LES ATELIERS DU FUTUR

ADF

Quarterly Climate Review #3

Green Technologies:

Recent Developments and Outlook

June 2025

Green Techs:

Recent Developments and Outlook

GREEN TECHNOLOGY DEPLOYMENT MOMENTUM FACING HEADWINDS TO MEET REQUIRED PACE OF DECARBONIZATION

Many risks are surging concerning almost all green technologies, and their mitigation is more complicated in the present **geopolitical instability**, not only in **developed countries** but also in **developing countries.**

Renewable energies

If the development of ***solar power is in line with the NZE trajectory***, the ***wind power market is struggling*** more except in China, both for on-shore wind (penalized by the complexity and length of authorization procedures) and for offshore wind (increase in costs of materials, labor and interest rates, new US administration's "Zero-wind" policy…). And a new risk appears for renewable energy projects: if the ***necessary investments in transmission grids*** (expansion and modernization) are not made at the right pace, this could lead to a ***bottleneck*** in the development of renewable energies.

Stationary storage:

Despite a rather dynamic development of projects, **the bar to jump is so high** that it is imperative to deploy alternative solutions to batteries because Lithium resources are not infinite. Without waiting for new battery technologies, mature solutions exist, in particular by accelerating on switchable renewable energies (geothermal energy, biogas, biomass, etc.) and on the storage of heat and cold (geothermal energy with active recharge, thermal storage wells, etc.).

Biogas and biomethane:

Being both a green fuel for heavy vehicles and a mature, switchable and interesting renewable energy for heavy industry decarbonization, **we must strongly accelerate (x3.7)**, especially since it is also a solution for waste treatment issue and a source of income for the agricultural sector. **The EU objective is ambitious but not binding**. We should increase support for this sector to develop "*Biomethane Purchase Agreements*".

Electric vehicles

While the market is still expanding, a combination of rising costs, reduced governmental support, infrastructure challenges, and technological uncertainties pose ***real risks to continued rapid growth***. Overcoming these hurdles will require coordinated efforts across industries and governments, focused on continuity in policies, improving affordability, building charging infrastructure, and advancing battery technology.

Low carbon hydrogen:

Europe is clearly lagging behind and risks missing out on this new market whose development is essential to achieve the NZE (storable green energy, solution to decarbonize part of heavy industry, green fuel for heavy vehicles, aviation fuel after recombination with biogenic CO2, etc.). Clarification and simplification of European support policy to hydrogen projects is essential.

Critical materials:

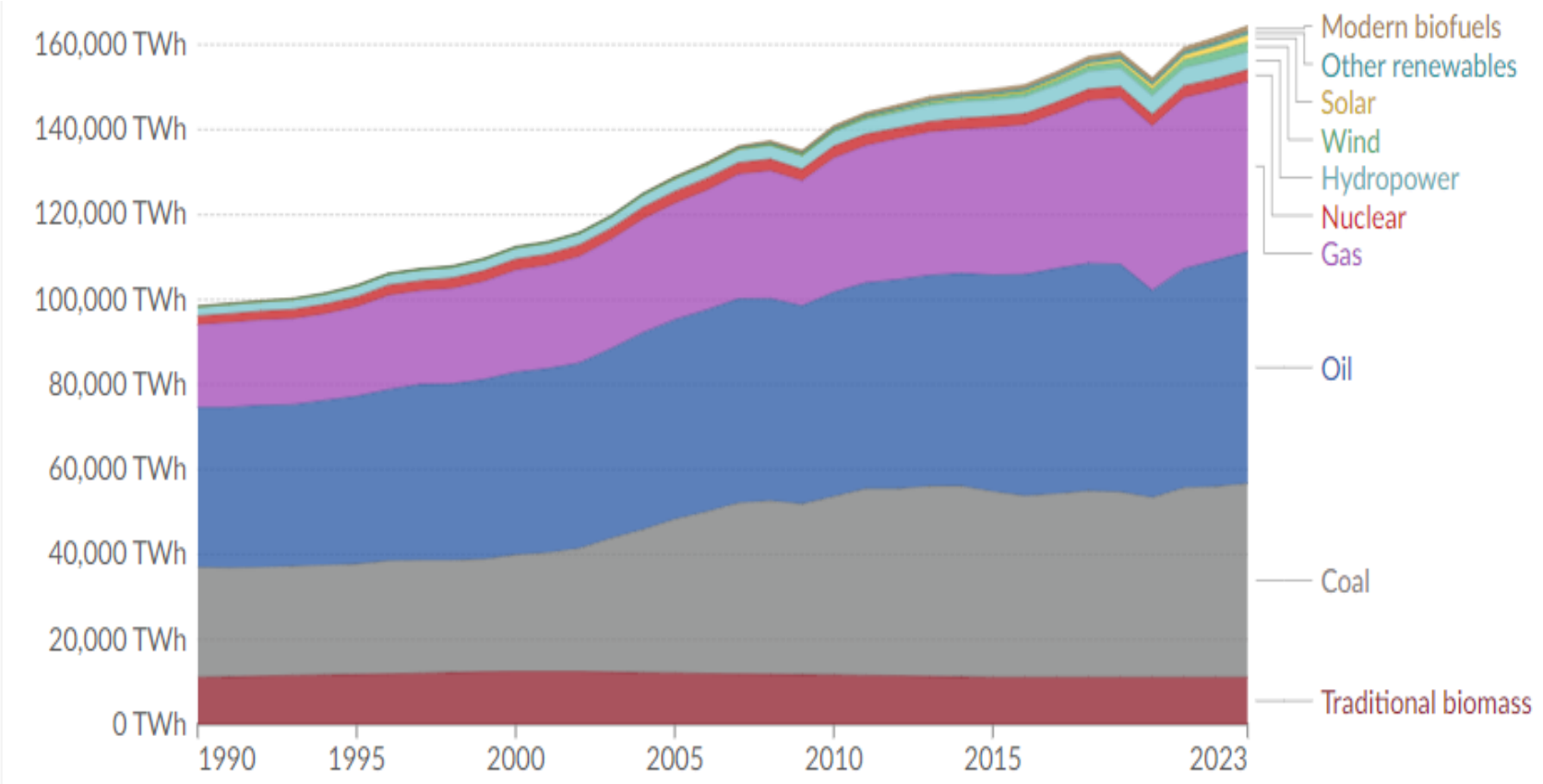
To avoid developing new dependencies on a very small number of countries, we must accelerate on 3 levers: the **search for new mining resources**, particularly in developed countries, to **diversify the supply sources**; strongly encourage the recycling of critical materials; **develop alternative technologies** that consume less critical metals.

R&D and Innovation:

According to the IEA, **35% of the emissions reductions expected in 2050 will come from technologies not yet commercialized**. It is therefore appropriate to continue R&D at a high rate in all developed countries, both to achieve the NZE objective, but also to avoid developing new technological dependencies on a small number of countries.

GLOBAL PRIMARY ENERGY CONSUMPTION STILL 80% FOSSIL – THE RENEWABLE CAPACITY ADDITIONS DOUBLED DURING THE LAST 3 YEARS, COVERING THE INCREASE OF ENERGY CONSUMPTIONS

Global direct primary energy consumption [TWh*)



The share of carbon-free energies in the global mix **has doubled in ten years**, but they only represent **less than 20% of primary energies consumed**

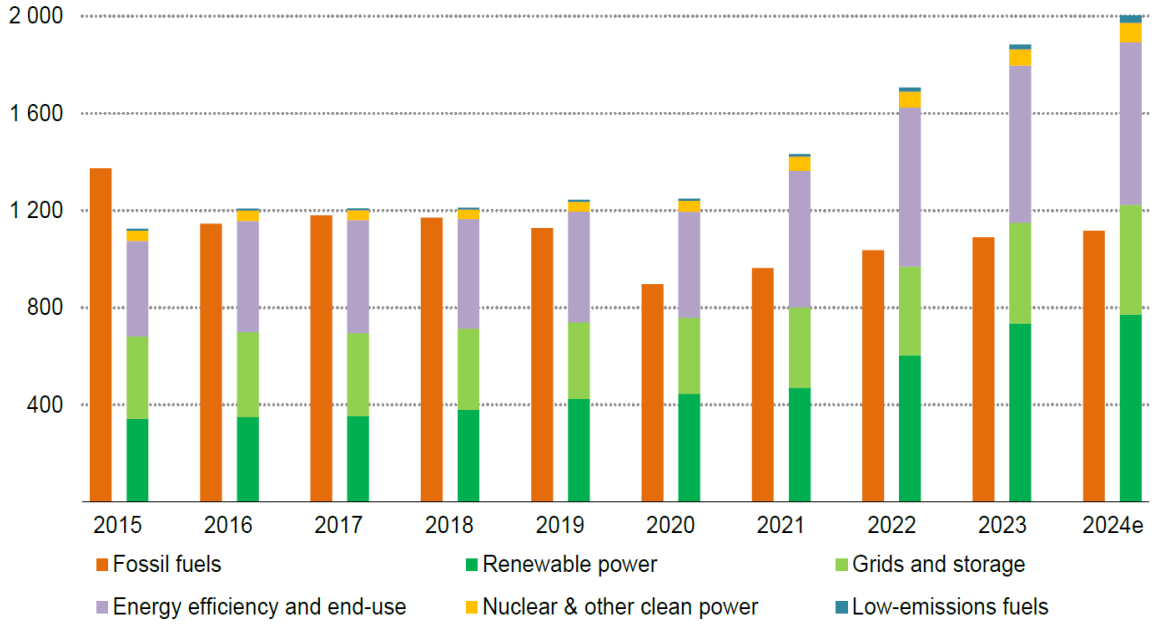
On a brighter note, **clean energy technology adoption surged at an unprecedented pace over the last three years**. **Total renewable capacity additions increased by a factor of 2 between 2022 and 2024!**

**: Energy consumption is measured in terawatt-hours, in terms of direct primary energy.*
This means that fossil fuels include the energy lost due to inefficiencies in energy production

Source: OUR WORLD IN DATA

THE WORLD INVESTS ALMOST TWICE AS MUCH IN CLEAN ENERGIES AS IT DOES IN FOSSIL FUELS, & INVESTMENT IN SOLAR PV NOW SURPASSES ALL OTHER GENERATION TECHNOLOGIES COMBINED

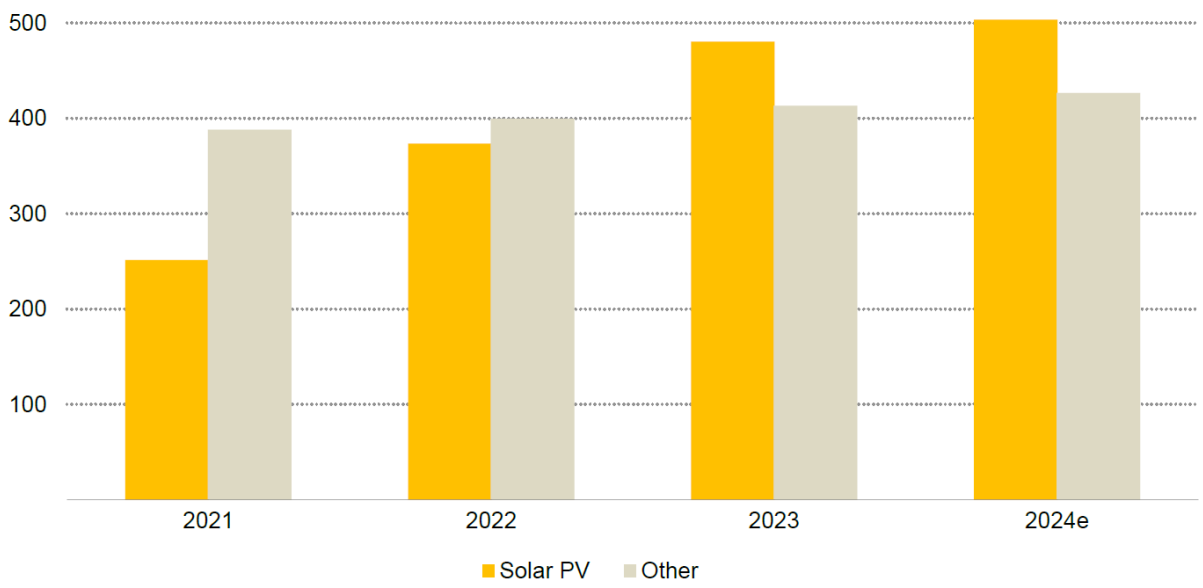
Global investment in clean energy and fossil fuels [US$ bn ; 2015-2024E]



Note: Other clean power = fossil fuel power with CCUS, hydrogen, ammonia, and large-scale heat pumps.
Low-emissions fuels = modern bioenergy, low-emissions H2 based fuels, and CCUS associated with fossil fuels and also includes direct air capture.
2024e = estimated values for 2024

Source: IEA

Global annual investment in solar PV & other generation technologies [US$ bn ; 2015-2024E]

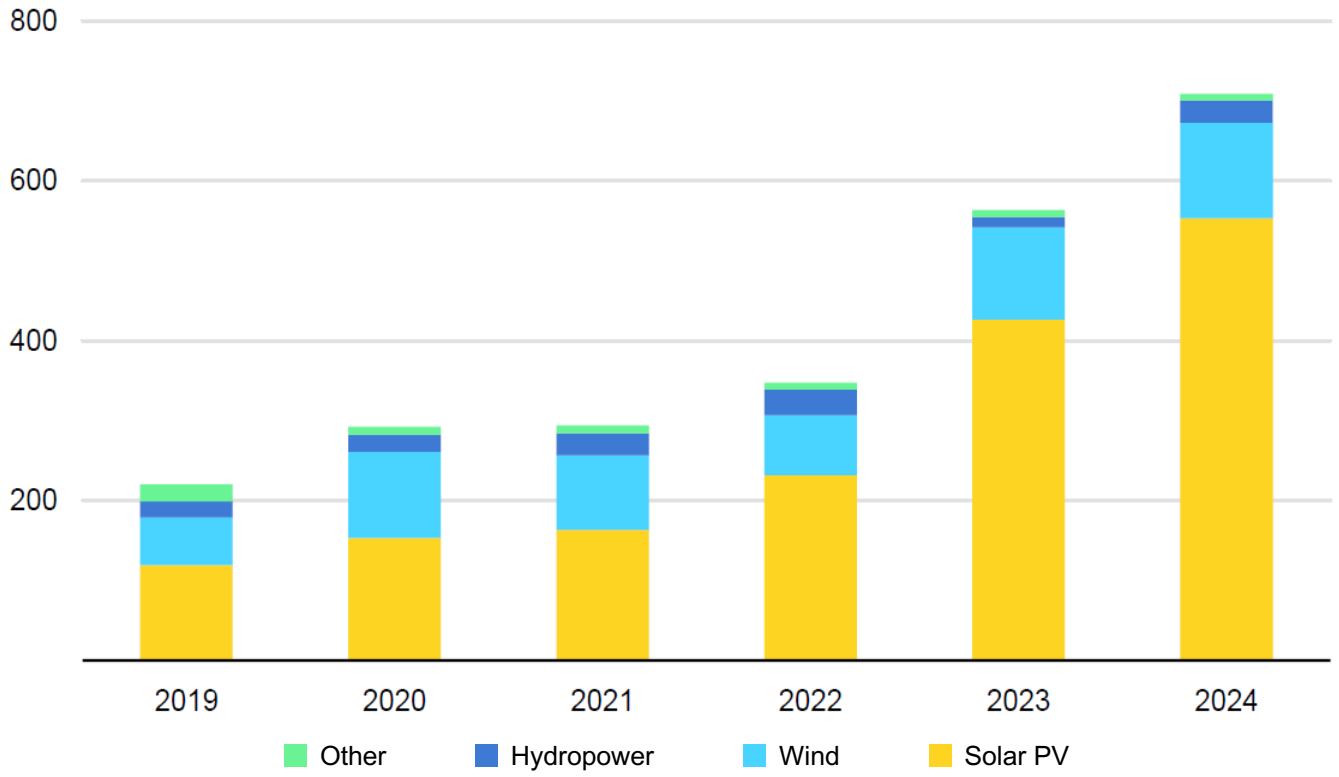


Note: 2024e = estimated values for 2024. Other = electricity generation from all other technologies including coal, oil, natural gas, wind, hydro and nuclear

Source: IEA

IN 2024, GLOBAL ANNUAL RENEWABLE CAPACITY ADDITIONS SURGED BY 25% TO AROUND 700 GW, WHICH IS IN LINE WITH THE COP28 GOAL OF TRIPLING 2022 CAPACITY

Total renewable capacity additions by technology [GW ; 2019-2024]



Note: 2024 values are based on both actual and estimated additions

Source: IEA

In 2024, global annual renewable capacity additions surged by an estimated 25% to around 700 GW – marking the 22nd consecutive year that renewables have set new records for expansion.

Solar PV accounted over 75% of renewable capacity additions, followed by wind (17%) and hydropower (4%), with bioenergy, geothermal, concentrating solar power and marine making up the remainder.

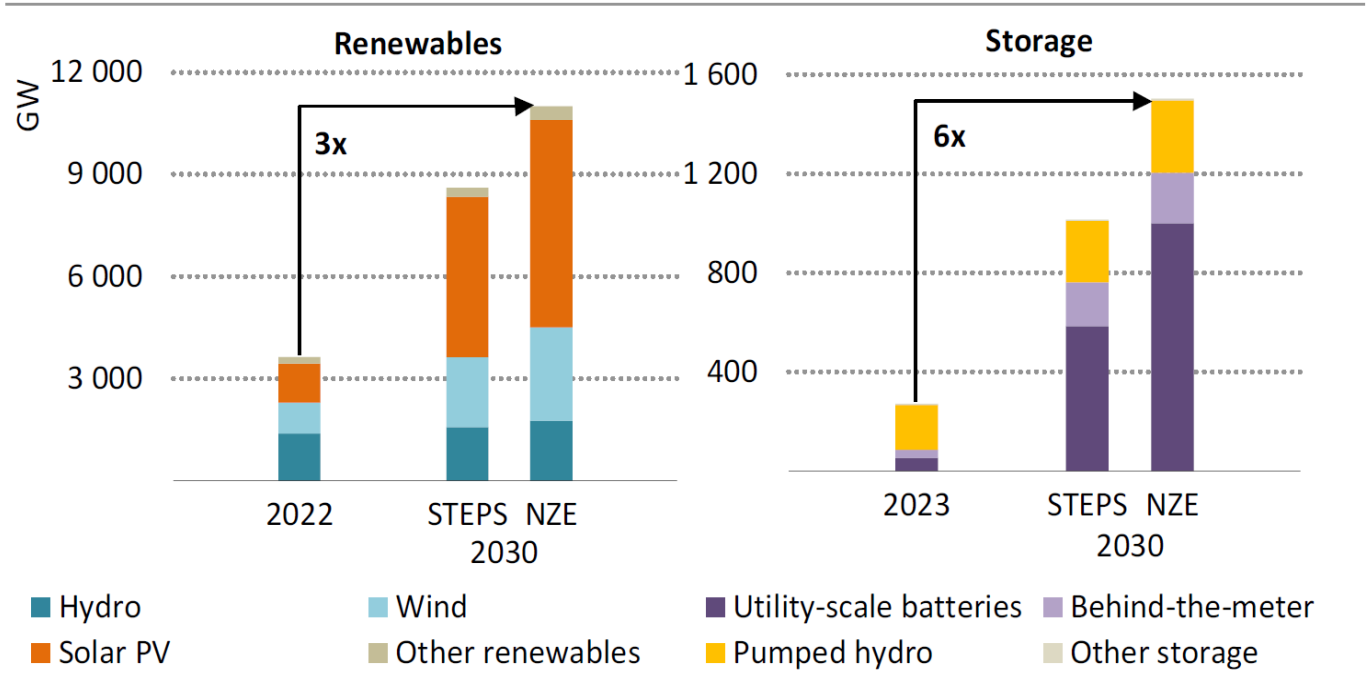
Solar PV additions in 2024 rose by almost 30% year-over-year, totaling about 550 GW. With this growth, installed solar PV capacity worldwide reached an estimated 2.2 terawatts (TW).

Annual wind additions remained stable at around 120 GW. **The wind power market is struggling except in China**, both for on-shore wind (penalized by the complexity and length of authorization procedures) and for offshore wind (increase in costs of materials, labor and interest rates). The **Trump administration's "Zero-wind" policy** might seriously affect the development of the US wind market in the next months.

Hydropower installations more than doubled to over 25 GW thanks to large projects commissioned in China, Africa and Southeast Asia.

MUCH HIGHER ELECTRICITY-STORAGE CAPACITIES ARE NECESSARY TO AVOID PRICE VOLATILITY

The x3 target for renewables decided at COP28 needs x6 for grid-scale storages

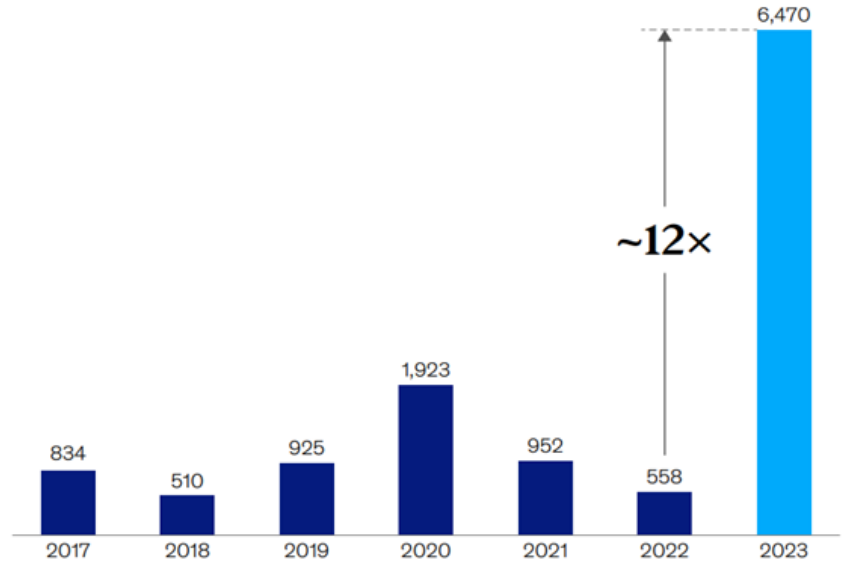


Note: Energy storage capacity, led by battery storage increases sixfold by 2030 in the NZE scenario and supports the tripling of renewables capacity goal

Source: IEA

The example of Europe, where the lack of interconnectivity leads to strong volatility of electricity prices

Yearly occurrences[1] of day-ahead negative electricity prices in the EU[2]



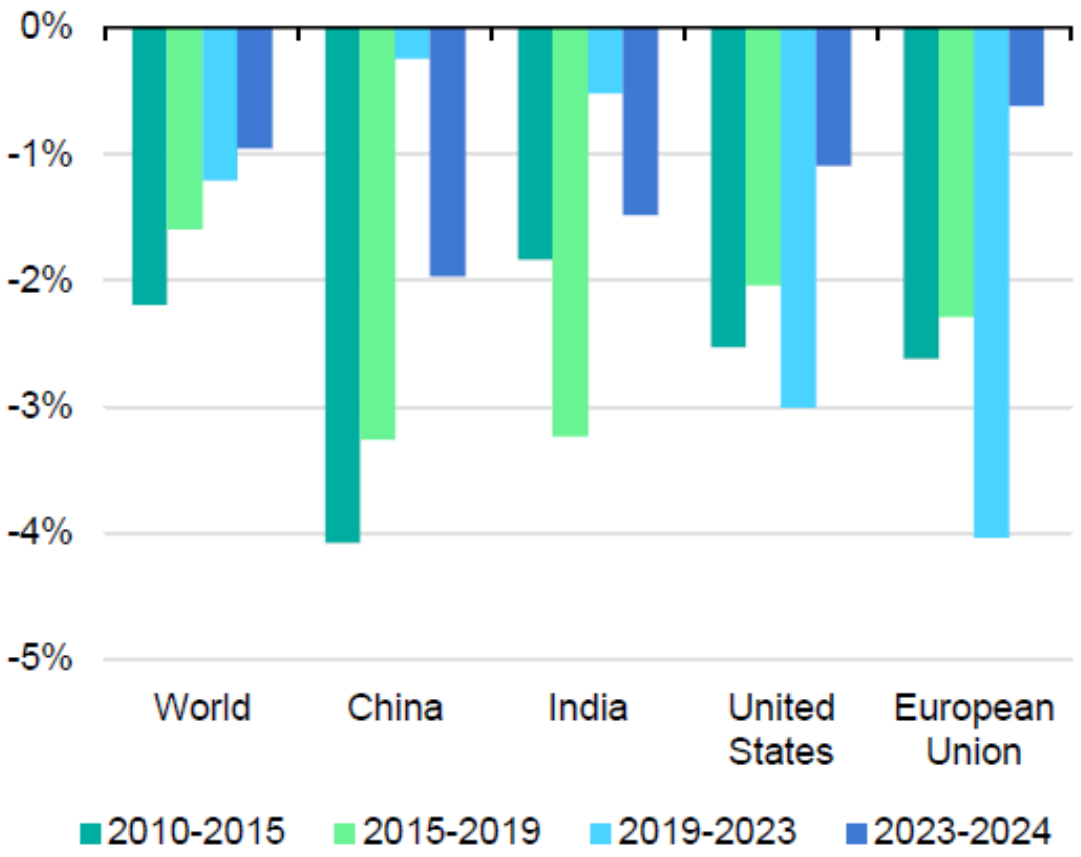
(1): One occurrence corresponds to one hour during which prices are negative

(2): EU + Norway + Switzerland

Source: EU Agency for the Cooperation of Energy Regulators

ENERGY INTENSITY IMPROVEMENTS CONTINUED TO SLOW IN 2024

Average annual rate of energy intensity improvement [selected regions ; 2010-2024]



After improving at an average rate of around 2% annually between 2010 and 2019, energy intensity improvements slowed to 1.2% per year between 2019 and 2023 and **only 1% in 2024**

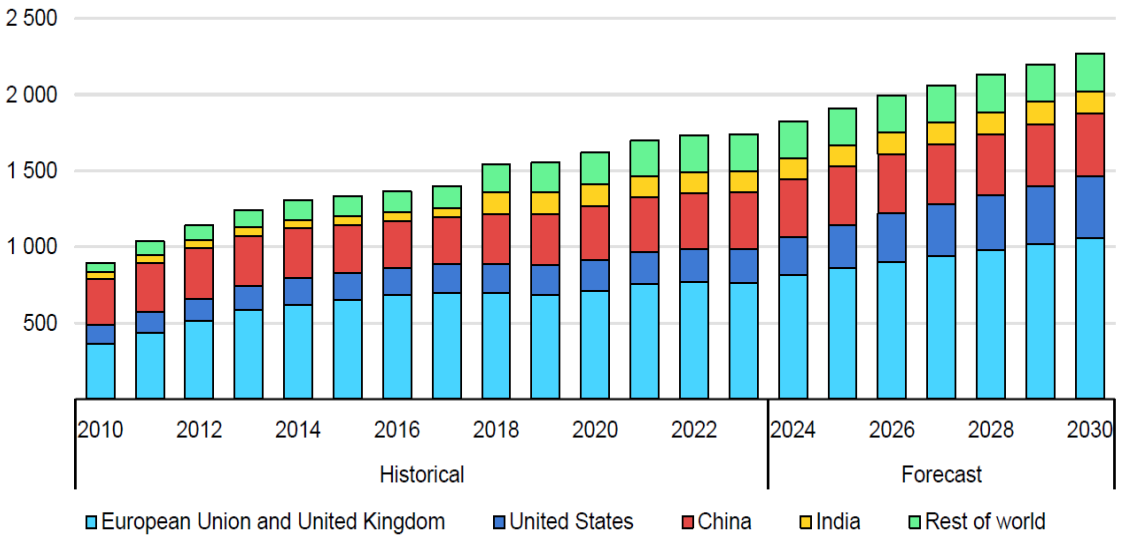
Key reasons for this recent slowdown include:

- investment and manufacturing-intensive post-Covid growth in major emerging and developing economies such as China and India;
- Higher energy demand due to extreme temperatures;
- and a trend of poor growth in hydropower output that was only partially reversed in 2024, leading to more consumption of less efficient fuels in some regions

BIOGASES DEVELOPMENT LED BY EUROPE AND NOT IN LINE WITH THE NZE SCENARIO

Biogas and Biomethane

Global historical and forecast demand for biogass [PJ/y ; 2010-2030F]



Source: IEA 2024 CC by 4.0

Biogas is a mature technology. It is a viable energy source for clean cooking, and for heavy vehicles. It can be used as a dispatchable source of low-carbon electricity generation, which will be increasingly important with the deployment of volatile renewables such as wind and solar

Combined global biogas and biomethane production reached more than 1.7 EJ in 2023 – a 17% increase from 2017

Almost half of the production is based in Europe, with Germany alone representing almost 20% of global consumption. Another 21% is produced in China, followed by the United States (12%) and India (9%)

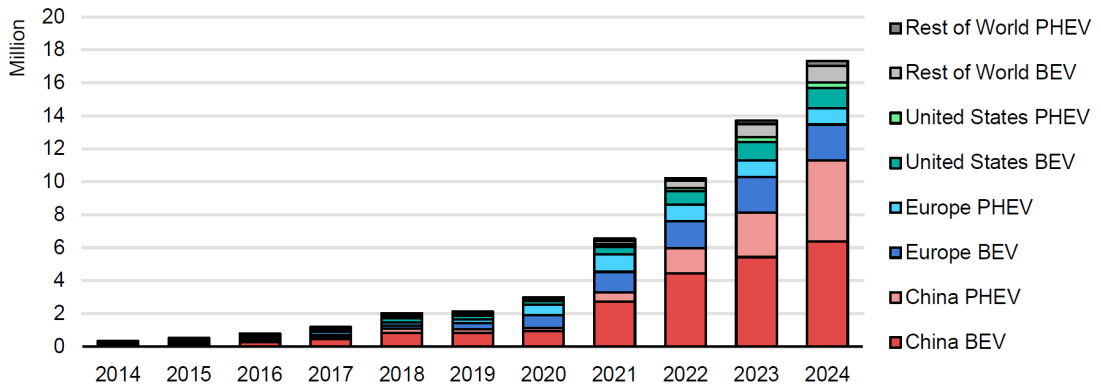
This current global production expansion is not in line with the IEA Net Zero by 2050 Scenario, which requires the production of biogases to **grow 3.7-fold by 2030**

Growth will primarily come from Europe and North America, owing partially to established infrastructure and experience, and driven by previous policies that make rapid deployment in a five-year term possible. Many other regions with strong biogas potential, such as Latin America and Southeast Asia, could make significant contributions to global growth if their countries introduce new policies to support the biogas sector

GREEN MOBILITY STILL ON TRACK FOR THE NZE SCENARIO BUT SOME STRONG WARNING SIGNALS ARE EMERGING, AND HEAT PUMPS SALES ARE DECLINING

Electric Vehicles

Global electric car sales [2014-2024]



Source: IAE

Electric car sales exceeded 17 million globally in 2024, reaching a sales share of more than 20%.

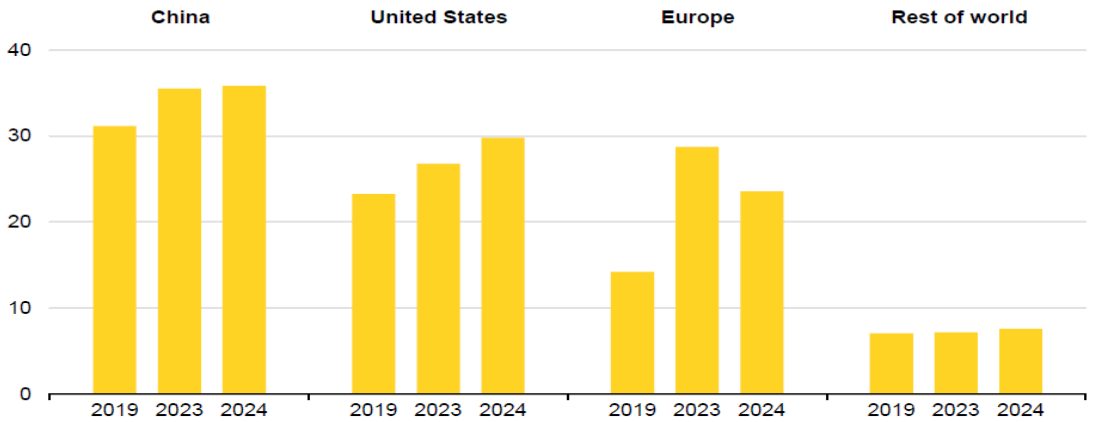
China maintained its lead, with electric cars accounting for almost half of all car sales in 2024, while emerging market and developing economies outside China witnessed a significant 80% annual increase in EV sales.

EV sales in US grew in 2024 by over 10%, thanks to the release of new EV models and availability of EV tax credits, which provided financial aid to consumers.

Electric car sales stagnated in the European Union, in large part due to Germany, where purchase subsidies were removed at the end of 2023. In contrast, EV sales in the United Kingdom surged, driven by the Zero-Emission Vehicle (ZEV) mandate.

Heat pumps

Heat pumps sales for selected regions [GW ; 2019-2024]



Source: IAE analysis based on the European Heat Pump Association (EHPA); the Air-Conditionning, Heating and Refrigeration Institute (AHRI); the Japan Refrigeration and Air Conditioning industry (JRAIA) and ChinaIOL

Global heat pump sales fell by 1% in 2024, recovering most of the decline recorded in the first half of the year

Some markets, notably Japan and the United States, showed a strong recovery in demand in the second half of the year, but it was not enough to offset the sharp annual decline in Europe and stagnation in China

Cost remains the major problem

**BEV Battery electric vehicle*

**PHEV : Hybrid/Plugging Battery electric vehicle*

CRITICAL MINERALS: LITHIUM REMAINS THE HIGHEST RISK FOR OUR 2030 MILESTONES

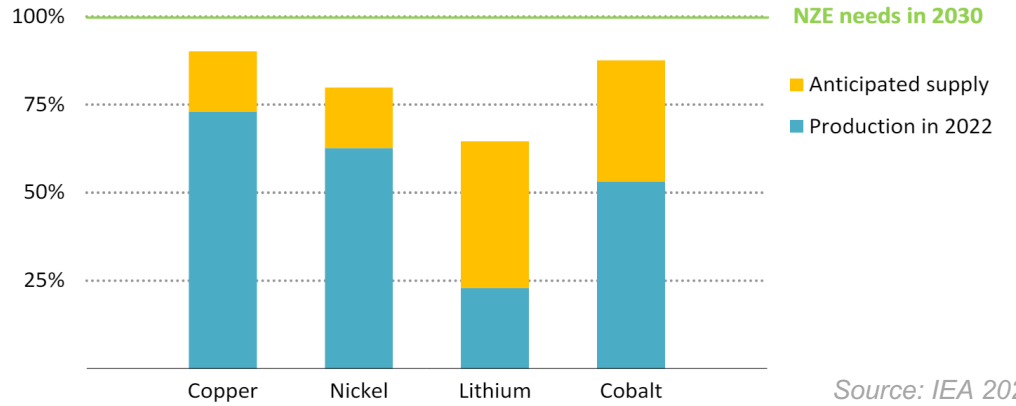
Despite the collapse in lithium, cobalt, and nickel prices due to oversupply, the **International Energy Agency (IEA) is sounding the alarm**. In its report on critical transition metals, published in May 2025, it warns its members of **future shortages of lithium and copper.**

IEA is also concerned about the **growing concentration** of metal production in a handful of countries, or even just one, most often in China. **Diversification is the solution** for ensuring energy security, but the critical metals world has **moved in the opposite direction**: according to IEA, the average market share of the top three countries for refining transition metals increased from around 82% in 2020 to 86% in 2024. The same is true for crude ore extraction, although the phenomenon is somewhat less pronounced. The top three producers accounted for an average of 73% of supply in 2020 and 77% in 2024.

In the present context of high geopolitical tensions, **critical minerals have become a key issue in ensuring global energy and economic security**. Too much concentration increases the risk of a supply shock, which can result in a price increase of 40 to 50% for consumers or a loss of competitiveness for manufacturers (*source : IEA*). The risk is all the greater given that 55% of strategic metals traded worldwide are subject to export restrictions.

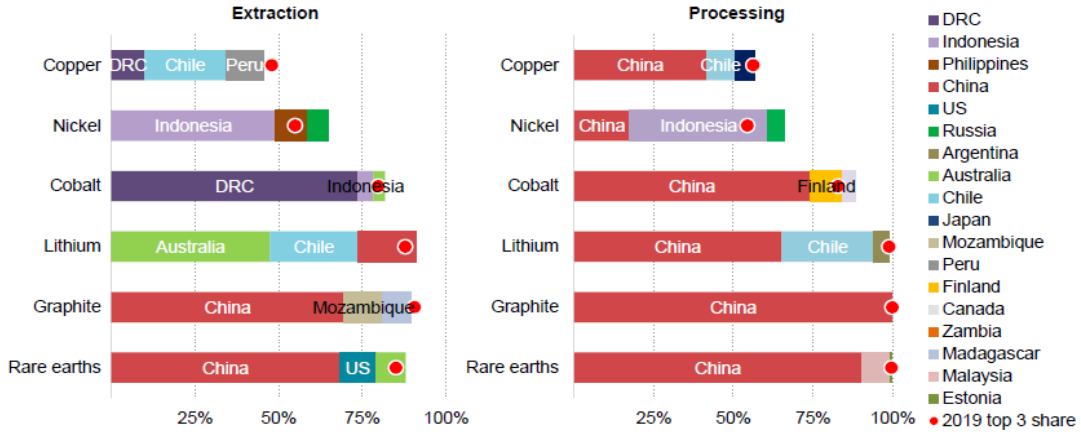
In addition to geographic diversification and recycling, **technological innovation** is another way to reduce tensions over critical metals. But despite policy efforts in the United States and Europe, **progress toward more diversified supply chains is expected to be slow** according to IEA.

Anticipated supply from the current pipeline of announced projects for key critical minerals would provide at least 65% of 2030's NZE Scenario requirements. Additional investments required.



Source: IEA 2022

Share of top 3 producing countries in total production for selected resources and mineral (2022)



Source: IEA 2022

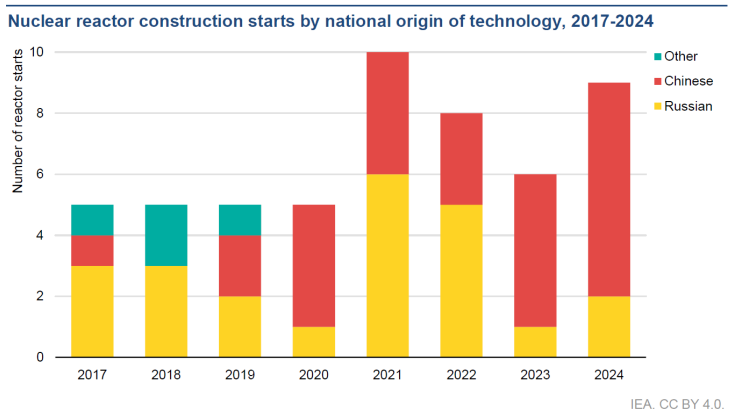
INVESTMENT IN OTHER LOW CARBON TECHNOLOGIES REQUIRED WITH EFFECTS AFTER 2030

Innovative & break-through technologies

According to the IEA, **35% of the emissions reductions expected in 2050 will come from technologies not yet commercialized**: new technologies of batteries, solid oxide electrolyzers, SAF, natural hydrogen extraction, advanced CCUS technologies, direct reduction of iron, small modular nuclear reactors…

Nuclear

In 2024, ***over 7 GW of nuclear power capacity was brought online***, ***33% more*** than in 2023. Electricity generation from nuclear in 2024 rose by 100 TWh.. Construction starts for nuclear power plants grew by 50% in 2024, ***exclusively using Chinese and Russian designs***.



Note: Capacity is reported in gross terms.
Source: IEA analysis based on IAEA PRIS database (Accessed 6 February 2025).

Hydrogen

Except in China, most regions have witnessed ***steady growth in electrolyzer deployment*** in 2023. Demand uncertainty and lack of regulatory clarity, coupled with inflation, fall in fossil fuel prices, and slow implementation of support mechanisms have hindered faster adoption.

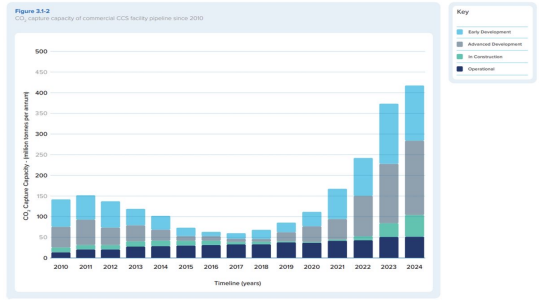
Globally, the pipeline of projects shows that more than **400 GW of electrolysis production capacity should run by 2030**. This could potentially meet the milestones of the APS IEA scenario if all planned projects go ahead, but cost inflation and supply chain bottlenecks could hamper progress.

LARGEST GREEN HYDROGEN PROJECT IN CHINA (150 MW) INSTALLED IN CHINESE CHEMICAL FACTORY OF NINGXIA BAOFENG GROUP

CCUS

Carbon capture and storage (CCS) is seen by many experts as a ***vital tool*** in combating climate change. CCS technologies are considered especially important ***for hard-to-abate industries*** that cannot be easily replaced by electrification, such as oil and gas, iron and steel, and cement and refining. However, CCS is still very much in its infancy, capturing just 0.1 percent of CO_2 emissions per year.

In July 2024, ***the total capacity of CCS projects in development worldwide was 416 million metric tons per annum*** of carbon dioxide (Mtpa CO_2). Those in advanced development had a capture capacity of 180 Mtpa CO_2.



Who we are

LES ATELIERS
DU FUTUR

ATELIERS DU FUTUR, AN NGO OF EXECUTIVES WHO ACT TO ENHANCE BUSINESS MOBILIZATION FOR THE CLIMATE

Our purpose

In response to the interconnected challenges of climate change and biodiversity loss, our **mission** is to **act for the Climate**

Who we are ?

A multidisciplinary group of business executives and senior managers
All volunteers, we are **experts in modeling** (trained in climatology), engineers focused on **energy** and **green technologies**, or **finance specialists**
Our experience facilitates their mastery of business climate strategies

Our strategy

A focus on the **Climate**
An international vocation, as key governance for the normative framework of businesses and citizens is at global and regional levels
An orientation towards corporations, as they alone meet the key conditions to successfully decarbonize our activities: Ability to do, know-how, and, to some extent, willingness to do

Our actions

Raising awareness - policy makers and governing bodies (public or private)
Challenging corporate strategies and public policies with a constructive, optimistic yet ambitious mindset.
Training future generations through Universities/Schools

LES ATELIERS DU FUTUR

INDEPENDANT NGO
ACTING
FOR THE CLIMATE

contact@lesateliersdufutur.org

92210 SAINT-CLOUD