Renewable Energy Systems: Current Status in the World Prospects and Problems

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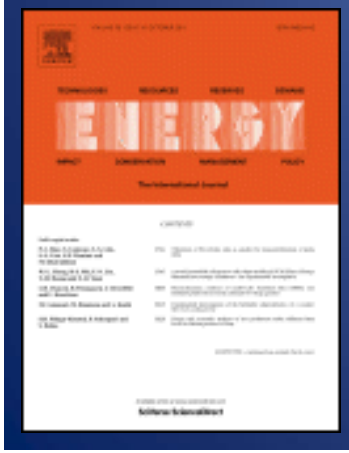

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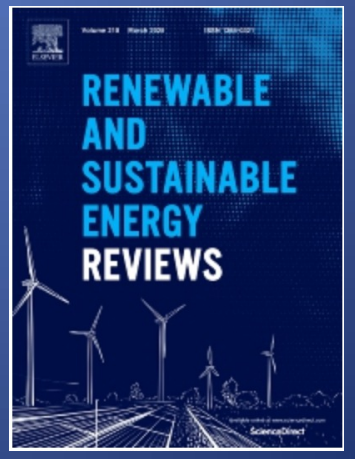

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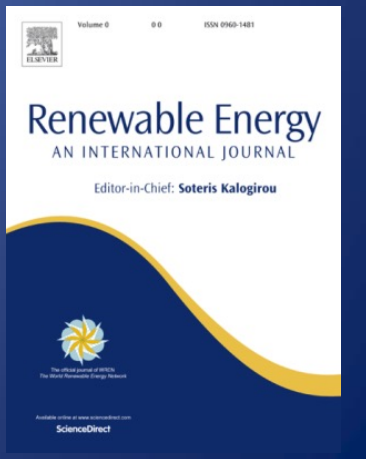


Outline

- Introduction – Climate change
- Status of Renewables
  - Solar thermal
  - Photovoltaics
  - Hydro Power
  - Wind Energy
  - Biomass
  - Other technologies
- Prospects – New research
- Problems associate to RES

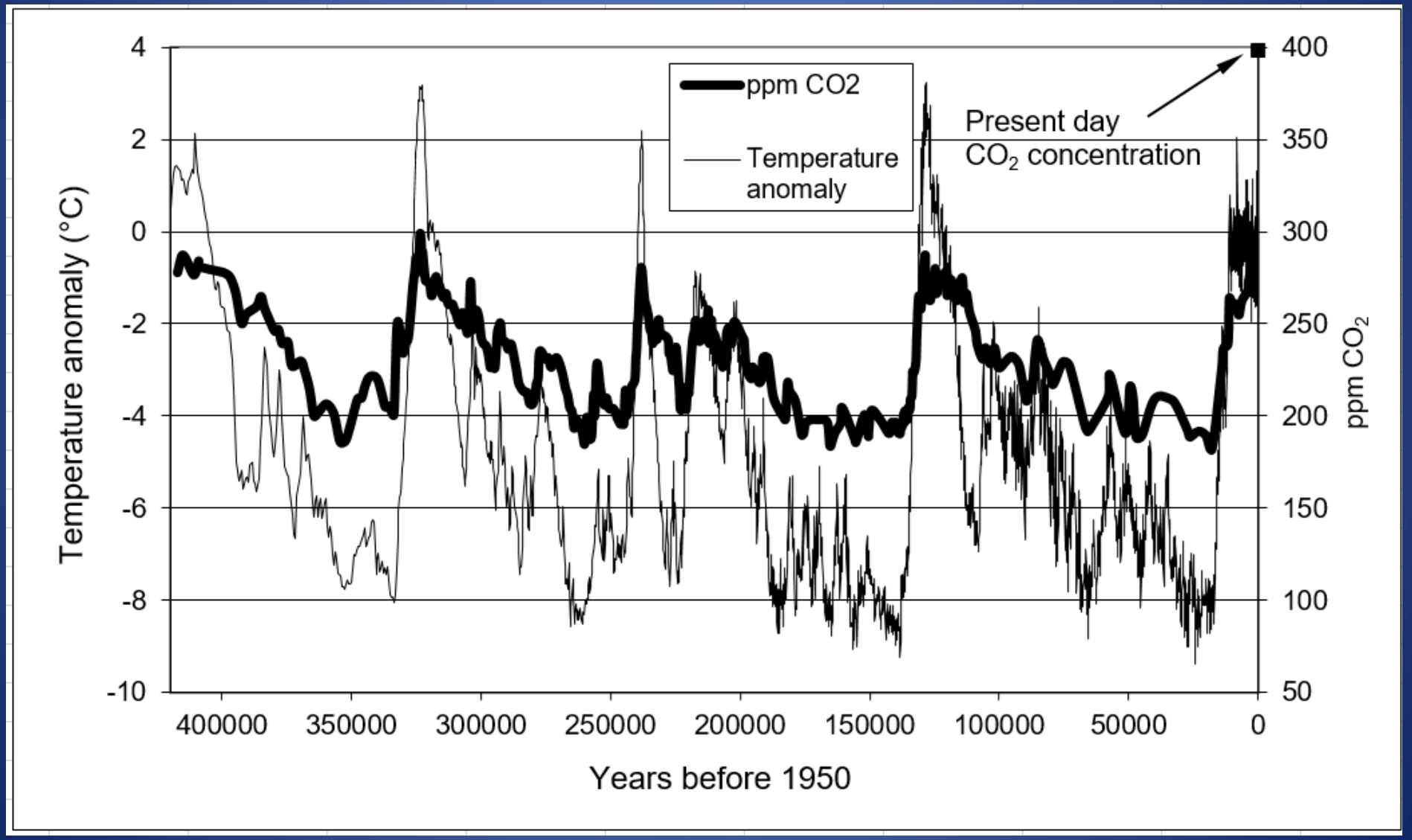
Convincing Evidence

The term Climate Crisis represents better the situation instead of Climate Change or Global Warming

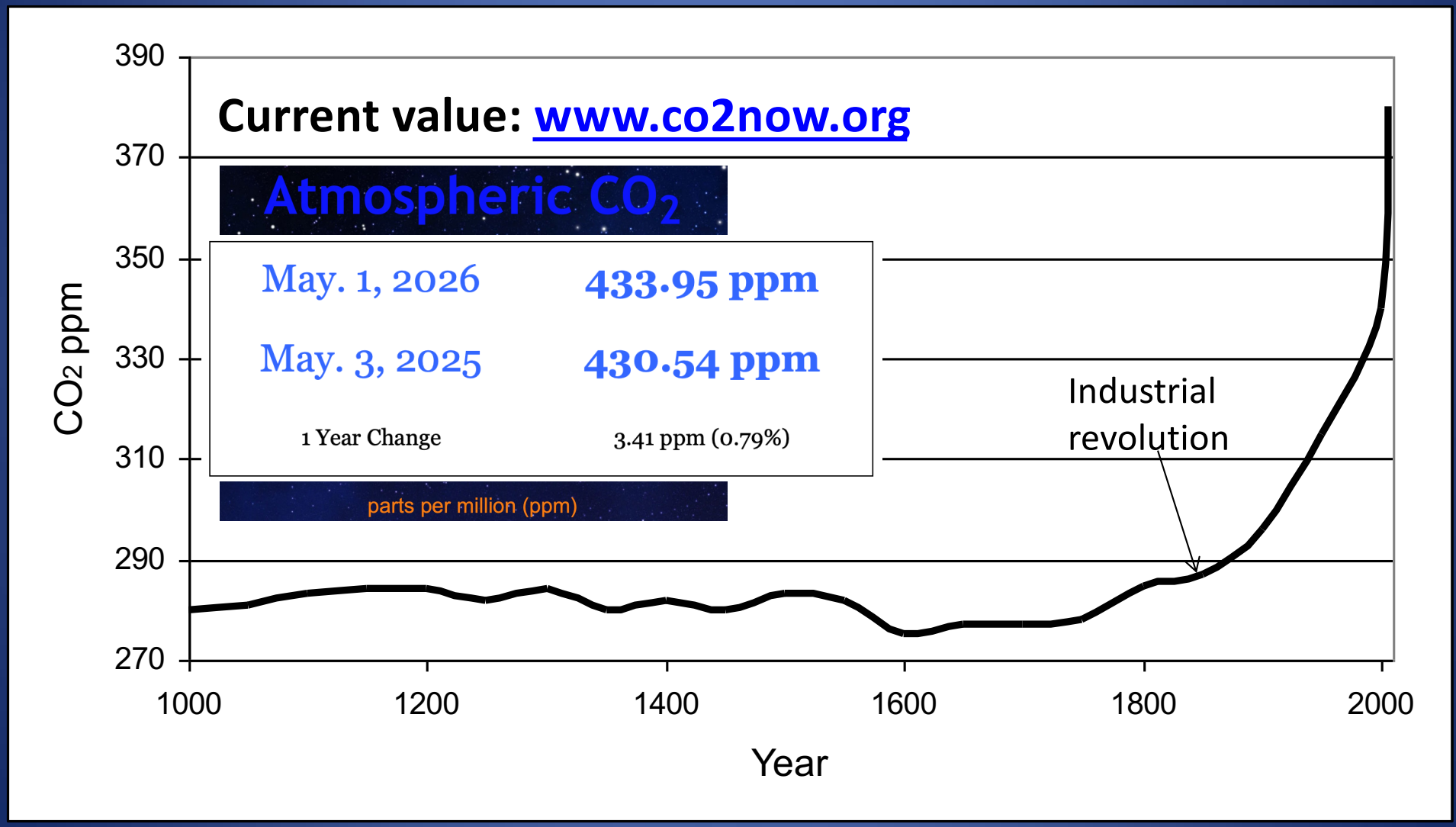
Climate refugees

Effect of Climate Change

Temperature anomaly and CO_2 concentration From Vostok ice-cores (East Antarctica)



CO_2 in the last 1000 years

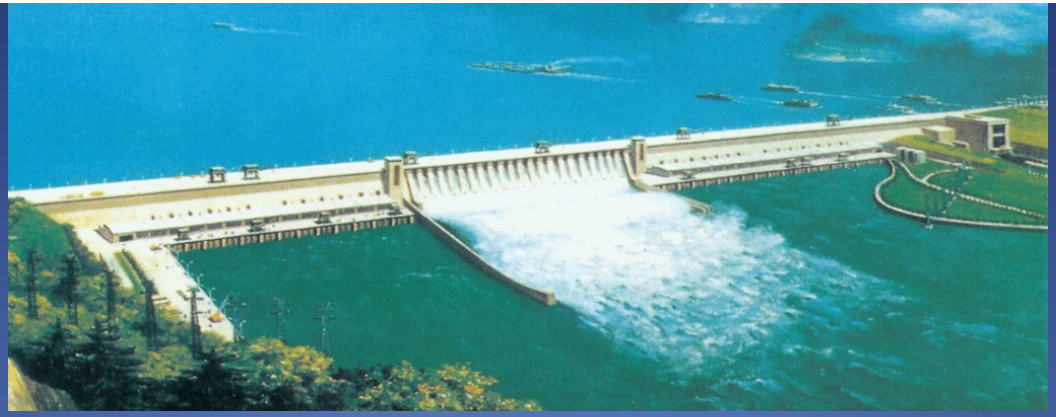


Conventional Fuels – Reserves (end of 2020)

- Coal ~ 139 Years
- Crude Oil ~ 53.5 Years (because of shale oil)
- Natural Gas ~ 48.8 Years

* BP Statistical Review of World Energy 2021, 70th Edition

Biggest problem: Environmental issues related to the use of these fuels – China & India are the most polluting countries



Renewable Energy Systems

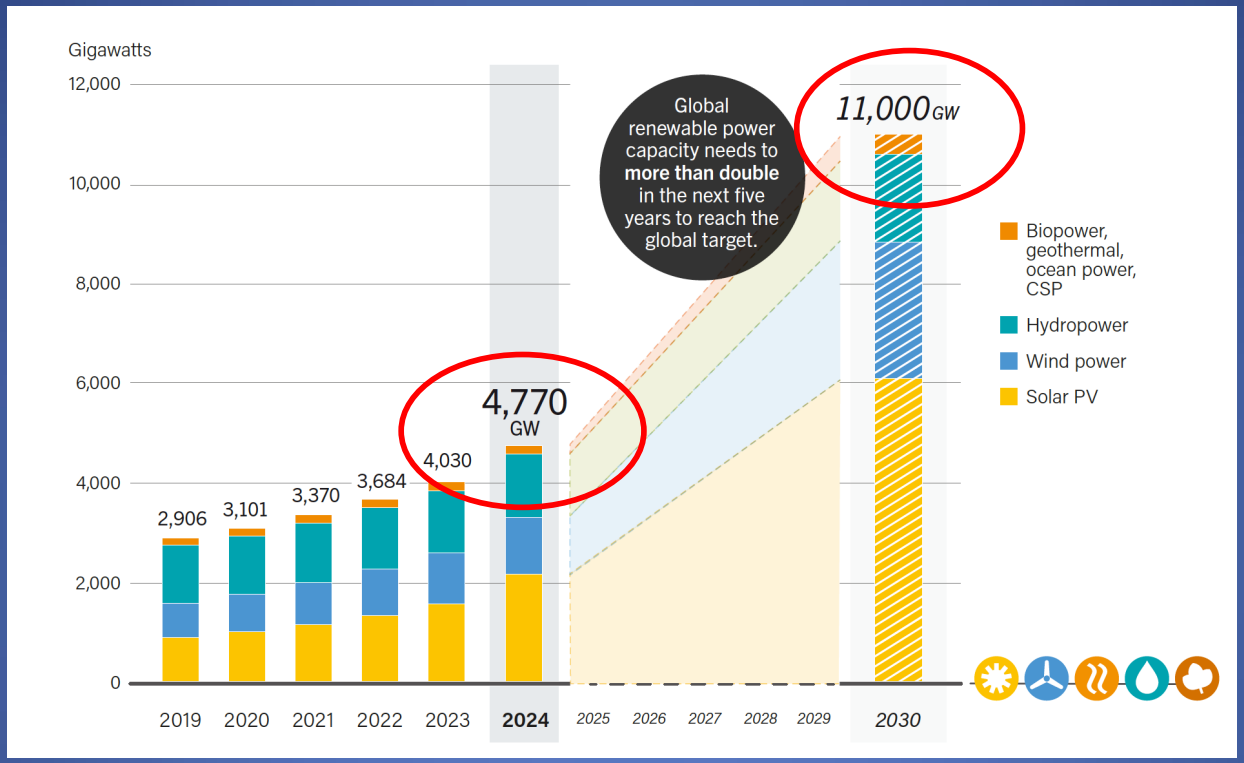
Solar power (solar thermal & PV)

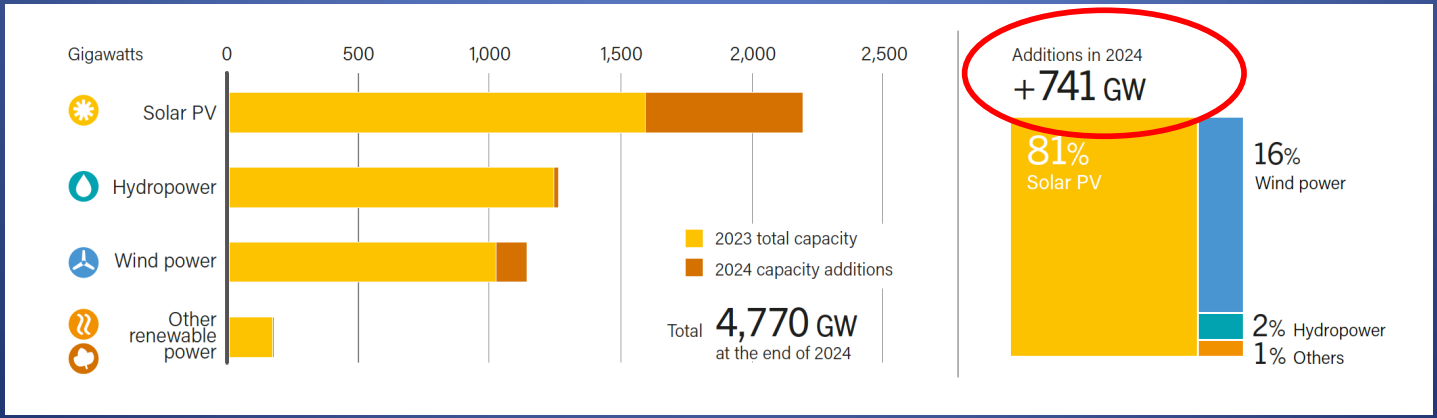
Hydro systems

Wind energy systems

Biomass-Biogas-Biofuels

Renewable Energy Indicators 2024



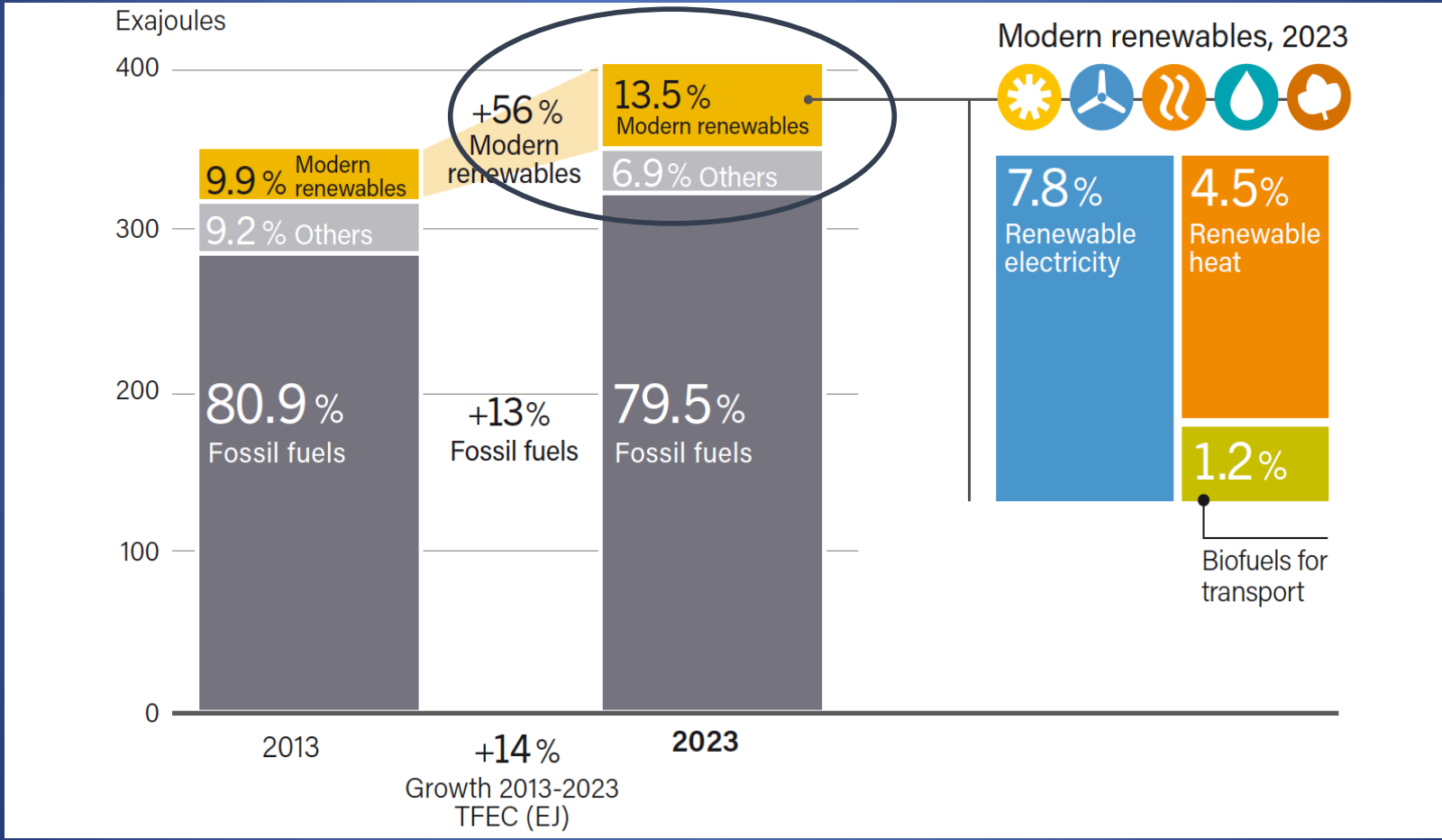


Source: Renewables 2025: Global Status Report, REN21

2024 data…

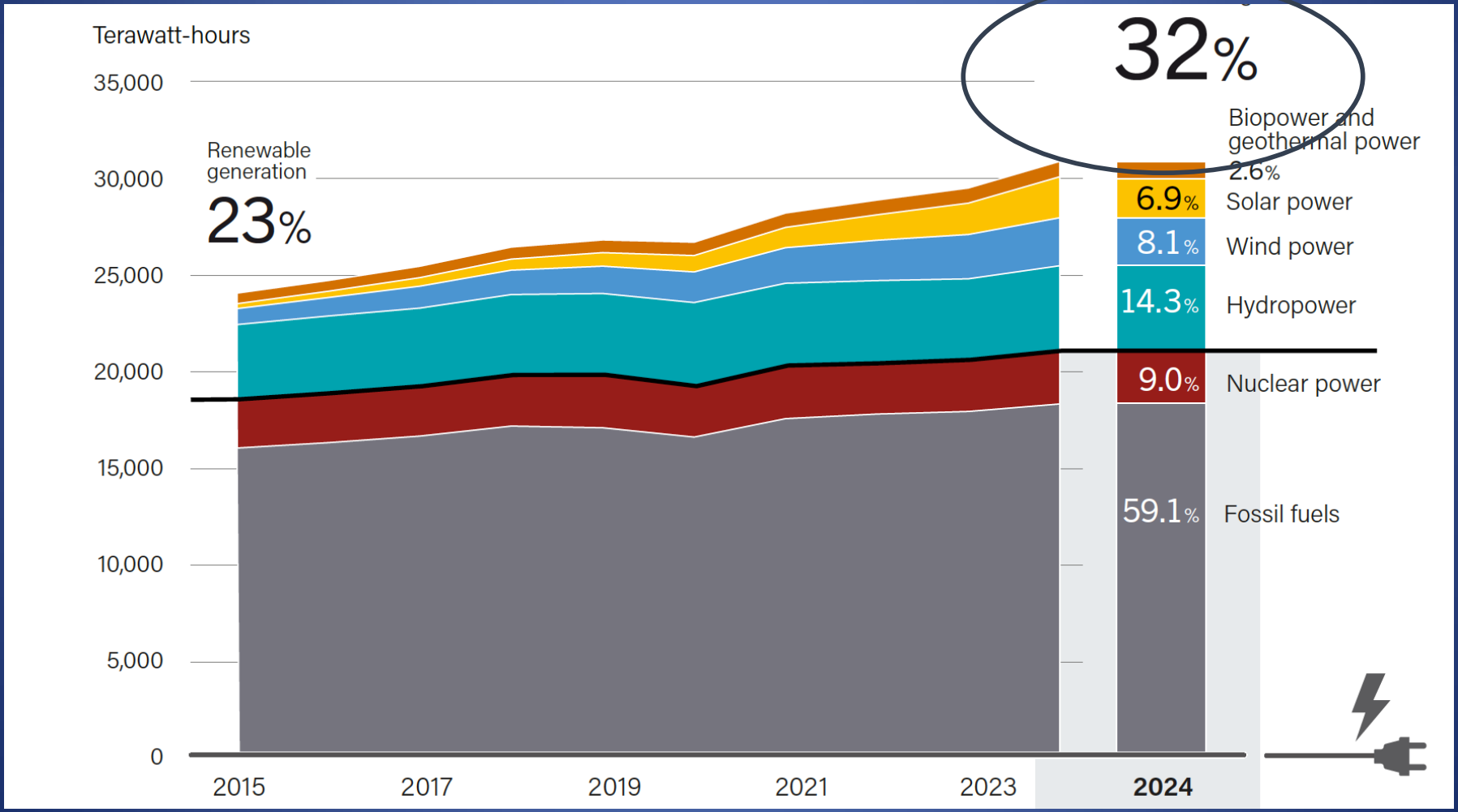
- A record 741 GW of renewable power capacity added in 2024!
  - By far the largest annual increase today.
  - PV accounted for more than three-quarters of that growth – due to falling technology costs and rising demand.
  - **Problem:** While renewable deployment is increasing, system transformation is not progressing so fast.
- In developing countries rooftop PV grew 22% → clearly indicating a shift towards decentralised energy systems.

Total Final Energy Consumption by Source



Source: Renewables 2025: Global Status Report, REN21

Electricity Generation by Energy Source 2015-2023

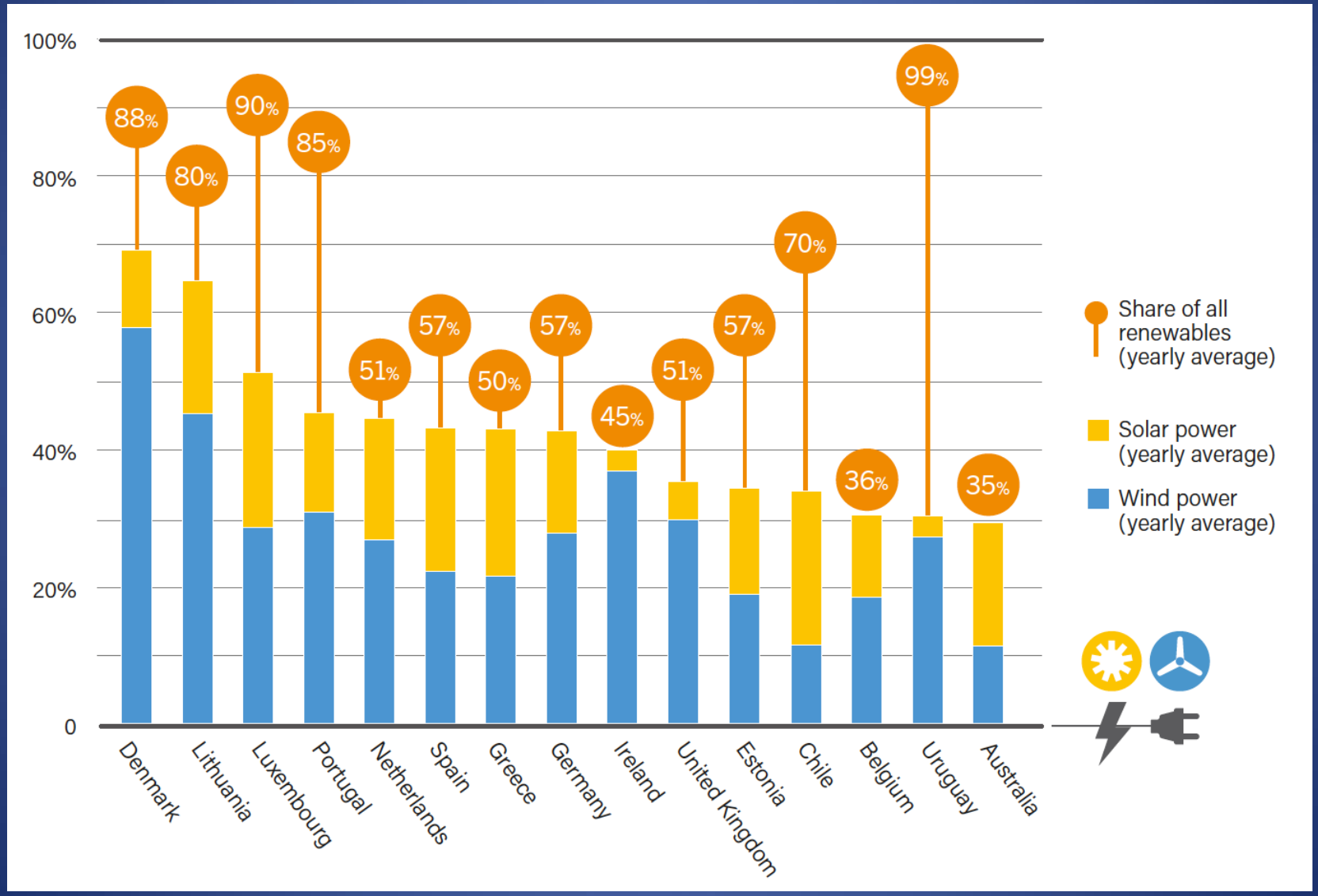


Source: Renewables 2025: Global Status Report, REN21

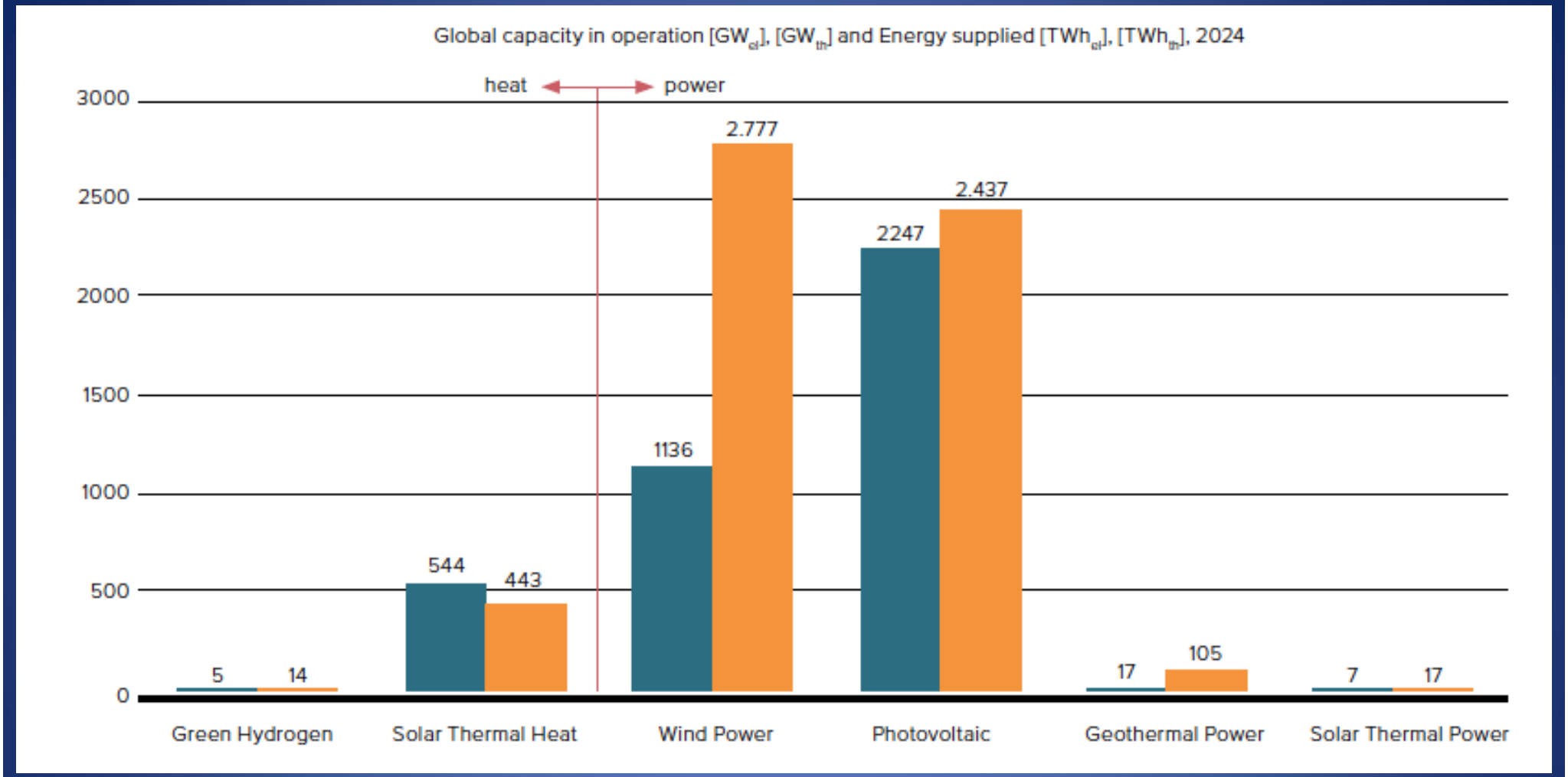
We need to do more…..

- Go beyond the power systems – heat and fuels account for more than three-quarters of total energy consumption.
  - Renewables only meet 5.7% of this demand
  - Renewables in transportation need to substantially increase
  - Electrification across end use is slow and uneven across sectors
- Long-term energy planning and institutional reform are needed to enable economy-wide energy transition and accelerate the shift towards renewables.
- **Positive sign:** Record global EV sales, representing more than 1 out of 5 car sales in 2024.

Countries with High Shares of Wind and Solar Generation in Their Power Systems, 2024

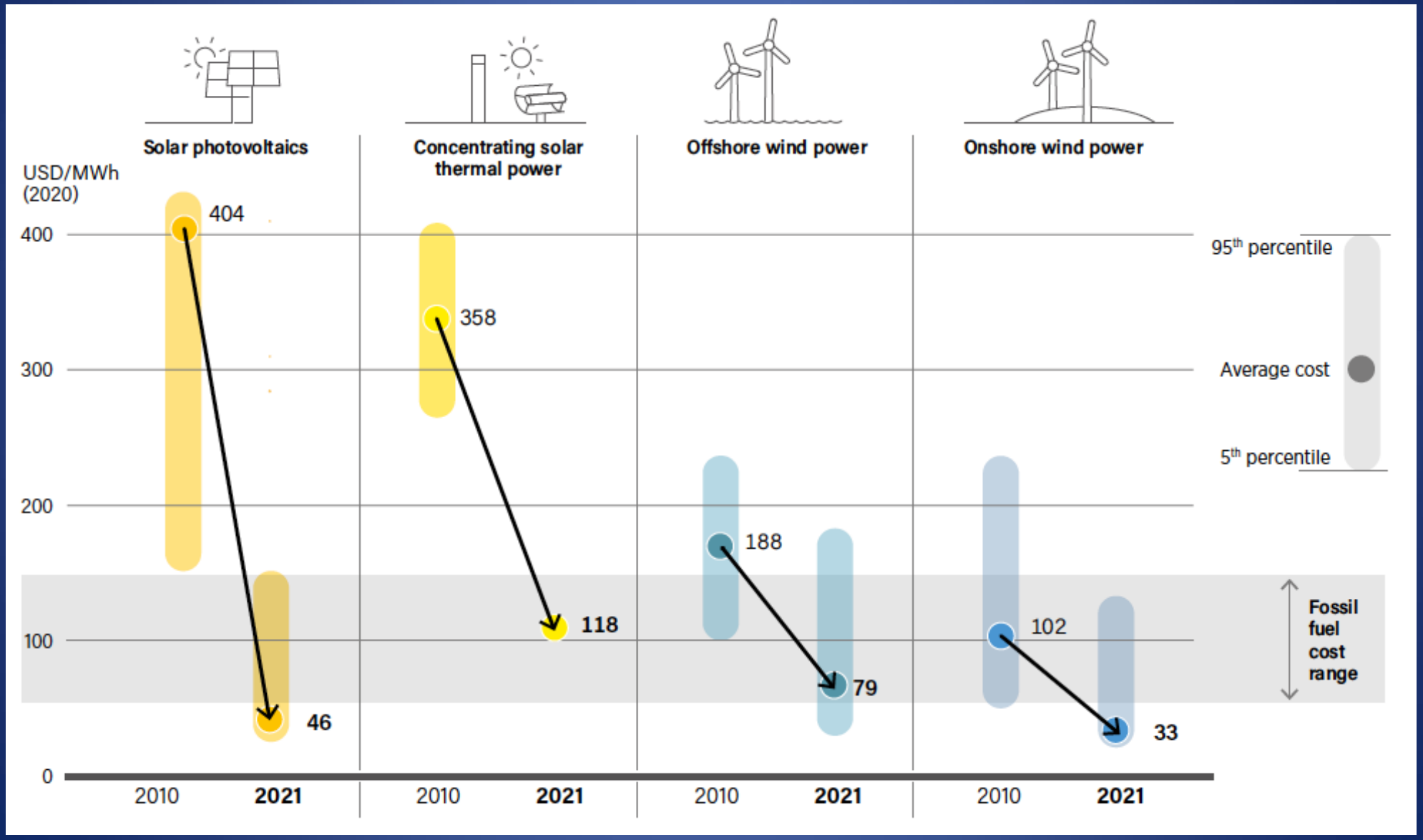


Source: Solar Heat Worldwide: Global Market Development and Trends in 2024, Edition 2025



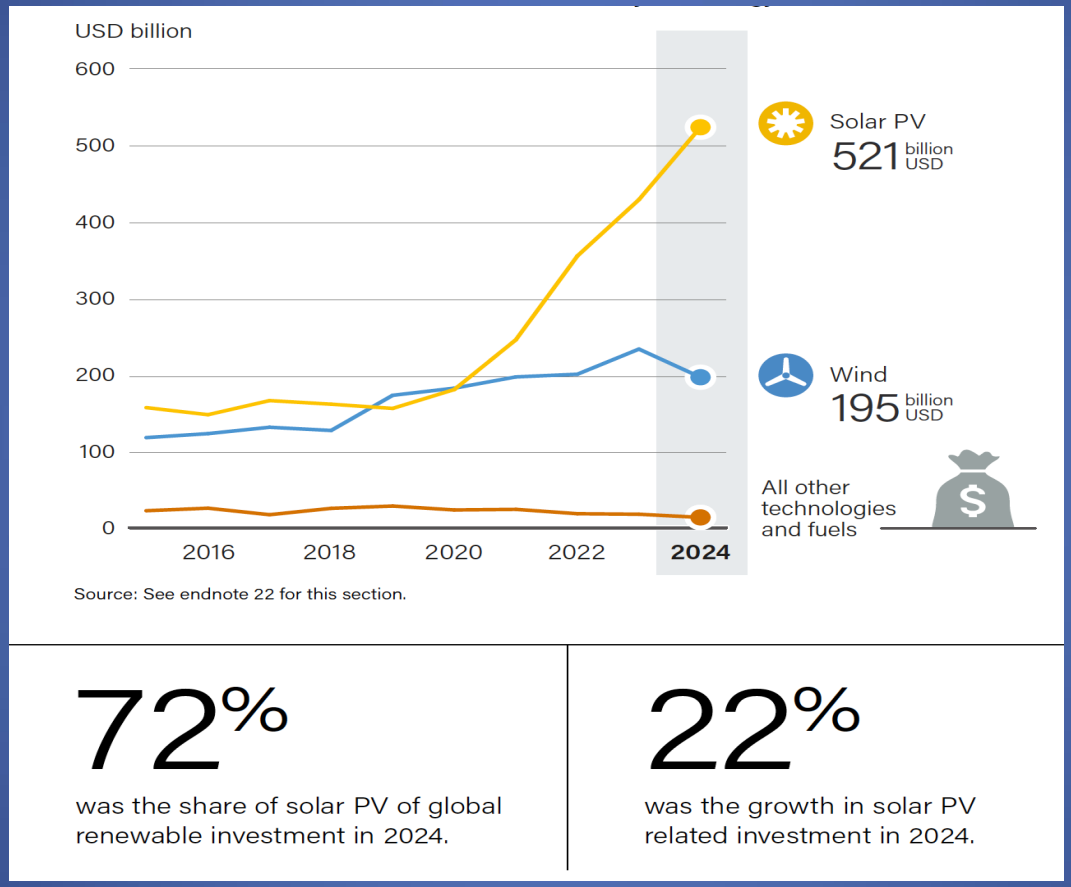
Source: Solar Heat Worldwide: Global Market Development and Trends in 2024, Edition 2025

Global Levelized Cost of Electricity (LCOE) for utility scale RES 2010-2021



Source: Renewables 2022: Global Status Report, REN21

Global Investment in New Power Capacity by type 2024

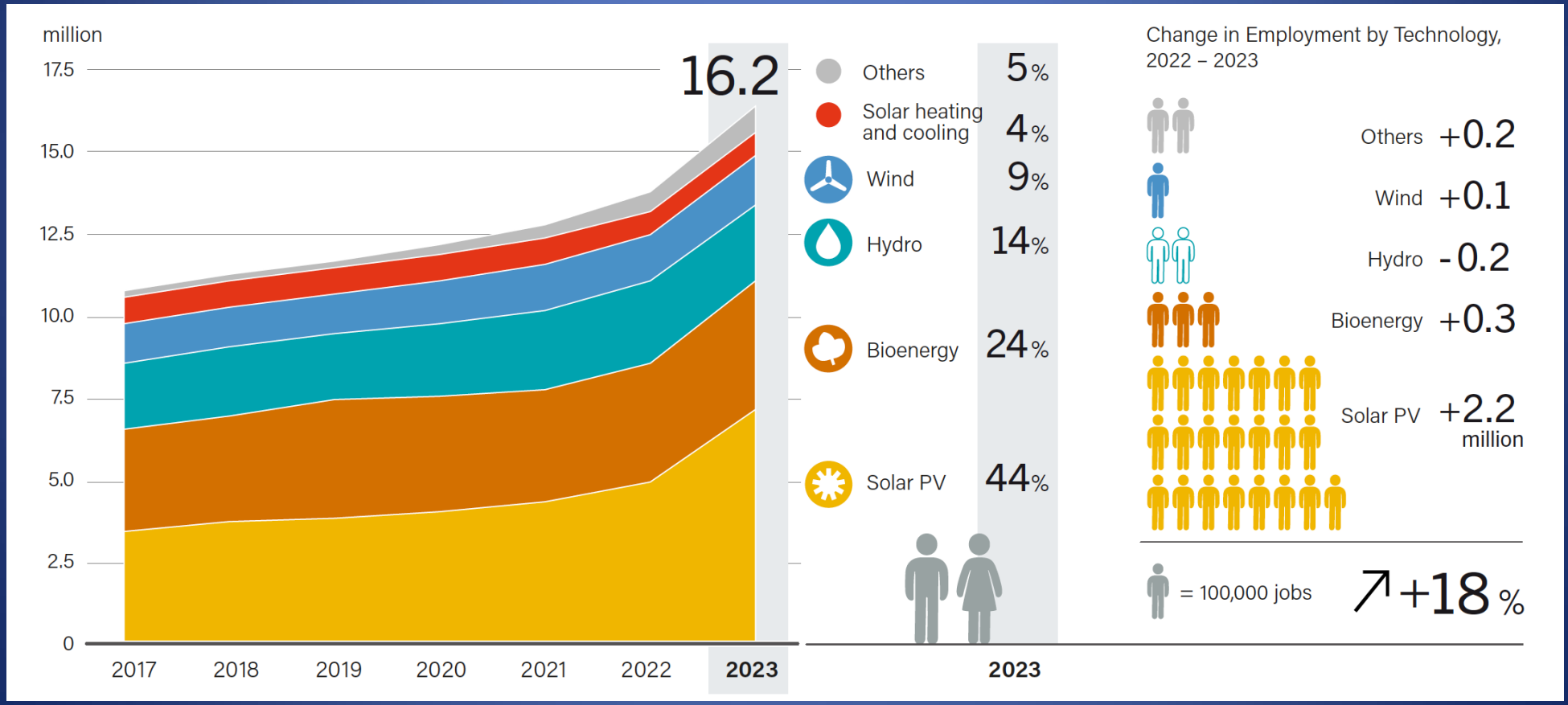


→Only 6% goes to investment on other technologires

Investment in 2024 reached 728 billion USD but remain concentrated in China, EU and the US.

Source: Renewables 2025: Global Status Report, REN21

Global Renewable Energy Employment, by Technology, 2017-2023



Source: Renewables 2025: Global Status Report, REN21

Warning!

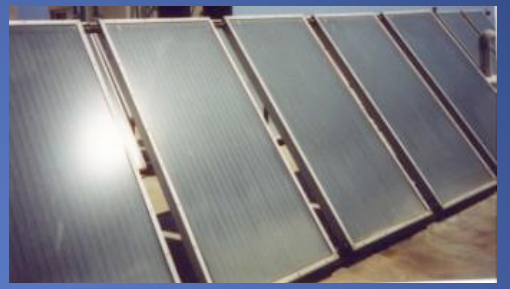
- Although we are deploying renewables in record numbers we are not building the systems needed to transition to a renewable-based economy.
- **Need:**
  - Coherent policies,
  - Coordinated planning, and
  - Resilient infrastructure including mainly grids and storage.
    - Example: PV-EV chargers can help to reduce grid loading and improve stability
- Renewables must be treated as core economic infrastructure which is essential for energy security, resilience and prosperity.
- Need to align policies and planning the soonest, to support a full transformation of economies and soceities.

Solar Thermal Power

- Systems utilising either the thermal radiation or the light of solar irradiance.
- Solar thermal systems
  - *Low temperature* systems (mostly for water heating and industrial processes)
  - *High temperature* systems (mostly for CSP and high temperature industrial processes)
- Solar photovoltaics

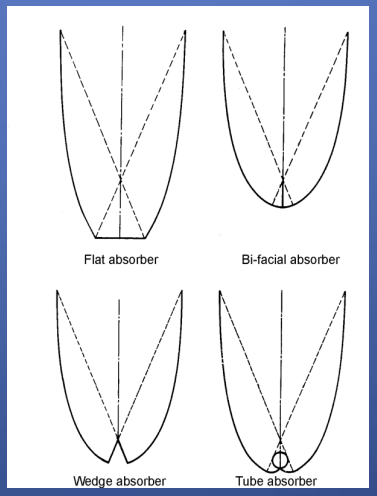
Low temperature collectors

- Flat plate collectors

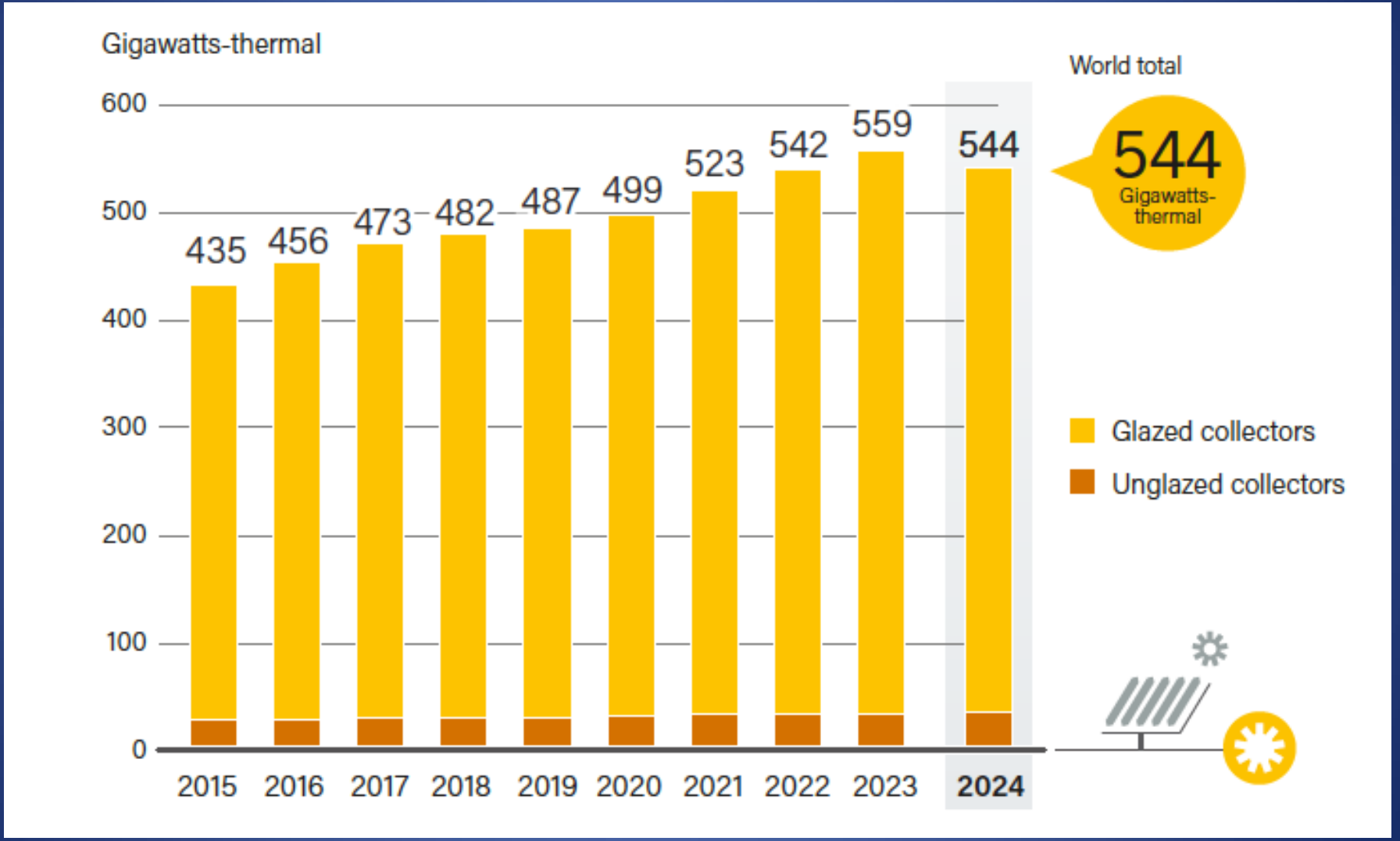


- Evacuated tube collectors

- Compound parabolic collectors



Solar Water Heating Collectors Global Capacity, 2015–2024



Source: Renewable 2025: Global Status Report, REN21

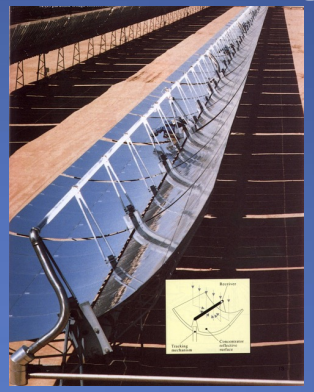
Solar water heating in Cyprus
A success story

Research led to several new innovations

- Use of polymeric materials for the manufacture of solar thermal absorbers to:
  - reduce cost due to lower raw material and manufacturing costs.
  - reduce weight compared to copper or aluminium.
- New transparent covers with anti-reflective coatings for high optical transmission.
- Development of new selective absorber for high absorptance and low emission coatings.
- Vacuum insulation for flat-plate collectors
  → use of high vacuum or noble gases

High temperature systems

- Parabolic trough collector



- Linear Fresnel collector

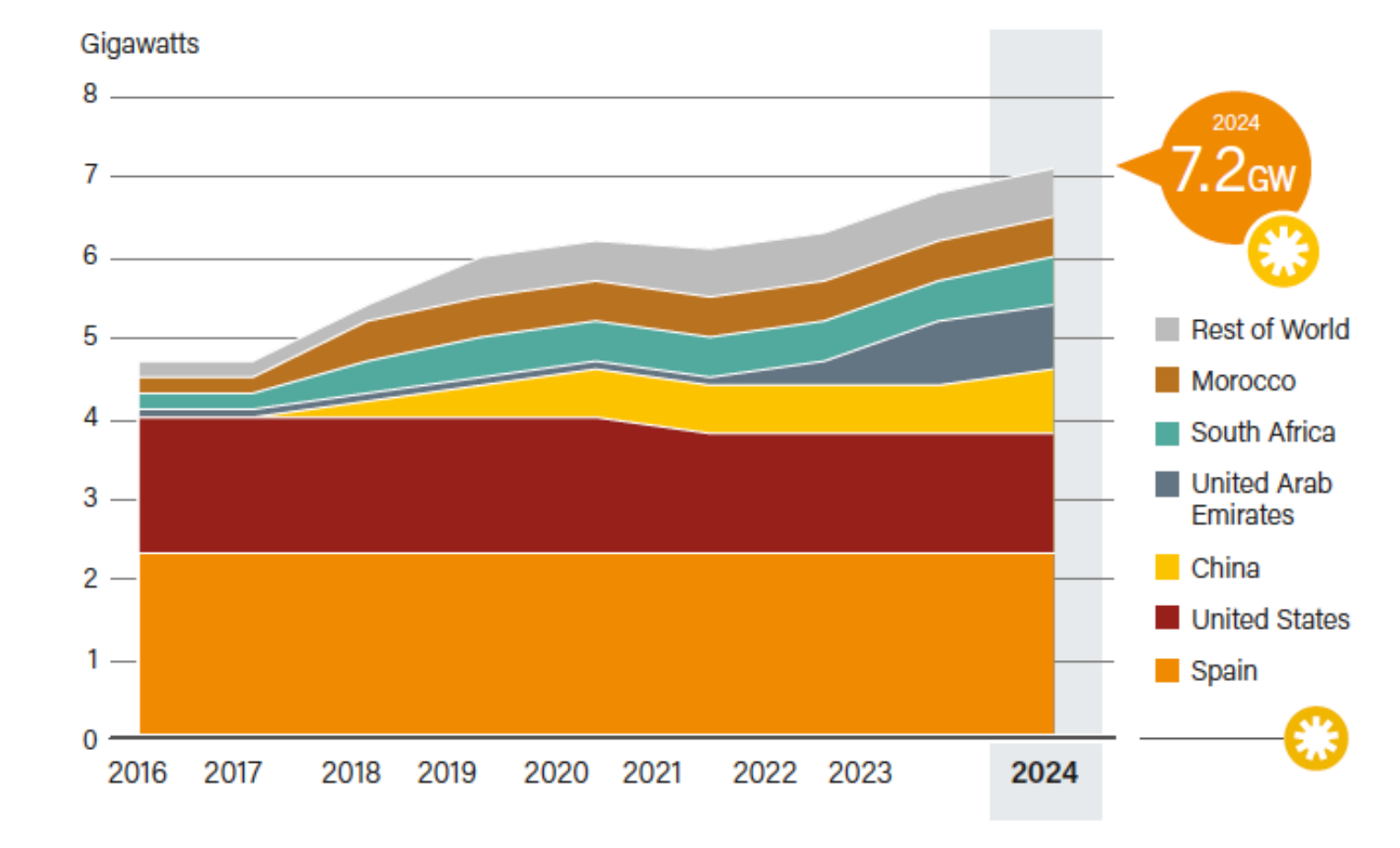
- Solar dish

- Solar tower

Solar Two

Gemasolar

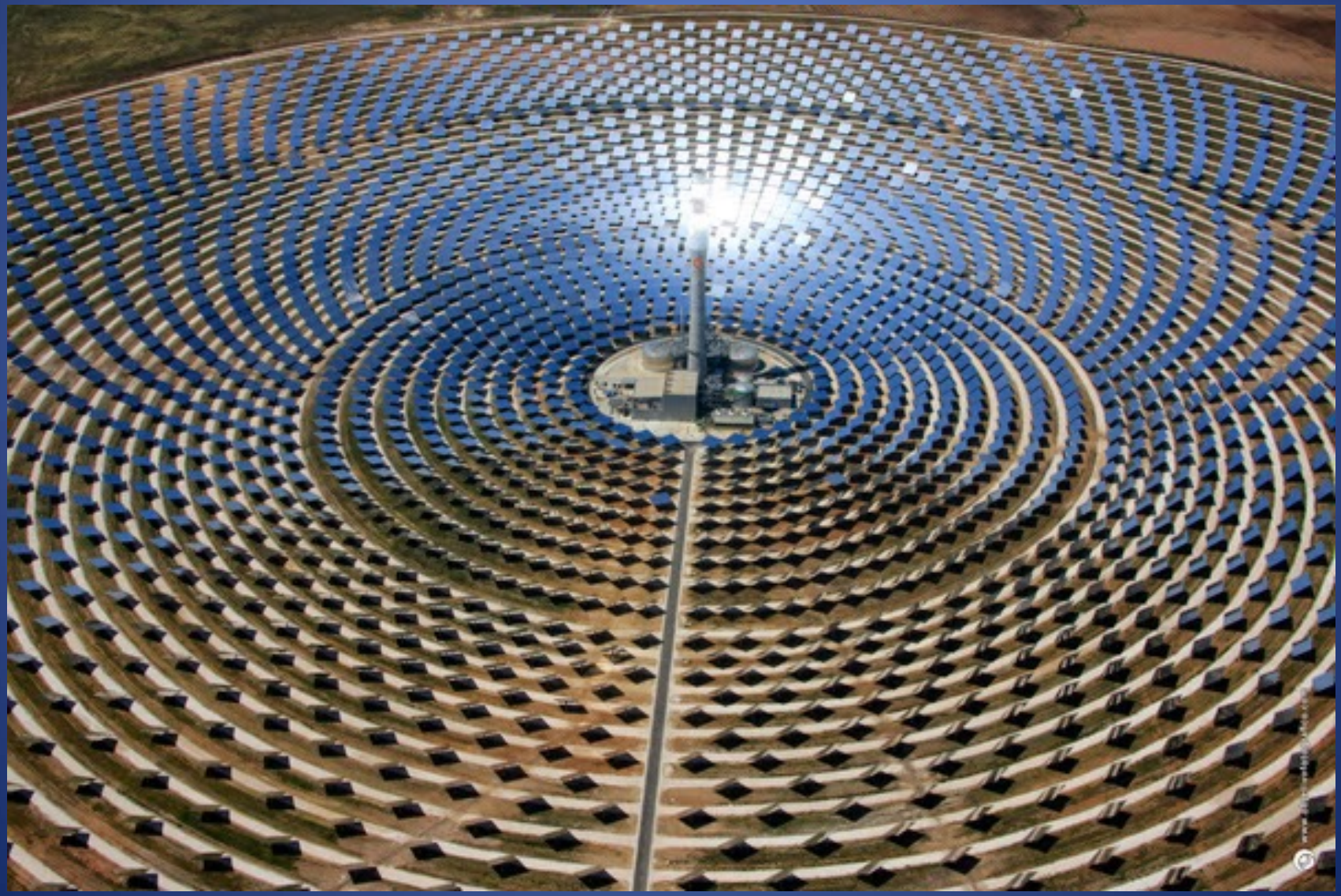
Concentrating Solar Thermal Power Global Capacity, by Country/Region, 2016–2024



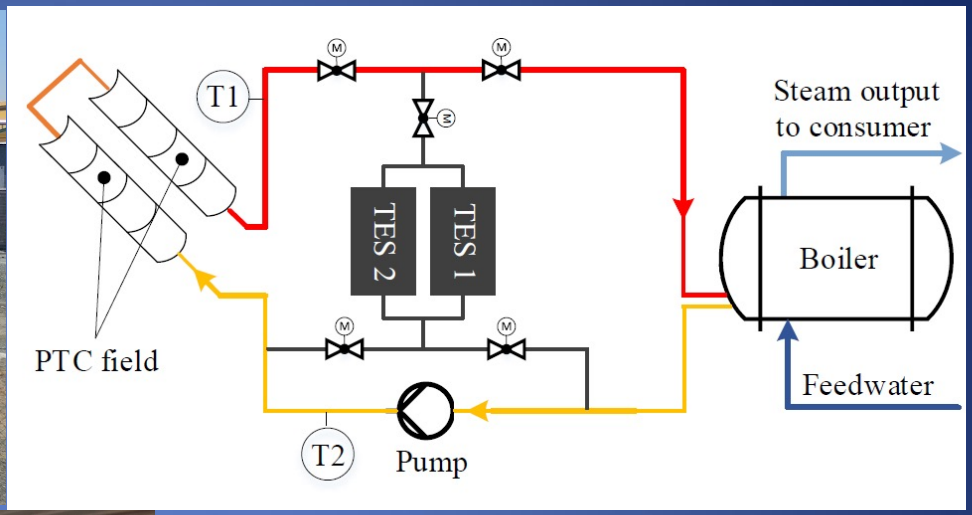
→ **Many CSP systems are under development in many countries of the world**
→ **All new facilities incorporate thermal ENERGY STORAGE**

Source: Renewables 2025: Global Status Report, REN21

Biggest CSP: Noor Ouarzazate Solar Complex, Morocco (2018), rated capacity: 510 MW, and thermal storage capacity of 3005 MWh, enabling a discharge of 5.9 hours



Industrial Process Heat-Solar Juice



Storage and plantroom containers

Concrete storage

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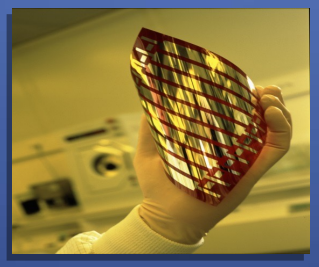
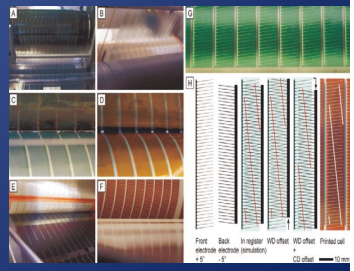
Photovoltaics

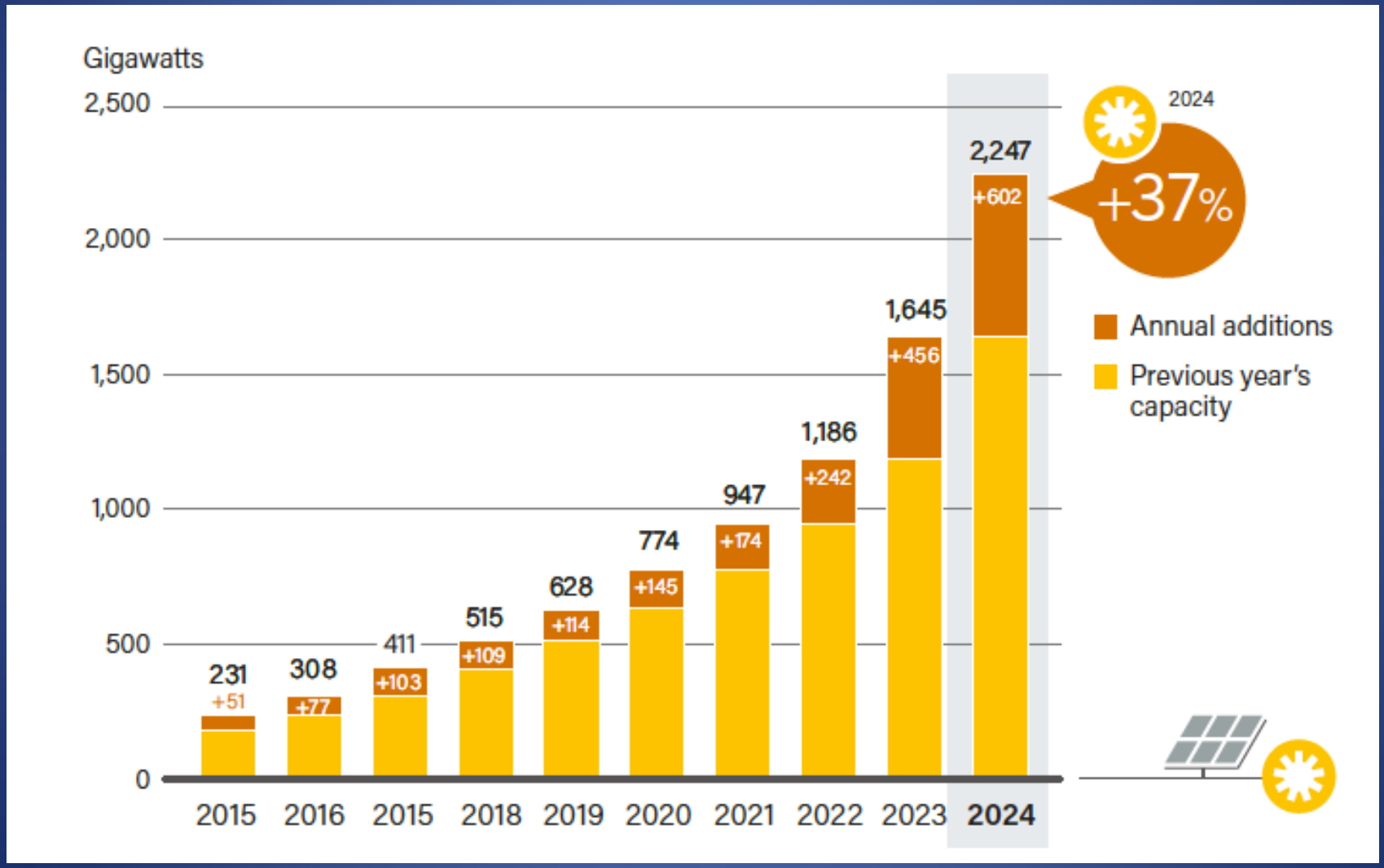
- Four basic technologies:
  - Polycrystalline silicon cells
  - Monocrystalline silicon cells
  - Amorphous silicon cells

  - Other thin film cells



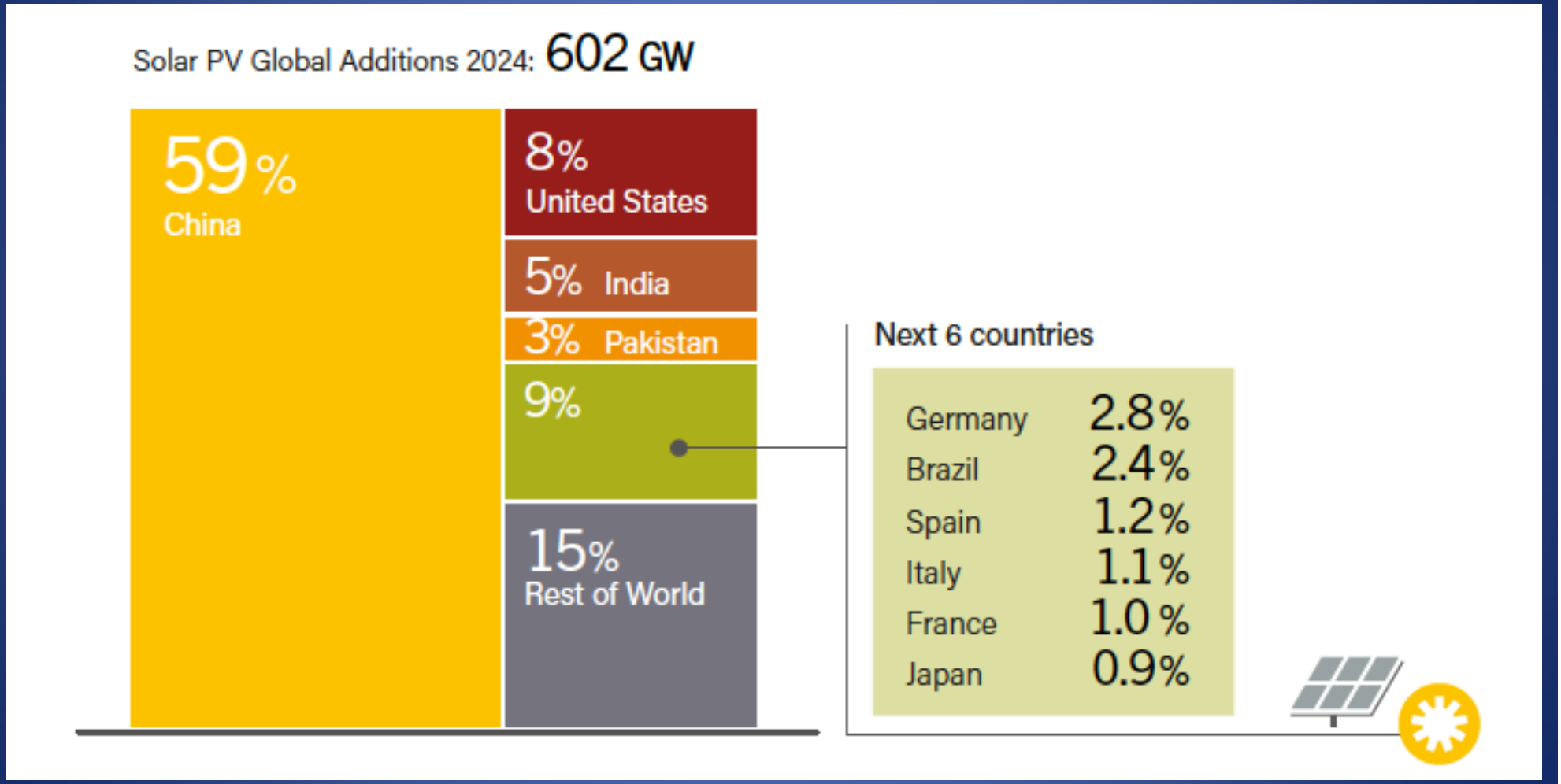


Solar PV Global Capacity and Annual Additions, 2015-2024



Source: Renewables 2025: Global Status Report, REN21

Solar PV Global Capacity, Top 10 countries and Rest of the World, 2024



Source: Renewables 2025: Global Status Report, REN21

Current PV Research:

- Higher performance cells/modules
- New nanomaterials applications
- Advanced manufacturing techniques
- Trend towards very large systems

Kurnool Ultra Mega Solar Park, India – 1000 MW, 2017

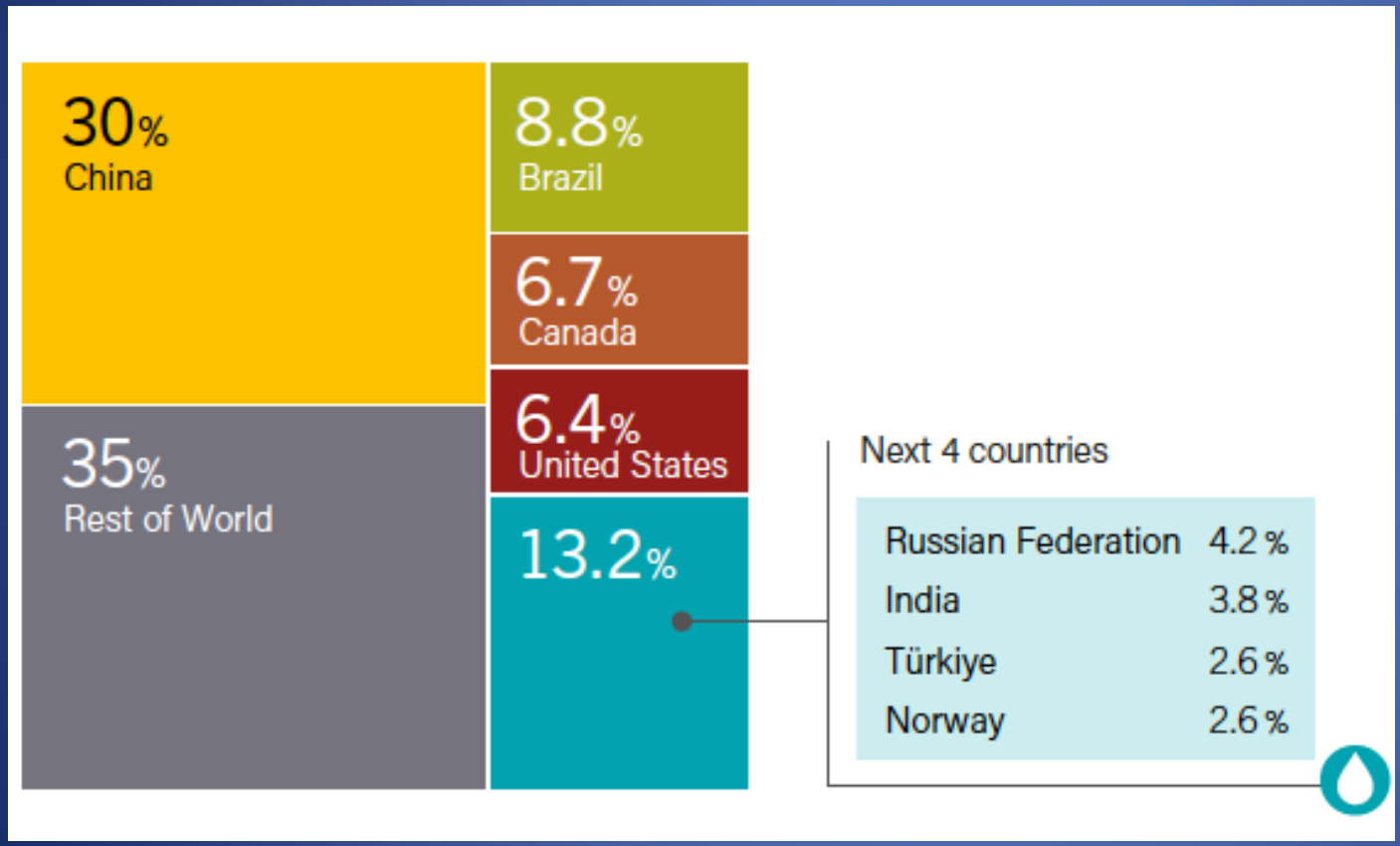
Tengger Desert Solar Park – 1547MW – China

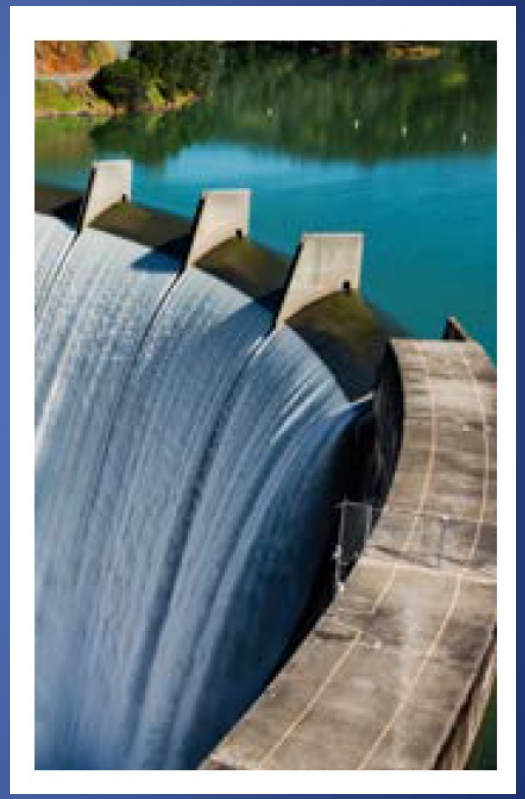
The largest solar power plant in the world right now.
Installed in Zhongwei, Ningxia.
Tengger desert (Inner Mongolia).
The area of the solar field is 1,200 km^2

Hydro Power

- **Comes in a variety of sizes:**
- **<u>Large</u> Hydro (>10 MW)**
  - 18 GW scheme at the Three Gorges, China (largest) now expanded to 70 GW
  - An example of Large Hydro (> 10 MW)
- **<u>Small</u> Hydro (1 – 10 MW)**
- **<u>Mini</u> Hydro (100 kW – 1 MW)**
- **<u>Micro</u> Hydro (< 100 kW)**
- **And finally, <u>Pico</u> Hydro (< 5 kW)…**

Hydropower Global Capacity, Shares of Top 10 Countries and Rest of World, 2024

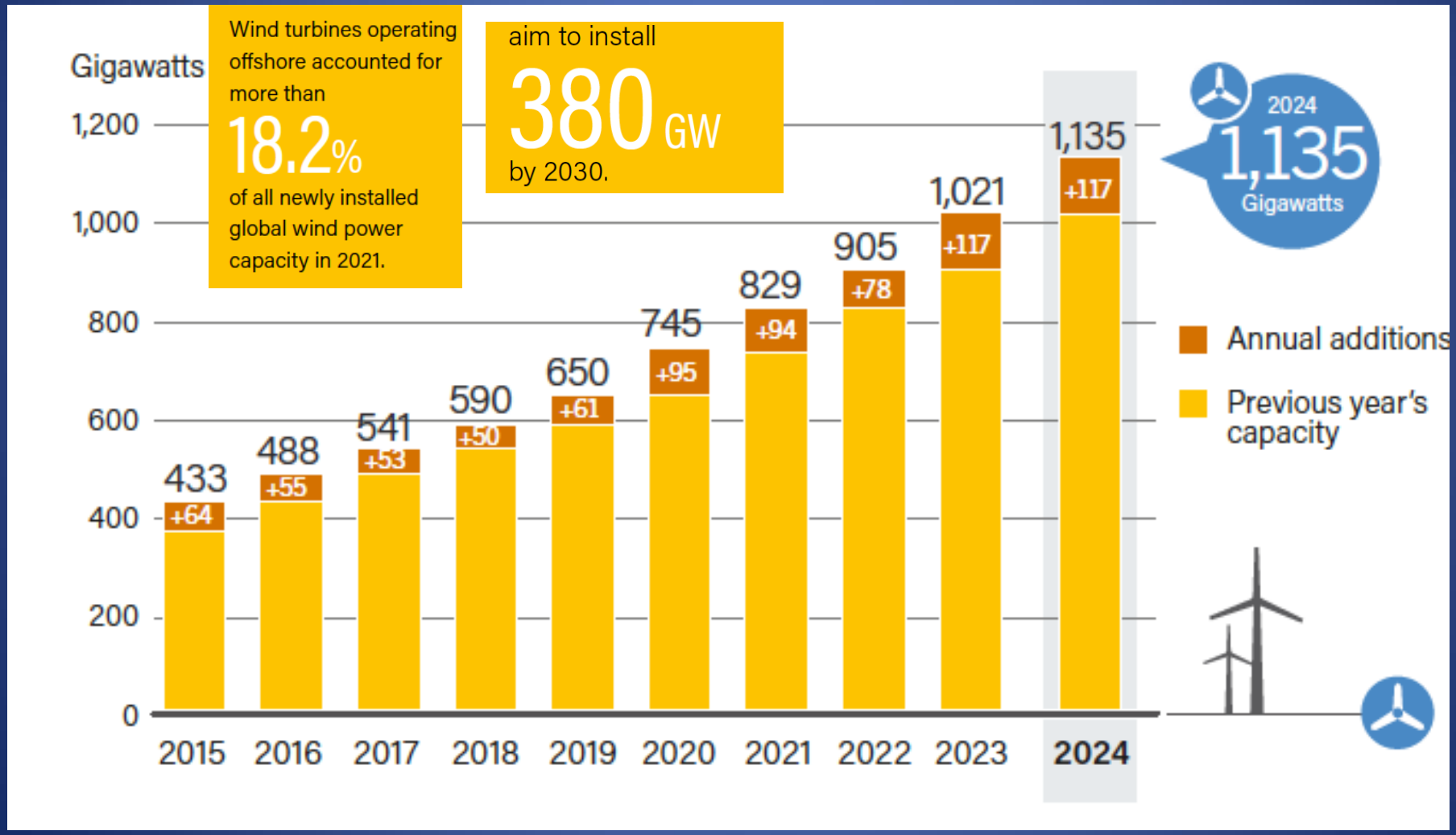




Source: Renewables 2025: Global Status Report, REN21

Wind Power

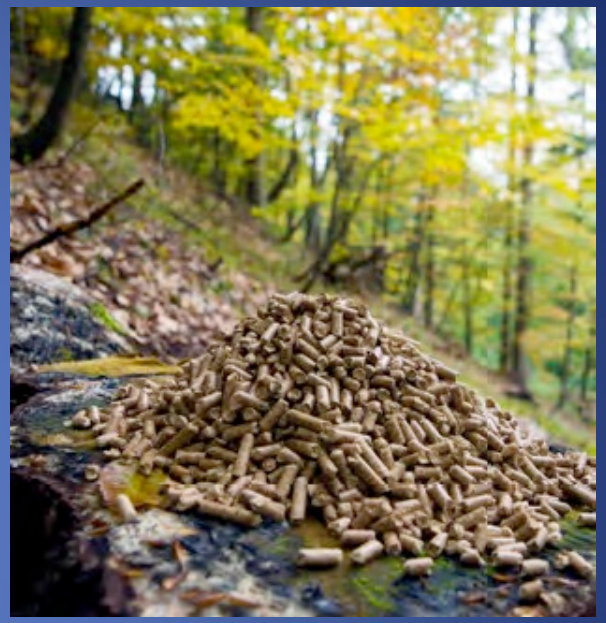
Wind Power Global Capacity and Annual Additions, 2015–2024



Source: Renewables 2025: Global Status Report, REN21

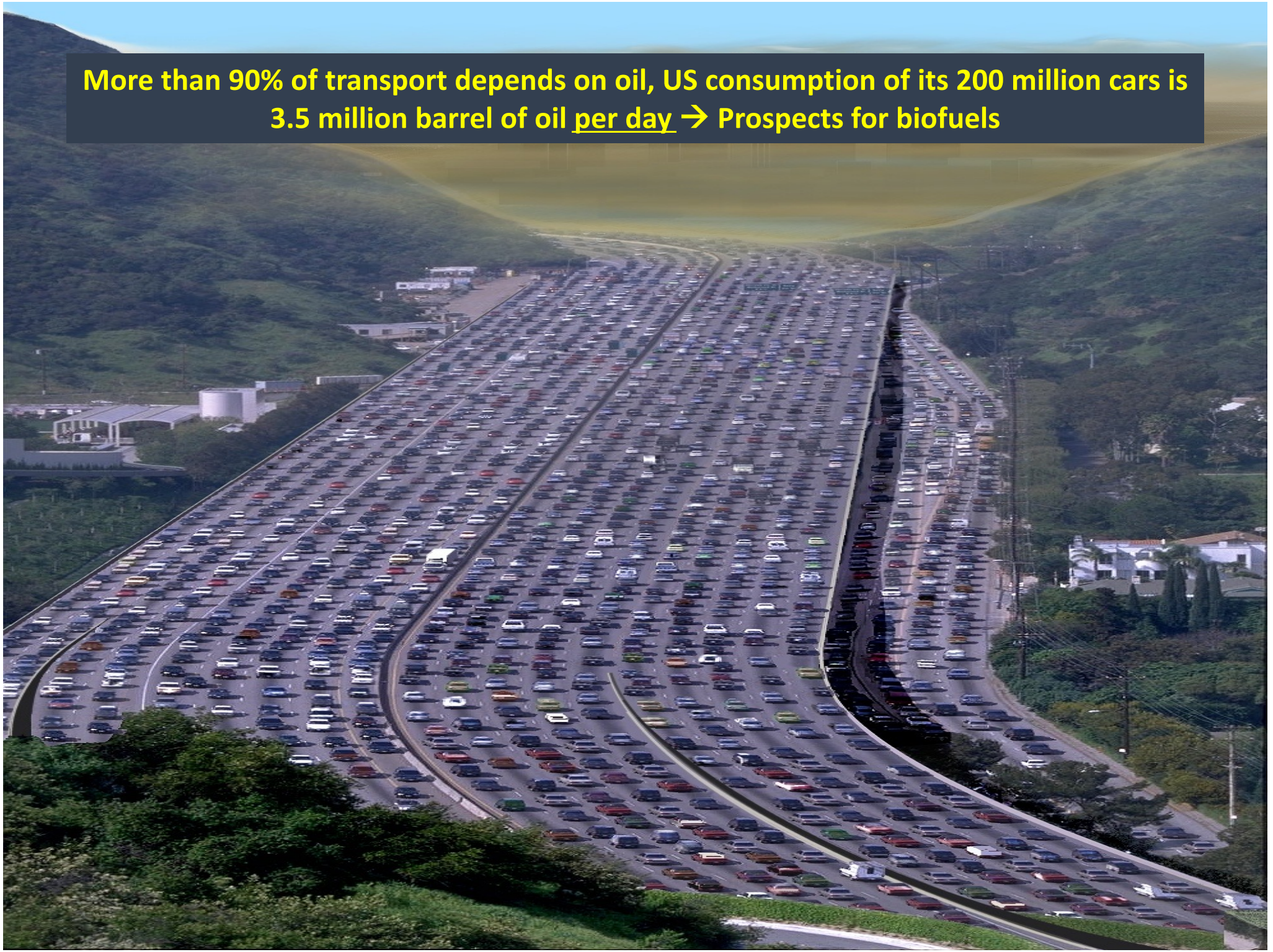
Biomass

- Main areas:
  - Biomass
  - Biogas
  - Biofuels (biodiesel)
  - Waste (MSW, landfills [?])

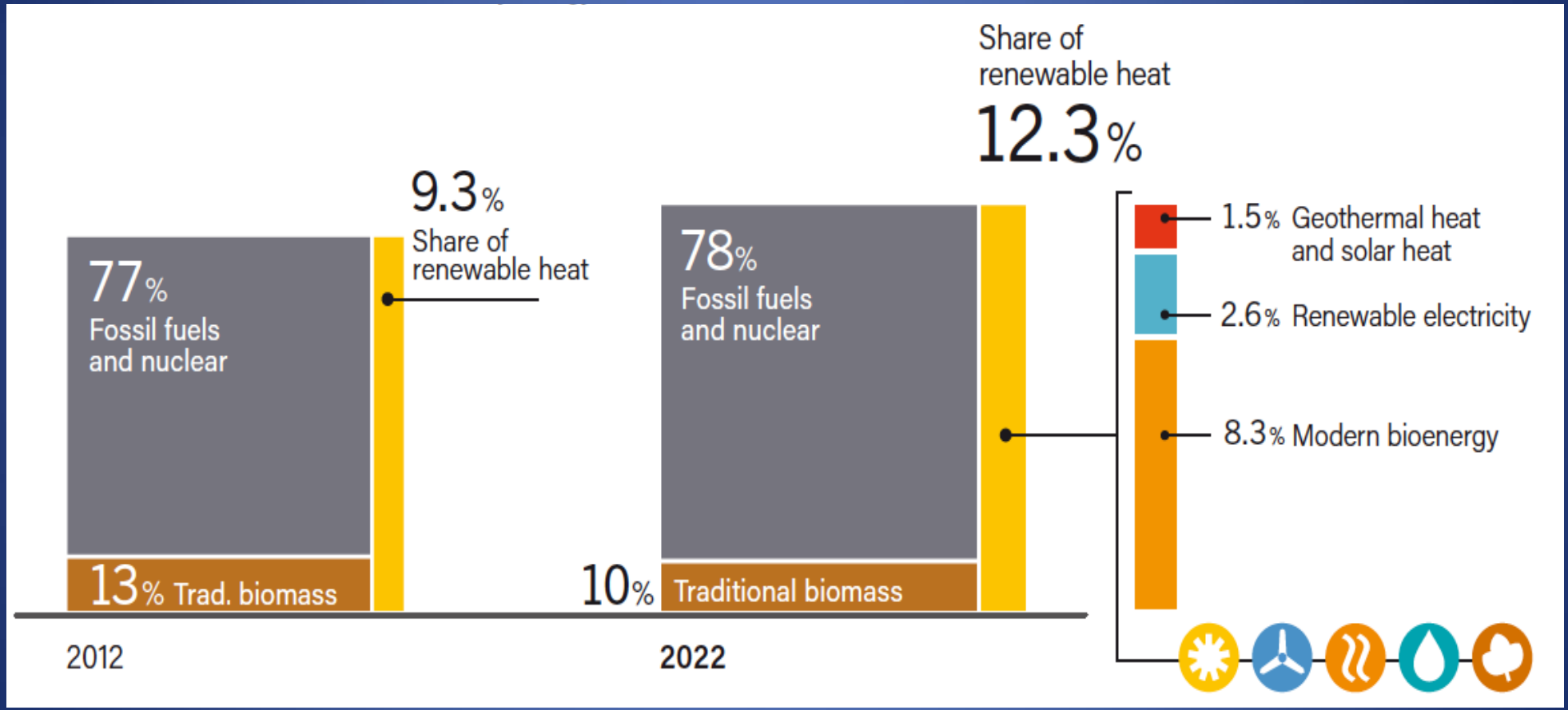


Biomass – Question food for fuel?

→ Land availability for energy crops

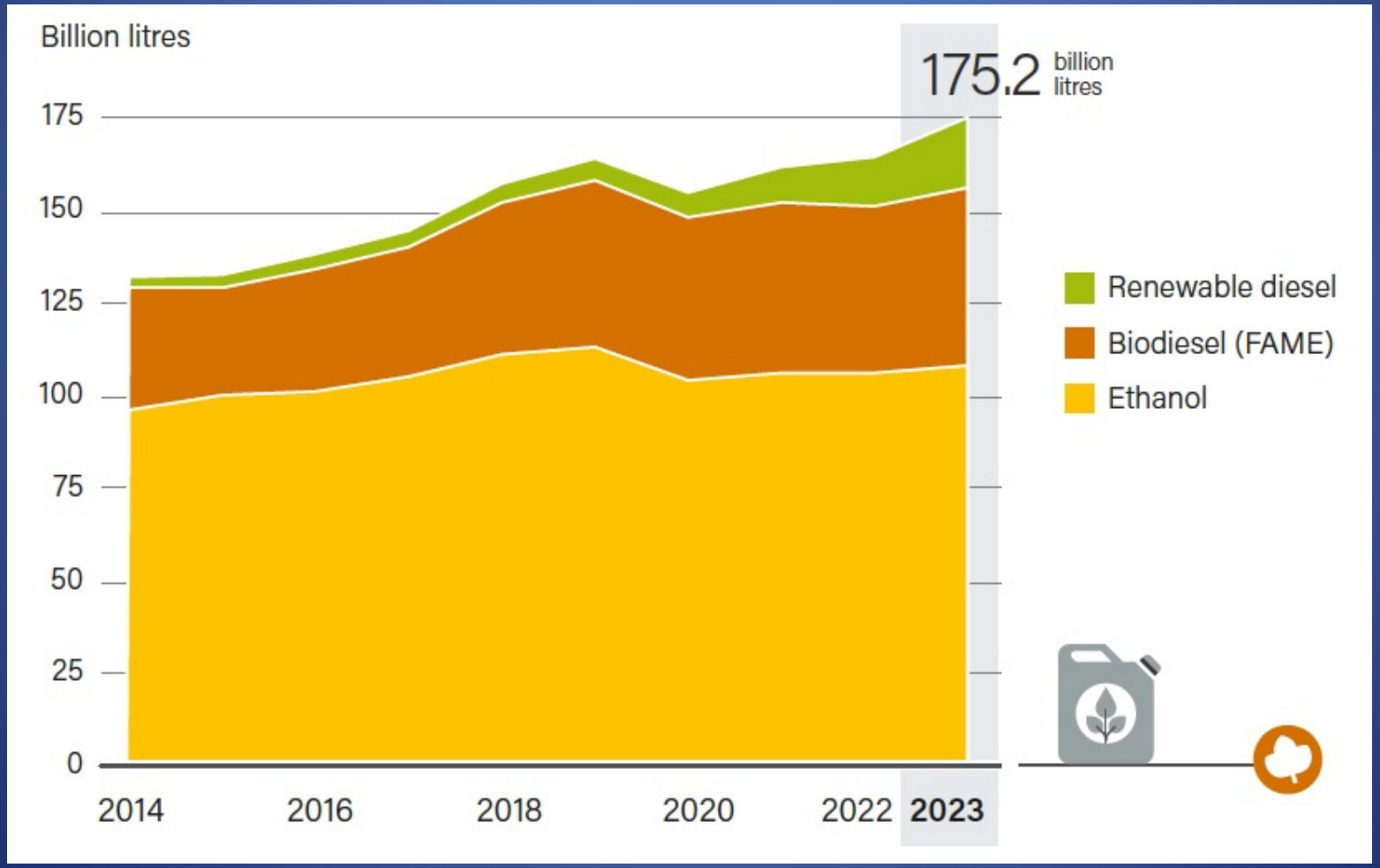

More than 90% of transport depends on oil, US consumption of its 200 million cars is
3.5 million barrel of oil per day → Prospects for biofuels

Shares of Bioenergy in Total Final Energy Consumption, Overall and by end-use sector, 2022



Source: Renewables 2025: Global Status Report, REN21

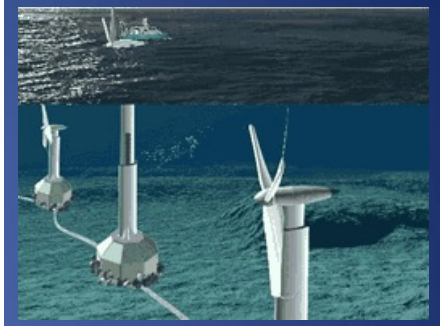
Global Production of Ethanol, Biodiesel and Renewable Diesel 2014-2023



Source: Renewables 2025: Global Status Report, REN21

Other areas of renewables

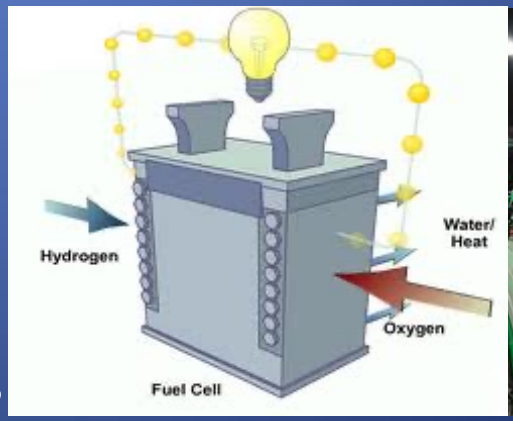
- Ocean energy systems
  - Wave, tidal energy conversion, OTEC
  - Total capacity: 513 MW (2024)



- Geothermal
  - Global capacity: 15.1 GW (2024)

- Hydrogen

Used both for storage and Fuel Cells



PV powered EV Charging

- PV powered EV charging stations, combine onsite solar electricity generation with EV charging infrastructure, are a sustainable solution for electric vehicle adoption, offering several benefits:
  - Reduction in Greenhouse gas emissions (clean PV electricity).
  - For house PV systems close to zero transportation cost.
  - Smart Charging Control: Possibility to apply smart charging strategies like V2G services, which enhance grid flexibility and maximise solar energy utilisation.
  - Possibility for integration with microgrids providing a more efficient and sustainable energy solutions.
  - At a bigger scale there are specific challenges for charging Electric Busses with solar energy which offer the potential for these stations to drive sustainable mobility.

Hydrogen busses: The Future of Clean Public Transport

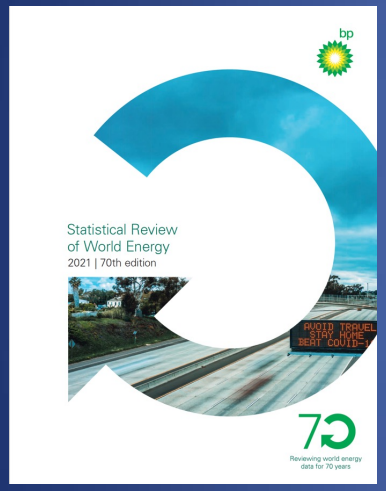
- Hydrogen fuel cell buses are a promissing solution for urban trnsportation, offering zero-emission operation and ability to cover long distances without frequent refueling.
- Refueling is a quick process-advantage over EV charging.
- Routes within cities eliminate potential hazards because of the use of hydrogen.

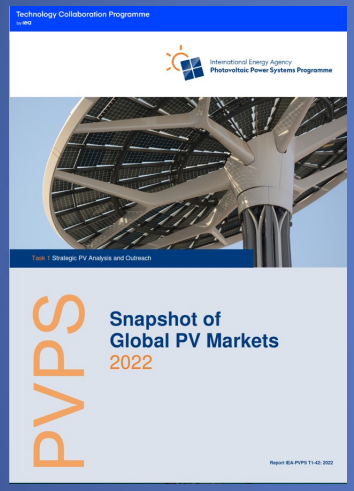
Prospects - Hot research areas

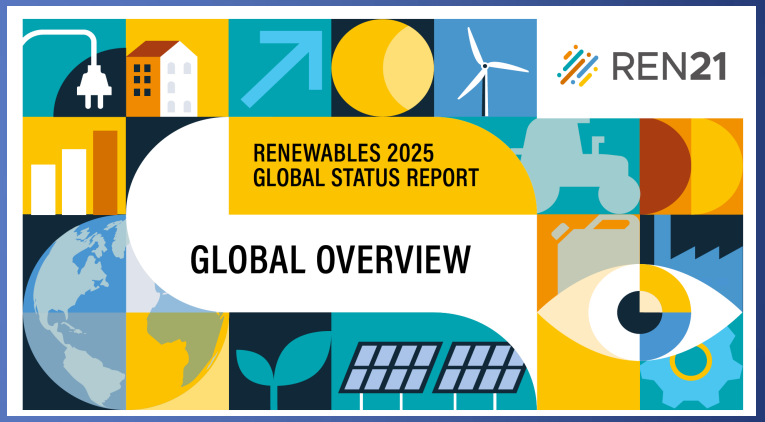
- Main purpose:
  - Increase efficiency of various RE technologies
  - Design renewable energy components at lower cost
- Extensive use of RES (many regions, even countries consider transformation into 100% renewables)
  - High shares of renewables
  - Power system transformation
  - Storage/integration (smart energy systems)
  - Develop large-scale smart regions – like smart cities
- Effective coupling not only for electricity but also heating + cooling and transportation

Acknowledgements

- Main reports used for this survey:







Concluding:

- → There are a lot of possibilities to utilise effectively renewable energy technologies
- → These are nowadays more cost-effective options than conventional fuels
- → We should never underestimate the climate problem
- → It is in our hands to utilise renewables effectively

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Final conclusions

- The energy transition is an oportunity to transform our countries economies.
- Renewables can be viewed as catalysts of system change but need governments to align behind long-term strategies.
- **Conclusion:** Governments, industry and international institutions need to move beyond deployment targets and commit to system wide reform which should include:
  - Long-term energy planning
  - Modernising grids
  - Investment in storage
  - Reducing energy consumption
  - Eliminate financial barriers
  - Moving away from fossil fuels and accelarate shift to a reneable-based economy.

Thank you for your attention

I will be happy to answer questions…

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