The obstacles to a clean sweep

Uneven funding and geopolitical uncertainty are clouding the renewables boom. **By Benjamin Plackett**

Enthusiasm for lower carbon emissions is fuelling record investment in energy technologies. In 2024, global energy investment exceeded US$3 trillion for the first time, two-thirds of which went towards clean-energy technologies and infrastructure. This trend, detailed in the *World Energy Investment 2024* report by the International Energy Agency (IEA), is mirrored by a surge in research on affordable and clean energy. In the Nature Index, which tracks output in selected natural- and health-science journals, such research accounted for just 3.7% of all papers in 2015. By 2023, that figure had grown to 8.3%. While these are positive steps in the transition away from fossil fuels, a deeper look at the data reveals challenges that must be addressed for clean energy to be scaled up globally.

"There is a ramping up of clean-energy investment against a backdrop of plateauing fossil-fuel spending," says IEA investment and finance analyst, Tanguy De Bienassis. But, he adds, it's probably premature to say that the halcyon days of oil and gas are finished, because that plateauing could simply mean that fossil fuels don't need as much investment as they once did to remain competitive.

The fact that renewables don't meet demand in key areas emphasizes the work that needs to be done to reduce reliance on fossil fuels. According to the IEA report, global demand for heat energy — used to warm buildings and power industrial processes — is outstripping the rate at which renewables can be deployed to meet the need. The subsequent use of fossil fuels for heat is predicted to drive a 5% increase in annual carbon dioxide emissions from the energy sector between 2024 and 2030.

At the same time, the way that clean-energy investment is shared between countries is highly uneven (see 'Stark imbalance'). China, for instance, is responsible for roughly one-third of global spending on renewables (and a similar share of global carbon emissions). In 2023, it spent an estimated $890 billion in clean-energy sectors, up by 40% on 2022, according to an analysis by the Centre for Research on Energy and Clean Air in Helsinki. This is just shy of the total global investments in the fossil-fuel supply in 2023, at $950 billion, as reported by the IEA.

A big part of China's efforts in clean energy is building renewable power facilities. The country invested $359 billion in this area in 2024, compared with $85 billion from the United States and the European Union's $106 billion. Emerging and developing economies, including Brazil, India and South Africa, account for just 15% of global renewables investment, and risk missing out on the benefits of clean-energy technologies, including energy independence.

Solar stronghold

Among renewables, solar energy dominates research and investment. In 2023, solar outperformed investments in every other energy type combined for the first time. This happened again in 2024, and the gap widened (see 'Solar supremacy'). "We're always underestimating how much solar is going to come online," says De Bienassis. "It shows that the technology is rich and reaching its maturity. It's very easy to install and that's what makes it a success."

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China boasts the world's most advanced manufacturing base for solar-energy generation. The Tongwei Company, for example, which is headquartered in Chengdu, produced enough solar panels in 2023 to meet 10% of global demand that year. But the vast solar-panel plants that China specializes in have their weaknesses. De Bienassis notes that if one of them underwent an industrial accident, "it would completely disrupt the supply chain". For now, however, China remains the leading force in solar-energy technology and facilities.

China's dominance also extends to nuclear power. Over the past five years, China has added 11 gigawatts to its nuclear power capacity, according to the IEA report, far outstripping any other country. It was one of only two countries (the other being Egypt) that started construction on a new nuclear power plant in 2023, and of the estimated $80 billion spent on nuclear power globally last year, China contributed the lion's share. "They're the country that builds the most nuclear plants, the most solar and the most wind," says De Bienassis. "We call them the powerhouse of the clean-energy transition."

The United States, meanwhile, is likely to continue decoupling its trade and supply chains from China. President Donald Trump has signalled that he favours fossil fuels over renewables and pledged to withdraw the United States from the Paris climate accord earlier this year.

The Chinese government's consistently favourable view on renewables is helping it to attract investors, says Bert Scholtens, an economist at the University of Groningen in the Netherlands, who has studied the financial impact of divesting from fossil fuels . "Political stability is crucial for long-term investments," says Scholtens. "Political systems like China's, with all their downsides, provide stability, whereas the US political system does not."

This could also explain why so little is being spent on renewables in Africa — just US$22 billion in 2024 for the whole continent, according to the IEA report. Many African countries offer ideal conditions for solar power, says Scholtens, but those in conflict are struggling to find investors. "You don't want to have a solar field in Sudan because of the civil war," says Scholtens.

This principle doesn't just affect countries at war, but entire regions, as investors fear the possibility of conflicts crossing borders, he adds. War hampers fossil-fuel development, too, but not as badly as it does for renewables. "You can trade oil with warlords, whereas electricity is very difficult to trade because you need to store it," says Scholtens.

Ultimately, having a range of renewable energy types will be key to scaling up global deployment. "Solar investments are, of course, good news, but we need to see more on wind," says De Bienassis. "No one technology is going to solve it all. You will need all of the technologies together to have a resilient system."

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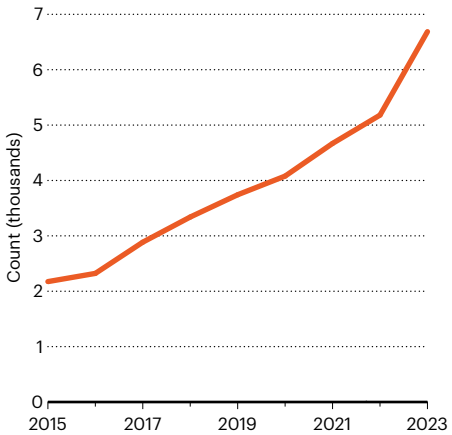
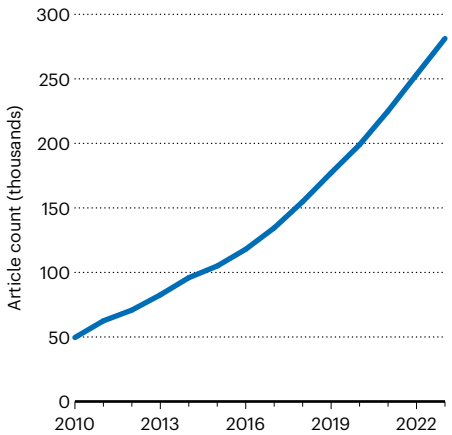
GREEN SURGE

Research output on clean and affordable energy in Nature Index journals (left) increased by more than 200% from 2015 to 2023. In 2023, almost 9% of all articles in the Index were related to this topic, up from almost 4% in 2015. In the Dimensions database, research output on the topic increased by almost 470% between 2010 and 2023.

Energy Count in the Nature Index

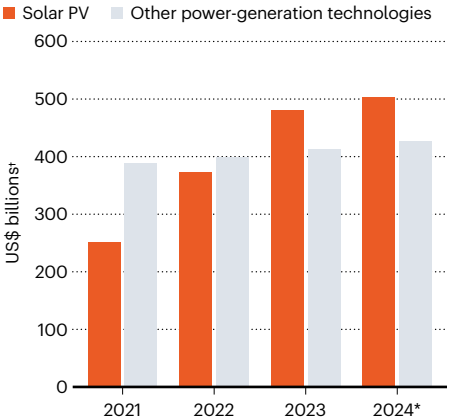


Energy article count in Dimensions



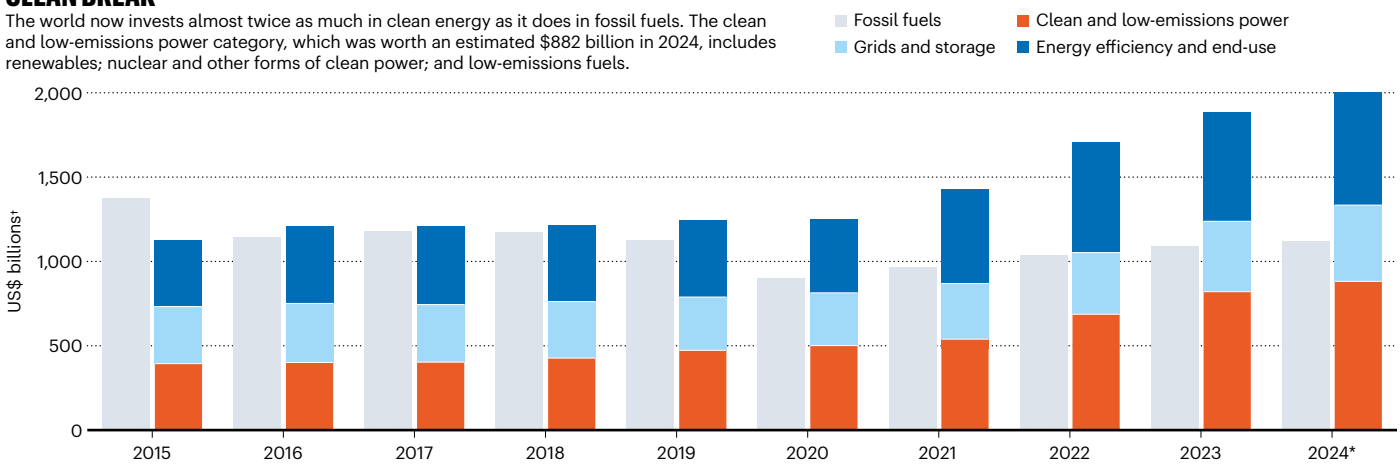
SOLAR SUPREMACY

Global spending on renewables hit record levels in 2023, driven by solar photovoltaic (PV) and wind. Investment in solar PV, shown here for the period 2021 to 2024*, now surpasses all other power-generation technologies combined.



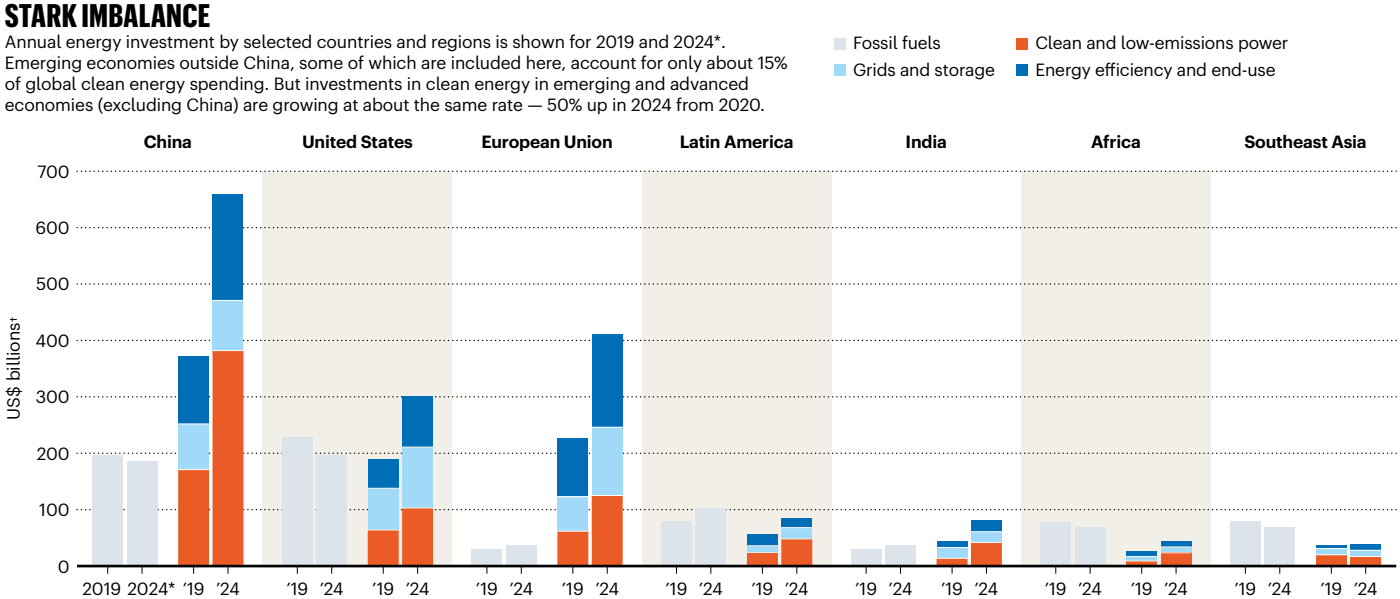
CLEAN BREAK

The world now invests almost twice as much in clean energy as it does in fossil fuels. The clean and low-emissions power category, which was worth an estimated $882 billion in 2024, includes renewables; nuclear and other forms of clean power; and low-emissions fuels.



STARK IMBALANCE

Annual energy investment by selected countries and regions is shown for 2019 and 2024*. Emerging economies outside China, some of which are included here, account for only about 15% of global clean energy spending. But investments in clean energy in emerging and advanced economies (excluding China) are growing at about the same rate — 50% up in 2024 from 2020.



SOURCE: NATURE INDEX; DIMENSIONS BY DIGITAL SCIENCE; *WORLD ENERGY INVESTMENT 2024* (IEA, 2024).

*Values for 2024 are estimates. †US dollar values reflect the 2023 market exchange rate.