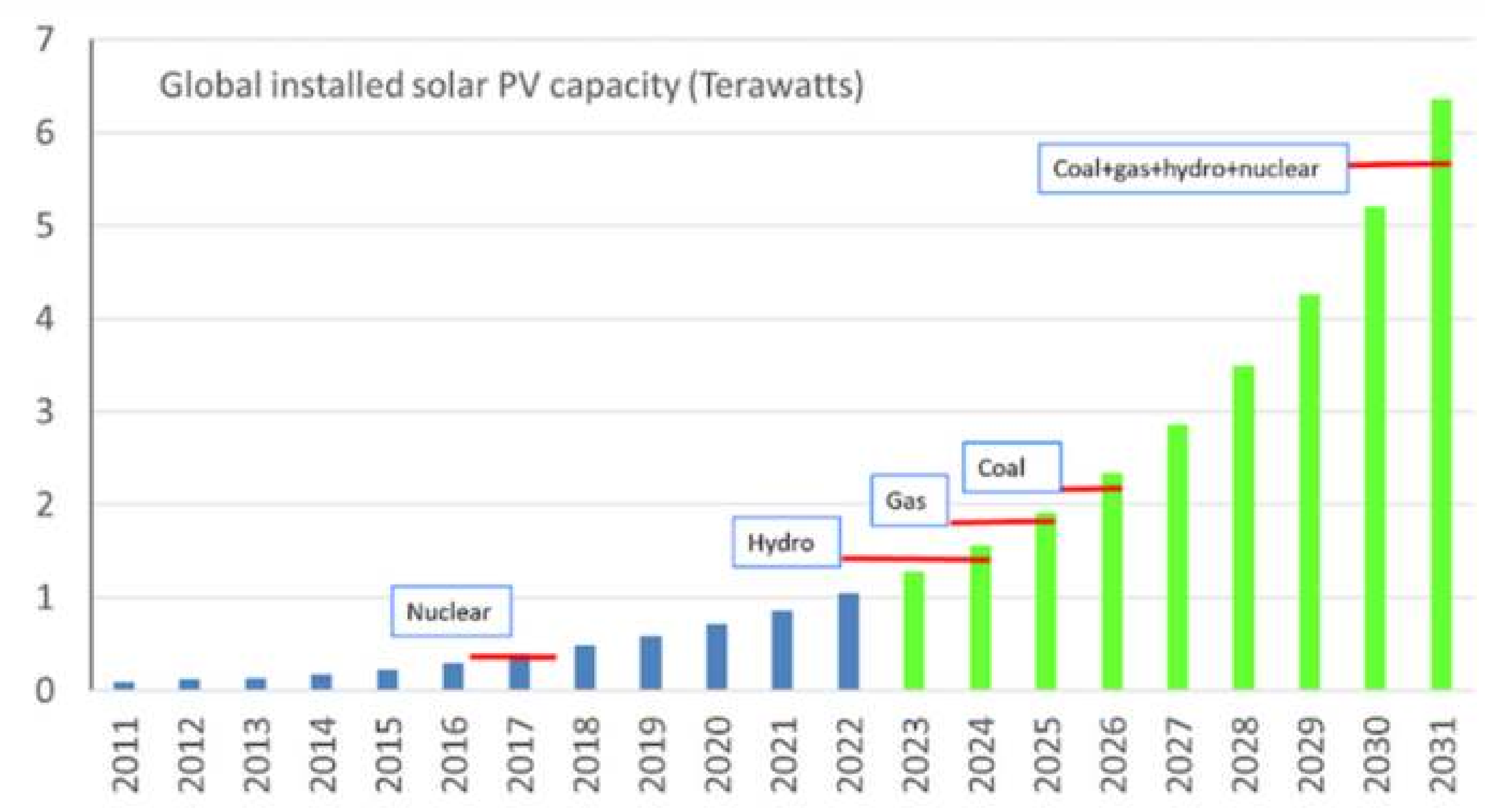
- **Minimizing Air and Water Pollution**

  Solar energy generates electricity without releasing harmful emissions or contaminating water sources

- **Habitat Preservation**

  Reducing reliance on fossil fuels helps protecting ecosystems from drilling, mining…

Solar Growth Potential: Technical, Economic & Political Drivers



- **The global solar capacity pipeline is projected to reach ~2.9 TW in the coming years.**
- **China alone represents nearly 35% of planned future capacity.**
- **Technical improvements (higher efficiency panels, better storage) will boost long-term deployment.**
- **Economically, falling costs and economies of scale make new solar investments increasingly viable.**
- **Politically, strong policies and support in emerging markets will drive rapid adoption.**

SWOT Representing Solar Energy Growth Potential

S — Technological Advancements

Increasing efficiency, reducing costs

W — Low Capacity Regions

Parts of Africa, South America, Asia

O — Cost Competitiveness

Competitive with fossil fuels

T — Policy Instability

Unpredictable market conditions

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