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The global clean energy supply chain

The Edge, Malaysia

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US President Donald Trump's decision to impose tariffs on imports from all countries has sparked concerns about the future of the low-carbon energy transition, as products such as solar panels, battery storage and electric vehicles (EVs) rely heavily on global supply chains.

China, which has been hit the hardest by Trump's tariffs, is the world's leading supplier of clean energy technologies and a net exporter of many of them, according to the International Energy Agency (IEA).

Some analysts have highlighted that if the tariffs go through, China might divert its exports of clean energy to other countries in Southeast Asia (SEA) and Europe.

Last year, the US imposed tariffs on solar panel imports from four SEA nations — Malaysia, Cambodia, Vietnam and Thailand — that are mostly manufactured by Chinese companies. Tariffs on solar panels imported from China have been imposed by the US since at least 2012.

Many observers expect the latest round of tariffs to further drive up costs of clean energy production in the US, whether due to the higher price of steel for wind turbines or the elevated cost of batteries for EVs.

To bring global energy emissions to net zero by 2050 and limit temperature rise to 1.5°C , a greater deployment of clean energy is required. The IEA projects annual clean energy investment worldwide to more than triple by 2030 to around US$4 trillion, while the use of coal, oil, and gas is projected to decline sharply.

Here is a snapshot of where the critical clean energy technologies come from.

GRAPHIC BY FREEPIK, VECTEEZY

SOURCE: IEA

The raw materials

70% of cobalt is derived from the Democratic Republic of Congo

60% of rare earth elements (REE) are from China

55% of lithium is mined in Australia, and 25% in Chile

40% of nickel is from Indonesia

Manufacturing and refining

CHINA

- Refines 90% of REEs and up to 70% of lithium and cobalt
- Holds at least 60% of the world's manufacturing capacity for most mass-manufactured technologies such as solar photovoltaic (PV) panels, wind systems and batteries, and 40% of electrolyser manufacturing
- Supplies almost one quarter of Europe's electric cars and batteries, and nearly all solar PV modules and fuel cells
- Supplies solar PV equipment directly to all markets except North America

SOUTHEAST ASIA

- Supplies two-thirds of the US' PV modules, mostly from Chinese solar manufacturing firms' production sites in this region

Present and future

IEA's projection for global net zero emissions by 2050 requires almost 90% of global electricity generation to come from renewable sources, with solar PV and wind accounting for nearly 70%.

Where is the world now? This is the latest data, according to Ember Energy's *Global Electricity Review 2025*, released in early April:

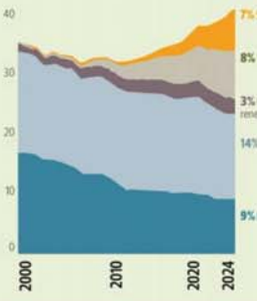
- 40.9% of global electricity generation was from low-carbon sources (renewables and nuclear)
- Hydro was the largest source (14.3%), followed by nuclear (9%), wind (8.1%) and solar (6.9%)
- 29% growth rate for solar generation was observed, a six-year high. It was the fastest growing source of electricity for the 20th year in a row, with more than half of the increase recorded in China
- 4% increase in electricity demand growth, amplified by heatwaves, which also contributed to a small increase in fossil generation

SOURCE: EMBER ENERGY

Source of global electricity generation in 2025

Solar and wind boom pushes world past 40% clean electricity in 2024

Share of global electricity generation



SOURCE: IEA

Critical minerals used for clean energy technologies

	COPPER	COBALT	NICKEL	LITHIUM	REEs	CHROMIUM	ZINC	PGMs	ALUMINIUM
Solar PV	■	■	■	■	■	■	■	■	■
Wind	■	■	■	■	■	■	■	■	■
Hydro	■	■	■	■	■	■	■	■	■
CSP	■	■	■	■	■	■	■	■	■
Bioenergy	■	■	■	■	■		■	■	■
Geothermal		■	■	■	■	■	■	■	■
Nuclear	■	■	■	■	■	■	■	■	■
Electricity networks	■	■	■	■	■	■	■	■	■
EVs and battery storage	■	■	■	■	■	■	■	■	■
Hydrogen	■	■	■	■	■	■	■	■	■

The IEA projects that demand for the five key critical minerals — lithium, cobalt, nickel, copper and neodymium— will increase 1.5 to seven times by 2030, if the world wants to achieve net zero emissions by 2050. The largest gap, based on anticipated investments, is in the supply of lithium, as lead times for new mines are long and uncertain.

However, the mining of these minerals also comes with environmental and social impacts. This includes human rights abuses such as child labour and negative impacts on indigenous peoples' rights; greenhouse gas emissions from energy-intensive mining and processing; and environmental impacts from loss of biodiversity and pollution, according to the United Nations Environment Programme.

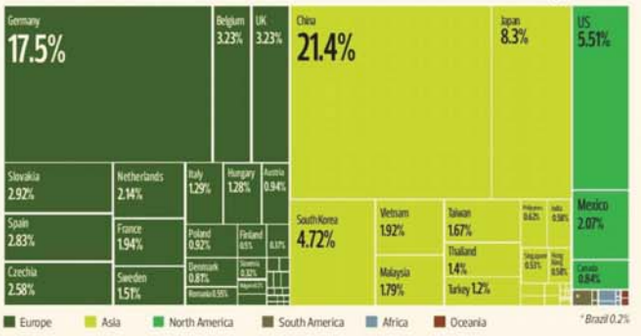
Importance: ■ High ■ Moderate ■ Low

SOURCE: OBSERVATORY OF ECONOMIC COMPLEXITY (OEC)

THE MAJOR PLAYERS

Countries that export clean energy technologies (2021)

Total: **US$379 bil**



Solar PV

China supplies nearly a third of global demand for this technology to Europe and Asia

Wind turbine

Components of this technology are mostly supplied by Germany, Denmark and China

EV batteries

Half of the world's supplies are exported by China, Germany and the US