World Energy Investment 2025

10th Edition

INTERNATIONAL ENERGY AGENCY

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Abstract

This year's *World Energy Investment* report, marks the 10th edition of this flagship analysis and provides a full update on the investment picture in 2024 and an initial reading of the emerging picture for 2025.

The report provides a global benchmark for tracking capital flows in the energy sector and examines how investors are assessing risks and opportunities across all areas of fuel and electricity supply, critical minerals, efficiency, research and development and energy finance.

The report highlights several key aspects of the current investment landscape in the context of recent policy and macroeconomic developments and a heightened focus on energy security. It explores the different drivers of energy investments and identify emerging trends and priorities.

This year's edition also reflects on energy investment trends over the last decade, highlighting major milestones and lessons from different energy sectors and regions. It also includes an expanded regional analysis as well as extensive analysis on the sources of investment and sources of finance in the energy sector, including insights on the role of development finance institutions in energy investments across emerging and developing economies. It will also look at how investment trends in clean energy compare with those in fossil fuels, as well as the geographic distribution of these investments.

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Executive Summary

Executive Summary

Despite elevated geopolitical tensions and economic uncertainty, this tenth edition of the IEA's *World Energy Investment* shows that capital flows to the energy sector are set to rise in 2025 to USD 3.3 trillion, a 2% rise in real terms on 2024. Around USD 2.2 trillion is going collectively to renewables, nuclear, grids, storage, low-emissions fuels, efficiency and electrification, twice as much as the USD 1.1 trillion going to oil, natural gas and coal. Open questions about the economic and trade outlook means that some investors are adopting a wait-and-see approach to new project approvals, but we have yet to see significant implications for spending on existing projects.

Rapid growth in spending on energy transitions over the past five years was kicked off by post-pandemic recovery packages and then sustained by a variety of economic, technology, industrial and energy security considerations, not only by climate policies. Some 70% of the increased spending came from net fossil fuel importers. This was led by China's drive to reduce reliance on oil and gas imports and exert leadership in new technology areas; Europe's push to accelerate spending on renewables and efficiency gains after Russia's full-scale invasion of Ukraine and the consequent cut to pipeline gas deliveries; and a pick-up in spending on solar in India. Another 20% of the increase came from the United States, where supportive policies were motivated in part by the desire to challenge China's position in emerging clean technology supply chains. Emissions reductions provide a powerful reason to invest, but are often not the primary driver for investment in technologies that are increasingly mature and cost-competitive.

Investment trends are being shaped by the onset of the 'Age of Electricity' and the rapid rise in electricity demand for industry, cooling, electric mobility, data centres and artificial intelligence (AI). Ten years ago, investments in fossil fuel supply were 30% higher than those for electricity generation, grids and storage. Today, these positions are reversed. Investment in the electricity sector is set to reach USD 1.5 trillion in 2025, some 50% higher than the total amount being spent on bringing oil, natural gas and coal to market. There is also increasing expenditure on the electrification of end-uses, largely reflecting the additional cost of buying an electric vehicle (EVs) versus an internal combustion engine model, even though many EV models being sold in China – the leading market for sales – are now competitive on an up-front basis with their conventional equivalents.

Spending on low-emissions power generation has almost doubled over the past five years, led by solar PV. Investment in solar, both utility-scale and rooftop, is expected to reach USD 450 billion in 2025, making it the largest single item in our inventory of the world's investment spending. Fierce competition among suppliers and ultra-low costs are seeing imported solar panels, often paired with batteries, become an important driver of energy investment in many emerging and developing economies.

Chinese solar exports to developing economies surpassed those to advanced economies in early 2025, with countries such as Pakistan having imported a reported 19 GW in 2024 alone (equivalent to about half the country's grid-connected electrical capacity). Global spending on batteries for power sector storage is set to reach USD 66 billion this year.

Nuclear investment is making a comeback, rising by 50% over the past five years, and approvals of new gas-fired power are rising. Spending on new nuclear plants and refurbishments is set to exceed USD 70 billion, with the promise of further growth given the burgeoning interest in new technologies such as small modular reactors. The United States and the Middle East accounted for nearly half of a resurgent level of Final Investment Decisions (FID) for natural gas power.

Fast-growing electricity use and concerns about electricity security underpinned a wave of coal plant approvals in China. China gave the green light to almost 100 GW of new coal-fired plants in 2024, and India a further 15 GW, pushing global approvals to their highest level since 2015. By contrast, for the first time on record, there were no new steam turbine orders for coal-fired power plants in advanced economies in 2024.

Investment in grids is struggling to keep pace with the rise in power demand and renewables deployment. Each year, some USD 400 billion is now spent on grids worldwide, compared with around USD 1 trillion on generation assets. Maintaining electricity security amid rising electricity use requires a rapid increase in grid spending, moving towards parity with the amount spent on generation. However, this is being held back by lengthy permitting procedures, tight supply chains for transformers and cables, and – especially in developing economies – by the poor financial condition of many utilities.

Lower oil prices and demand expectations are set to result in a a 6% fall in upstream oil investment in 2025, the first year-on-year decline since the Covid slump in 2020 and the largest since 2016. Our initial expectation for 2025, based on company announcements, was that upstream oil and gas spending would be flat, but sentiment has since become more downbeat as oil prices came under pressure. While spending in natural gas fields is set to maintain the levels seen in 2024, lower expenditure on oil brings our expectation for overall upstream oil and gas investment for 2025 to just under USD 570 billion, a decline of around 4%. Of this, 40% is dedicated to slowing down production declines at existing fields. Global refinery investment in 2025 is set to fall to its lowest level in the past 10 years.

Its short investment cycle makes US tight oil the bellwether for changing market dynamics, with an anticipated fall of almost 10% in spending in 2025. Nonetheless, a recent wave of consolidation and technology improvements have kept costs in check and production is still set to grow in 2025.

Spending on new LNG facilities is on a strong upward trajectory as new projects in the United States, Qatar, Canada and elsewhere prepare to come online. Despite some delays and cost overruns in LNG projects that are planned and under construction, the period between 2026 and 2028 is likely to see some of the largest ever annual expansions in LNG capacity. Projects under construction in the United States (130 billion cubic metres of annual export capacity) promise to nearly double its export capacity, bringing not only additional volumes but also destination-flexibility to international gas markets.

Investment in low-emissions fuels is set to reach a new high in 2025, but at less than USD 30 billion, it remains small in absolute terms and projects remain heavily dependent on policy and regulatory support. If all approved projects for carbon capture, utilisation and storage (CCUS) move ahead, then investments in CCUS will rise more than tenfold by 2027 from current levels. Low-emissions fuel projects are particularly prone to policy uncertainty. Some hydrogen projects have been cancelled or delayed in the past 12 months, but there remains a pipeline of approved projects that requires around USD 8 billion of investment in 2025, almost double the level seen in 2024.

Investments in coal supply continue to tick upward with another 4% increase expected in 2025, a slight slowdown compared with the 6% annual average growth seen over the last five years. Nearly all the growth in coal investments in 2024 came from China and India to meet domestic demand.

End use investments in electrification and other efficiency improvements have nearly doubled over the last decade. Boosted by strong EV sales, progress with building renovations and the electrification of industrial processes, demand-side investment is set to reach about USD 800 billion in 2025. Investment in the buildings sector is pulled down by slower construction starts, notably in China, but this is offset by higher anticipated sales of efficient appliances and cooling systems.

Costs for some key clean technologies have resumed their strong downward trend, while supply chain pressures are still visible for grid materials and in the oil and gas sector. The IEA's Clean Energy Equipment Price Index hit a record low in early 2024, a 60% fall compared to 10 years ago, with Chinese solar panel and wind turbine prices down 60% and 50% respectively since 2022 (by contrast, wind turbine prices in Europe rose). But inflationary pressures loom larger in other areas, notably for grid materials which have nearly doubled in price in the last five years as a result of rising demand for cables and transformers. Upstream oil and gas costs are set to climb by about 3% in 2025. Cost pressures on the oil and gas sector, and for all large engineering projects, in the United States include the effects of higher tariffs on imported steel and aluminium.

Despite growing concerns about the high supply concentration for critical minerals, growth in investment slowed in 2024 amid lower prices, and exploration activity was flat year-on-year. Projects outside the main incumbent producers were most affected by the price uncertainty. The large integrated mining companies

continued to raise their investment, but specialist players scaled back. While exploration spending in Canada and the United States increased marginally compared with the previous year, it decreased in Australia and Latin America.

The geography of energy investment is shifting in ways that will have long-term implications. China is the largest global energy investor by a wide margin, and its share of global clean energy investment has risen from a quarter ten years ago to almost one-third today. Spending on renewables and low-emissions fuels in the United States almost doubled over the last 10 years but is now set to level off as supportive policies are scaled back. Meanwhile, spending on upstream oil and gas is gravitating towards large resource-holders in the Middle East. The region's share of global upstream investment is kept in check by very low costs but is set to reach 20% in 2025 – the highest level on record – while constrained spending in Russia has brought its share down to around 6%.

Spending patterns remain very uneven – with many developing economies, especially in Africa, struggling to mobilise capital for energy infrastructure. Currency depreciation and higher interest rates have made it more difficult to access and service debt: in Africa, overall debt servicing costs are equivalent to over 85% of total energy investment in 2025. Energy investments in Africa are one-third lower in 2025 than they were in 2015, as a decline in oil and gas spending has been only partially offset by higher investments in renewable power. Africa accounts for only 2% of clean energy investment despite having 20% of the world population.

Although well behind China, energy investment trends in India and Brazil stand out among emerging and developing economies. Strong and sustained policy support has enabled these countries to take advantage of low cost solar power, accompanied by significant wind and bioenergy investments, and the development of Brazil's large offshore oil resources. India looks set to reach its 2030 target of 50% non-fossil generation capacity ahead of schedule. Southeast Asia's deployment of emerging technologies lags behind other regions, but the region is finding a place in clean energy supply chains, second only to China for solar manufacturing, while Indonesia is the world's largest nickel producer.

A growing finance gap in developing economies points to a larger role for international sources. Mobilising international finance for clean energy investment in emerging and developing economies will need to be combined with the development of domestic capital markets. International public finance can be a catalyst for private finance and accounts for around 7% of EMDE's (excluding China) clean energy investment (about USD 32 billion annually), but this is well below developing country needs and expectations.

A growing share of China's external energy investments and official financing support is going to clean energy and to clean technology manufacturing. China has long been a major overseas investor in energy-related sectors, across a wide range of fuels and technologies (with the exception of new coal-fired power plants since 2021), as well as in critical minerals. There are signs of a shift in

emphasis in recent years. In the last five years, Chinese EV and battery manufacturers have announced some USD 80 billion of investment to set up and expand manufacturing facilities in major markets, including Indonesia, Thailand, Brazil, Mexico and Türkiye. Solar manufacturers, long established in Southeast Asia, are also reassessing their overseas strategies, and looking closely at opportunities in the Middle East.

New analysis on export credit agencies (ECAs) highlight the evolving roles that they play in financing the energy sector. ECAs mainly provide credit guarantees that have enabled much larger volumes of commercial finance to flow, particularly to emerging and developing economies. Over the last decade, these institutions have been shifting a larger portion of their funding away from fossil fuels.

The rise of sustainable finance over the last decade is facing headwinds. Some elements are still robust, notably sustainable debt issuances, led by green bonds. But the previous flurry of activity from financial institutions to 'green' their own practices has slowed, as regulatory and policy support has ebbed in key markets.

Energy innovators are adjusting to higher costs of capital and policy uncertainty, amid signs of a shift in focus for venture capital investment towards AI-related projects. Clean energy R&D spending continued to grow in 2024, supported by both the public and corporate sector. However, energy-related venture capital has been declining over the past two years, while spending on AI grew to reach USD 84 billion in 2024, or three times the level of energy-related venture capital (VC) funding.

The composition of the top 20 firms ranked by energy R&D budgets has changed dramatically since 2015. Ten years ago, the rankings were dominated by US and European automotive companies and oil and gas players, with the only exceptions being China State Grid Company and Petrochina. In 2024, the top 20 included a pure-play battery manufacturer for the first time (CATL, a Chinese firm), and two EV-focused carmakers (BYD and Tesla). Three other firms that seek to position themselves as equipment suppliers for electrification are also on the list (Denso, Schneider Electric and Robert Bosch), while the only oil and gas companies are state-owned Petrochina, Sinopec and Saudi Aramco.

Investment flows are not yet on track to deliver on the renewable and efficiency goals agreed at COP28. The annual investment required in renewable power still needs to double to achieve a tripling of installed renewable capacity by 2030, accompanied by rising spending on grids, storage and other forms of flexibility to ensure secure and cost-effective utilisation of this capacity. Spending on efficiency and electrification needs to almost triple within the next five years to deliver a 4% annual energy intensity improvement by the end of the decade.

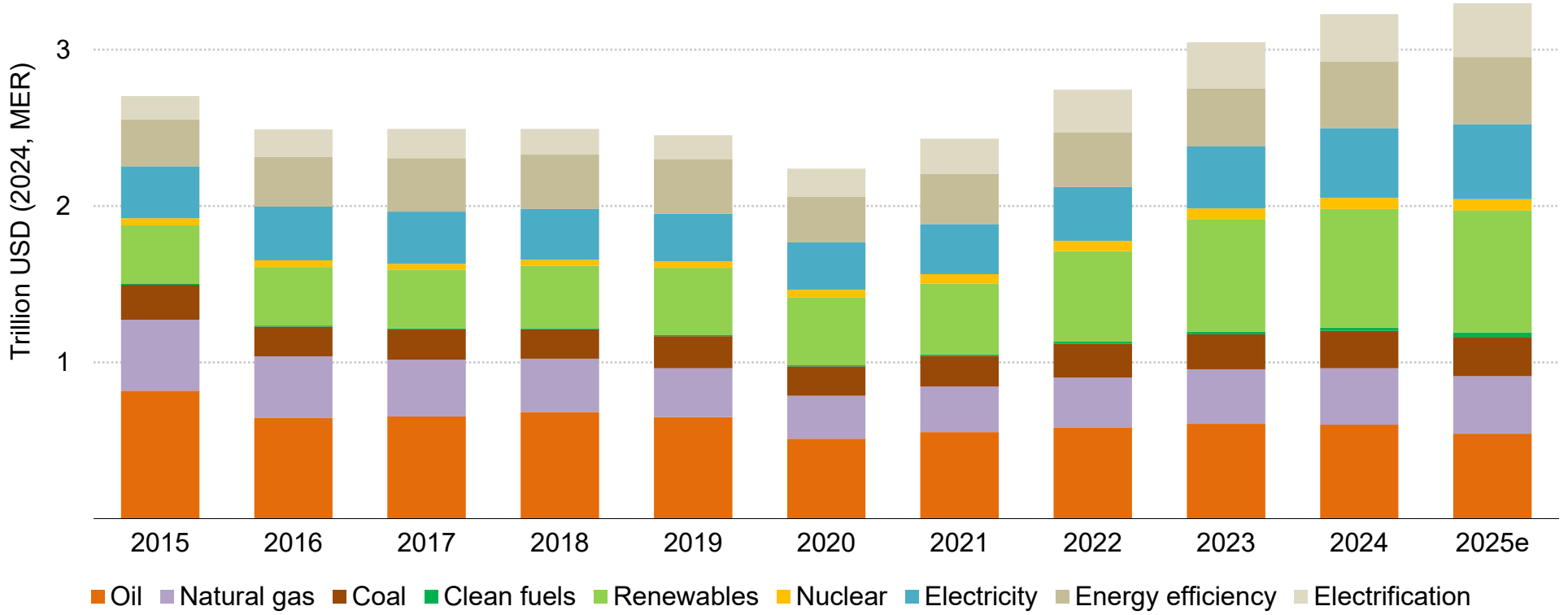
Efforts to reduce the cost of capital need to be the cornerstone of 'the Baku to Belem Roadmap', launched at COP29, that aims to mobilise at least USD 1.3 trillion in finance for low-emissions projects in developing economies by 2035. Scaling up climate

finance to developing countries requires targeted policy action to address a variety of real and perceived risks impeding investments in clean energy that are driving up the cost of financing in these countries. Mobilising private capital hinges on the ability of developing economies to conduct policy reforms and set up predictable regulatory environments. International public finance needs to be better targeted at managing project risks through guarantees, and other credit enhancement tools.

The energy world has changed dramatically since the release of the first *World Energy Investment* report a decade ago. Nonetheless, some of the trends that we discussed in our first report echo in the 2025 edition. Then, as now, we analysed the impact of price pressures on the oil sector, with shale in the front line. We reported that China edged ahead of the United States as the largest global energy investor. And we found that a "major shift in investment towards low-carbon sources of power generation is underway". The need for adequate, timely investment remains as important as ever for energy security, sustainability and affordability. Today's energy decision makers are facing new geopolitical tensions and the risk of energy shocks remains high. However, they have at their disposal a much broader range of highly competitive new technologies than was the case in 2015, and an accumulated wealth of policy experience on how to accelerate their deployment.

Energy investment continues to rise amid economic uncertainty

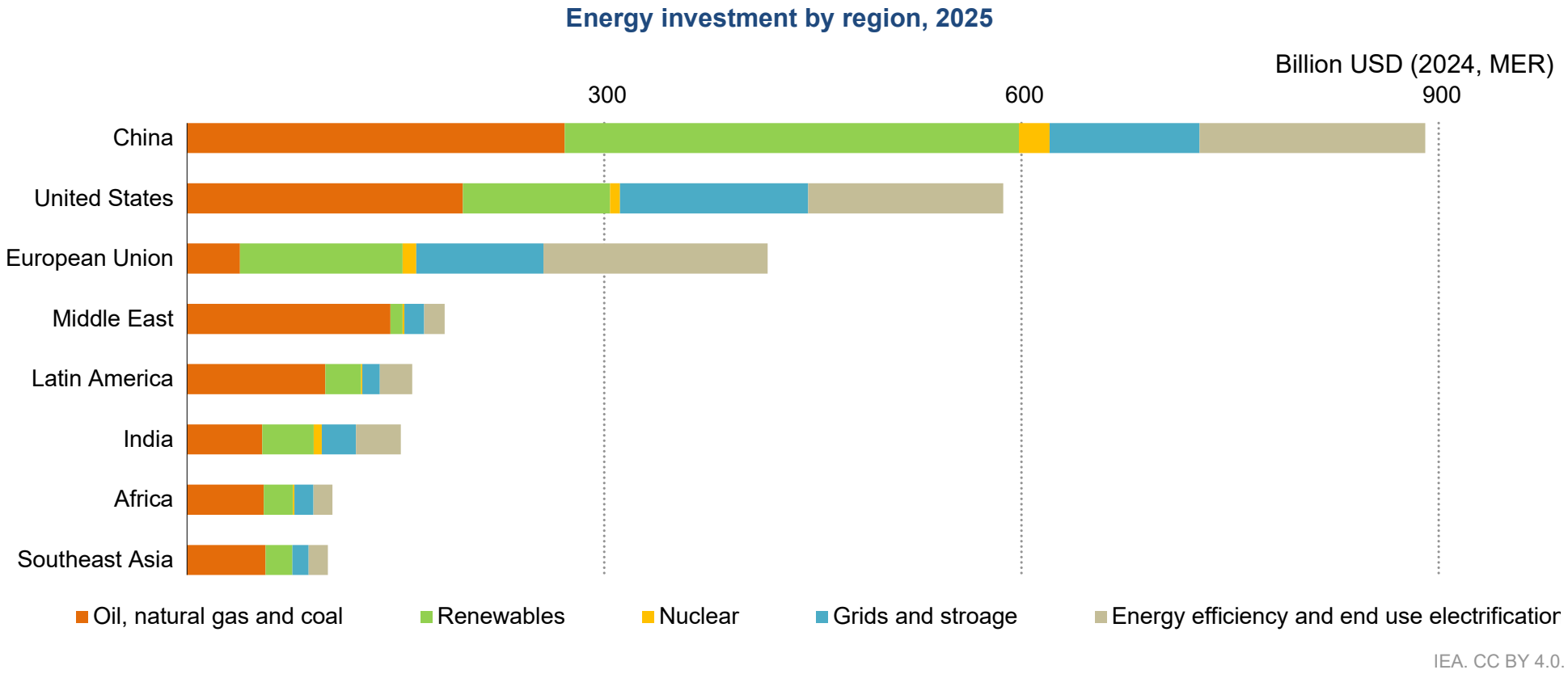
Global investment in energy, 2015-2025



Global energy investments in 2025 is set to reach USD 3.3 trillion. Clean energ hits a new high of USD 2.2 trillion with record additions of renewables, strong EV sales and rapid deployment of batteries. Fossil fuel investments see the first decline since 2020.

Note: Clean fuels = modern bioenergy, low-emissions H 2 based fuels, and CCUS associated with fossil fuels and also includes direct air capture. 2025e = estimated values for 2025

China sets the pace, as energy security drives spending growth

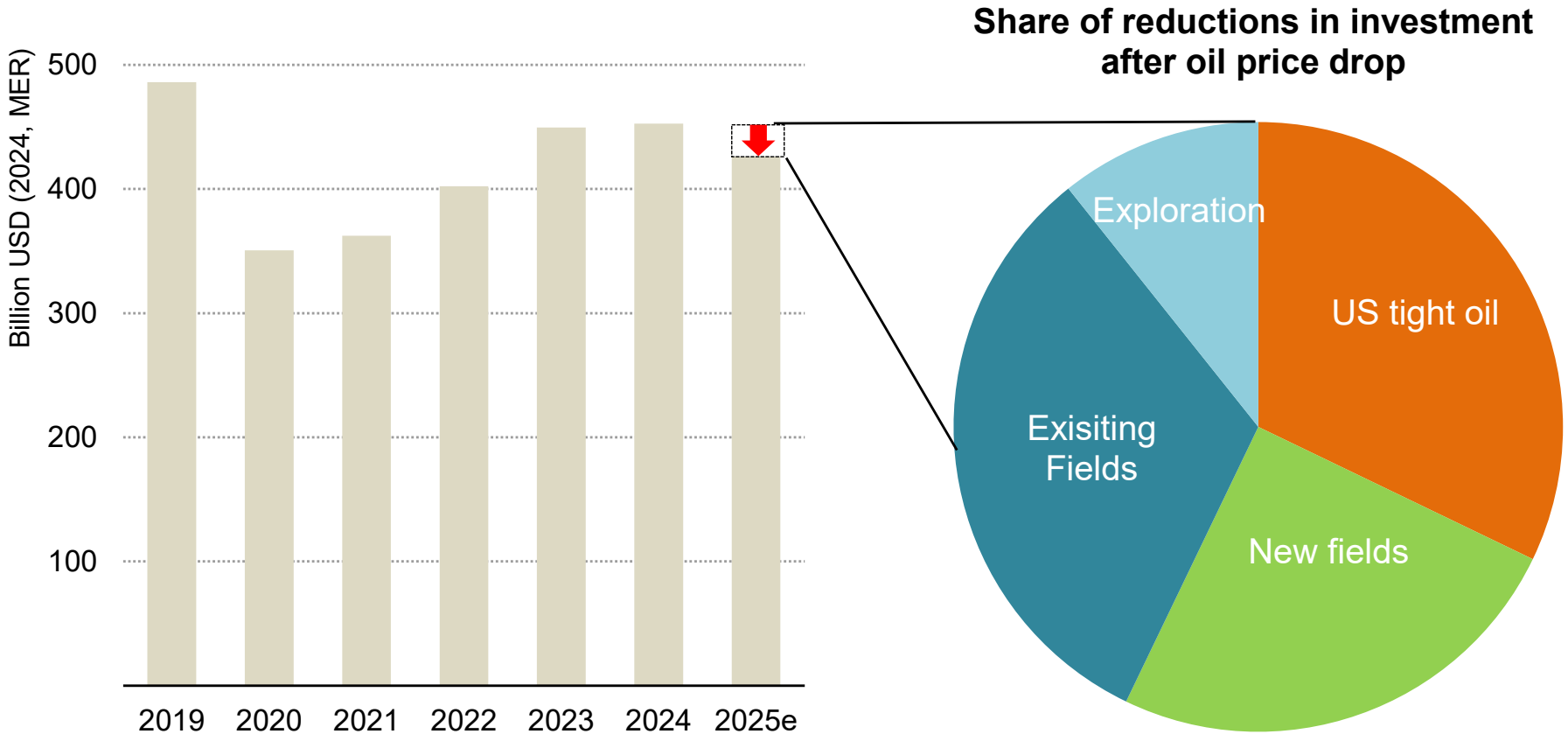


More than one-quarter of global energy investment takes place in China. Most of the growth in spending in recent years has been in fossil fuel importing countries looking to bolster their energy security by accelerating transitions

Note: 2025e= estimated values for 2025

Upstream oil investment is set to fall for the first time since 2020

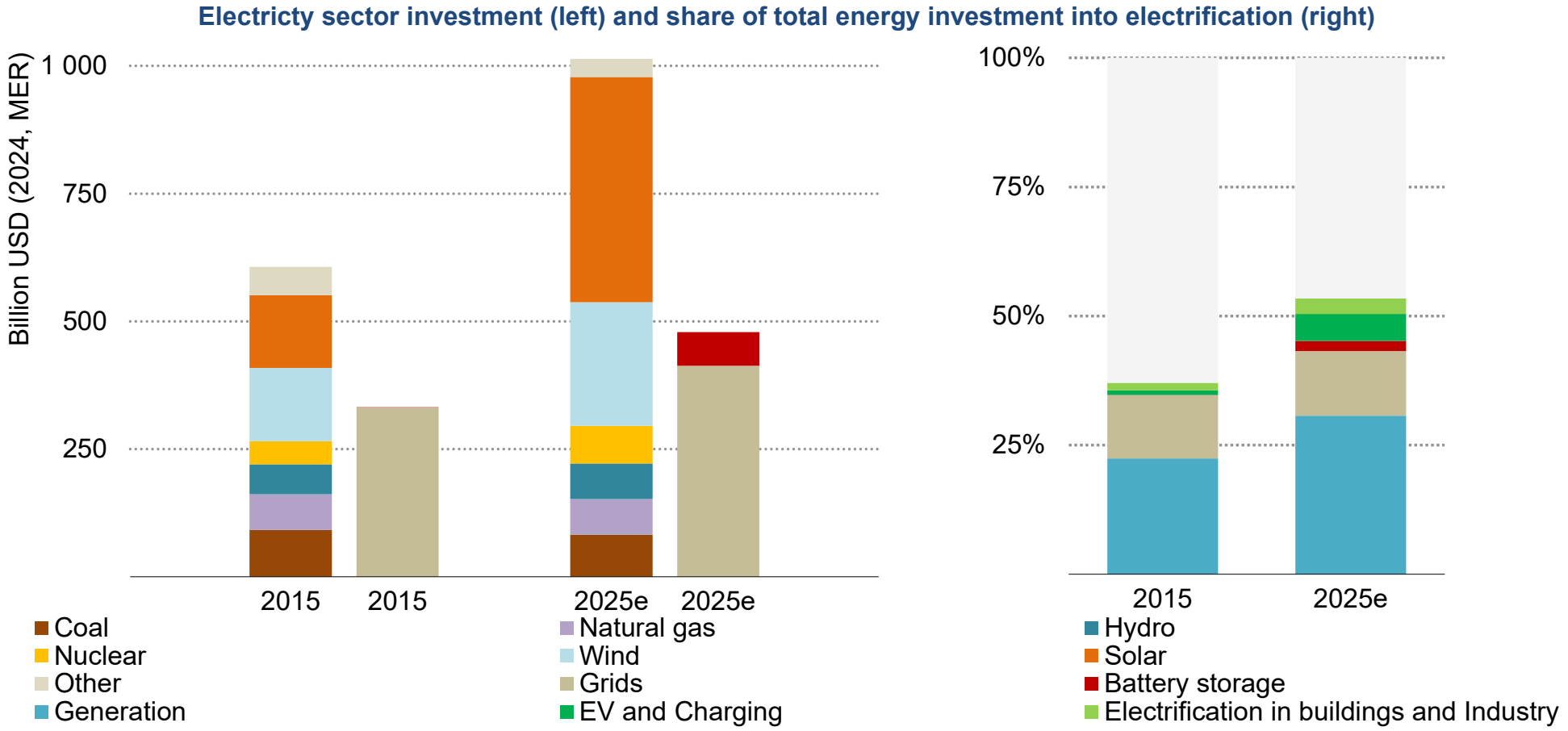
Upstream oil investment and changes in 2025 given latest company guidance



Investments in natural gas – especially in LNG – are robust, but spending on oil has been revised down in light of the new economic outlook and cost pressures, and global investment in refineries is hitting a new 10-year low

Note: 2025e= estimated values for 2025

The Age of Electricity is shaping investment trends



Solar PV and wind account for 98% of the growth in investment in electricity generation over the past decade. Today, over half all energy investment goes into the power sector and towards the electrification of end-uses.

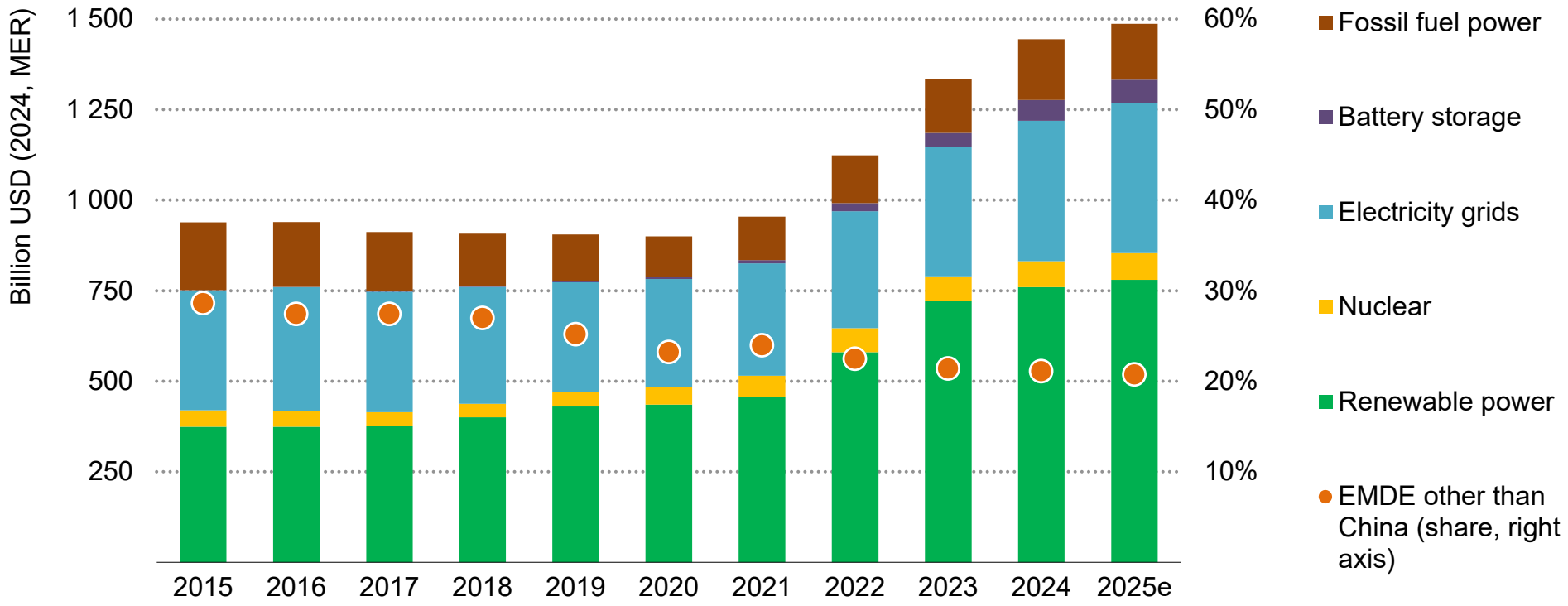
Note: 2025e= estimated values for 2025

Power

Overview

Total power investment grew 8% to USD 1.5 trillion in 2024

Global annual investment in the power sector by category, and EMDE share, 2015-2025

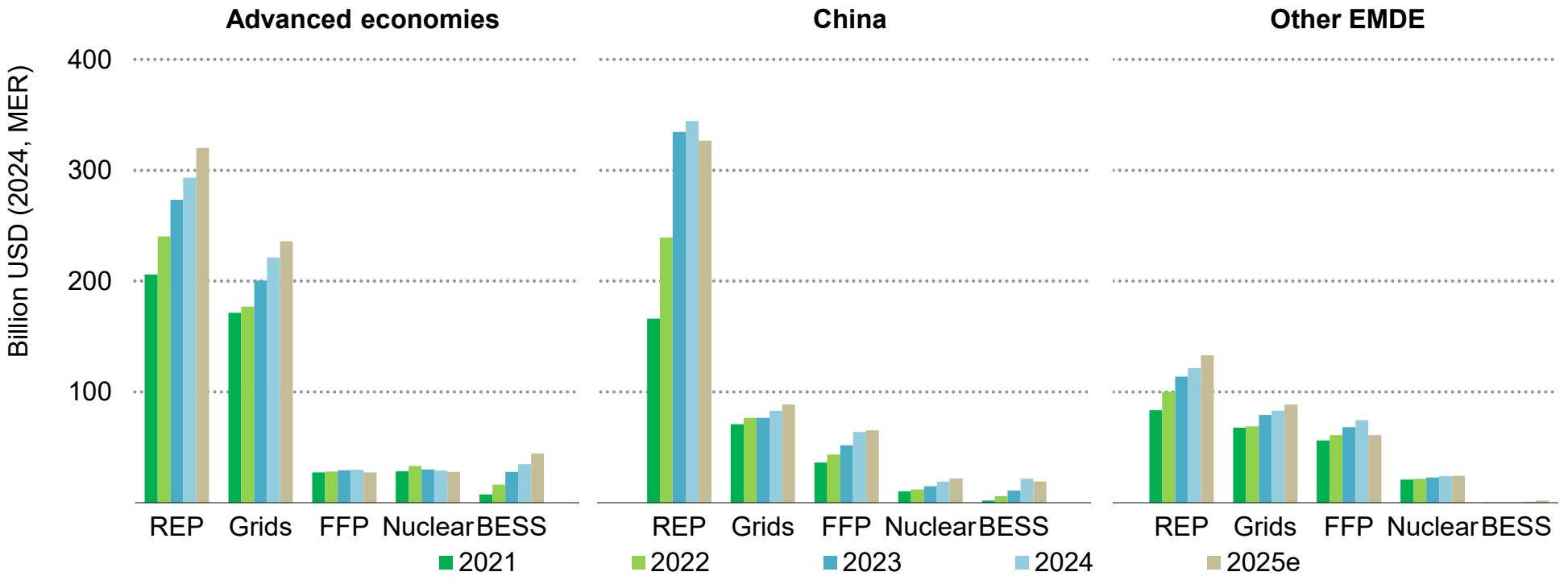


Investment in low-emissions power, grids and storage now represents nearly 90% of total power investment. However, the share of global investment going to EMDE continues to decline.

Notes: EMDE = emerging market and developing economies; MER = market exchange rates; 2025e = estimated values for 2025. Investment throughout is measured as ongoing capital spending on new and existing power capacity. Fossil fuel power includes unabated and abated power. Low-emissions generation = renewables, nuclear, and fossil fuels or non-renewables waste equipped with CCUS. Pumped hydro storage is included under renewables, not battery storage.

Combined investment in low-emissions generation and battery storage towers above fossil generation by 12:1 in advanced economies and 6:1 in China, and by 2:1 in other EMDE

Annual investment in the power sector by region and category, 2021-2025



Low-emissions generation, battery storage and grids saw record investment in advanced economies, China and other EMDE in 2024. Fossil generation investment is also rising due to new projects in China but is set to decline in other EMDE in 2025.

Notes: REP = renewable power; FFP = fossil fuel power; BESS = battery energy storage system. Spending on BESS in other EMDE is estimated at less than USD 2 billion in 2024, and can barely detected on the chart. Pumped hydro storage is included under REP. 2025e = estimated values for 2025.

After moderate growth in 2024, clean power generation remains the preferred destination for new power sector investment, but grids remain a constraining factor

2024 in review

Power sector investment reached a new high of USD 1.5 trillion in 2024, driven primarily by record investment in sources of low-emissions generation, as well as grids and battery storage.

Advanced economies (39%) and the People's Republic of China (hereafter "China") (45%) remain the largest markets for renewable power, but 2024 saw solar investment accelerate in emerging market and developing economies (EMDE) such as India, the Middle East and North Africa, and Central Asia. With the help of increasingly competitive solar panels and batteries, distributed systems have emerged as an important driver of new investment in EMDE. Imports of Chinese solar cells and modules are rising quickly, with Pakistan having imported 19 GW in 2024 alone.

The flip side of very cost-competitive solar for developers, businesses and consumers has been financial difficulties experienced by solar manufacturers. Manufacturers ranging from polysilicon producers to module assemblers made significant losses in 2024 as companies fought for market share. Solar cell output among Chinese manufacturers hit record levels in March 2025, suggesting that efforts to curb oversupply are having mixed success. Lower-tier companies may not be able to endure in an environment of intense competition and innovation should prices remain at very low levels in 2025.

The offshore wind market continues to face a different set of challenges. Policy support in the United States is being scaled back, with uncertainty over the prospects for some projects that are under construction. Markets looking to encourage additional investment also saw setbacks, notably the cancellation of Ørsted's Hornsea 4 Offshore project in the United Kingdom. Some developers have significantly pared back their ambitions or restructured their businesses due to higher costs and uncertain policy frameworks. The onshore wind market, meanwhile, has remained more resilient to increasing prices, but growth is still being constrained by grid bottlenecks. With order books for wind turbines being replenished at higher prices and cost pressures having mostly subsided, western manufacturers saw both profits and returns recover in 2024. However, competition is also heating up as low-cost Chinese manufacturers expanded their market share in 2024.

Momentum behind other sources of low-emissions generation accelerated in 2024. Data centres are creating demand for zero-carbon baseload power for which small modular reactors (SMRs) and advanced geothermal are suitable candidates. Increasing construction starts of conventional large-scale reactors, mainly in China, led investment to grow to USD 72 billion in 2024. A number of new agreements between developers and technology companies, backed by broad government support, is expected to boost investment in the medium term. Efforts to commercialise and scale

advanced geothermal are also progressing with the help of new partnerships between data centre operators and frontier developers.

The AI-led investment boom may also be contributing to an increase in thermal generation investment in advanced economies due to the relatively flat load profile of data centres. The orders of gas turbines have increased in 2024, as numerous power agreements were signed. USD 18 billion of cumulative investment in natural gas generation specifically for data centre energy demand is expected by 2030. This comes on top of a significant rise in construction starts for new coal-fired generation in China and India, against a backdrop of rapidly increasing electricity demand and worries about electricity security. Global investment in coal and gas-fired generation reached its highest level since 2017.

Expectations for 2025

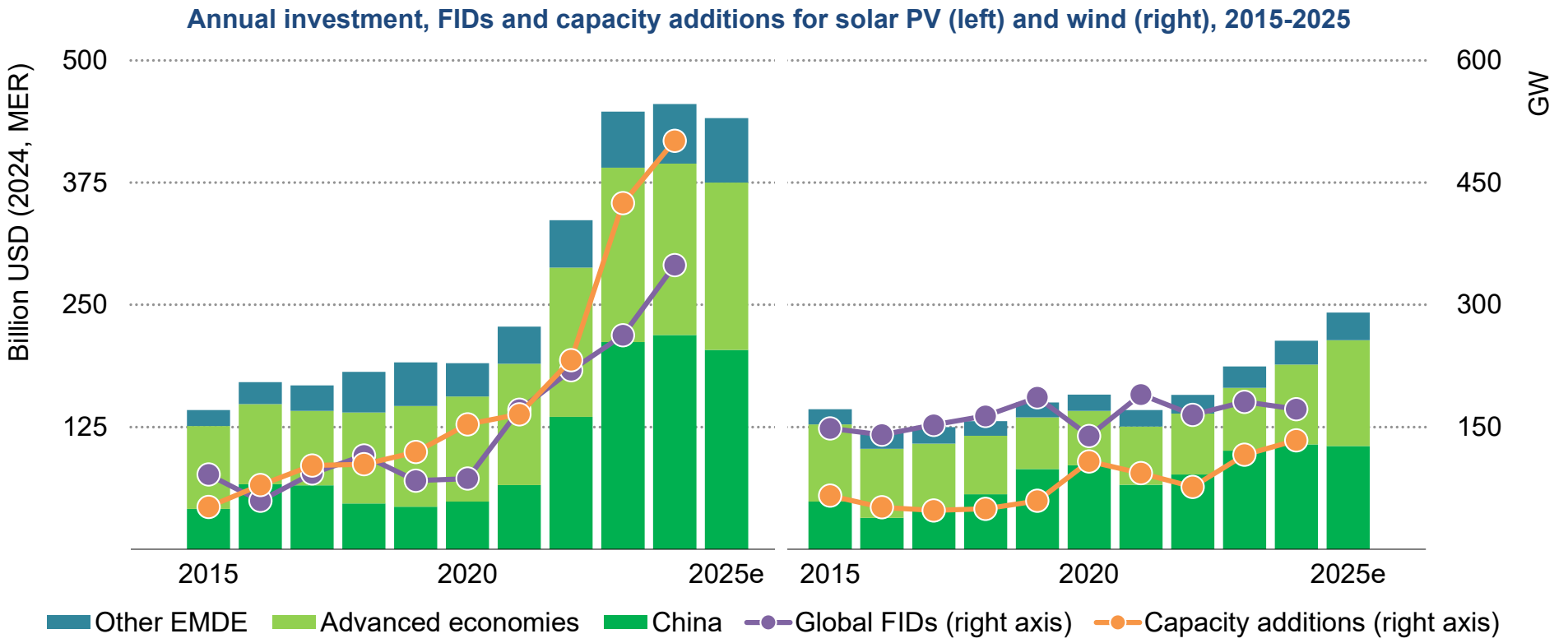
Although recent events have cast doubts on the speed of interest rate cuts for 2025, inflationary pressures eased in 2024 in many parts of the world, leading to a decline in costs for new debt issuance. This should help to support utility-scale renewable financing, the investment decisions for which are sensitive to interest rates and rely on access to affordable debt.

At the same time, a marked increase in business uncertainty and a potential slowing of economic growth may put a dampener on some aspects of global power investment. Beyond financial markets, parts of the electricity system continue to move at different speeds, and these growing pains are slowing the pace of power sector investment. Due to lengthy permitting times and connection queues, rising equipment costs and persistent challenges to financing, grids are now a key bottleneck. A concerted effort to improve regulatory frameworks, business models and financing structures is underway, but grid infrastructure is expected to constrain near-term deployment of utility-scale generation capacity.

Finally, China's shift to more liberalised power markets in 2025 and changes to subsidy regimes from mid-year could moderate new renewable and battery storage capacity additions in the second half of the year. In conjunction with further declines in the price of solar and batteries in most regions, the combined effect of all the factors mentioned above is expected to result in a cooling of power investment growth in 2025 to 3%.

Generation

A slowdown in spending on solar PV in 2024 was largely due to declining costs; meanwhile, wind investment continues to grow despite recent setbacks in the offshore market

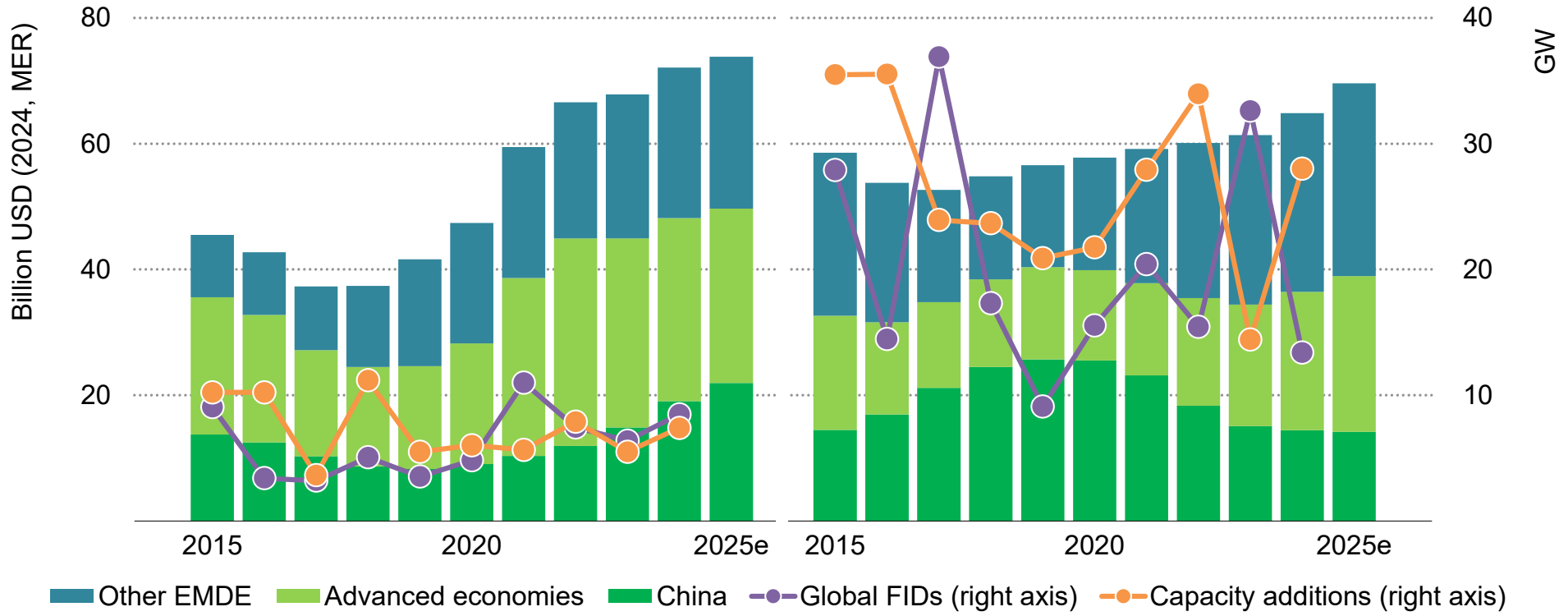


Declining costs are behind the stabilisation of solar investment despite record capacity additions and new project FIDs. For wind, capacity additions and FIDs slowed in 2024, but investment is expected to grow in 2025 as construction commences on higher-cost projects.

FID = final investment decision. FIDs are an indication of the scale of future capacity to come online in the coming years. The IEA tracks projects that reach financial close or begin construction to provide a forward-looking indicator of future capacity additions and spending activity. 2025e = estimated values for 2025. FIDs and capacity additions not shown for 2025e.
Source: IEA analysis based on Clean Energy Pipeline (2025).

Growing SMR demand from the tech industry may be a tailwind for nuclear in the coming years, but currently new growth is mainly attributable to Chinese investment in large-scale reactors

Annual investment, FIDs and capacity additions for nuclear (left) and hydro (right), 2015-2025



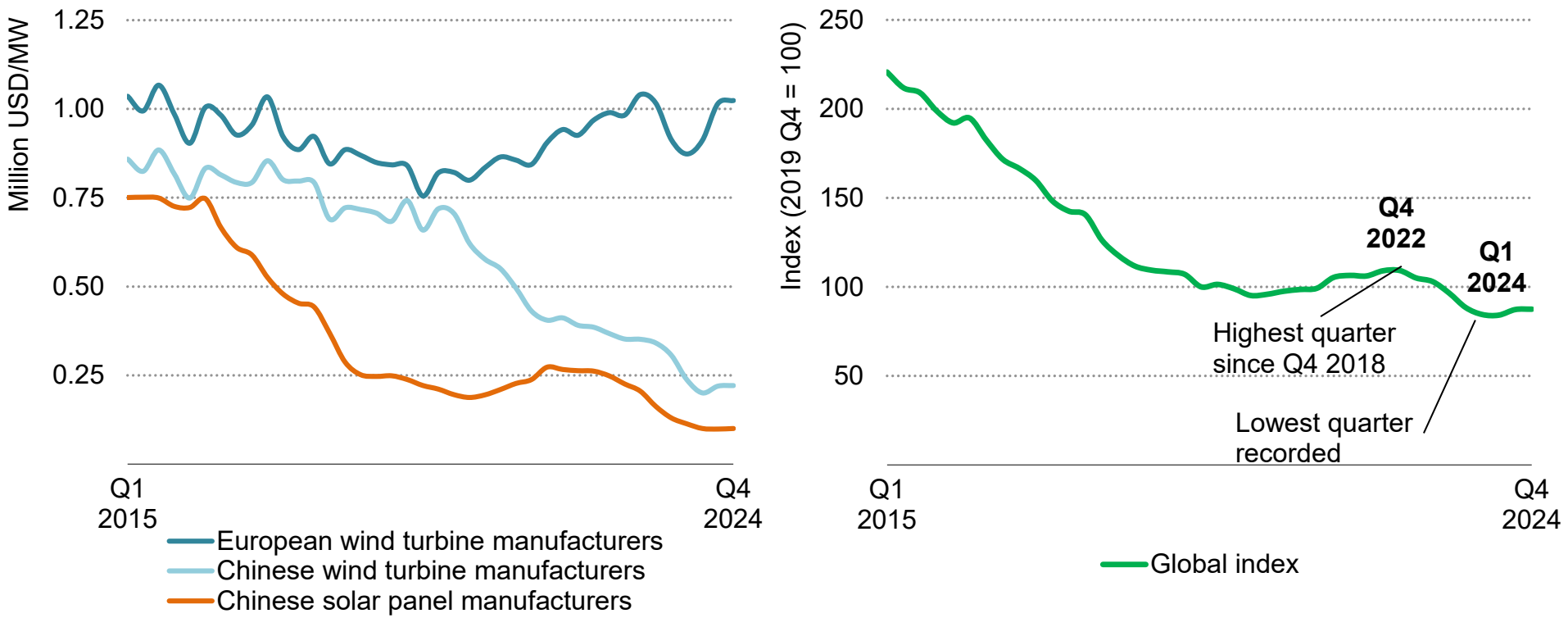
Over 8 GW of new nuclear reached FID in 2024 as nuclear investment continues its comeback. Hydro investment is also on the rise due to new hydroelectric projects in EMDE and pumped hydro storage in advanced economies.

Notes: SMR = Small Modular Reactor; EMDE = emerging market and developing economies; FID = final investment decision; 2025e = estimated values for 2025. FIDs and capacity additions not shown for 2025e. Hydro investment here includes pumped hydro storage.

Sources: IEA calculations based on McCoy Power Reports (2025) and International Atomic Energy Agency data (2025).

Prices for solar continued to decline throughout 2024 but began to stabilise at the end of the year, while wind turbines have seen some volatility

Manufacturers' average selling prices (left) and IEA clean energy equipment price index (right)



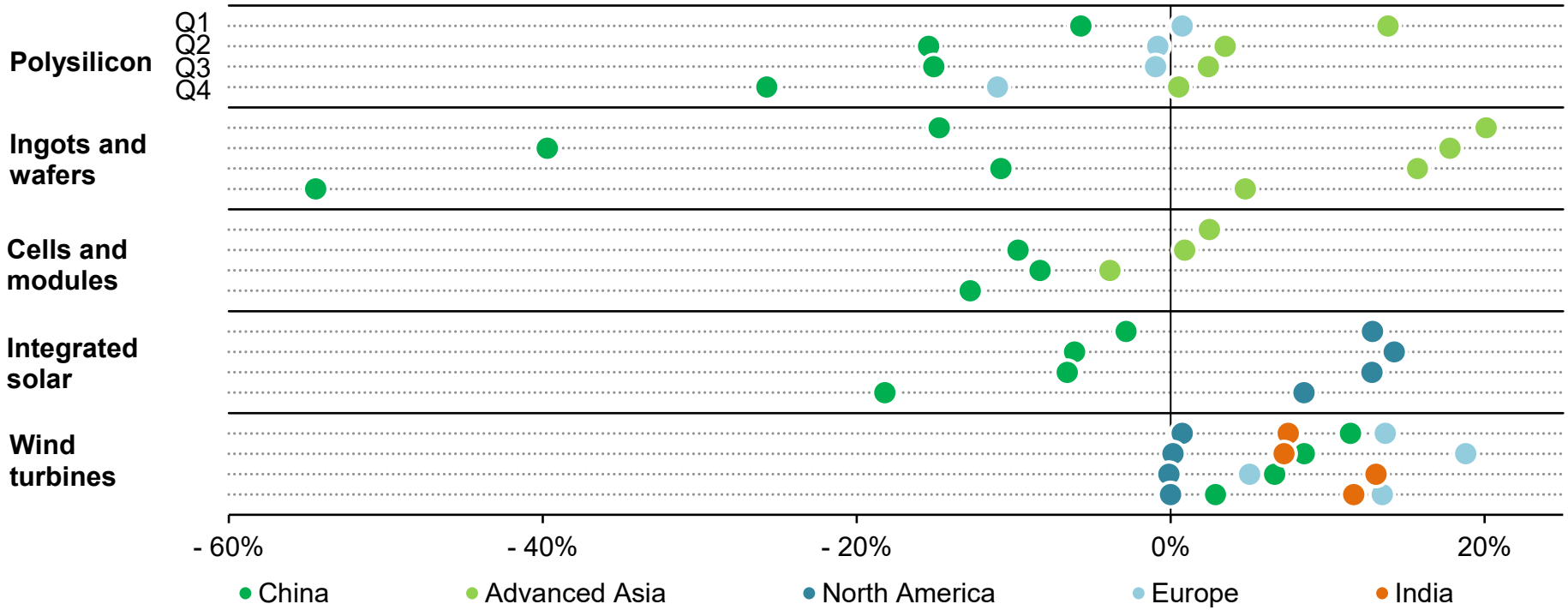
Clean energy equipment is now less than half the price it was a decade ago. Whereas Chinese solar manufacturers have seen a steady decline in cost since 2022, there has been a clear divergence between western and Chinese wind turbine manufacturers.

Notes: The clean energy equipment price index, developed by the IEA, tracks price movements in a global basket of solar PV modules, wind turbines, lithium-ion batteries for electric vehicles and utility-scale battery storage, weighted by share of investment.

Sources: IEA calculations based on companies' financial reports, Bloomberg data (2025), and BNEF data (2025).

Whereas many solar firms endured negative margins to maintain market share throughout 2024, EU wind manufacturers kept prices high to recover from previous years' cost pressures

Weighted average quarterly profit margins for selected solar and wind manufacturers by country of headquarter, Q1 to Q4 2024



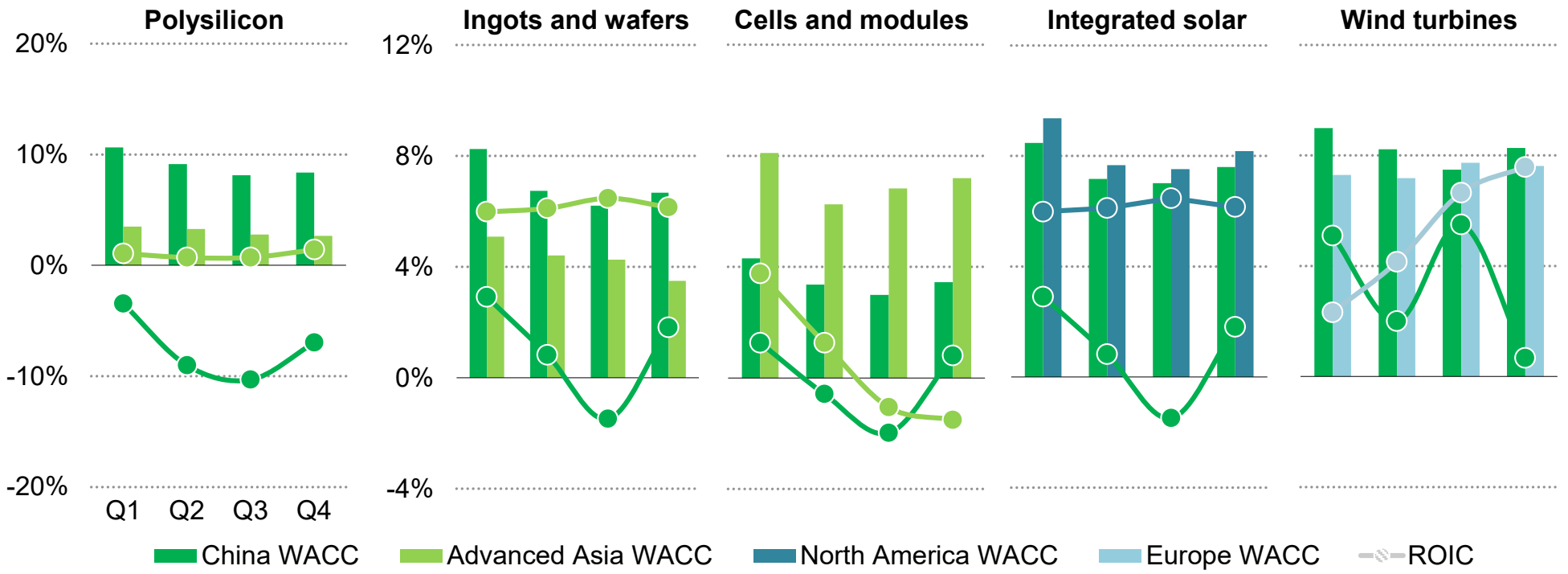
For solar, North American integrated players and manufacturers headquartered in advanced Asia with access to more lucrative export markets were less exposed to oversupply in 2024. European wind manufacturers are also benefiting from more profitable orders.

Notes: Profit margins are averages using company revenues weighted by their respective share of total revenues in a particular value chain segment (e.g. polysilicon) and HQ region (e.g. China). Integrated solar includes vertically integrated companies engaged in manufacturing, installation and project development. Total sample set includes 51 unique companies. Average Chinese cells and modules profit margins for Q4 (-61%) not shown.

Source: IEA calculations based on S&P Capital IQ data (2025).

Some Chinese solar and European wind turbine manufacturers are staging a recovery, but returns are generally low, and other companies show financial health continuing to deteriorate

Weighted average quarterly WACC and ROIC for selected solar and wind manufacturers by country of headquarter, 2024 Q1-Q4



Polysilicon and cell and module manufacturers headquartered in China were the hardest hit in 2024, enduring negative returns in 2024. Market exits and stabilising prices in Q4 underpinned a turnaround in ROI for Chinese producers, but losses have continued into 2025.

Notes: WACC = weighted average cost of capital (after deducting corporate taxes); ROIC = return on invested capital. WACC and ROIC are averages using company revenues weighted by their respective share of total revenues in a particular value chain segment (e.g. polysilicon) and HQ region (e.g. China). Integrated solar includes vertically integrated companies engaged in manufacturing, installation and project development. Total sample set includes 51 unique companies.

Sources: IEA calculations based on S&P Capital IQ data (2025) and Bloomberg data (2025).

Renewables companies are feeling the pain from diverging price trends for solar and wind

2024 ended with another historic low for solar module prices as competition from Chinese manufacturers intensified amid acute overcapacity. Major Chinese manufacturers pursued an aggressive strategy to preserve market share by pricing out lower-tier producers, dragging margins into negative territory from polysilicon production to module manufacturing and raising the average debt-to-equity ratio by as much as 86% from Q1 to Q4 in 2024. Those with strong cash positions are better positioned to endure, but the least-affected companies have been manufacturers in countries with access to profitable export markets such as Japan and Korea, and North American integrated players insulated from foreign competition.

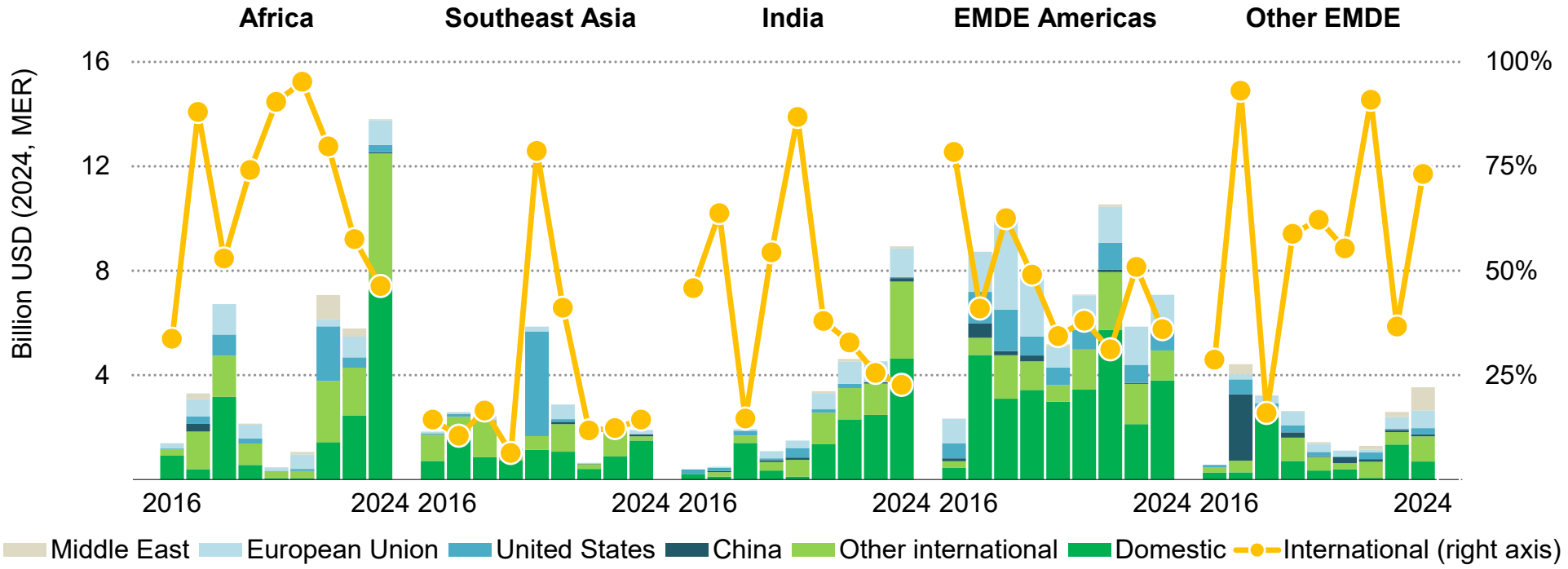
Declining ROI is disincentivising new investment, yet efforts to onshore production are having some impact. Module manufacturing in the United States tripled last year, and tariffs are already leading to a reduction in imports from some highly-exposed Southeast Asian countries, having reached all-time highs in 2024. Meanwhile the reinstatement of India's solar ALMM with the aim of achieving 100% locally manufactured cells for government projects by 2026 will further restrict export opportunities for Chinese companies. The success of China's Photovoltaic Industry Association price floor is uncertain: although prices temporarily rose in Q1 of 2025, solar cell production is growing. It will be years before demand catches up with supply, suggesting a leaner, more competitive industry may emerge.

For wind manufacturers, price pressures have eased significantly since 2023. Despite this, western manufacturers are looking to shore up their finances by maintaining higher prices for new turbine orders, and 2024 margins have improved as a more lucrative project pipeline replaces cheaper legacy orders. 2024 ended strong with Q4 European turbine orders surging by 140% to 7.8 GW.

Rising sellers' prices, however, have consequently made some prospective projects uneconomical, especially when combined with waning government financial support. The onshore wind market has proved more resistant to the challenges caused by higher equipment prices, with major markets like Germany seeing record bids for its largest-ever auction in Q4. The offshore market meanwhile shows signs of continued weakness as developers like Ørsted have significantly pared back investment plans in response to increasing project costs. BP (now JERA) was seeking an unlevered IRR of 6-8% vs 15-20% for its oil and gas portfolio, and other oil majors are also spinning off or scaling back their offshore wind portfolios, citing higher costs and unfavourable government terms. Inadequate returns have culminated in lacklustre interest in recent auctions; in response, some countries are reassessing direct support. Despite recent setbacks in the United Kingdom, 11.7 GW of offshore wind are due to be auctioned in Europe in 2025. With market exits and lessons learnt from failed auctions, conditions may improve for traditional developers in 2025.

Affordable solar is enabling record clean power investment in some EMDE, but a mixed global picture underscores persistent challenges in attracting financiers for utility-scale projects

Transaction value of FIDs for utility-scale renewables primary project finance in selected EMDE, 2016-2024



Primary project finance for renewables hit record highs in Africa, India and other EMDE, but EMDE Americas and Southeast Asia continue to see sporadic growth from both domestic and international sources.

Notes: Primary project finance does not include asset acquisitions, asset refinancing, or any on-balance sheet finance. Project finance is more common in Africa and Southeast Asia, accounting for a respective 30% and 34% of utility-scale solar and wind investment in 2024, whereas in India it accounted for only 25%.

Source: IEA calculations based on IJGlobal data (2025).

Low-cost Chinese solar panels are enabling higher distributed solar investment in EMDE…

FIDs for utility-scale renewables projects have reached new highs in regions such as Africa (USD 14 billion) and India (USD 9 billion), but significantly more investment, likely involving international finance, is needed. Certain EMDE, such as India, have seen both domestic and international finance from commercial banks and investors increase in recent years due to a more stable macroeconomic environment, mature capital markets and improved financial health of distribution companies. However, in regions like Africa and Southeast Asia, foreign exchange and country risks have made utility-scale projects unbankable for some international financiers, barring the involvement of development finance institutions and export credit agencies. Without a robust domestic financial sector to fill the gap, utility-scale investment has consequently failed to take off in many EMDE.

However, there are signs in some markets of very competitively priced solar panels, typically imported from China, making their way into EMDE. Pakistan provides an illuminating example of how plummeting solar costs have enabled households and businesses to circumvent the challenges of financing utility-scale solar. A combination of poor planning, rising energy prices and currency devaluation has led to excessive capacity payments to underutilised coal and natural gas power plants. Faced with rolling power outages and a 155% increase in tariffs since 2021, ratepayers have turned to small-scale solar as a more affordable electricity source to supplement consumption from the National Grid of Pakistan. Retail investment has surged as a reported 19 GW of solar was imported in 2024. With or without net metering, individuals and businesses are finding enough cost savings to recoup their investment in two to four years. As a result, national grid electricity sales have decreased by about 10% since 2022.

Pakistan may well serve as a bellwether for a more decentralised, bottom-up model of solar uptake. Of Chinese solar equipment exports, 44% by value made their way to EMDE in 2024, up from 33% two years ago, and 41 different EMDE recorded their highest ever imports from China in 2024 even without adjusting for price reductions. Growth in Africa is particularly notable: whereas the dollar value of Chinese solar imports into advanced economies and EMDE other than China has been falling, likely in large part due to module price reductions and the relocation of Chinese manufacturing to Southeast Asia, African countries such as Nigeria have seen impressive growth in recent quarters, albeit from a low base.

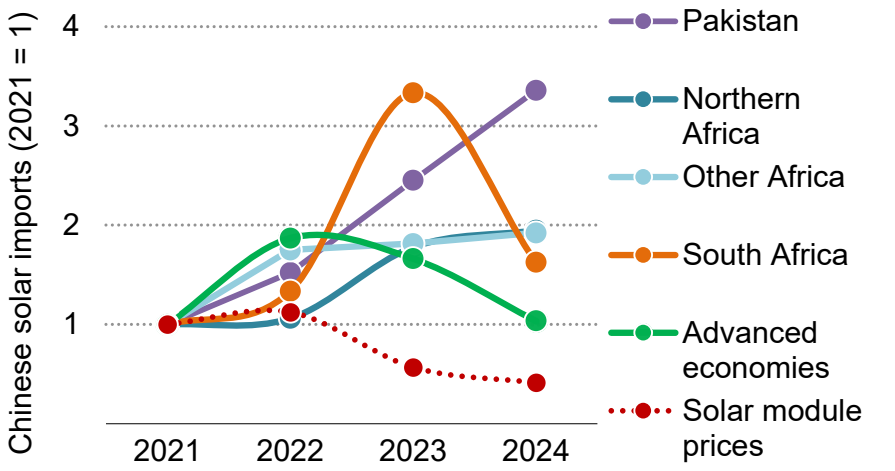
It is unclear what percentage of these imports are intended for rooftop, mini-grid or off-grid installations; for example, there are signs that utility-scale projects are accelerating in some African countries. However, the double- or triple-digit import growth in many EMDE do not always coincide with a marked improvement in economic conditions that are conducive to utility-scale investment.

…and could present a more financially sustainable route to renewables deployment if coupled with forward policy planning and electricity infrastructure investment

While the magnitude of capacity payments and generosity of net metering incentives may be unique to Pakistan, electricity tariffs have been rising in recent years in numerous EMDE where the financial health of state utilities and distribution companies has deteriorated due to currency depreciation and higher energy prices. Among many examples, a 13% increase in electricity tariffs was granted by the South African energy regulator in January 2025 (less than half the 36% requested by Eskom), tariffs tripled in Nigeria for households that consume about 40% of the country's electricity, and in Ghana tariffs increased by almost 50% in the first two quarters of 2023.

Like Pakistan, net metering incentives are offered in some EMDE, but the trends in solar imports seen in countries with and without net metering indicate a more muted impact to date. Nonetheless, taken together – rising tariffs, load shedding, decreasing solar equipment prices and incentives for retail investment – the conditions that led to Pakistan's solar boom seem also to be present in other EMDE to varying degrees, and hence may also represent a forewarning: actions seen as necessary for the financial recovery of state utilities could have the opposite effect if not carefully managed. A decentralised model enabled by cheap solar could present a more financially sustainable route to scale solar deployment in EMDE given the high complexity and cost of financing utility-scale projects today.

Chinese solar imports by value in selected regions, 2021-2024

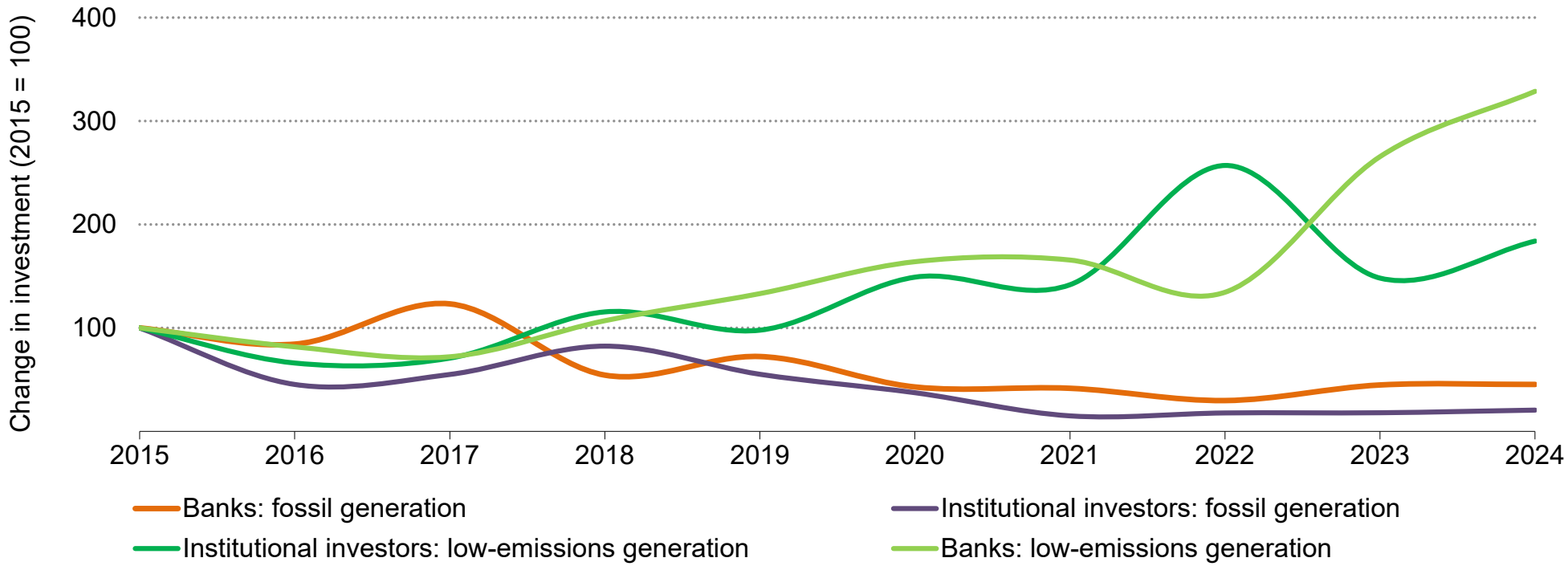


Source: BNEF (2025), Solar PV Equipment Supply Chain Trade

However, in Pakistan, limited commercial financing options for distributed solar have led to uptake mostly among affluent households with high electricity consumption, eroding the ratepayer base, thereby leaving low-income households to foot the bill of fixed charges via tariffs. Incentives targeted specifically at lower-income households in conjunction with grid modernisation to better accommodate a decentralised electricity system could avoid such a scenario, and this could improve access to electricity at affordable prices without compromising the financial health of utilities.

Most banks and institutional investors have significantly increased primary finance for new renewables projects over the past decade, whereas finance for fossil power has declined

Change in primary finance for electricity generation projects provided by banks and institutional investors, 2015-2024



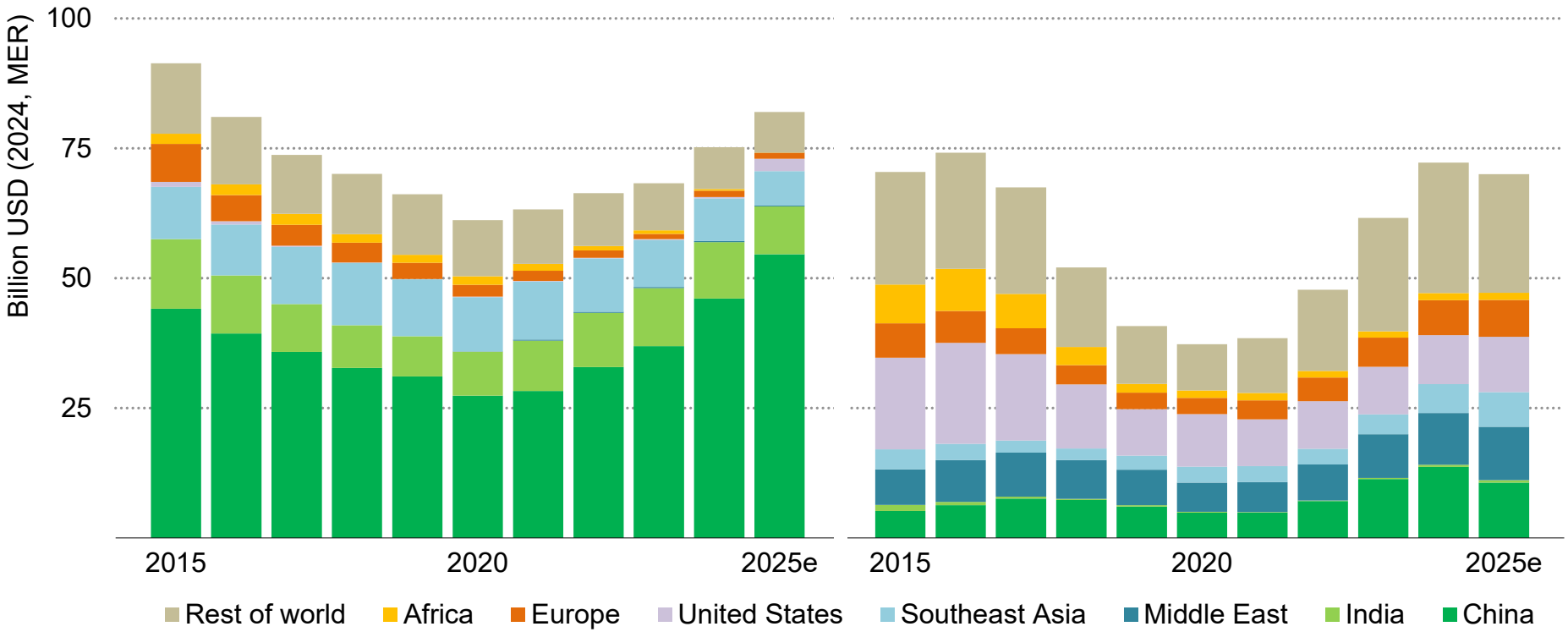
The low-emissions share of primary project finance for new generation assets among banks and institutional investors has increased from 71% and 65% in 2015 to 96% and 93% in 2024, respectively.

Notes: Figure only includes primary finance specifically for off-balance sheet instruments where the investor or financier is publicly disclosed. Calculations do not include other forms of primary financing such as new bond or equity issuances, or secondary finance via refinancing or acquisitions. Chinese state-owned banks are not included.

Source: IEA calculations based on IJGlobal data (2025).

Having met its renewable power target six years ahead of schedule, China is also making significant investment in coal-fired generation against a backdrop of rapidly rising demand

Annual investment in coal-fired generation (left) and natural gas-fired generation (right) by region, 2015-2025

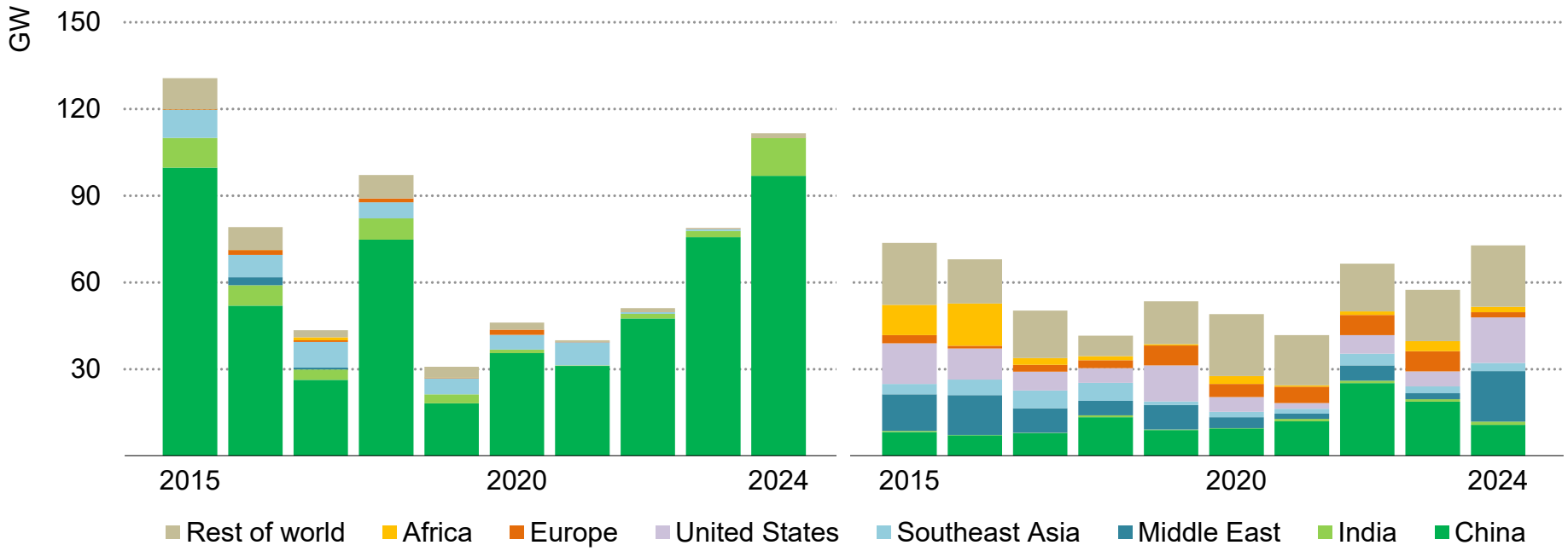


Coal is capturing a security premium due to continued geopolitical tensions in natural gas and LNG supplies. Chinese investment in natural gas generation is expected to decline in 2025, while continued investment is being seen in the Middle East and the United States.

Notes: 2025e = estimated values for 2025. Includes coal- and gas-fired generation with or without CCUS.
Source: IEA calculations based on McCoy Power Reports (2025).

New Chinese coal construction starts take new coal plant FIDs to their highest point since 2015, while natural gas plant FIDs are also picking up, especially in the United States and Middle East

FIDs for new coal-fired generation (left) and natural gas-fired generation (right) by region, 2015-2024



New FIDs for coal generation hit ten-year highs in both China and India in 2024, accounting for 99% of the global total. Meanwhile, the United States and the Middle East accounted for nearly half of all new natural gas-fired FIDs.

Notes: FIDs are an indication of the scale of future capacity to come online in the coming years and the time it takes for a new plant to go online can vary: a new natural gas plant might take up to four years, for example, while a new nuclear plant can take up to 15 years. All build times come from IEA (2024), World Energy Outlook 2024. For coal power in China, FIDs are measured in construction starts. For all other regions and for natural gas generation, FIDs are measured using turbine orders specifically intended for new projects in that country, not for re-export. Includes coal- and gas-fired generation with or without CCUS.

Sources: IEA calculations based on McCoy Power Reports (2025) and Global Energy Monitor (2025), Global Coal Plant Tracker 2014-2024.

New data point to a resurgence of coal-fired plant commissioning in China and India

In the face of rapid electricity demand growth and concerns linked to security of supply, such as various geopolitical risks as well as uncertainties over hydropower output, China and India are approving increasing amounts of new coal-fired power. New data shows that new final investment decisions for new coal-fired power plants in both countries hit their highest levels in a decade. By contrast, for the first time on record, there were no new steam turbine orders for coal-fired power plants in advanced economies in 2024.

Although the jump in India is particularly noteworthy, construction on over 95 GW of new coal-fired power plants in China commenced last year – approximately nine times greater than the number of steam turbine orders in India over the same period. As a result, China's annual coal-fired generation investment was USD 46 billion in 2024 and is expected to grow to USD 54 billion in 2025. The large pipeline of announced or permitted projects and a new policy allowing construction to continue to at least 2027 suggest that investment may continue for years to come.

Five-year plans since 2016 have sought to adjust the long-term role of coal from baseload to a provider of system flexibility and adequacy. For example, 300 GW of existing coal has been retrofitted since 2021 to meet new flexibility requirements. The utilisation rate of coal generation is therefore an important indicator of any change in the role of coal-fired plants. For the moment, this indicator remains around the levels seen over the previous decade, with coal power plants operating on average at around half their capacity nationwide. However, some new coal plants will be required to run at much lower utilisation rates (20% or less) and often with the main function of balancing electricity supply from intermittent sources.

Whereas renewables deployment is already sufficient to satisfy most new electricity demand in China, the same is not true for India, which could become the key driver of coal investment over the next decade. Renewables investment in India grew by 17% to USD 33 billion in 2024 and is expected to climb a further 12% 2025. However, against the backdrop of expected annual growth in electricity demand to 2030, new coal capacity is expected to service some of the incremental demand not met by renewables and to provide a round-the-clock firming solution to support renewables, as seen in China.

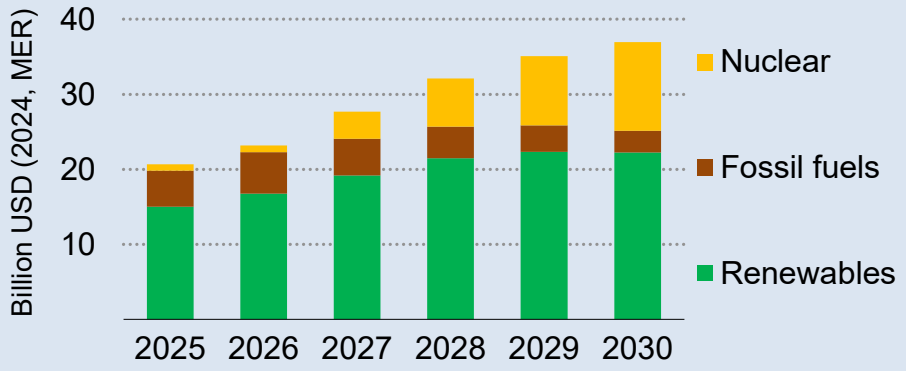
Bottlenecks in the issuance of power sale agreements (PSAs) and power purchase agreements (PPAs) have led to a backlog of renewable tenders in India. Awarded renewable projects totalling 40 GW were awaiting PSAs as of Q1 2024, equivalent to approximately 15% of total operational renewable capacity today. This is discouraging further investment and auction participation. A more efficient tendering process, better synchronised with new transmissions and distribution infrastructure, is imperative to slow the pipeline of new coal projects and meet the 2030 renewables target.

The impact of AI and data centres on electricity generation investment

Annual data centre (DC) investment has surged by 67% over the past two years. Another USD 4.2 trillion of investment is expected from 2025 to 2030 globally, and electricity demand from DCs could double to 950 TWh by 2030. Access to energy has consequently emerged as a principal concern for DC operators. New power demands will require over USD 170 billion for new generation capacity by 2030.

While renewables are expected to meet the majority of additional DC electricity demand, there has been considerable interest in next-generation energy solutions, foremost among them nuclear SMRs. In addition to being more easily financed and tailored to project specifications, the draw of nuclear for DCs stems from their flat load profiles: both are capital-intensive projects, hence running at close to full capacity is essential to recoup investment costs. This has led to numerous PPAs and other agreements between major technology companies, contributing about 27 GW of capacity from new or recommissioning mothballed reactors, mostly in the United States, but also in India, Japan and Korea. The AI-led private sector pull is complemented by broad political support: six new countries joined the pledge to triple global nuclear capacity by 2050, and more than 40 countries have plans to build, or are considering building, new reactors. However, given uncertainties over costs, lead times and design approvals, operational SMRs are unlikely until the 2030s.

New power generation investment for DCs, 2025-2030



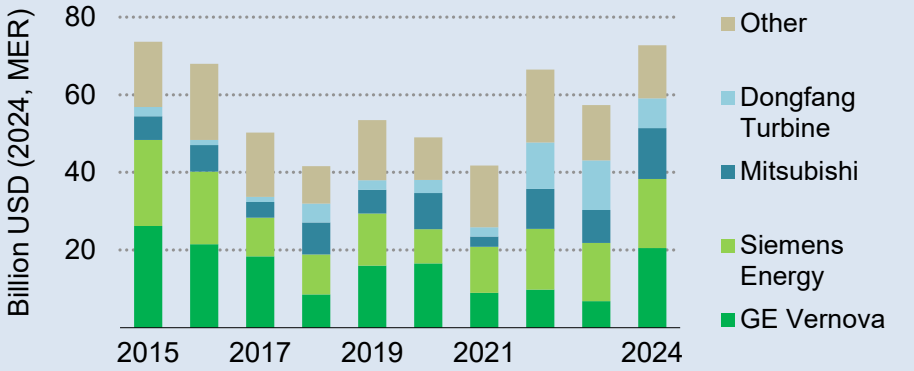
Note: MER= market exchange rates.

Due to geothermal's similar qualities, technology companies are also exploring partnerships with next-generation geothermal companies to meet new DC demand. Venture capital and private equity firms have helped to drive early- and growth-stage investment from a few million in 2017 to nearly USD 1 billion in 2024. Google and NV Energy signed a green tariff agreement commissioning 115 MW of new geothermal capacity from developer Fervo Energy, and this was followed by a separate PPA between Meta and Sage Geosystems Inc. for an additional 150 MW project. These and other companies are among a handful of new players focusing on next-generation technologies, which exploring the potential for carbon capture and storage and others not.

have the potential to significantly expand the role of geothermal by tapping locations previously thought inaccessible.

At the same time, given the lead times and uncertainties associated with nuclear and advanced geothermal, technology companies and DC operators are turning towards conventional sources of dispatchable power to ensure reliability in the short term. Hence the AI-led DC spending spree may also be ushering in a new wave of fossil-fired generation in advanced economies, the United States in particular.

Gas turbine orders by OEM, 2015 to 2024



Note: OEM = original equipment manufacturer.
Source: IEA analysis based on McCoy Power Reports (2025).

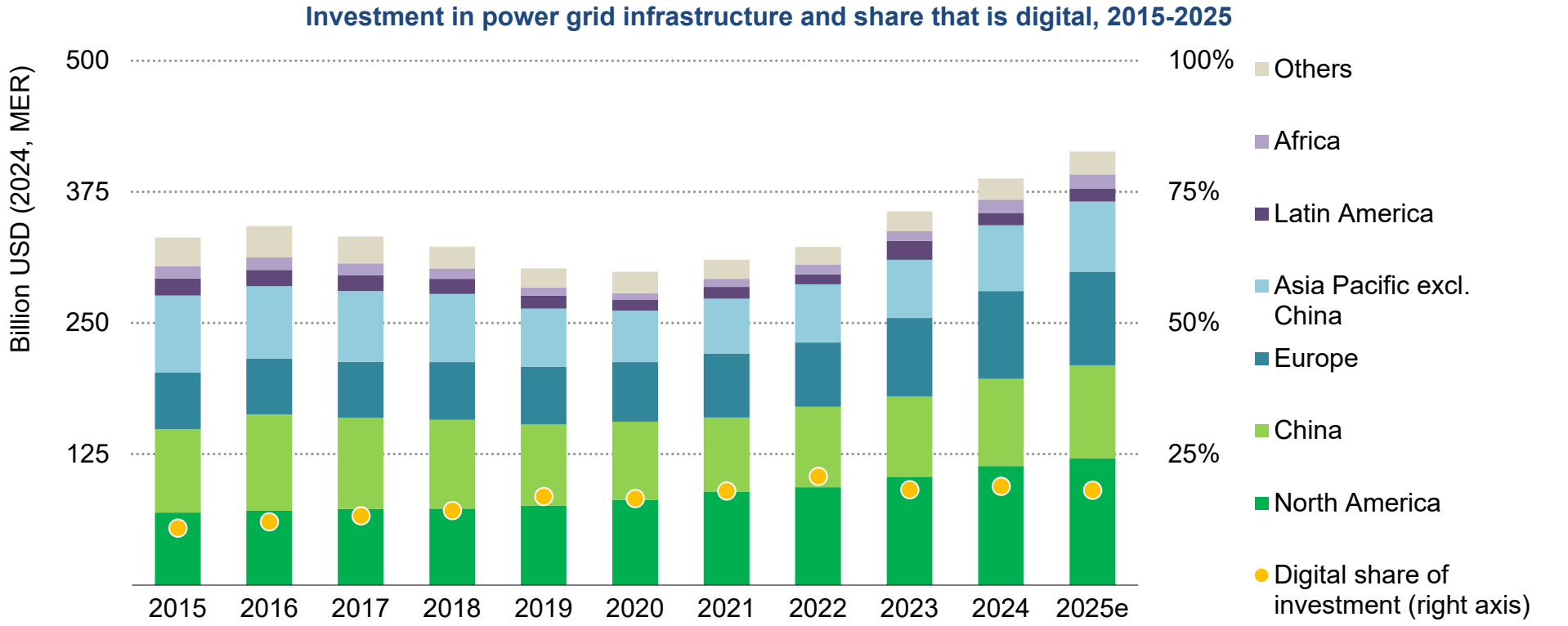
There has been a flurry of recent activity involving oil and gas majors, technology companies, project developers and turbine. manufacturers concerning new gas-fired power plants, some of them

The state of Virgina is now estimating that 9.9 GW to 15.3 GW of new fossil power would be needed by 2040 even if the Virginia Clean Energy Act was met in full given the concentration of DC load growth in exempted co-op territories. In total, 19 GW of gas-fired power capacity for DCs is expected to come online in advanced economies by 2030, 95% of it in the United States. This is consistent with the order books of western manufacturers such as Siemens and GE Vernova, the latter alone seeing 20 GW of new turbine orders in 2024 (vs 9.5 GW in 2023). This may not fully reflect the surge in demand coming from DCs as deposits on reservations are not captured in financial statements or order books.

However, there are several factors at play which might limit new gas-powered generation investment, particularly in the short term. Turbine manufacturers are emerging from a downturn with less free capital to invest. Having previously experienced financial difficulties from cycles of boom and bust, the industry also has a strong incentive to impose capital discipline and avoid overextension. Uncertainty in load growth and recent cancellations of new DCs provide further justification to proceed with caution, and some companies may be choosing to reduce their exposure to DCs rather than invest in new manufacturing capacity. Engie's cancellation of two gas-fired projects in Texas, specifically citing delays in equipment procurement, is an early signal of supply chain constraints. Of the 17 projects initially part of Texas' programme to fund new gas-fired generation, 8 have been cancelled or withdrawn.

Grids and storage

Global grid investment is set to reach a new milestone, surpassing USD 400 billion in 2025



Advanced economies and China continue to lead grid investment, as they have historically. While investment is expected to keep climbing, rising component costs mean growing budgets deliver less on the ground.

Notes: 2025e = estimated values for 2025. Digital investment includes smart meters, automation and management systems, end-point communication systems, transformers, EV charging infrastructure and analytics software.

Sources: IEA analysis based on transmission and distribution companies' financial statements, S&P Capital IQ data (2025), Global Transmission data (2023).

More effort is needed on grids to match renewable growth and overcome supply chain issues

Grid investment reached a new high of USD 390 billion globally in 2024 and is set to surpass USD 400 billion for the first time in 2025, 20% higher than a decade ago. Nonetheless, while renewables deployment has accelerated at an unprecedented rate, grid investment has not kept pace. About USD 0.60 was invested in grids for every dollar spent on new generation capacity in 2016; today, that number has declined to less than USD 0.40 even despite declining costs for renewables and increasing costs for transformers and cables. With 1 650 GW of solar and wind awaiting connection globally in 2024 due to grid investment and permitting delays, equivalent to six times the generation capacity of Germany, reform is urgently needed to maintain high levels of renewables deployment growth.

Overall, grid investment grew by 9% in 2024 compared with the previous year. Two-thirds of total grid investment was directed towards distribution networks. Advanced economies and China continue to dominate grid investment, accounting for 80% of the total. China saw 10% growth in grid investment and now represents one-fifth of global investment in this sector. In emerging market and developing economies, investment trends are mixed but showing positive signs. Latin America experienced a decline in investment due to Brazil's exceptional investment in 2023, which has since returned to a lower level, albeit higher than in 2022. In 2024 Chile announced plans to build its longest transmission line to date, aimed at bridging the gap with renewable connections by 2029. China is playing an increasingly prominent role in Latin American grid development, participating in several Brazilian transmission auctions and expanding its presence in Chile.

Investment in grids is expected to grow across multiple regions over the coming decade. Recognising the importance of timely investment and long-term strategic planning, several countries have extended the timeframe of their grid plans. India, Brazil and South Africa have adopted planning horizons of nearly a decade, reflecting the long lead times associated with grid development. India, for example, recently approved USD 110 billion for transmission infrastructure investment between 2024 and 2032. With a growing share of variable renewable generation and an increasing need for improved data management, digitalisation is proving essential for maximising the efficiency of existing grids. Artificial intelligence is also playing a crucial role in optimising grid performance and reliability. Regulatory frameworks are evolving to support this shift, with many jurisdictions introducing performance-based remuneration systems that incentivise the optimisation and improvement of existing grids. Looking ahead, regulatory mechanisms are expected to further adapt, promoting efficiency, enhancing grid quality and reducing losses through performance-driven incentives.

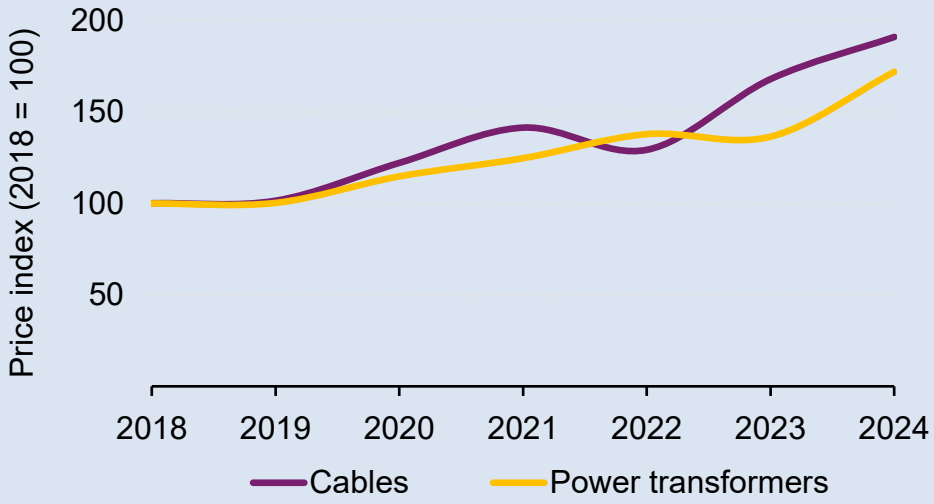
Supply chain constrains have emerged with the rising global demand for grid components

The rising global demand for transmission capacity, driven by simultaneous expansion plans and a surge in high-voltage projects, is straining supply chains for cables, transformers and key materials. Prices and lead times for key grid components have nearly doubled in the past five years. Recent IEA analysis based on new survey data found that cable procurement now takes two to three years, while large power transformer procurement can require up to four. For some specialised components, direct current systems for example, wait times exceed five years.

Cables have nearly doubled in cost since 2018 and power transformers have risen by 75%, driven by soaring demand and material costs for copper, aluminium and electrical steel. Manufacturers are expanding capacity as a reaction to the surge in demand, but uncertainties over future demand and skilled labour shortages pose challenges. Around 8 million people work in grid construction and maintenance today, but the workforce needs to grow by 1.5 million by 2030 to meet current policy goals, in addition to investment in training and qualification. Trade is playing a growing role in balancing supply and demand. The global power transformer market reached USD 13.5 billion in 2023, with exports from China, Korea, Türkiye and Italy making up half of total trade.

The United States and Europe have more than doubled their trade value for transformers since 2018, while Africa's imports have grown by 20%. These shifts highlight evolving global trade dynamics amid rising grid investment needs.

Power transformer and cables price index in real terms, 2018-2024

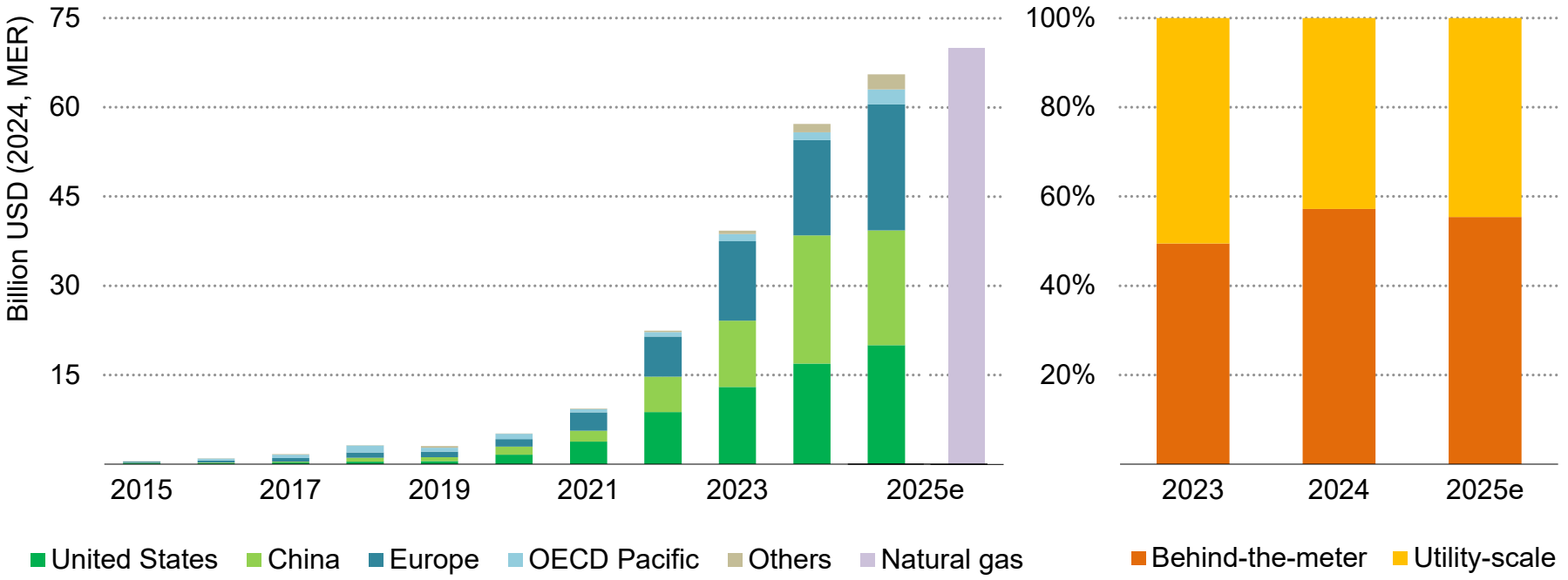


Note: Analysis based on cable auctions > 320 kV (excluding submarine) and IEA survey on underground cables.

Sources: IEA (2025), Building the Future Transmission Grid.

The cost of utility-scale batteries has fallen by two-thirds over the past decade, and global battery storage investment is approaching the level of gas-fired power generation investment

Battery storage investment by geography (left) and segment (right), 2015-2025



Battery storage investment has seen remarkable growth over the past decade, from around USD 1 billion in 2015 to an expected USD 66 billion in 2025. Investment in EMDE has historically been marginal but is expected to pick up in 2025 in countries like India.

Notes: OECD Pacific = Japan, Korea, Australia and New Zealand; 2025e = estimated values for 2025. For this report, we improved our methodological approach to battery storage investment. This involved a more accurate association of capacity to utility-scale, commercial and residential battery storage projects as well as their corresponding capital costs. Natural gas = total investment in 2025e for gas-fired generation without or without CCUS.

Sources: IEA calculations based on BNEF (2025), 1H 2025 Energy Storage Market Outlook; Wood Mackenzie (2025); China National Energy Agency (2025); CNESA (2025), Energy Storage Industry White Paper 2025.

Strong government policy support remains a crucial driver of battery storage growth, amid ongoing challenges from supply chain limitations

Global investment in battery storage continued its strong growth trajectory in 2024, growing 45% over 2023 levels. The United States, Europe and China remained the dominant markets, accounting for over 90% of total investment. This expansion has largely been driven by government policies and the design of the business model, as well as increasing wholesale market volatility.

In the United States, California, Texas and Arizona are among the most attractive markets for battery storage thanks to strong utility offtake through resource adequacy and tolling agreements. The sector's expansion is also being fuelled by rising energy demand from data centre growth. However, tariffs on Chinese imports have the potential to reduce battery deployment in the United States by several GW compared to initial projections, predominantly in particular utility-scale segments where demand is more sensitive to cost increases.

Europe's battery storage market, after a decade of strong growth, saw momentum slow in 2024. Policies, regulatory measures and targeted incentives remain a key element in driving further progress, especially amid growing power price volatility, which is calling for more battery storage. In China, policy mandates requiring energy storage integration in new renewable projects have fuelled continued growth in utility-scale battery storage, but policy reforms are expected to cool growth in the second half of the year. In contrast, other emerging market and developing economies continue to struggle with high financing costs, with financing costs for battery storage projects reaching twice the levels seen in advanced economies. Battery storage investment in India stands out, and is expected to surpass USD 1 billion in 2025.

Battery storage projects are increasingly relying on multiple revenue streams, such as energy arbitrage, frequency regulation, peak shaving and renewable energy integration, to ensure profitability. However, an adequate regulatory framework is needed to unlock its full potential and ensure its cost-reflectiveness for investment. Utility-scale storage remains essential for grid flexibility and renewable energy deployment. It accounted for over half of total battery storage investment in 2024, and over two-thirds of capacity additions. China and the United States dominate investment in large-scale storage.

Recent fluctuations in critical mineral prices have raised concerns about supply stability in the battery market. After a sharp surge in 2022, prices for key minerals like lithium declined significantly in 2024, easing cost pressures on battery production. However, this downturn risks discouraging investment in new mining projects, potentially limiting future supply growth and increasing the likelihood of renewed price volatility. Ensuring secure and diversified mineral supply remains essential for the long-term expansion of storage.

Implications

Deploying clean power is now cheaper than ever, but securing electricity supply still implies greater investment in grids, the creation of viable business models and policy support

The dramatic decline in the price of many renewable technologies and batteries over the past decade has been an important driver for rising investment in these technologies, helping renewable capacity additions to progress towards the tripling by 2030 target agreed at COP28. Whether this target is met will depend in part on the investment environment for renewables, but also on whether obstacles to accelerate investments in grids are overcome and whether new wind and solar generation can be cost-effectively integrated into power systems.

The onset of the Age of Electricity, with rising electricity demand from a variety of sources, is set to be a major driver of investment. This is being felt across the board. Electricity demand from data centres and AI is driving interest in nuclear power and investments in SMR development, although these will take time to materialise. Anticipated growth in data centre demand is already leading to a new wave of orders for gas turbines, particularly in the United States.

Electricity security is a major focus for policymakers in the wake of the Iberian Peninsula blackout in April 2025. Approvals of dispatchable capacity are rising alongside strong deployment of wind and solar. A wave of new approvals in China is pushing new FIDs for coal to their highest levels since 2015.

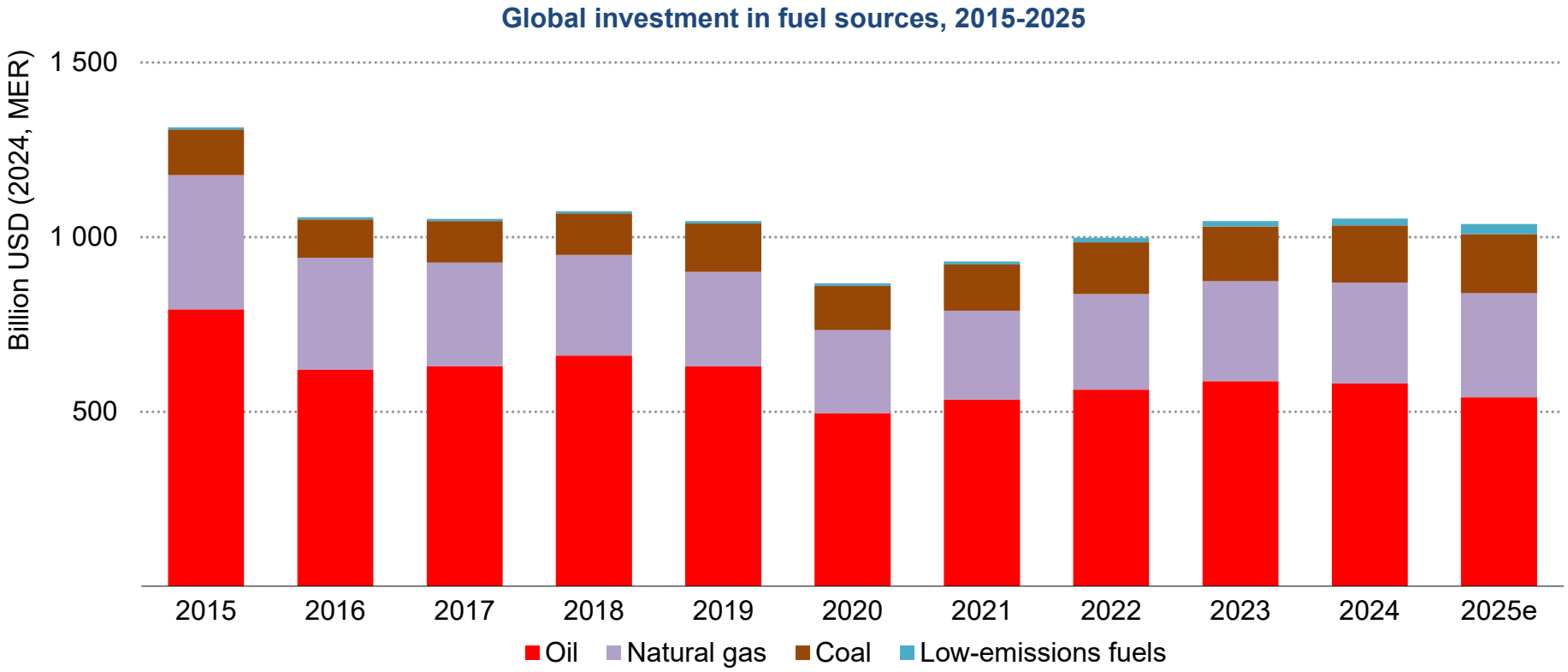
A modern and resilient grid is vital for secure electricity supply. Efforts to reduce the large backlog of projects waiting for grid connections is underway. A new challenge has emerged in the form of rising costs and delivery times for cables and power transformers. Manufacturers need greater visibility of project pipelines and future demand to justify new capacity investments.

Some developing economies, like Africa and India, saw record utility-scale renewable commitments last year but the share of global power sector investment taking place in EMDE other than China continues to decline. High financing costs remain a barrier and continued efforts are needed to improve the risk return profile in these markets.

Despite these challenges, Pakistan offers an intriguing case study on the transformative potential of low-cost solar from China. The estimated value of Chinese solar exports into Pakistan in 2024 was over USD 2 billion, equivalent to 0.5% of gross domestic product for that year – Pakistan showcases how a network of small developers can quickly scale-up to match utility-scale projects. However, widespread adoption of off-grid renewables is not without its own set of challenges. Developing new business models and regulatory frameworks that support both decentralised electricity and traditional grid players will be critical for emerging market power systems.

Supply

Headwinds in 2025 as lower oil investment brings fossil fuel spending down by 2%; low-emissions fuel investment expands, but from a low base



The drop in prices and uncertain investment climate means fossil fuel investment in 2025 is set to fall for the first time since 2020. Low-emissions fuel investment is growing, but still makes up only 3% of total fuel investment.

Notes: Oil, natural gas and coal include upstream, refining and infrastructure investment. Low-emissions fuels comprise modern bioenergy, low-emissions hydrogen, hydrogen-based fuels, and carbon capture, utilisation and storage (CCUS). 2025e = estimated values for 2025; MER = market exchange rates.

Fossil fuel investment is set to fall in 2025 for the first time since 2020; there is a healthy pipeline of low-emissions fuel projects, but these rely on continued strong policy support

Based on announced and revised plans by companies and the pipeline of projects under construction, investment in fossil fuel supply in 2025 is set to total USD 1 trillion. This is around 2% lower than investment levels in 2024 and marks the first drop in overall investment since 2020. The sharp drop in oil prices, rising operational costs, the impacts of tariffs and concerns about potential oversupply have led many companies to revise their investment plans as they look to protect stakeholder value.

Upstream oil and gas investment is set to fall by around 4% to just under USD 570 billion in 2025. This is driven by a year-on-year decline in upstream oil investment of around 6% (to around USD 420 billion), with some of the largest declines in tight oil in the United States where the drop in oil prices is challenging profitability. Investment in existing conventional projects is expected to prove more robust in 2025, but a prolonged period of low prices could mean larger cuts.

All developers are facing the prospect of higher costs. Tariffs and inflation are affecting production costs – especially for basic materials – and we estimate that unit costs for non-tight oil producers will rise by around 3% in 2025. This translates into lower activity for a given level of expenditure, although operators are reacting to these pressures by squeezing oil and gas service industry margins.

Refinery investment is set to drop to a record low in 2025: around 1 mb/d of new capacity is set to be added, but this will be offset by a similar level of closures, meaning no overall change in capacity at a global level. More than 90% of refinery investment now takes place in emerging market and developing economies (compared with a 66% share in 2015).

Several liquefied natural gas (LNG) liquefaction projects have seen their development timetables pushed back over the past 24 months and a number are expecting cost increases. More than USD 20 billion is set to be invested in LNG in 2025, and one new LNG project has recently achieved a final investment decision (FID). The period between 2026 and 2028 is likely to see some of the largest ever annual expansions in LNG capacity, around 40% of which will take place in the United States.

Oil and gas companies invested around USD 22 billion in low-emissions energy technologies in 2024, around 25% less than in 2023. Many of the companies that had previously led the push to diversify into new technology areas announced large downward revisions to their low-emissions targets, and we expect oil and gas industry investment in low-emissions technologies to fall by a further 10% in 2025. Nonetheless, recent years have seen increased

spending by a new cohort of companies, including large independents and national oil and gas companies, and this is offsetting some of the drop seen elsewhere.

The increase in coal investment to a record level in 2025 is being led by the People's Republic of China (herafter, "China") and India. Investment is increasingly focused on countries looking to boost production for domestic consumption rather than for export. Companies have also been increasing their focus on coking coal mines given their importance for steel production.

Methane emissions from fossil fuel operations remain at a stubbornly high level of around 120 million tonnes (Mt). Financing methane abatement remains a problem in many countries; external sources of finance – such as the World Bank's Global Flaring and Methane Reduction Partnership – currently total less than USD 1 billion, but this could catalyse far greater sums.

Around USD 4 billion was invested in carbon capture utilisation and storage (CCUS) in 2024 and more than 50 Mt of CO_2 capture capacity is currently operational around the world. There is also a healthy project pipeline of CCUS projects that have received FID, and these will require a tenfold increase in investment over the next three years if they are all to be successfully developed on time. Developing all announced projects, which are mainly in power generation, would increase CCUS capacity to 430 Mt CO_2 in 2030.

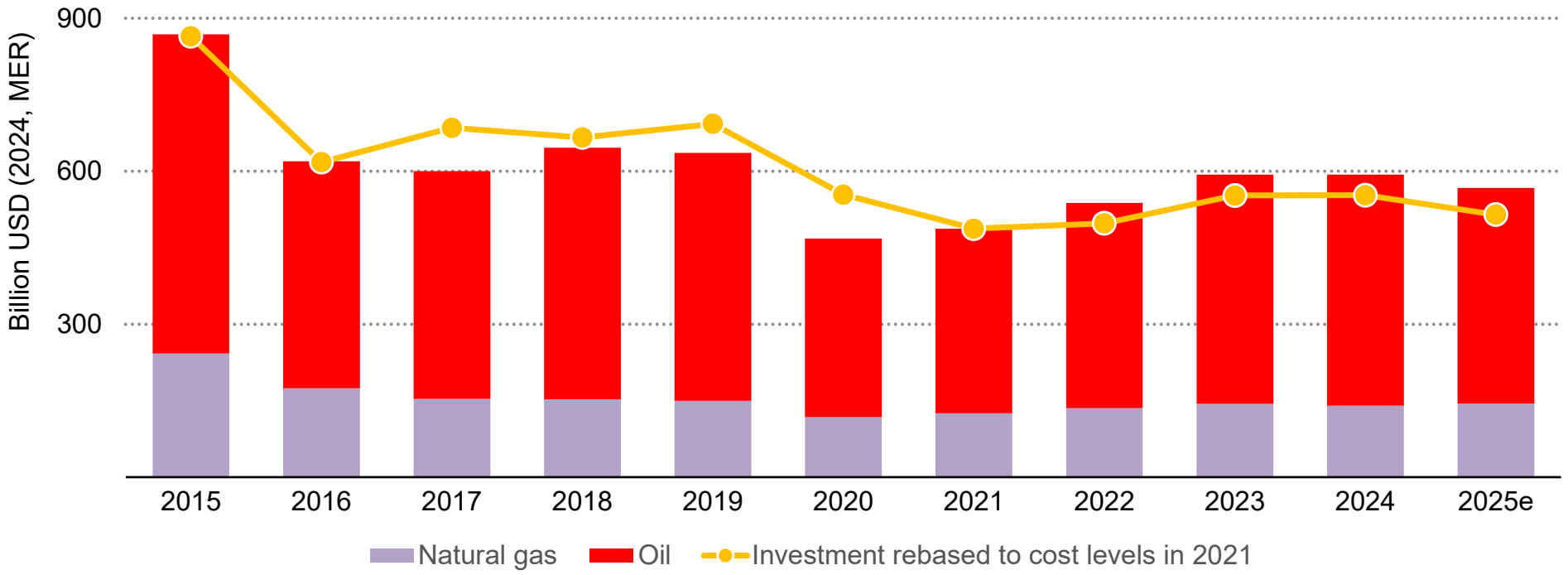
Investment in liquid biofuels, biogases and low-emissions hydrogen is set to rise by 30% in 2025 to a record high close to USD 25 billion, building on a 20% rise in 2024. Policies and regulations remain essential to this growth: mandates, quotas and other forms of policy support have underpinned the high levels of investment in biodiesel and ethanol in the United States and Brazil and in biogases in Europe. Some hydrogen projects have been cancelled or delayed in the past 12 months, but there remains a pipeline of projects that have received FID, requiring around USD 8 billion of investment in 2025, a 70% increase from the level in 2024.

Despite growing worries about the high concentration of supply, growth in critical mineral investment slowed in 2024 amid lower declines, with projects outside the main incumbent producers most affected by the price uncertainty. The large integrated mining companies continued to raise their investment, but specialist players scaled back.

Oil, natural gas and coal

Lower investment in oil brings down upstream oil and gas investment by 4% in 2025; costs have also been rising, meaning that activity levels are set to fall by an even greater amount

Upstream oil and gas investment in real terms and rebased to 2021 cost levels, 2015-2025



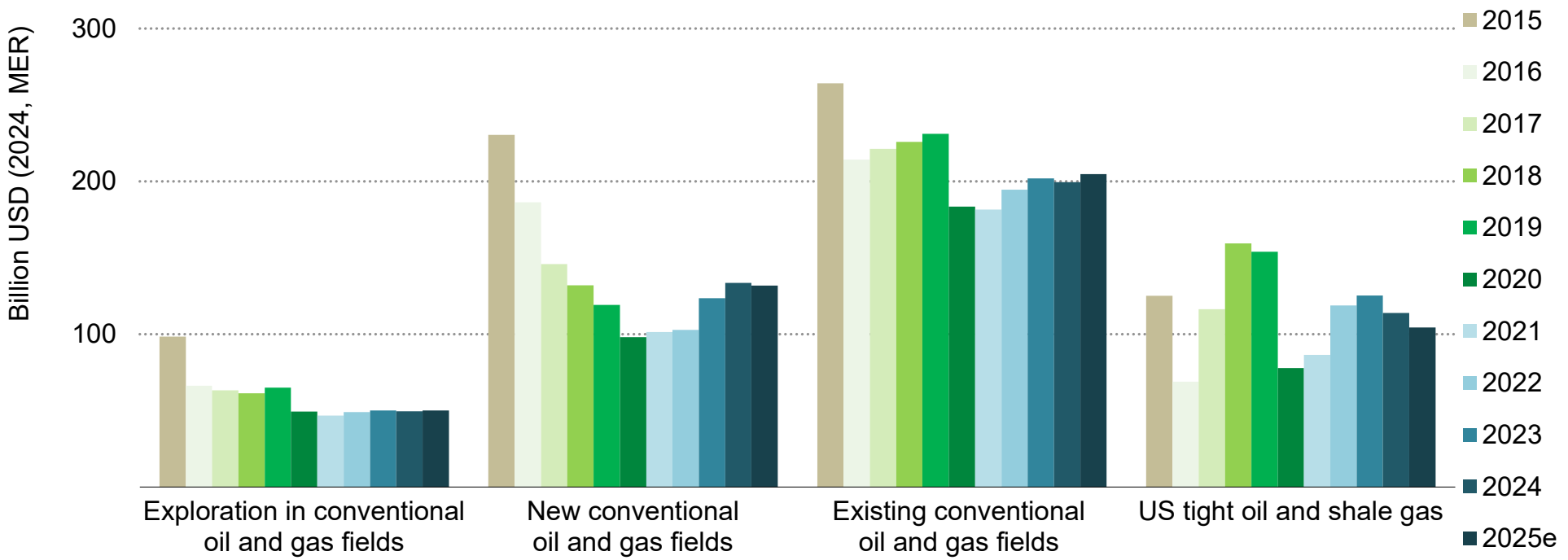
Falling prices and ongoing market uncertainty have led several companies to cut back on upstream investment in 2025. Costs have also risen, although the impact on resource development has been offset by technology advances and capital efficiency improvements.

Notes: "Investment rebased to cost levels in 2021" adjusts investment in real terms by the IEA's Upstream Capital Cost Index and US Shale Upstream Capital Cost Index to give an indication of the industry's activity levels. 2025e = estimated values for 2025.

Sources: IEA analysis based on Bloomberg (2025), Terminal, FRED (2025), Producer Price Indexes, IEA (2024), WEO Database, IMF (2025), World Economic Outlook Database, and Rystad (2025), UCUBE.

Investment in US tight oil and in some new projects is most affected by demand and price uncertainty, with investment in existing oil and gas fields set to be more robust

Upstream oil and gas capital expenditure by activity and field type, 2015-2025

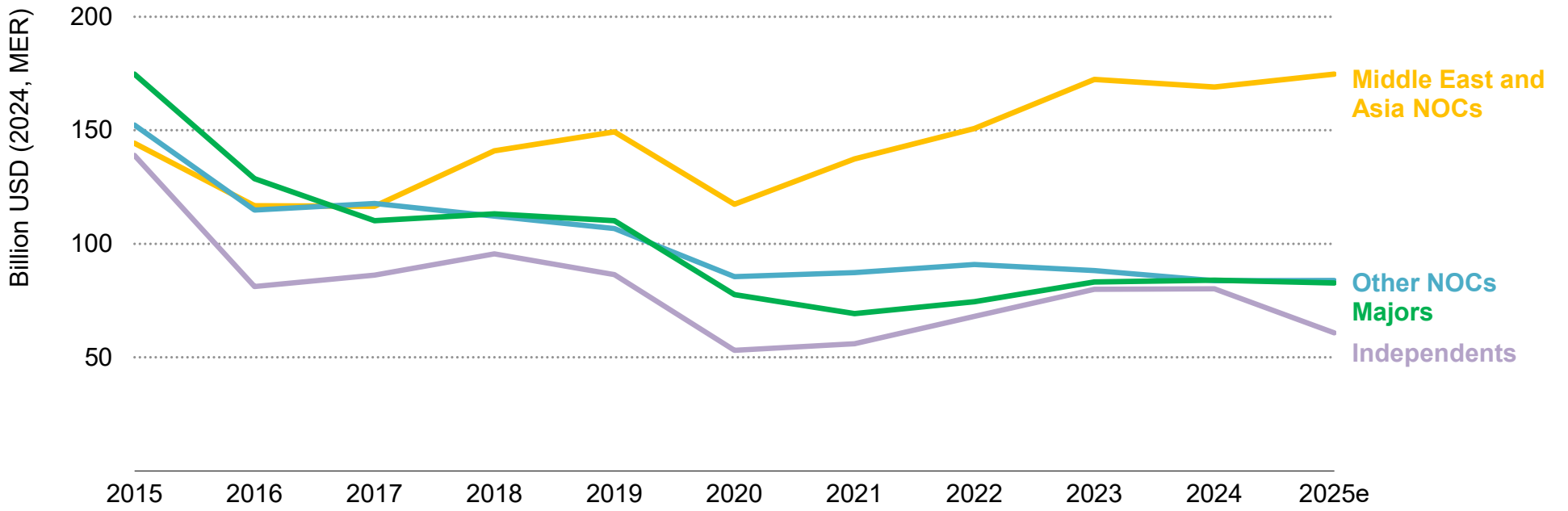


The drop in prices, rise in operational costs and concerns about oversupply are hitting investment in new conventional fields and tight oil and shale gas. Investment in existing fields is stronger as these often have lower risk and faster returns.

Notes: 2025e = estimated values for 2025.
Source: IEA analysis based on Rystad (2025), UCUBE.

Upstream investment by the majors is set to dip slightly for the first time since 2021; current levels remain well below 2015, as do their share of total upstream spending

Upstream oil and gas investment by company type, 2015-2025



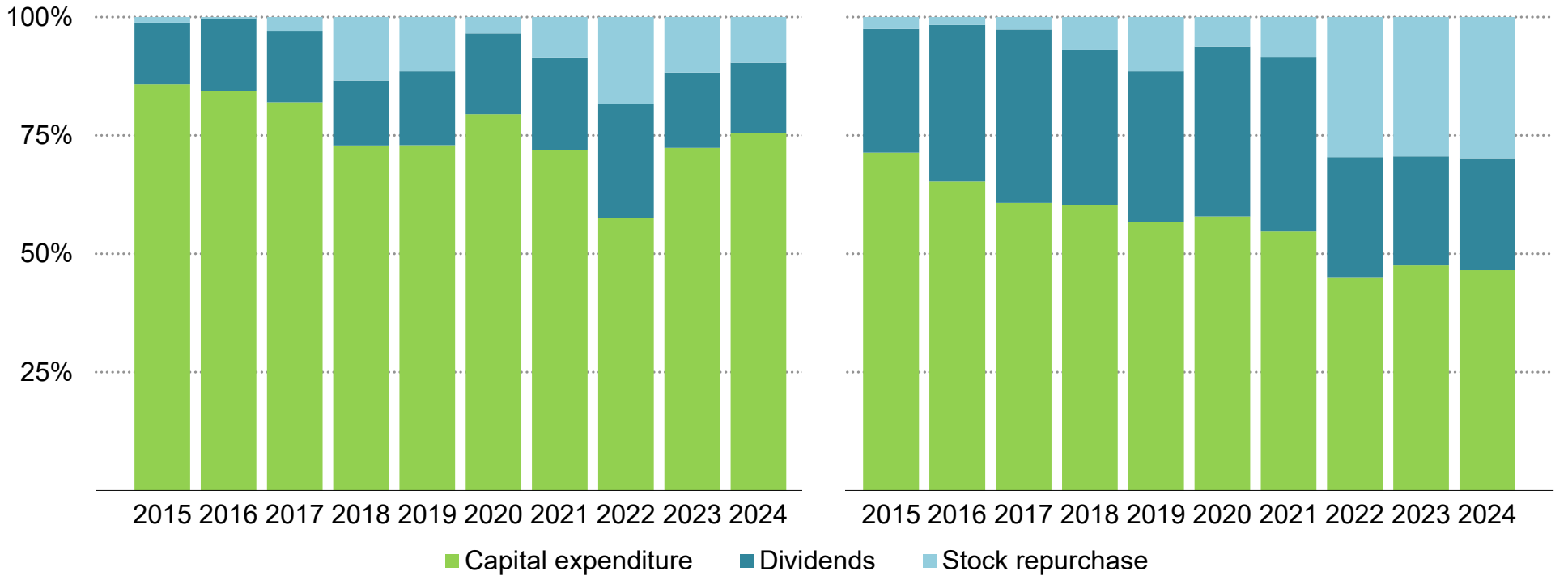
Middle Eastern and Asian national oil companies now account for about 40% of upstream investment, up from 25% in 2015. Investment by independents is set to fall due to lower oil prices and higher costs, despite recent M&A moves that cut expenses via consolidation.

Notes: Includes a sample of companies that are responsible for about 70% of global production. Majors = BP, Chevron, ConocoPhillips, ENI, ExxonMobil, Shell and TotalEnergies; NOCs = national oil companies; 2025e = estimated values for 2025; M&A = mergers and acquisitions.

Sources: IEA analysis based on Bloomberg (2025), Terminal, Rystad (2025), UCUBE, and annual reports.

For the third year running, capital expenditure by the majors in 2024 comprised less than half of their cash utilisation

Oil and gas company capital expenditure, dividends, and stock repurchase, independents (left), majors (right) 2015-2024



Independents allocate a much greater share of their cash utilisation to capital expenditure than is the case for the majors. The majors are indicating a preference to cut capital and operating expenses in order to maintain shareholder distributions in 2025.

Note: Includes 133 listed oil and gas companies with significant upstream activity.

Source: IEA analysis based on Bloomberg (2025), Terminal.

Some oil and gas companies have revisited investment plans in light of the drop in oil prices, but the implications for spending are far from uniform

We estimate upstream oil and gas investment will fall by around 4% in 2025 to just under USD 570 billion. This would be the first drop in upstream investment since 2020. Our detailed review of the spending plans that companies announced at the beginning of 2025 suggested that investment would remain broadly flat, but some companies have revised their plans in light of downward moves in oil prices, an uncertain economic outlook, and cost pressures.

The 2025 global drop in upstream investment stems entirely from an overall reduction in oil investment – which is expected to decrease by over 6% – as investment in gas is set to rise marginally. This reflects the increased emphasis many companies are placing on shifting their portfolios from oil to gas. Some upstream investment in gas is also to be used in LNG projects – on which very large sums have already been spent – and so they are less sensitive to the recent drop in prices and uncertain investment climate.

The majors were some of the earliest companies to revise their plans and we estimate that their overall investment will fall slightly in 2025. The majors continue to emphasise the importance of distributions to shareholders – share buybacks and dividends accounted for more than half of their cash allocation from operations in 2024 – and have indicated that they will aim to maintain these in 2025, preferring to cut back on capital and operating expenses.

Investment in exploration and new oil and gas developments is markedly lower than levels seen ten years ago. Exploration is likely to remain broadly flat in 2025 at around USD 50 billion (although this could be cut if the price environment deteriorates further). Around 25% of upstream investment in 2025 is set to be spent on new fields, similar to the level seen in 2024. New field approvals could be trimmed in 2025 as operators await greater clarity over the economic and oil market outlook. Slightly higher spending, closer to 40% of total budgets, goes to boosting production (or slowing declines) at existing fields, as these investments often yield faster returns with less risk.

The potential for cost inflation in upstream activities around the world is another uncertainty for the industry in 2025. Basic materials account for around 40% of upstream costs, and tariffs (for US operations) and higher offshore drilling day rates are set to increase unit costs in 2025, although impacts will vary between companies and countries depending on where materials are sourced from and on what contractual terms. We estimate that conventional upstream costs increased marginally in 2024 and that they will rise by a further 3% in 2025; costs for US onshore unconventional developments are set to rise by 2% in 2025, a lower level since rates for drilling and completion rigs look set to fall this year. Adjusting upstream investment for cost inflation, this means that activity levels are set to fall globally by around 8% in 2025.

US tight oil and shale gas currently account for around 15% of global upstream investment and this is the area most immediately affected by the drop in prices. We expect investment in shale to drop by up to 10% in 2025. A recent wave of mergers and acquisitions and continued technology improvements have continued to pull down costs and production is still set to grow in 2025 despite the fall in investment. Permian player Diamondback spent nearly USD 1 billion of its USD 3.5 billion plan for 2025 in the first quarter and expects lower investment for the remainder of the year.

The Middle East NOCs' share of global upstream investment is set to be greater than 20% in 2025 – an all-time high – more than double its share 10 years ago. A large portion of this is to expand projects for natural gas, including the Jafurah field in Saudi Arabia, the LNG feed gas fields of Rub Al-Khali in the United Arab Emirates, and the North Field developments in Qatar.

The Russian Federation's (hereafter "Russia") share of global upstream investment fell to 6% in 2024, the lowest levels since 2015. Investment may rise slightly in 2025 as companies seek look for new ways to offset declines in mature fields, but there remain major open questions about the investment outlook given lower prices, the difficulty to adequately replace the loss of the European market, continued sanctions, fiscal pressures and higher taxes.

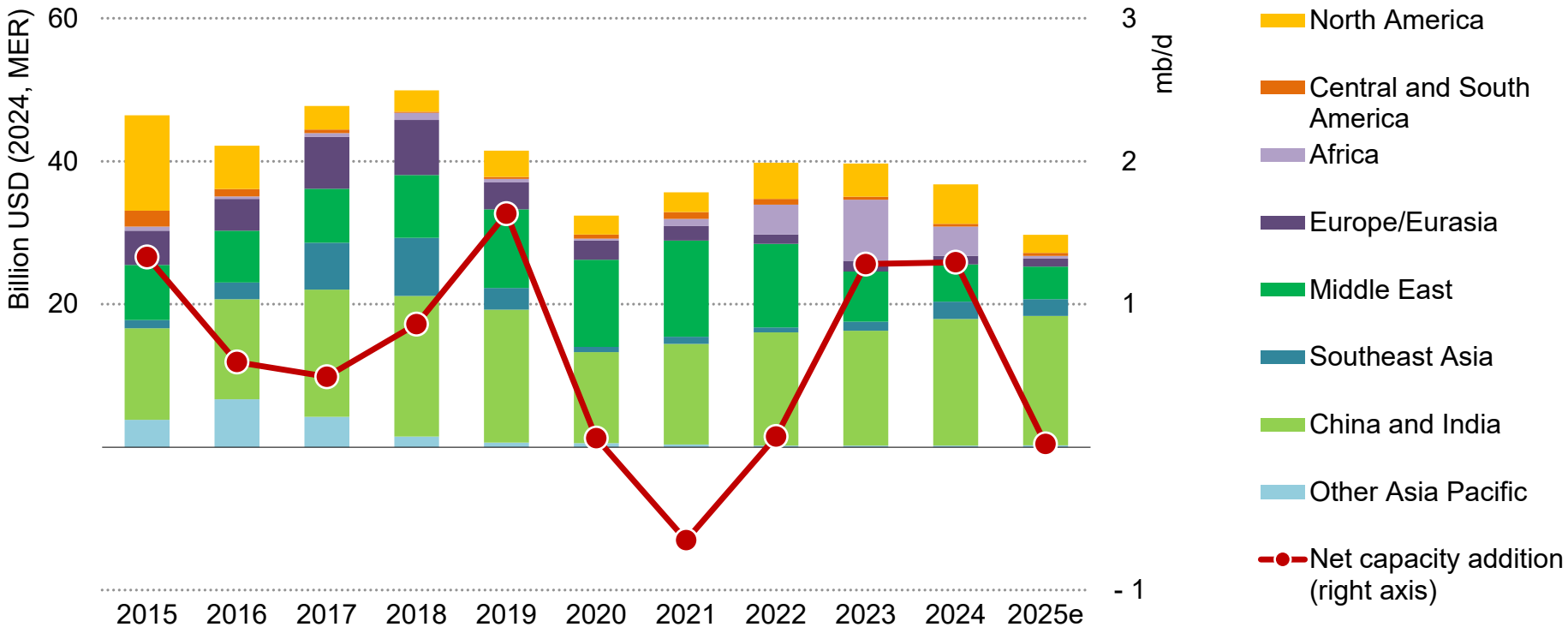
In Latin America, offshore deepwater and tight oil projects continue to ramp up and upstream investment is set to be flat in 2025 compared with 2024; the region is responsible for around 10% of global upstream investment. Notable projects include Petrobras's commitment to develop its pre-salt projects with USD 110 billion of investment over the next five years, and developments in Guyana and Suriname supported by the majors and Asian NOCs. YPF Argentina plans to continue to develop the Vaca Muerta formation – including for natural gas exports – with around USD 4 billion annual average upstream investment over the period to 2030.

In North Africa, upstream oil and gas investment is set to contract by around USD 1 billion to USD 15 billion in 2025 (its share of global upstream investment will be around 3%). A number of countries in the region are looking to attract foreign investment but with mixed success to date. Libya is offering its first bid round in 18 years, and Algeria plans to invest USD 36 billion to 2028 for exploration and production and is continuing with an auction of oil and gas blocks that began in 2024.

In sub-Saharan Africa, upstream investment is set to drop by around 15% in 2025, and the region will comprise less than 5% of the global total. Upstream investment is likely to rise in the coming years, however, given some exploration successes in Namibia and the recent government approval of the USD 7.2 billion for the Coral North FLNG project in Mozambique. Nigeria has recently increased production and an improved policy environment may spur additional investment.

Refinery investment in 2025 is set to fall to its lowest level in the past ten years

Investment in refineries by region and net refining capacity change, 2015-2025



Investment in refineries globally fell slightly in 2024 but is set to drop much more sharply in 2025. Refinery investment has dropped by more than 50% in advanced economies in the past ten years and by around 10% in emerging market and developing economies.

Notes: 2025e are estimated values based on the announced project pipeline.

Increasing refinery retirements and a drop in new additions mean that there will be almost no net capacity additions in 2025

Annual global investment in refineries (excluding maintenance spending) fell in 2024 but is set to drop much more sharply to less than USD 30 billion in 2025. This is the lowest level in at least a decade. Asia and the Middle East are set to account for around three-quarters of global investment in 2025, with the share in advanced economies (10%) far lower than the level in 2015 (34%).

Net global refinery capacity increased by 1.3 mb/d in 2024, but this is set to be almost zero in 2025. Around 1.1 mb/d of new capacity is set to come online in 2025, mainly in China and India, but this is largely offset by around 1 mb/d of refinery capacity due to be retired globally, mainly in North America and Europe. In North America, the USD 20 billion Olmeca refinery in Dos Bocas, Mexico, has begun the early phases of commissioning; with 340 000 b/d capacity, this refinery operation could offset potential upcoming retirements elsewhere in North America.

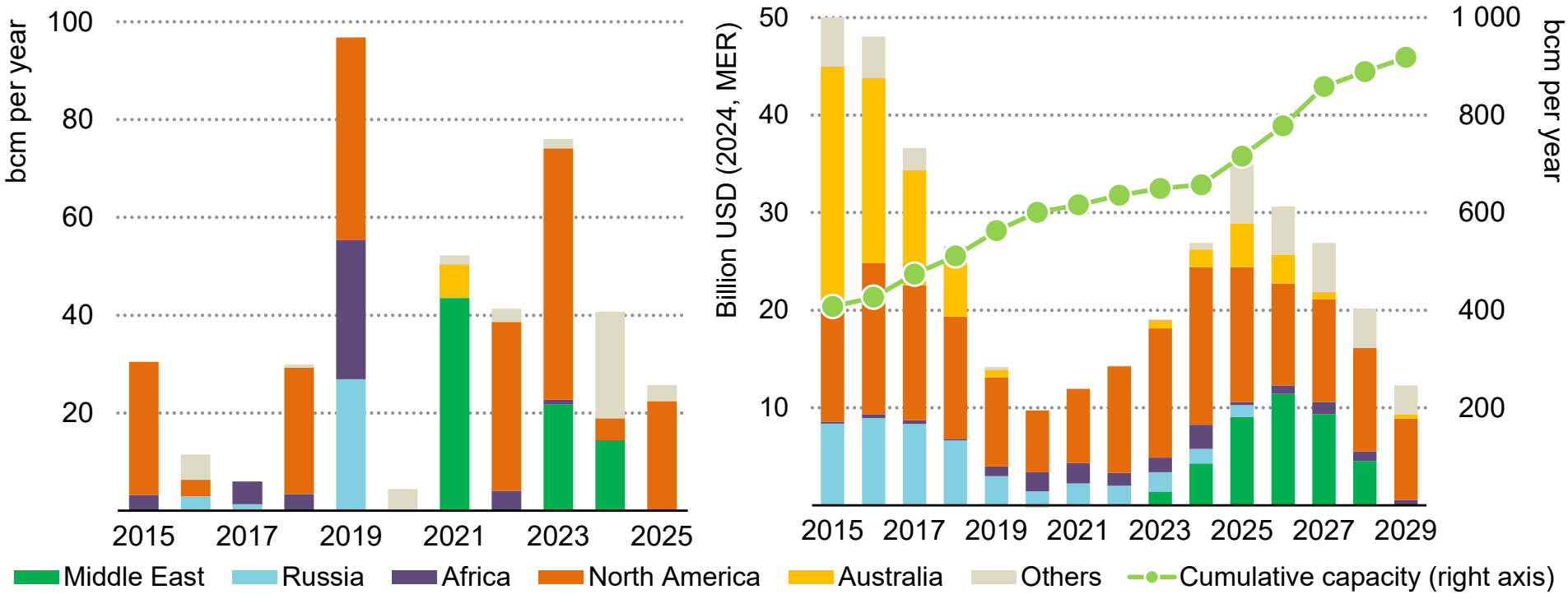
The global petrochemical market is set to grow substantially in the coming years, and refiners are continuing to invest in integrated refinery-petrochemical complexes to improve margins. This trend is especially evident in China: for example, the Fujian Petrochemical Complex will combine refining (300 000 b/d) and ethylene production (1.8 Mt/yr), and ExxonMobil and BASF are expanding ethylene capacities in the country. Elsewhere, India's Reliance Industries is retrofitting its Jamnagar refinery (1.4 mb/d) to produce 20 Mt/yr of petrochemicals by 2027, and SOCAR Türkiye is investing USD 7 billion in polyolefin facilities.

Meanwhile, Europe faces continuing declines in refining capacity as older refineries close and demand continues to fall. Refineries are a major source of emissions associated with oil production, and a number of them are looking to integrate CCUS and blend with biofuels to help meet emission reduction requirements set both by their host country and – increasingly – by importers. For example, Bahrain's Bapco is investing in co-located carbon capture, and PTT is investing 20% of its capital expenditure in biofuels and hydrogen.

Several oil refiners are diversifying activities by investing in biofuel production facilities. Biojet and renewable diesel refining capacity increased by 25% in 2024 and is set to rise by another 40% this year to 0.8 mb/d. The United States accounts for half of the growth; Phillips 66, for example, converted its existing Rodeo refinery in California to a 50 000 b/d biofuel facility for USD 1.3 billion (although this was USD 0.4 billion higher than anticipated due to increased labour and material costs, as well weather and permitting challenges).

A busy period of construction activity has delayed some development timelines, but a wave of new LNG supply projects is due to hit global gas markets soon

Final investment decisions for LNG export capacity (right) and investment and cumulative export capacity (left)



Investment in LNG is cyclical. A new wave of capacity, dominated by the United States and Qatar, is due online over the next few years, challenging investment decisions for new projects elsewhere.

Note: 2025 includes data up to May 2025.

While a number of under-construction and planned LNG projects have been delayed or seen cost overruns, the upsurge in LNG investment will substantially expand supplies by 2030

Over USD 250 billion has been invested in LNG liquefaction capacity over the past ten years, and a further USD 115 billion has been invested in regasification. Around 270 bcm/yr of new liquefaction capacity is due online by 2030, adding around 50% to global supply. Several projects have seen their development pushed back over the past 24 months, but the period between 2026 and 2028 is likely to see some of the largest ever annual expansions in LNG capacity.

The United States is the world's largest LNG exporter, with around 130 bcm of existing annual export capacity, and a further 120 bcm under construction. To date, cost pressures have not caused LNG developers to pause construction, and in April 2025 Woodside sanctioned the USD 17.5 billion Louisiana LNG project, marking the first US FID since mid-2023. However, market and tariff uncertainties hang over the long queue of additional projects looking to reach FID; steel and aluminium make up around a quarter of the capital costs of an LNG project, complicating negotiations for engineering, procurement and construction (EPC) contracts.

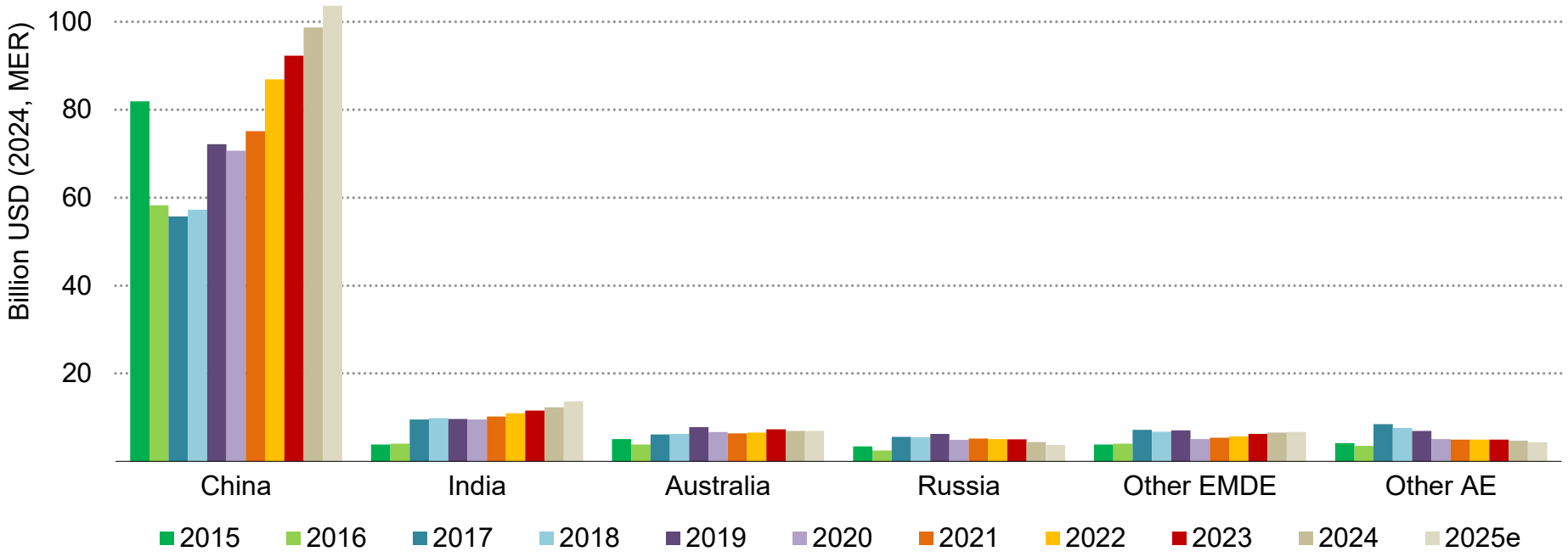
In Canada a third major LNG project was sanctioned in 2024, the USD 4 billion Cedar LNG project. This follows the USD 30 billion LNG Canada project that is set start operations in 2025 and the Woodfibre LNG which was sanctioned in 2022 with first deliveries expected in 2027.

Qatar has greenlit two major LNG expansion projects since 2021, which add a further 65 bcm to its existing 105 bcm annual supply capacity at an estimated investment cost of USD 37 billion. A third project, the North Field West, is also in the early stages of development. The USD 5.5 billion Ruwais project in the United Arab Emirates and the smaller USD 1.6 billion Marsa project in Oman were also sanctioned in 2024. TotalEnergies recently indicated a possible mid-2025 restart of the USD 20 billion Mozambique LNG project which was under force majeure. Russia's USD 21 billion Arctic LNG 2 project is under sanctions and start-up remains uncertain.

Investment in LNG is sometimes seen as a barometer of confidence in the growth of natural gas demand, especially in emerging and developing economies in Asia. Given the typical four- to six-year lag between an investment decision and a project's start-up, new LNG FIDs imply confidence that price-sensitive buyers will be able to absorb the upcoming wave of new LNG supply and that global gas markets could require new supplies as early as 2029. Much also depends on which entities are willing to take the risk; in recent years, large LNG portfolio players – including a number of the majors – have used their own balance sheets to help finance new projects, filling a gap left by buyers hesitant to commit to long-term offtake over several decades.

Investment in coal production is set to increase by 4% to an all-time high in 2025 as growth in emerging and developing economies more than offsets declines in advanced economies

Investment in coal production, 2015-2025



The 4% increase in global coal investment expected in 2025 is half the average annual increase seen in the years since the pandemic, but total coal investment is still set to reach an all-time high.

Notes: Other AE = Other advanced economies; Other EMDE = Other emerging market and developing economies; 2025e = estimated values for 2025.

China and India lead the overall increase in coal investment, but a shortening coal supply project pipeline and lower prices suggest growth may soon slow globally

Global investment in coal production is expected to rise by around 4% and to reach an all-time high in 2025, following a similar increase in 2024. These rates of increase are half the 6% average annual increase seen over the past five years. The project pipeline for new coal mines suggests a further slowdown in rates of growth in the coming years as the long-term outlook for coal demand remains bearish.

China and India were responsible for nearly all of the growth in global investment in 2024, and they are likely to again lead the growth in 2025. An increase in investment is also expected in South Africa and Southeast Asia, where Viet Nam and other producers continue to increase supply for domestic use.

The profitability of export-oriented coal mines remains volatile, but coal operations have generated very high revenues in recent years, most of which have been returned to shareholders or used to acquire existing assets. Most new export projects under consideration are in Australia (62%), Russia (11%) and South Africa (10%).

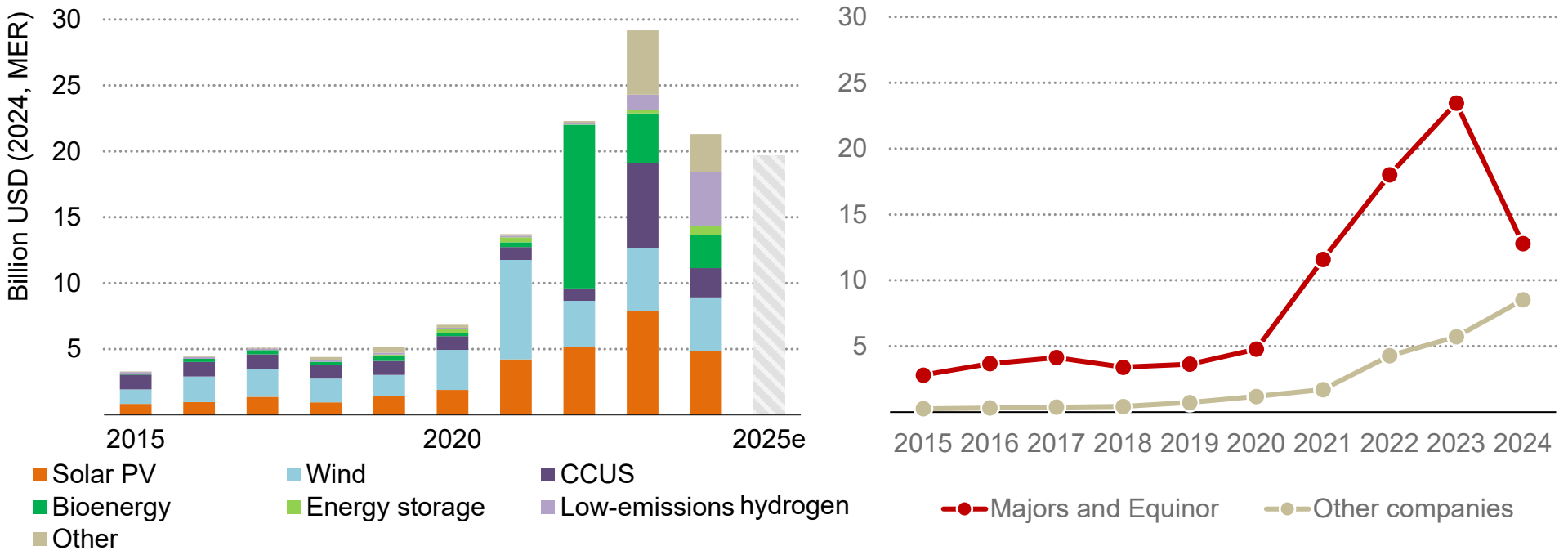
Several countries around the world are still looking to develop new coal infrastructure. For example, in Indonesia and Mozambique new railways and ports are being constructed to increase export capabilities. Russia is enhancing its coal terminal infrastructure in the eastern region, in a move to strengthen ties with the Asian market. Mongolia and Russia have announced new rail connections with China aimed at increasing coal exports in the future. This is part of a broader trend of coal markets pivoting more towards Asia, accelerated by the European Union (EU) ban on Russian exports after its invasion of Ukraine.

Coking coal projects continue to look more attractive to investors than steam coal projects, with steam coal set to see a decline in its share of new mining projects. Steel production from iron ore is likely to continue to be highly dependent on coal, as alternative inputs are not expected to reach commercial viability soon, while steam coal is already being substituted by alternative options in electricity generation.

An increasing share of investment is likely to be directed towards existing coal assets in the coming years. New coal mines are facing headwinds due to the weakening economic outlook, a drop in prices, and the impact of climate policies as well as opposition from shareholders, financial institutions and the general public. Insurers have also been reluctant to sell polices to new coal projects, meaning insurance premiums are often very high or coverage is not available at all.

Low-emissions investment by oil and gas companies fell back to its 2022 level in 2024, and is set to fall by a further 10% in 2025

Clean energy investment by selected oil and gas companies, 2015-2025



A number of major oil and gas companies have revised their earlier commitments, leading to a large overall drop in low-emissions investment by the industry. However, a new cohort of companies are expanding efforts, and this will offset some of the decline.

Notes: 2025e = estimated values for 2025; CCUS = carbon capture, utilisation and storage; Other = EV infrastructure, geothermal, tidal, critical minerals, and mergers and acquisitions. Other companies = ADNOC, Canadian Natural Resources, Inpex, Oxy, OMV, Petronas, Petrobras, PetroChina, PetroEnergy Resources, PTTEP, Repsol, Santos, Saudi Aramco, Sinopec, Suncor Energy and Woodside.

Sources: IEA analysis based on Bloomberg (2025), Terminal, Clean Energy Pipeline (2025), Data, and companies' annual reports and presentations.

Low-emissions energy investment by oil and gas companies is recalibrating amid evolving markets

The oil and gas sector invested around USD 22 billion in low-emissions energy technologies in 2024, around 25% less than in 2023. This represented around 2.5% of the oil and gas industries' total capital budget in 2024.

Low-emissions investment by oil and gas companies is expected to decline by a further 10% in 2025. Around 60% of low-emissions investment by the oil and gas industry in recent years has come from four companies: BP, Equinor, Shell and TotalEnergies (which each spent around 15-25% of their total budgets on low-emissions energy). With the exception of TotalEnergies, these companies announced large revisions to their previous targets on low-emissions spending. For example, BP reduced its target for the share of low-emissions technologies in its total capital budget in 2030 from 50% to 10-15%; Shell reduced its 2030 target from 15-20% to 10%; and Equinor cut its planned share of low-emissions spending for 2025 from 30% to 13%, and dropped its previous target to invest 50% by 2030.

Some of this drop is being offset by increased low-emissions spending from a new group of companies. This cohort, which includes smaller firms and NOCs like ADNOC, Petronas, Saudi Aramco, and Sinopec, doubled its collective spending between 2022 and 2024, reaching approximately USD 8.5 billion. This group of companies spent around 3% of their capital budgets on low-emissions technologies over this period.

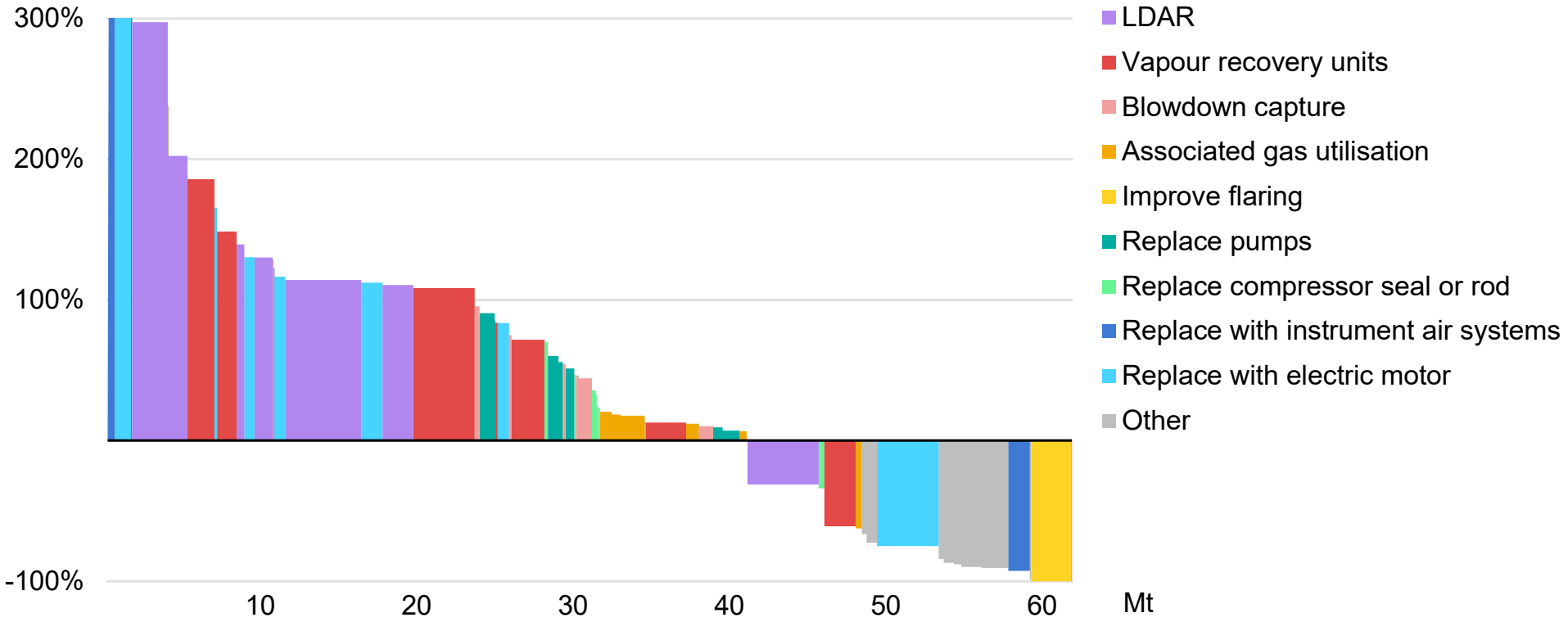
Looking at trends by technology, investment by the oil and gas industry in solar PV and wind in 2024 remained at a similar level to 2023. This was boosted by Equinor's acquisition of a 9.8% minority stake in Ørsted and occurred despite a number of withdrawals by oil and gas companies from offshore wind projects around the world. Low-emissions hydrogen saw the largest increase in both relative and absolute terms, rising to USD 4 billion in 2024. A large share of this reflects Woodside Energy's acquisition of a low-emissions ammonia plant in Texas. TotalEnergies expanded its hydropower assets in Africa by acquiring stakes in projects in Uganda, Rwanda and Malawi. Eni added to its biofuels portfolio, entering a joint venture with LG Chem for a new biorefinery in South Korea and reaching FID with Petronas and Euglena for a facility in Malaysia. Equinor acquired a 45% share in two lithium project companies in the United States.

Public reporting of investment in low-emissions energy technologies by oil and gas companies remains quite limited, with some companies taking an expansive view on what qualifies as "low-emissions". Policies and regulations, such as the EU taxonomy, may lead to greater transparency and understanding of actual investment levels as well as plans and targets.

Greenhouse gas emissions management in fuel supply

Methane emissions reductions can deliver very high rates of return for oil and gas companies

Internal rate of return and methane emission reduction measures from oil and gas operations in 2024



Methane emissions from oil and gas operations can be cut by more than 40% using technologies with rates of return greater than 15%, which are robust returns greater than or equal to those usually sought by companies.

Notes: LDAR = leak detection and repair. The value of methane captured is based on net-back natural gas import prices in 2024 within each country, based on a societal perspective and assuming no domestic consumption subsidies.

Methane emissions from oil and gas operations remain stubbornly high, but increasing investment and transparency can help drive action by companies

The production, processing and transport and use of fossil fuels resulted in close to 120 Mt of methane emissions in 2024. Active oil and gas operations were responsible for just under 80 Mt, coal for 35 Mt, and abandoned wells and mines for around 8 Mt.

A growing share of oil and gas production is subject to methane abatement commitments, including through the Global Methane Pledge, the Oil and Gas Decarbonization Charter. The Oil and Gas Methane Partnership 2.0. LNG buyers are also working together with LNG producers to reduce methane emissions and ensure transparency, including through the Coalition for LNG Emission Abatement toward Net-zero (CLEAN) Initiative. However, several large emitters have yet to commit to methane cuts and about half of the industry has yet to set near-zero methane targets.

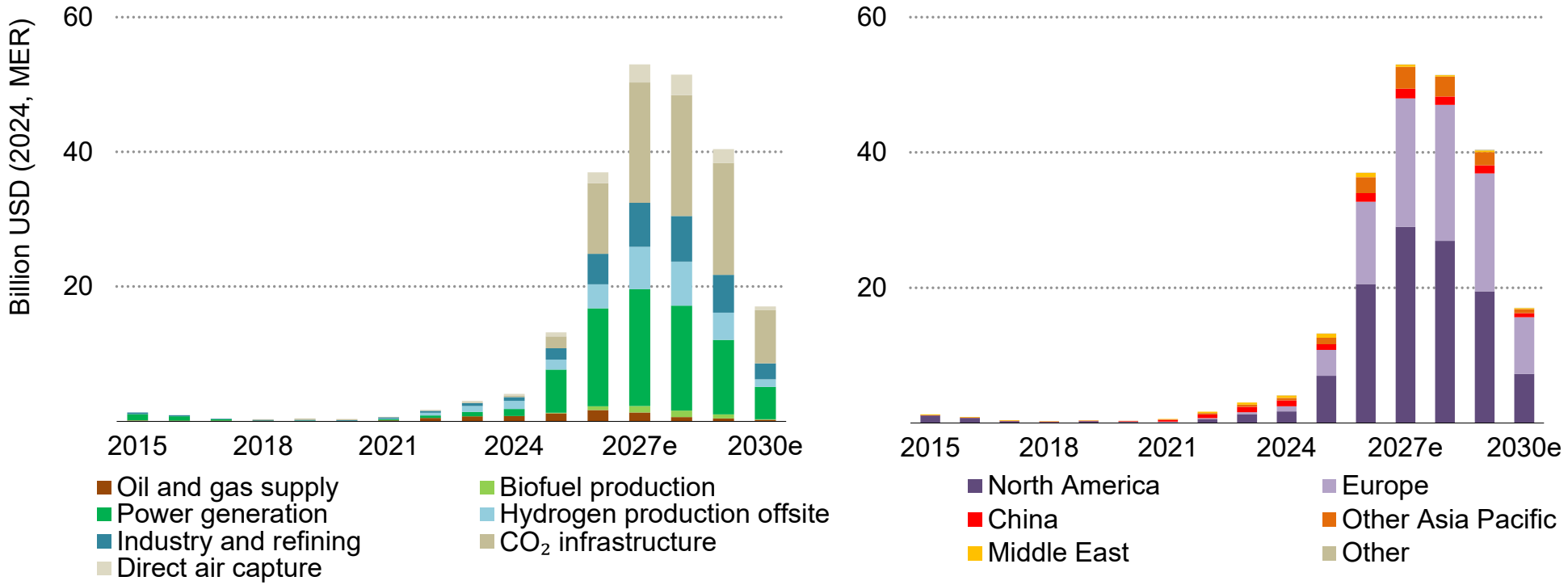
Some methane abatement measures have high upfront capital costs and in many cases there is no route for bringing captured gas to markets, requiring investment in new infrastructure or means of gas transport. Yet many abatement options can still pay for themselves within a year. In the oil and gas sector, we estimate that around 40% of the industry's emissions in 2024 could have been avoided with technology measures offering rates of return of more than 15%, i.e. with returns greater than or equal to those usually sought by oil and gas companies when considering new capital investment.

There are a number of reasons why companies may fail to invest in methane abatement despite these attractive rates of return. For example, they may be unaware of the scale of the problem or the available solutions. There may be higher-profile opportunities competing for investment resources, or leadership may perceive methane abatement as more costly than it is. There may be split incentives, whereby equipment owners do not directly benefit from reducing methane leaks, the contractual terms prevent transforming methane savings into revenue, or the owner of the gas does not see its full value. Securing capital for required upfront investment can be difficult, especially in developing economies. Companies may struggle to deploy sufficient staff or secure the necessary services to tackle the problem. Or they may not have identified a pathway or business case for bringing captured gas to productive use.

In some cases, external support to help companies reduce emissions may be needed – particularly when the available abatement options have very high upfront costs and access to capital is limited. Some resources, such as the World Bank's Global Flaring and Methane Reduction (GFMR) trust fund, are available, but new sources of financing are needed. To date, external financing aimed at reducing methane in the fossil fuel industry totals less than USD 1 billion, although this could catalyse much larger financial commitments.

There is a strong pipeline of new CCUS projects; successfully developing them would mean CCUS investment rising more than tenfold over the next three years

CCUS investment pipeline by type (left) and region (right) based on announced projects, 2015-2030



Announced CCUS investments are concentrated in North America and Europe, and are mainly for capture from power generation and for CO_2 transport and storage infrastructure.

Notes: Includes commercial capture facilities with a capacity of over 0.1 Mt CO_2 per year. Projected spending represents the capital costs of projects with announced capacities based on their planned capacities and operational dates. “Other” includes Africa and South and Central America.

Source: IEA analysis based on IEA (2025), CCUS Projects Explorer, and recent announcements.

Investment in CCUS rose to more than USD 4 billion in 2024 – a 35% increase on 2023 – as a number of new projects started construction

Just over 50 Mt of CO_2 capture capacity is currently in operation around the world and a number of first-of-a-kind projects were commissioned or started construction in 2024. The first natural gas power plant with CCS reached FID in the United Kingdom in December 2024 as part of the "East Coast Cluster". A plant in China became the world's first to capture CO_2 emissions from cement production on a large scale when it started operations last year, and the world's first large-scale storage project in a depleted gas field started operation in Australia.

A number of regions also saw their first ever FID in CCUS, with BP announcing FID for its plans to retrofit a natural gas LNG liquefaction plant in Indonesia for USD 7 billion, and a small-scale direct air capture (DAC) pilot starting construction in Kenya.

Government funding has been instrumental in helping projects get off the ground. The United Kingdom announced USD 28 billion in funding over 25 years to support CCUS and low-emissions hydrogen deployment in two industrial clusters; Denmark awarded USD 1.2 billion in annual operational subsidies to build a bioenergy with carbon capture and storage (BECCS) hub and USD 24 million for an additional three BECCS facilities; and Sweden awarded USD 1.8 billion in operational subsidies to the 0.8 Mt CO_2 per year Stockholm Exergi project.

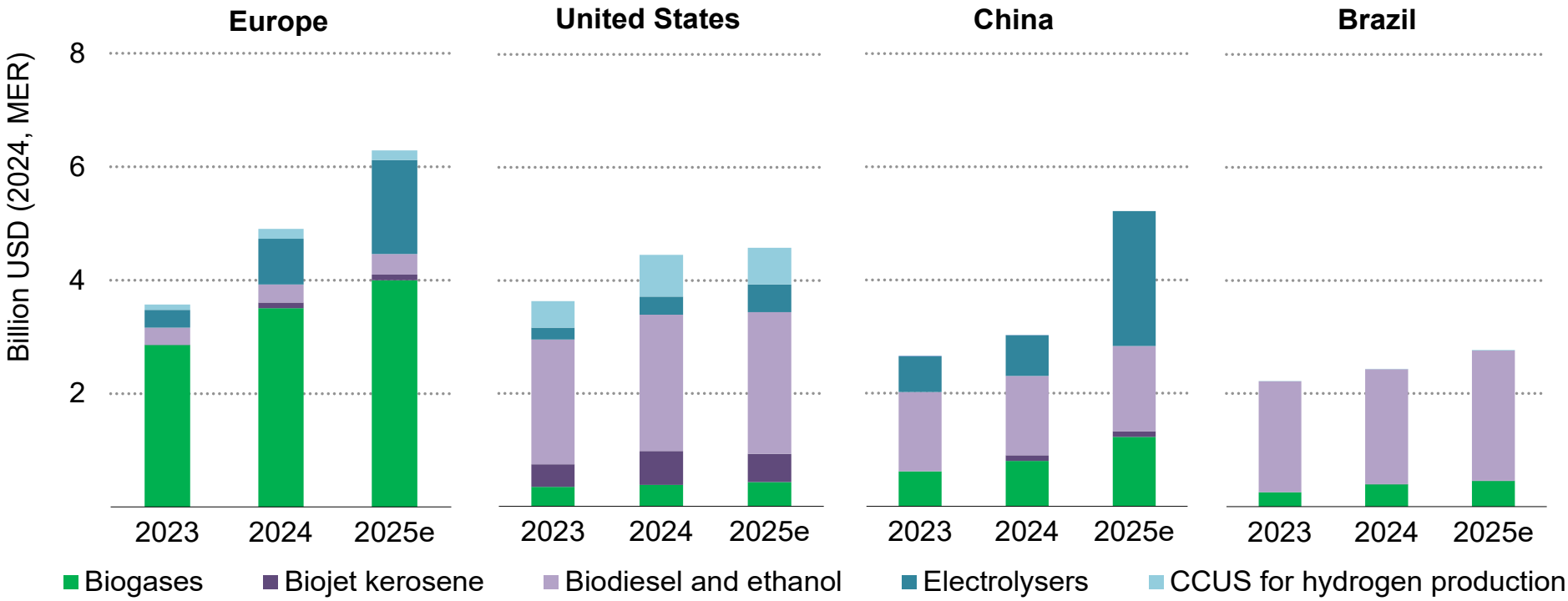
This has helped catalyse private capital to flow into these projects. For example, the CO_2 transport and storage elements associated with the UK East Coast Cluster (a joint venture between BP, Equinor and TotalEnergies called Northern Endurance Partnership) secured over USD 10 billion in debt, becoming the world's first project-financed CO_2 transport and storage project. On voluntary carbon markets, advanced offtake agreements worth close to 6 Mt of CO_2 removal were signed for BECCS and DAC projects in 2024, twice as much as in 2023.

A number of large projects are expected to receive FID in 2025 to add to the project pipeline, including the world's largest capture project at a cement plant in Norway, and the world's largest DAC plant in the United States. If all announced CCUS projects were to be completed, we estimate that capture capacity globally would reach around 430 Mt CO_2 per year by 2030 and storage capacity would reach around 670 Mt CO_2 by 2030. Achieving this level of growth would require investment to increase roughly tenfold to 2027 from current levels.

Low-emissions fuels

Investment in liquid biofuels, biogases and hydrogen is set to rise by 30% in 2025, to nearly USD 25 billion, building on a 20% rise in 2024

Investment in selected low-emissions fuels in selected regions, 2023, 2024 and 2025



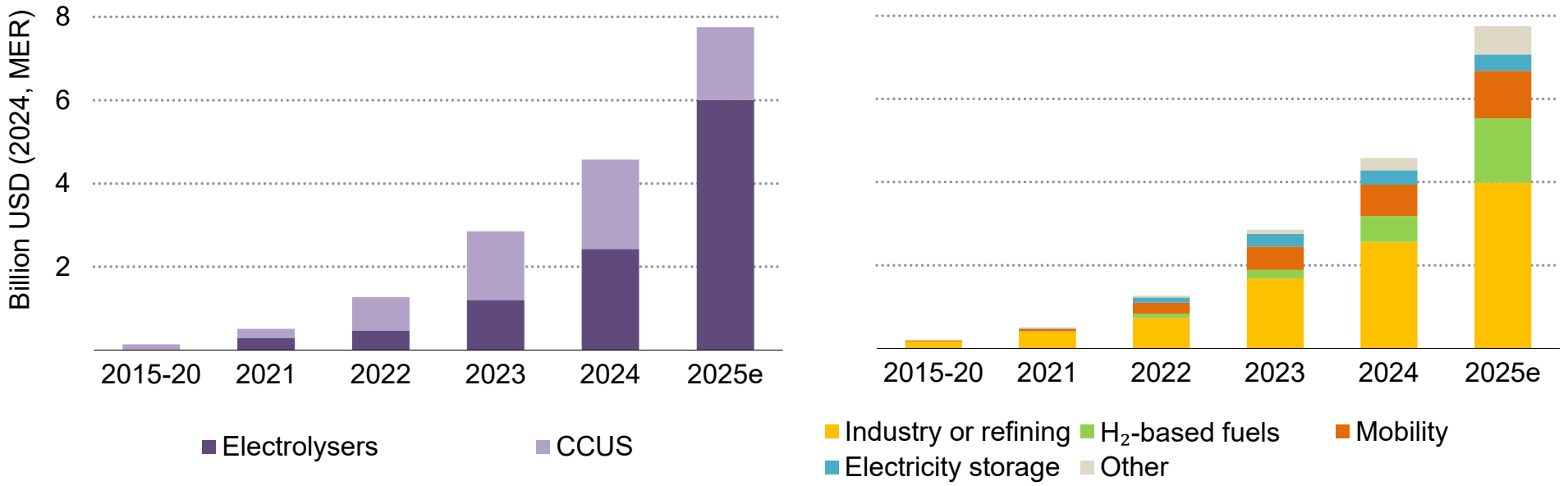
Low-emissions fuel spending varies greatly by region. In 2024, Europe accounted for 60% of global investment in biogases; the United States made up 70% of global investment in biojet kerosene; China has large investments in hydrogen; and Brazil focuses on liquid biofuels.

Notes: Investment in CCUS for hydrogen production includes the capture and compression of CO_2. Projected spending for 2025 represents the capital costs of projects with announced capacities based on their planned capacities and operational dates; 2025e = estimated values for 2025.

Sources: IEA (2025), CCUS Projects Explorer, IEA (2025), Hydrogen Production Projects Database, and recent announcements.

Investment in hydrogen rose by 60% in 2024, despite some project cancellations and delays; developing all projects that have received FID will require investment to almost double in 2025

Average annual investment in low-emissions hydrogen supply by type (left) and by intended use (right), 2015-2025



The current project pipeline of hydrogen projects implies that investment will be close to USD 8 billion in 2025. Most of the investment in 2025 is for electrolysers and industry or refining use.

Notes: Projected spending for 2025 represents the capital costs of projects with announced capacities based on their planned capacities and operational dates. Other intended uses include biofuel upgrading, grid injection, combined heat and power and domestic heating. Investment in hydrogen production with CCUS includes the capture and compression of CO_2. 2025e = estimated values for 2025.

Sources: IEA (2025), Hydrogen Production Projects Database, and recent announcements.

Investment in low-emissions fuels is set to reach a new record high in 2025, but projects remain heavily dependent on policy and regulatory support

For **bioenergy,** investment in 2025 is set to rise by 13% year-on-year to a record high of more than USD 16 billion. This is similar to the increase seen in 2024 (a 10% increase on 2023 levels) despite a slight slowdown in new capacity additions for liquid biofuels.

Around half of the investment in bioenergy is for biodiesel and ethanol, and most of this takes place in the United States and Brazil. Biofuel investment in Brazil has grown only marginally in recent years – it is set to reach around USD 3 billion in 2025 – but this could soon jump as its new Fuels of the Future Law could unlock up to USD 4 billion of average annual investment over the next decade. For example, Raízen, a joint venture between Shell and Cosan, has already committed USD 2 billion to build nine second-generation ethanol plants by 2035. The International Maritime Organization (IMO) reached an agreement last April, introducing a carbon levy and mandatory fuel standards to reduce shipping emissions, boosting prospects for biofuels in maritime transport globally.

Of total investment in biogases, 60% takes place in Europe – it produced around 25 bcm of biogas and biomethane in 2024 – supported by many EU and national policies. The European Union set an annual production target of 35 bcm in its REPowerEU plan in 2022 and investment is set to rise further in the coming years.

For **hydrogen**, there were a number of setbacks for projects around the world, including the cancellation of a 50 000 tonne (t) methanol project in Sweden two years after it had reached FID. Nonetheless, investment rose by 60% in 2024, and there remains a large pipeline of hydrogen production projects that have received FID. Government support has continued in 2025 globally, for example, through Australia's new tax incentives and the European Union's USD 200 million hydrogen funding scheme. Successfully developing all hydrogen projects that have received FID would require investment to rise by a further 70% in 2025 to almost USD 8 billion and would increase capacity to around 7.5 Mt in 2035, a near 15-fold increase on current levels.

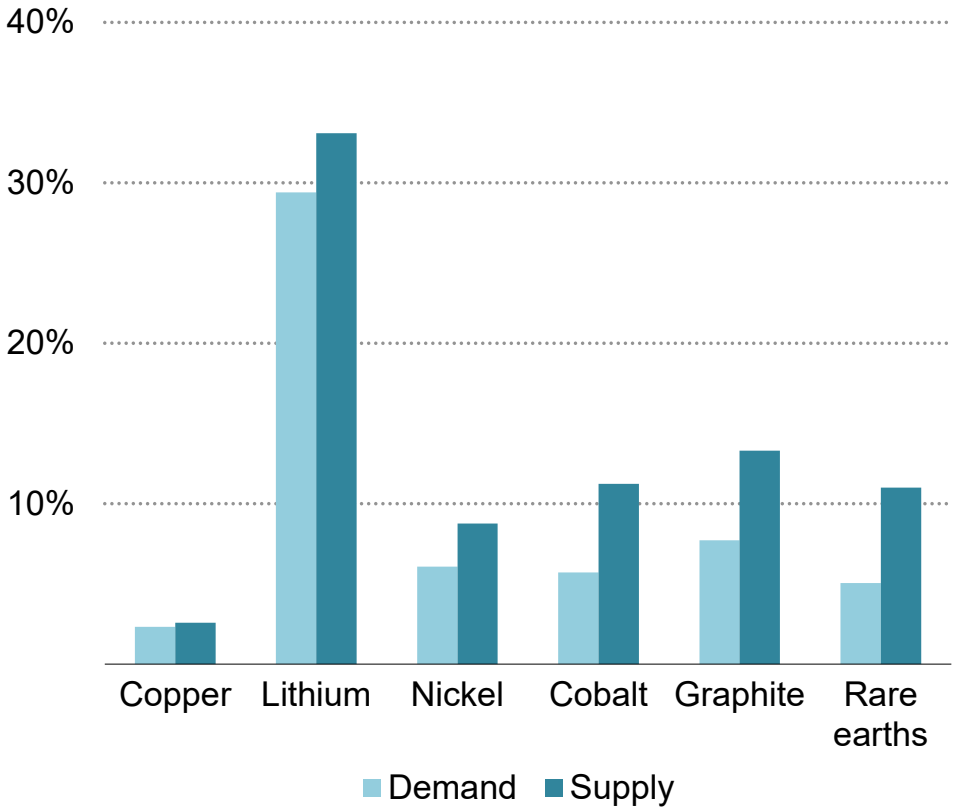
Electrolyser investment rose by 90% in 2024 to USD 2.5 billion and is set to jump by 150% this year. An increasing number of electrolyser projects are under construction, including a project in Kakinada, India that reached FID in mid-2024 and is set to produce 1 Mt of low-emissions ammonia per year by 2026, largely for export to Europe.

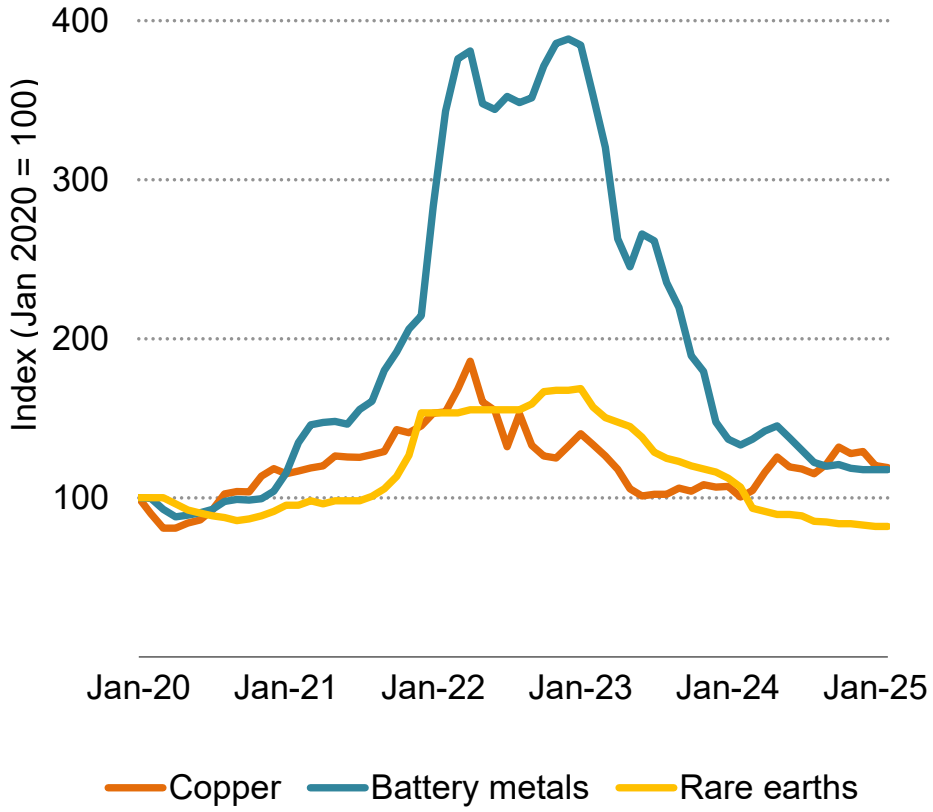
Around a third of the investment in CCUS-based low-emissions hydrogen is in North America. Some planned projects have recently been cancelled; for example, Air Products exited a 13 000 t hydrogen electrolyser project in 2025, and has paused the development of a 600 000 t complex in Louisiana until it can secure offtake agreements, despite the FID reached for this project in 2023.

Critical minerals

Recent supply growth in critical minerals has outstripped demand increases, leading to sharp reduction in prices across the board

Annual average demand and supply growth between 2021 and 2024 (left), and price developments (right) for selected minerals



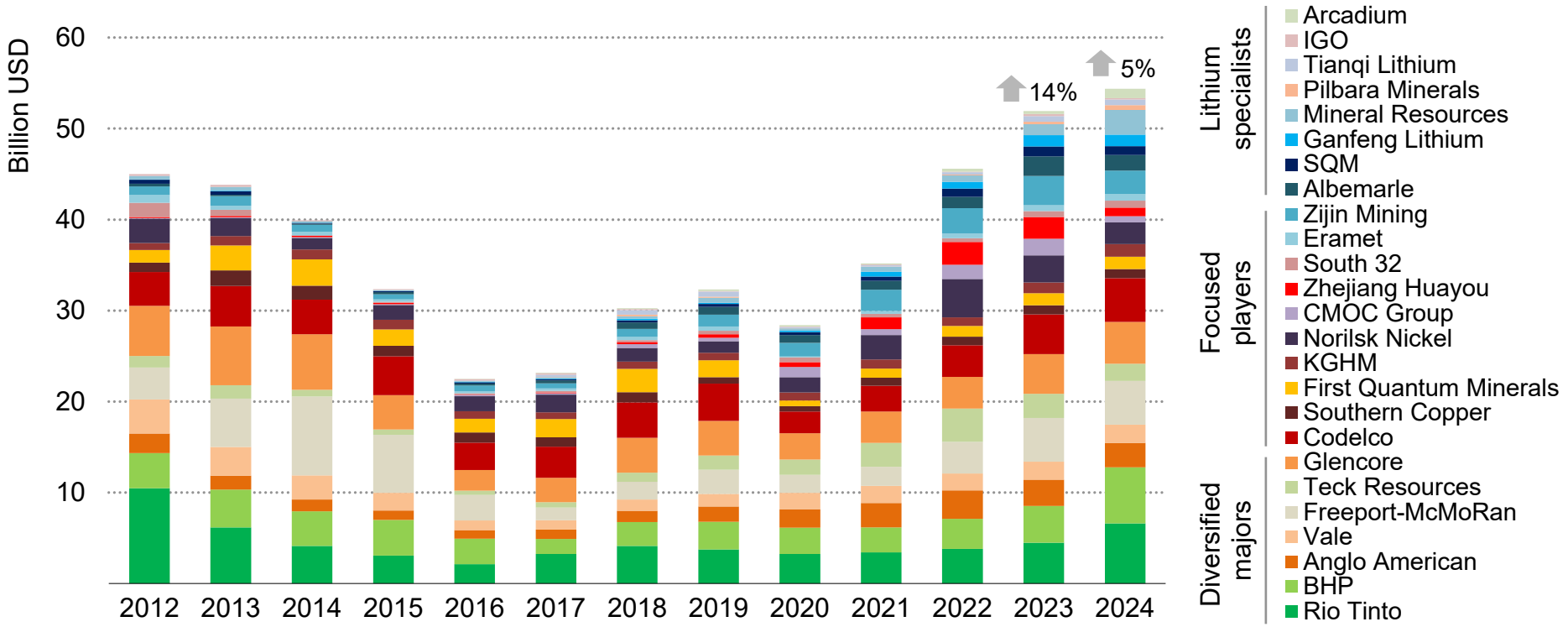


Critical mineral demand continues to grow, but prices have fallen as supply has been expanding even faster.

Notes: Supply growth rates are based on refined output. Rare earths are magnet rare earths only. Battery metals include lithium, nickel, cobalt, graphite and manganese.
Source: IEA (2025), Global Critical Minerals Outlook 2025.

Growth in critical mineral investment slowed in 2024, with the impact varying by company type

Capital expenditure on non-ferrous metal production by major mining companies, 2012-2024



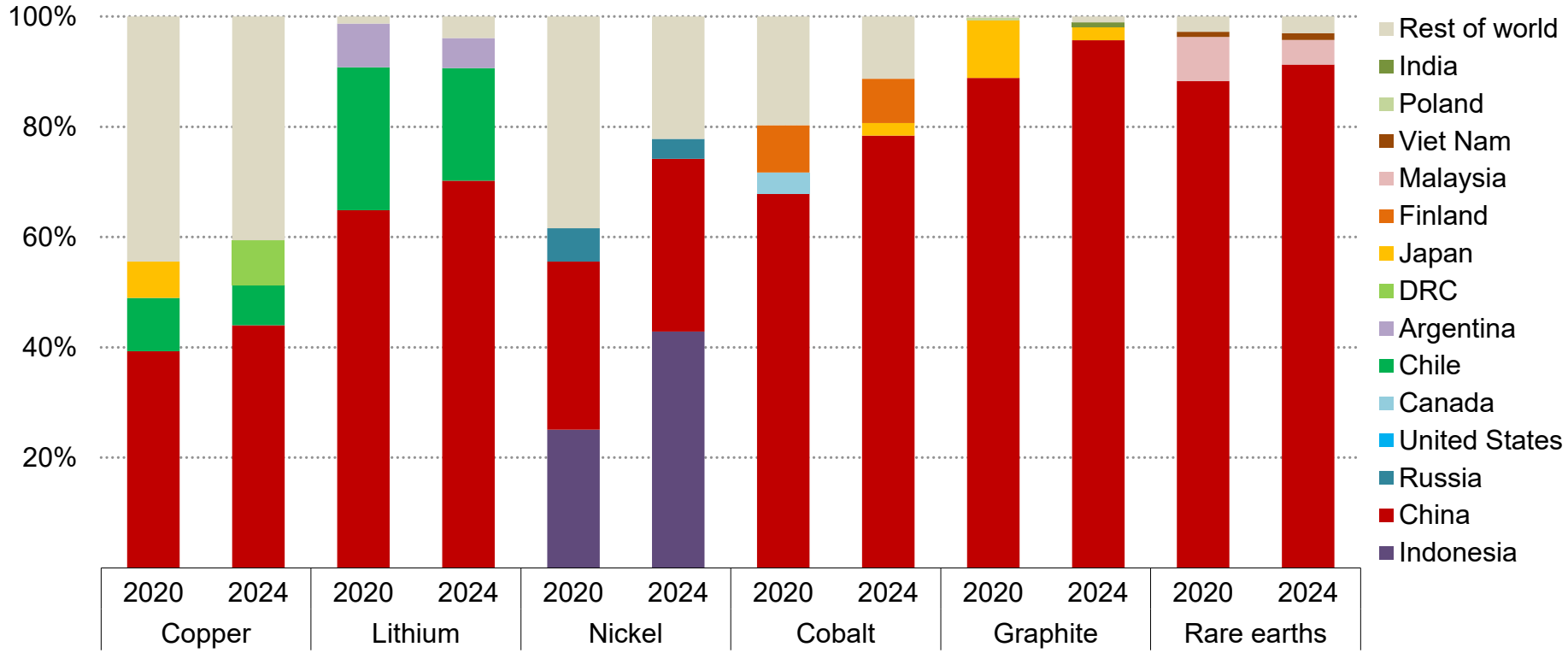
Investment in critical mineral mining grew by 5% in 2024, a smaller increase compared with 2023; while diversified majors continued to raise their investment, specialist players significantly scaled back on their capital spending.

Notes: For diversified majors, capex on the production of iron ore, gold, coal and other energy products is excluded. Nominal values. The results for Arcadium start from 2016.

Sources: IEA analysis based on company annual reports and S&P Global.

The geographic concentration of supply has risen in recent years for nearly all critical minerals

The share of top three producing countries in the production of key refined minerals, 2020 and 2024



The geographical concentration of refined material production has increased in recent years, particularly for nickel and cobalt.

Notes: DRC = Democratic Republic of the Congo. Graphite is for battery-grade (spherical graphite and synthetic graphite). Rare earths are magnet rare earths only. The figure depicts the share of the top three producing countries in a given year.

Source: IEA (2025), Global Critical Minerals Outlook 2025.

Price declines for critical minerals are stymieing efforts to diversify supplies

Demand for critical minerals continued to rise in 2024. Lithium demand rose by nearly 30%, sustaining the strong increase seen in 2023, despite a slowdown in EV deployment in some markets. Demand for nickel, cobalt, graphite and rare earth elements rose by 6-8% in 2024. Copper also saw robust demand growth of around 3%, outpacing the previous two years. However, increases in supply – driven by China, Indonesia and parts of Africa – outpaced the growth in demand and so prices continued to remain subdued. This was particularly the case for battery minerals: over the course of 2024, lithium prices declined by 40% and graphite and cobalt prices fell by around 20%, although these declines were less sharp than those seen in 2023.

Ongoing price declines have strained producers' financial capacity. Our assessment of 25 large mining companies suggests that investment in critical minerals mining grew by 5% in 2024, down from 14% growth in 2023. Adjusted for cost inflation, real investment growth in 2024 was just 2%. However, trends varied by company. Diversified mining majors increased capital spending by around 15%, while specialist players scaled back investment by 15%. Companies focused on lithium development increased investment by 27%, although this was lower than the 60% increase seen in 2023.

Exploration spending in 2024 was similar to levels in 2023, marking a pause in the strong growth trend that has been seen since 2020. Lithium, copper and uranium continued to attract most investment in exploration. Uranium exploration in particular saw a 30% increase in 2024. In contrast, nickel exploration was significantly affected by the low-price environment and changing battery chemistry choices, with spending falling by more than 30%.

Recent investment trends are severely affecting efforts to diversify supply. For refined materials, supply diversification has seen limited progress in recent years, and nickel and cobalt supply has become even more concentrated. The combined share of the top three producers rose from 60% to 80% for nickel and from 80% to 90% for cobalt between 2020 and 2024.

This concentration creates concerns for critical minerals security as disruption to critical mineral supply can have major impacts on technology prices, inflation, manufacturing competitiveness and the broader economy. A wide range of export control measures on critical minerals have been announced in recent months. In December 2024 China restricted the export of gallium, germanium and antimony to the United States, followed by additional export control announcements on materials including tungsten, tellurium, bismuth, indium and molybdenum in February 2025 and on seven medium and heavy rare earth-related items in April 2025.

Implications

The decline in oil investment and rising share of the Middle East in total investment has major security implications, and questions remain over who will absorb the upcoming wave of LNG

Two overarching trends in oil investment this year will have major implications for energy security. The first is the decline in oil investment – the first since 2020 – given the drop in the oil price and ongoing market uncertainty. The second is the continuation of the longer-term trend seen of a rising share of upstream oil and gas investment by NOCs in the Middle East; these companies were responsible for less than 10% of global investment in 2015. Despite some of the lowest costs in the world, this year they are set to comprise more than 20%.

Fuel investment trends are also increasingly being shaped by the rebalancing underway in the Chinese economy. This is visible for coal: global coal investment has consistently risen for the past eight years but there are signs that this growth is slowing, with new coal mines facing headwinds from a weakening economic outlook in this world's largest coal producer and consumer.

For natural gas markets, there have been some delays to new LNG start-up dates, but the period between 2026 and 2028 is likely to see some of the largest ever annual expansions in LNG capacity. This is likely to ease gas balances that currently remain tight, but it also raises the question of whether an attractive equilibrium can be found between what is needed for price-sensitive buyers to increase imports and what suppliers will need to recover costs.

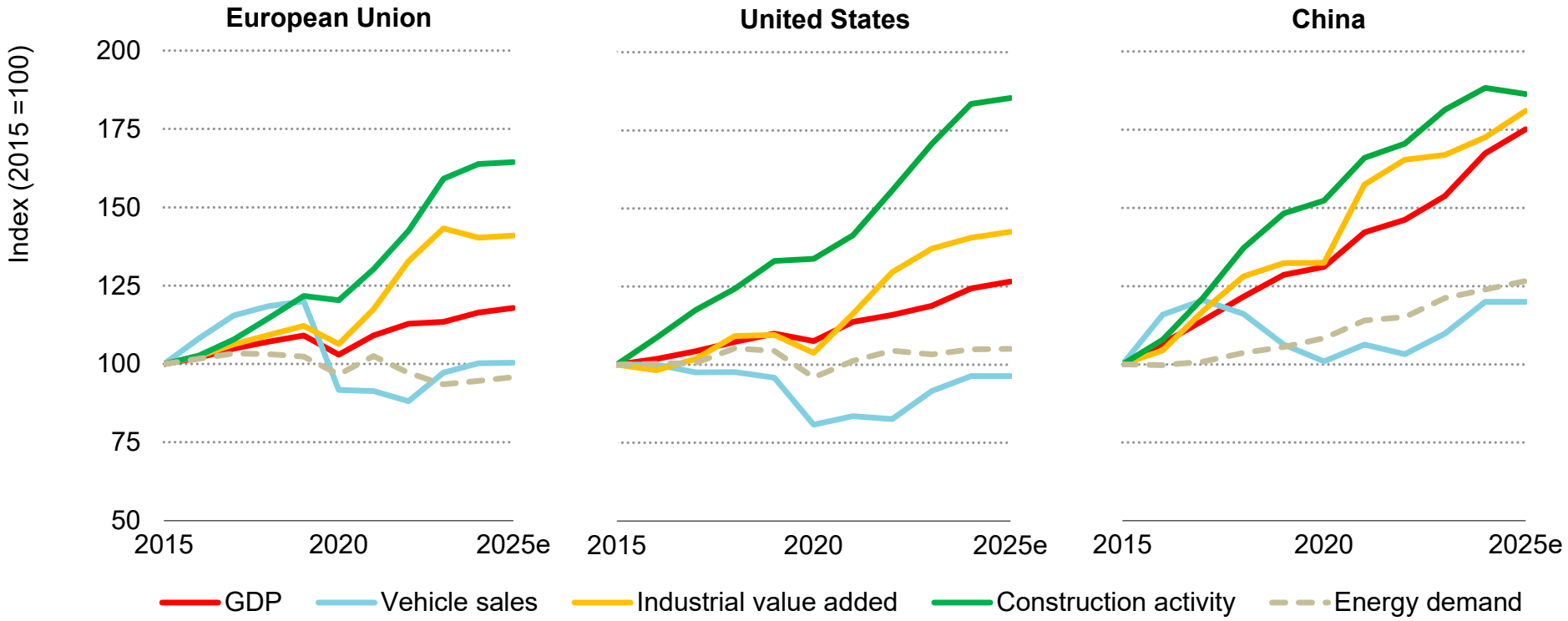
The IEA has consistently emphasised the importance of immediate reductions in the methane emissions from fossil fuels as it would reduce a powerful greenhouse gas and bring additional gas to markets. Many of the measures needed to do this would pay for themselves over their lifetimes – often several times over – but upfront investment is required. Efforts are ongoing to mobilise additional finance in this area, but achieving the overall reductions needed will not occur without a concerted push by regulators, policy makers, and the industry at large.

Critical minerals have emerged as a frontline issue in safeguarding global energy and economic security. Current investment trends highlight that diversification will not materialise through market forces alone and well-designed policy support and partnerships are essential.

For low-emissions fuels, there is a healthy pipeline of new projects, but these remain heavily reliant on continued policy support. A major challenge is mobilising the large level of investment levels required: completing all low-emissions hydrogen, biogases, liquid bioenergy, and fuel-based CCUS projects will require a 30% increase in investment in 2025 and considerably more in the next few years. If this is realised, these fuels can start to play a more significant role in meeting various climate and energy security goals.

Demand and electrification

Most macro indicators underpinning energy efficiency investment have risen steadily over the past ten years, but rising costs tend to hide slower levels of activity

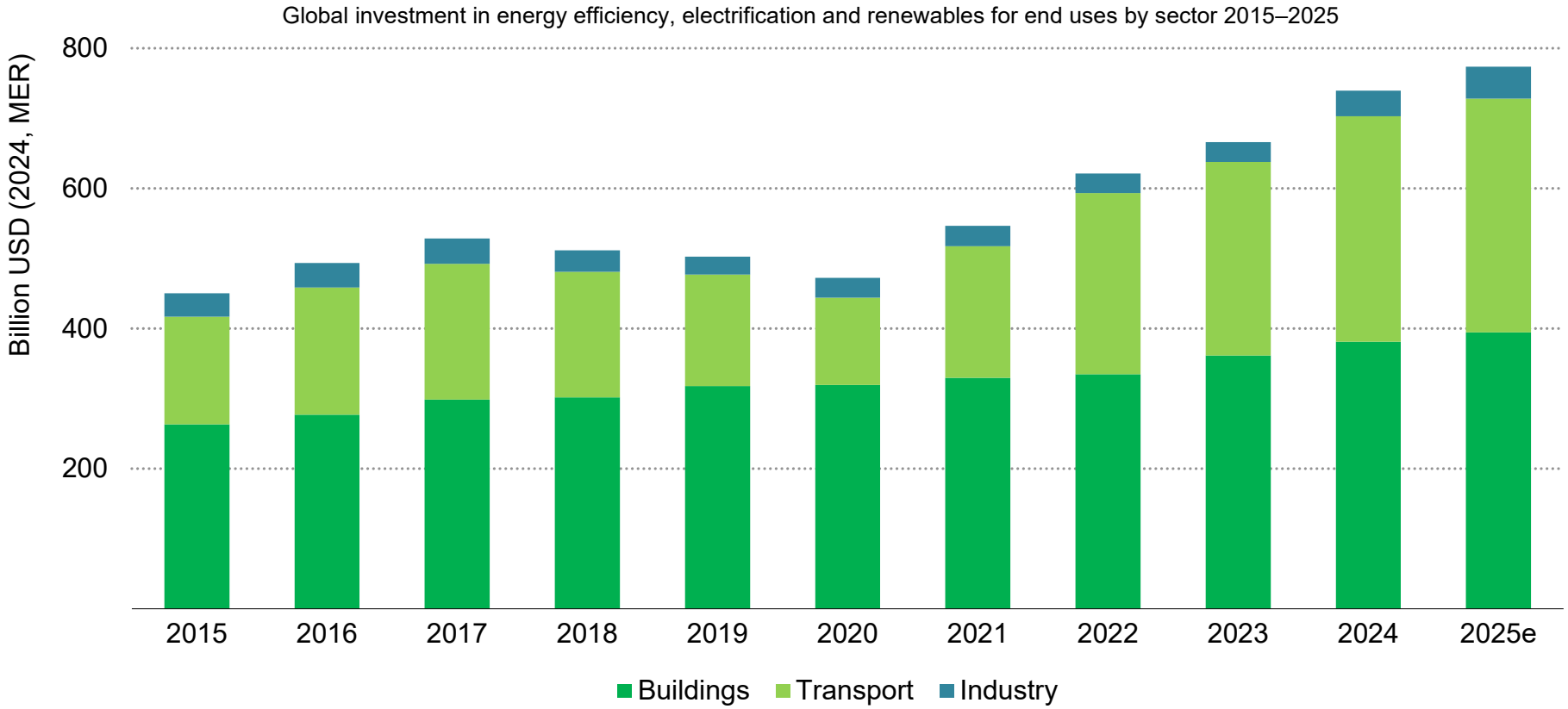


2015 to 2025 marked the decade of the rise of China as a global powerhouse of the energy system. China's activity in construction, industry and auto manufacturing helped shape the profile of energy consumption and investment in energy efficiency and electrification.

Notes: 2025e = estimated values for 2025. Industry value added for the United States is based on Q4 2024 updates. The European Union construction indicator is useful floor area for which building permits are issued (both residential and non-residential). The United States construction indicator is new privately owned housing units authorised by building permits in permit-issuing places. The China construction activity represents the economic value added of the sector.

Sources: IEA calculations based on Eurostat (2025); BEA (2025); NBS (2025).

Boosted by strong EV sales and efficiency gains in construction and industry, demand-side investment has nearly doubled since 2015



The levelling off of EV sales in some parts of the world was largely compensated by the increasing sales of Chinese vehicles in large EMDE markets, while investment in more efficient appliances kept investment in the buildings sector from declining.

Notes: EMDE = emerging market and developing economies; 2025e = estimated values for 2025. An energy efficiency investment is defined as the incremental spending on new energy-efficient equipment or the cost of refurbishments that reduce energy use (excluding labour). The intention is to capture additional spending compared to the reference technology and which leads to reduced energy consumption. The methodology for tracking demand investment was updated in 2025 and now tracks a broader range of technologies. Renewables for end use include behind-the-meter technologies such as solar water and geothermal heating.

The past decade has seen the rapid ascent of EVs and marked a period of strong policy support for energy efficiency and electrification

Over the past ten years the IEA has been tracking investment on the demand side of the energy system across the buildings, transport and industrial sectors. The period saw annual investment almost double to reach close to USD 800 billion annually by 2025, thanks to the rapid roll-out of electric vehicles (EVs) and widespread recognition of the need to renovate buildings and electrify industrial processes, not only to meet the objectives of limiting the effects of climate change, but because managing energy demand will become crucial for energy security, affordability and independence.

While the past ten years have seen strong policy support for efficiency and electrification, recent spikes in interest rates have constrained fiscal capacity, with governments facing reduced ability to fund targeted incentives. The rolling back of some policy support started in 2023 and continued in 2024, but not all sectors were affected equally.

The momentum behind efficiency and electrification is clearly visible on the transport side, where annual investment in EVs and in improving the efficiency of internal combustion engines has increased fivefold since 2015, and is set to reach almost USD 220 billion in 2025. The sector is proving resilient, as stagnant year-on-year EV sales in parts of Advanced Economies in 2024 were compensated by robust performance in other markets, including inroads made by Chinese car manufacturers both at home and in potentially large future EV markets (e.g. Brazil and Southeast Asia).

But the story on electrification is one of two speeds. Heat pump sales are on the decline for the second year in a row, as electricity costs have increased in Europe, gas prices have come down and support packages have been rolled back. This is compounded by the slower construction rate seen across the world, especially in the People's Republic of China (herafter "China"), where the focus remained on completing projects, often government-led, and a with decreasing number of new project starts. However, this stagnation is partly compensated in our numbers by an increase in material costs for envelopes and retrofits, as well as an increase in sales of efficient appliances and cooling systems. Overall, these trends produced a small uptick in energy efficiency and electrification investment for 2024.

At a regional level, about two-thirds of investment on the demand side occurs in the United States, China and the European Union, but the recent uptick in the demand for EVs in EMDE outside China means that the share of investment there has risen above 15% of the total.

Investment in energy efficiency and electrification decreased by 2% in the European Union, mainly because of reduced policy support in some markets and the slowdown in EV and heat pump sales. At the time of writing, our model anticipates a modest recovery for 2025, but

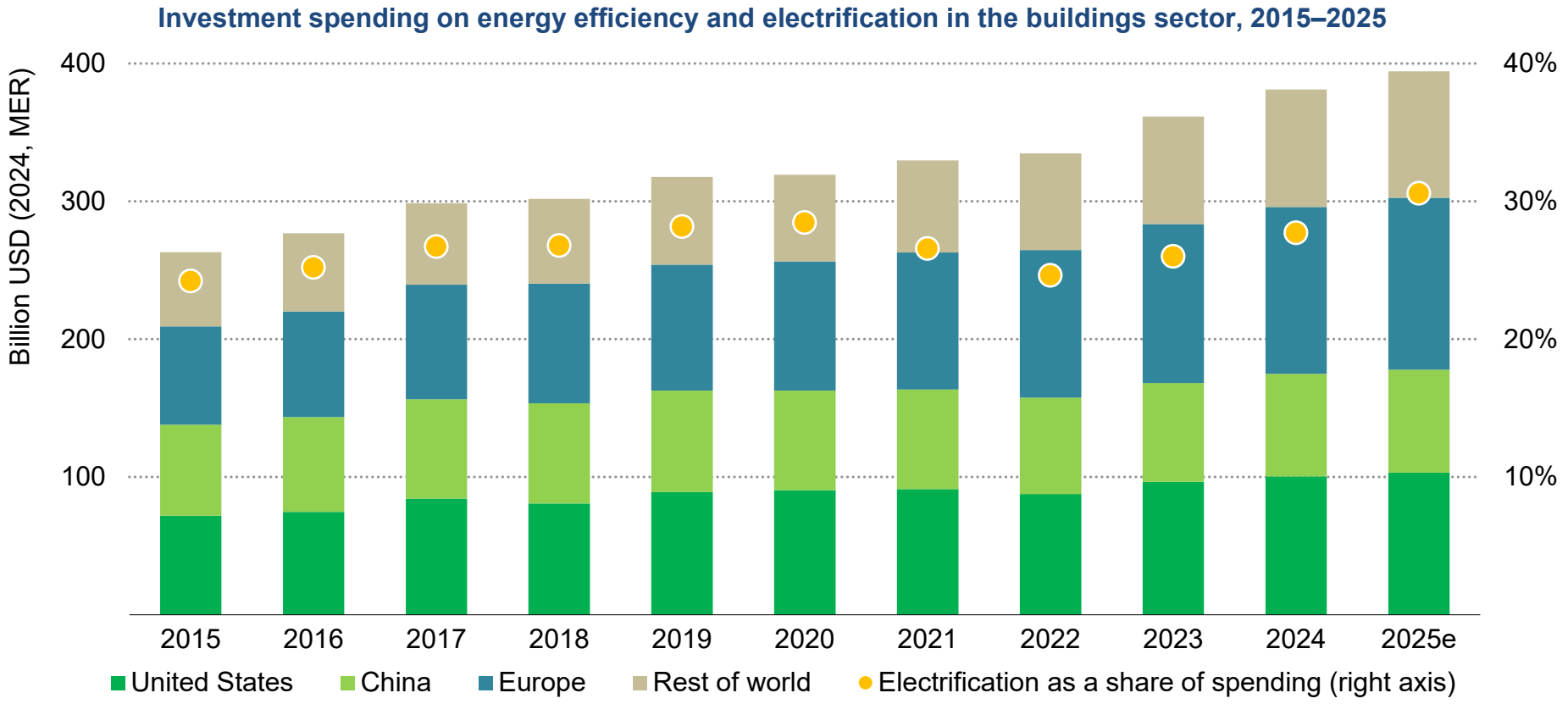
the picture is very uncertain as efficiency investment can be quickly affected by trade policies and material prices.

Investment in the United States remained relatively resilient thanks to a strong building market. Transport investment remained stable and a return to growth is anticipated for 2025, depending on the impacts of new trade policies.

In China, 2024 saw investment on the demand side rise slowly, by less than 2%. The 4% rise in investment in the buildings sector can be partly explained by rising material prices while the property sector also has yet to recover from the recent crisis. Investment in industry more than doubled in 2024 and is set to grow by a further one-third in 2025, driven by resilient demand for industrial production.

Buildings

Energy efficiency investment in buildings is set to decline in 2025, with economic pressures continuing to limit growth prospects



While overall investment in buildings energy efficiency has increased in the past decade, global growth has stalled, leading to an expected decline. Electrification as a share of spending grows consistently as investment in energy-efficient appliances increases.

Note: Spending on electrification (e.g. heat pumps) is included in the total spending and represented as a share of total spending on the right axis. 2025e = estimated values for 2025.

Declining public support schemes slowed growth in buildings energy efficiency in 2024 despite a decade of expansion

For the past decade of *World Energy Investment*, the IEA has sought to track how capital flows into energy efficiency in buildings, with a strong focus on the role of public financing schemes in enabling these investments. Previous assessments primarily examined how the expansion and reduction of public programmes such as subsidies, grants and efficiency mandates affected the availability of capital for efficiency improvements. These financing mechanisms played a key role in motivating voluntary efficiency upgrades by influencing the economics of retrofits and the adoption of energy-efficient technologies.

This year's analysis shifts towards a detailed categorisation of investment flows, distinguishing between investment in building retrofits and envelopes and spending on other measures to increase energy efficiency, such as the installation of high-efficiency appliances. This approach provides a more direct measure of how capital is being allocated, rather than primarily tracking the influence of policy-driven financing.

In 2024 global investment in buildings energy efficiency reached USD 275 billion, a marginal increase from the previous year. But growth was uneven across different segments. While spending on electric appliances, particularly in residential cooling units, helped sustain overall investment levels, weakening momentum elsewhere saw retrofits and envelopes stagnate or decline. These changes are a reflection of many factors, such as the slowdown in the real estate sector, the increase in building material costs and, more fundamentally, the fading impact of earlier support schemes that were instrumental in the previous decade of growth.

The most substantial shift in the buildings sector in 2024 was in Europe where significant reductions in government-backed programmes have been made. Following the reduction of Italy's Superbonus incentive from 110% to 70% for renovations in 2024 and further to 65% in 2025, a significant decline in renovation activity and applications was seen by the spring of 2025, once the backlog of applications still eligible for the 110% incentive had been processed. The drop in participation was further amplified by the removal of the option to transfer tax credits to third parties such as banks or financial institutions, which had previously played a key role in facilitating access to the scheme and driving investment in energy efficiency renovations.

Germany's largest programmes to support building energy efficiency retrofits have continued to change in scope in 2024. The Bundesförderung Effiziente Gebäude (Federal Funding for Efficient Buildings) scheme reduced its funding support by half to EUR 30 000 for heating and fabric measures, although this can be increased when undertaken through a roadmap assessment. France's government

spending allocations to finance energy-efficient building renovations reduced in 2024, with a further decrease announced for 2025.

Despite these declines in public support, overall investment in building retrofits and envelopes in Europe remained resilient in 2024, supported by projects already in the pipeline from previous funding schemes and a rush to secure incentives before reductions took full effect. However, as these effects fade and no large-scale replacement schemes emerge, a more pronounced decline in efficiency investment in buildings is expected in 2025.

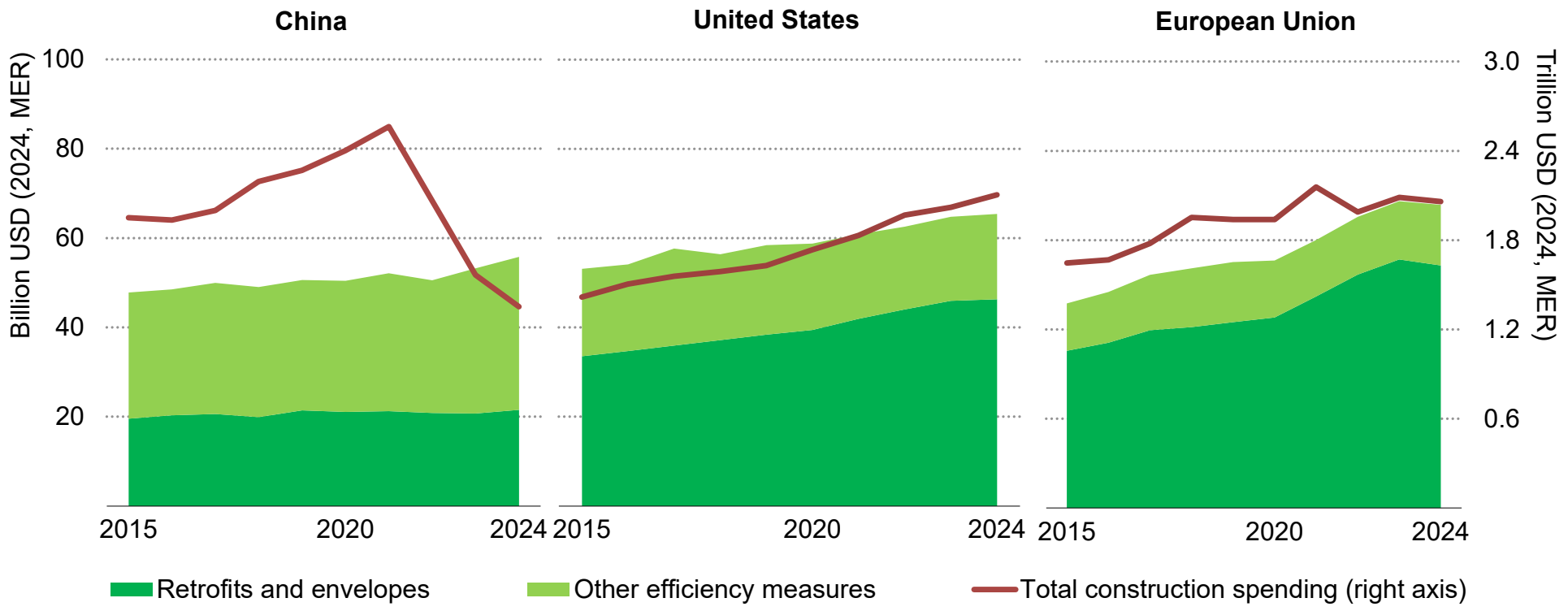
In China energy efficiency investments have historically been more concentrated in new building envelopes rather than retrofits. The sharp contraction in the construction sector – marked by a more than 10% year-on-year decline in real estate development – has pushed down the share of envelope investment. This is compounded by the impact of recent US tariffs and broader challenges in the real estate market. The weakening momentum in both new construction and renovation projects highlights the growing need for alternative funding and policy support. However, China's focus on green building construction and efficiency will continue during the 15th Five-Year Plan period (2026-2030), which prioritises green building construction and energy efficiency retrofits to support its climate goals. Key objectives include scaling up ultra-low-energy buildings, enforcing stringent green building standards and retrofitting existing urban buildings for energy conservation. The plan also emphasises promoting green rural housing, integrating renewable energy and adopting heat metering systems.

Despite a challenging macroeconomic environment, energy efficiency investment in the United States, especially in retrofits and envelopes, remained stable in 2024 thanks to the continuation of funding programmes through the Inflation Reduction Act (IRA), with a continuation of enacted weatherisation funding programmes. However, many of the programmes offered by the IRA are being channelled through to state-level programmes and many remain yet to open. California, for example, received USD 80 million in June 2024 for the Home Electrification and Appliances Rebates (HEEHRA) scheme, and also received USD 291 million in January 2025 for its Home Efficiency Rebate (HOMES) programme. Washington DC has a programme providing rebates for low-income households to improve fabric energy performance and rebates to support electrification.

In 2025 the growth in spending on high-efficiency appliances is expected to be insufficient to offset the decline in investment in retrofits and building envelopes. The sharp pullback in public spending on efficiency programmes in 2024 is likely to have a delayed impact, with many regions experiencing a reduction in both the scope and availability of funding for retrofits and renovations. Additionally, ongoing tariffs on construction materials are expected to further inflate costs, adding another layer of pressure on construction and renovation activities.

Energy efficiency investment shifts towards renovations amid a global construction slowdown

Investment in buildings energy efficiency and total construction spending, 2015-2024



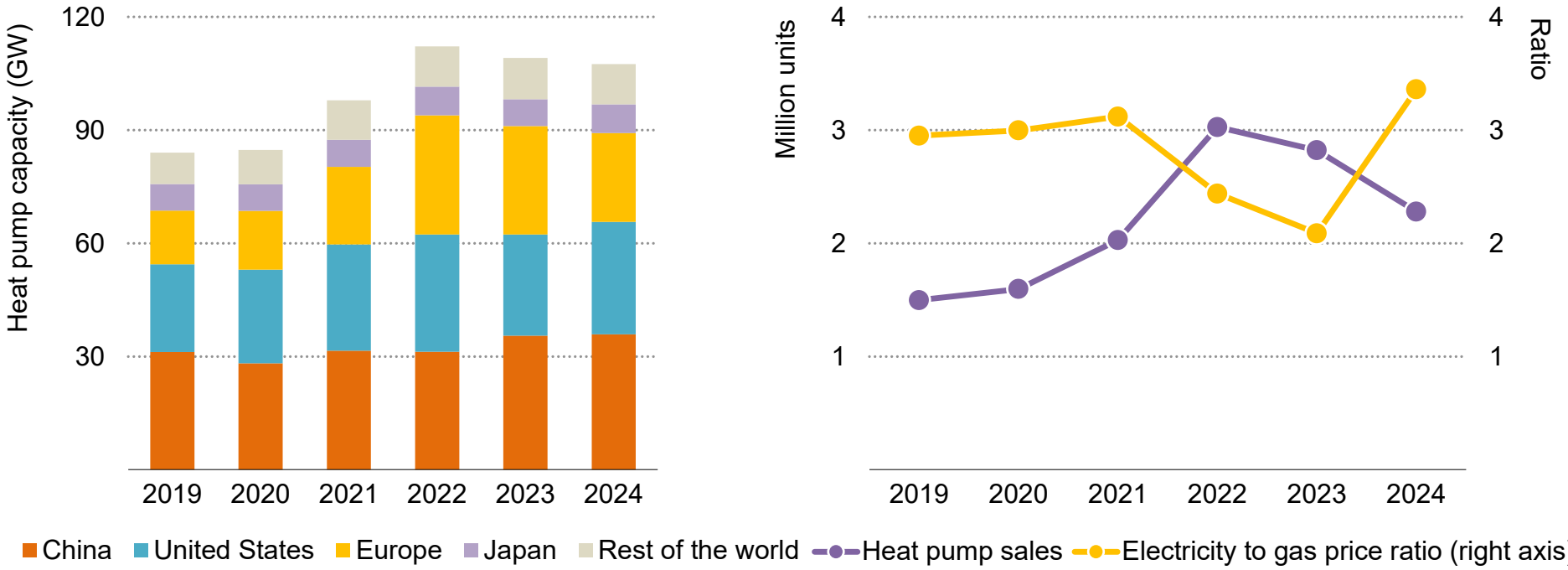
While global construction activity slowed in recent years due to rising costs and higher interest rates, investment in energy efficiency has increasingly shifted towards retrofits and envelope upgrades, reflecting the growing importance of renovation projects over new builds.

Notes: Construction spending for China refers to annual investment in real estate development; the United States statistic follows annual construction spending; the European Union statistic follows the gross fixed capital formation of total construction in EU-27 countries.

Sources: US Census Bureau (2025), Construction Spending; Eurostat (2025), Gross value added and income by main industry; National Bureau of Statistics (2025), Basic situation of the national real estate market in 2024 (2025).

Heat pump growth slows in the absence of stronger market and policy incentives

Global heat pump sales (right) and heat pump sales and electricity to gas price ratio in selected countries in Europe (right), 2019-2024



Global heat pump sales have decline for two consecutive years, as higher electricity prices relative to gas and weakening policy support dampened demand, notably in Europe. With sales closely tracking energy price dynamics, making the policy and market environment more conducive to heat pump uptake through targeted incentives will be key to reversing the slowdown.

Notes: Right figure comprises an analysis of the 13 member countries of the European Heat Pump Association.

Sources: IEA analysis based on data from ChinaIOL; European Heat Pump Association; Air-Conditioning, Heating, and Refrigeration Institute; Canada National Statistical Agency; Japan Refrigeration and Air Conditioning Industry Association.

The investment case for electrification and energy efficiency is strong, but financing and market conditions are key to scaling up

Electrification investment in the buildings sector is driven primarily by two factors: affordability and anticipated long-term cost savings. While public subsidies have long played a central role in advancing energy efficiency, sustainable long-term growth in the sector requires investment models that do not rely solely on one-off grants. To scale energy-efficient technologies, there must be a mix of financing mechanisms that help bridge upfront costs and ensure long-term economic viability.

The heat pump market illustrates this challenge. Heat pump sales in Europe fell sharply in 2024, dropping by a record 21% compared to the previous year. This decline follows a slowdown in 2023 and marks a stark contrast to the rapid growth seen in previous years. The downturn reflects a combination of higher electricity costs relative to falling natural gas prices, slowing construction markets and policy uncertainties that have weakened consumer confidence. Two years earlier, sales had surged as gas prices spiked, making efficient electric heat pumps the more cost-effective option. However, with gas prices now declining while electricity remains expensive – averaging over 2.5 times the price of gas in many European countries – consumers are less inclined to switch. Without financial mechanisms to offset the upfront costs and stabilise long-term returns, investment in heat pumps become highly sensitive to short-term energy price fluctuations.

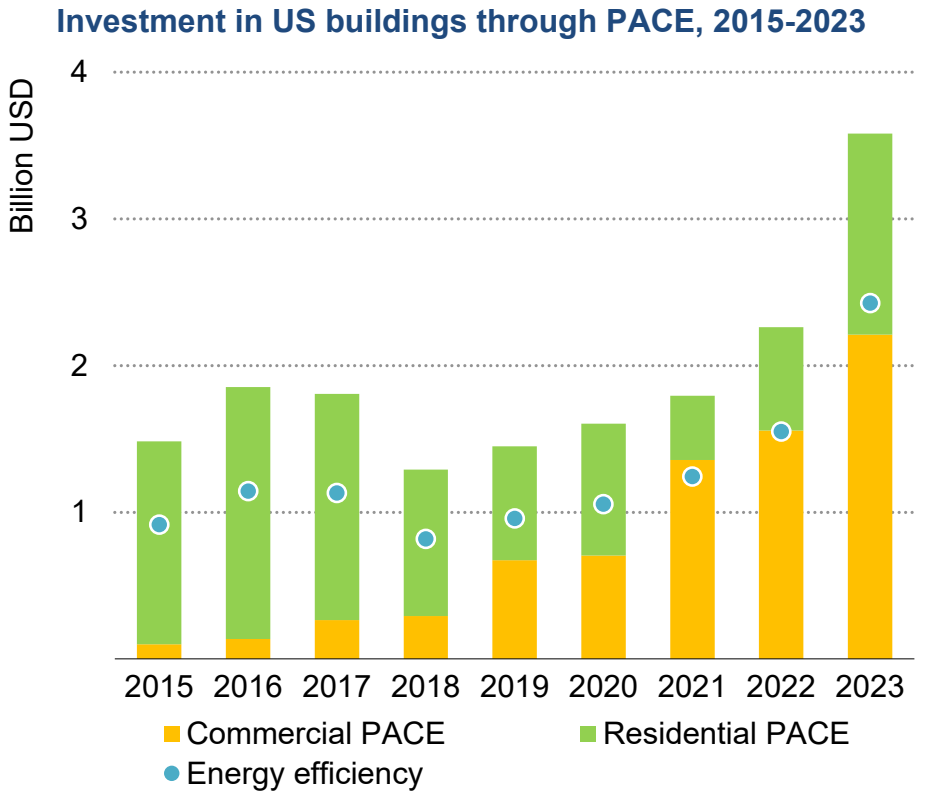
In contrast to Europe's declining heat pump market, China has seen consistent growth in heat pump sales for five consecutive years, even amid a real estate downturn. This resilience is largely driven by robust government support. The National Development and Reform Commission outlined a new action plan in April 2025, which aims to promote high-quality development in the heat pump industry, emphasising energy efficiency and carbon reduction in key sectors. The policy focuses on expanding heat pump applications in both residential and industrial settings, including replacing coal-fired heating systems with energy-efficient heat pumps. China's policy-driven approach that sets clear targets and offers incentives for energy savings demonstrates the importance of government support in driving sustained demand for energy-efficient technologies.

A similar challenge exists for other energy-efficient building investments. While zero-carbon-ready buildings can deliver significant cost savings over time, the initial capital required for measures like solar PV systems and battery storage can be a barrier. Research indicates that these investments can halve energy bills and CO_2 emissions while maintaining reasonable payback periods, but their financial viability depends on supportive financing conditions. Lower-cost capital for ESG-related projects and better valuation of zero-carbon-ready buildings could make these assets more attractive, but without structured financing tools, adoption remains limited.

To address these barriers, financial mechanisms beyond traditional subsidies are gaining traction. Across Europe, there is a shift towards a more diversified set of financing options, often referred to as "smart finance" solutions. These include publicly supported lower-cost loans, green mortgages, and on-bill or on-tax financing schemes, each designed to spread upfront costs and lower financial barriers to energy-efficient upgrades. European initiatives such as the Smart Finance for Smart Buildings (SFSB) facility, Private Finance for Energy Efficiency (PF4EE) and ELENA provide additional support by de-risking investments. In Ireland, for instance, credit enhancement schemes and the Climate Action Fund have emerged as key tools for encouraging private capital flows into energy efficiency.

Property Assessed Clean Energy (PACE) financing in the United States has also been a tool for providing low-cost, long-term funding for improving energy efficiency in buildings. Unlike traditional loans, PACE financing is repaid through property tax assessments, which allows property owners to invest in upgrades with minimal upfront costs and extended repayment periods. From 2015 to 2023, over 65% of the over USD 17 billion of lending through PACE was directed to improving energy efficiency and renewable energy projects in buildings.

Market incentives, energy price structures and financial frameworks all influence electrification investments. While technological feasibility is rarely the limiting factor, economic considerations dictate whether consumers and businesses choose to invest. Aligning affordability and profitability through consistent regulatory frameworks and well-structured financial mechanisms is a condition to accelerate electrification in the building sector.



IEA. CC BY 4.0.

Source: IEA analysis of PACENation.

Addressing imbalances in energy efficiency investment in EMDE

The COP28 goal of doubling the rate of improvement in energy efficiency requires at least a tripling of investment in buildings energy efficiency by 2030. While increasing the total volume of investment in the buildings sector is essential, addressing the regional imbalance in investment is equally important. In 2024 EMDE accounted for just 34% of global investment in buildings energy efficiency. There is a huge opportunity in this sector, given the rapid expansion of the buildings stock in many developing economies.

There are bright spots in EMDE investment in this area. India's green buildings market, though still only about 3% of global investment, continues to grow, with its certified green building space reaching more than 12 billion square feet in 2024. A newly updated energy code and expanded rooftop solar funding in the 2024 budget are expected to further accelerate this growth.

A new private equity initiative – the Africa Decarbonisation Fund I – illustrates growing investor interest in buildings sector efficiency in EMDE. With plans to raise USD 150 million to retrofit 30 000 buildings in Southern Africa, the fund targets solar energy, storage and smart-grid systems, offering businesses a cleaner and cheaper alternative to diesel. Backed by multilateral climate funds and EU institutions, the initiative signals how blended finance can help crowd in private capital and scale energy solutions tailored to regional needs.

Current concessional finance for green buildings in EMDE is relatively limited. Total international public finance specifically directed to energy efficiency investment in the buildings sector amounts to around USD 1 billion annually. The scale of funding remains insufficient to put the sector on to a more sustainable pathway.

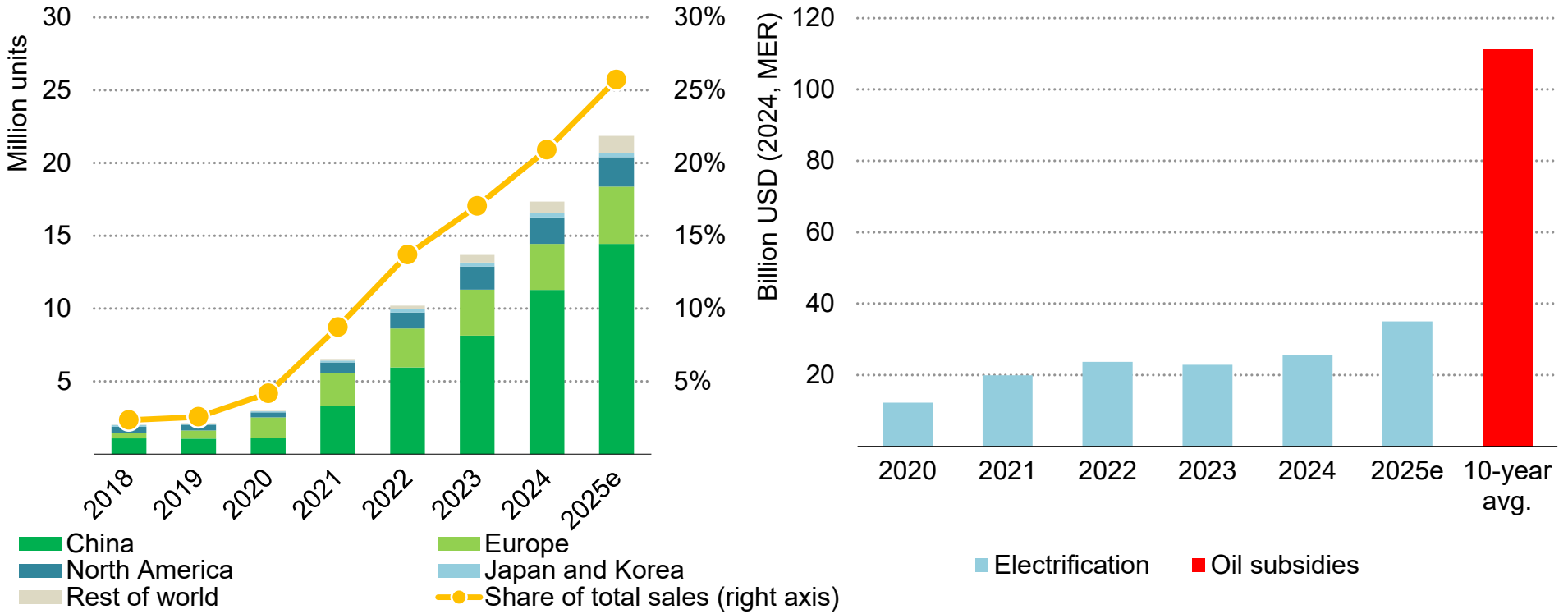
Beyond increased funding, new financial structures are also needed. The Energy Efficiency Revolving Fund (EERF), backed by the World Bank in the Western Balkans, allows public agencies to borrow for upgrades and repay loans through energy savings. The repaid funds then finance new projects, creating a cycle of reinvestment. Adapting similar models in EMDE could help address public-sector financing barriers.

Concessional finance alone will not suffice without stronger institutions. Many EMDE lack the capacity to implement and enforce green building codes, weakening investor confidence. Only around 80 countries have codes in place, and enforcement is often limited. Enhancing regulatory frameworks and compliance will be essential to attract large-scale public and private investment.

Transport

2024 saw record EV sales globally, and the pace of electrification of transport in EMDE other than China is picking up

Global EV sales (right) and clean transport investment relative to oil subsidies in EMDE excluding China (left)



Despite growing EV adoption globally, clean transport energy investment in emerging market and developing economies (excluding China) remains overshadowed by oil subsidies, which are four times larger on average.

Notes: Electrification includes investment in EVs and rail electrification, while oil subsidies refer to transport subsidies as reported by the IEA and OECD combined. 2025e = estimated values for 2025.

More than one in five cars sold in 2024 were electric, but for the moment sales are dominated by China, followed by Europe and North America

In 2024 more than 17 million EVs were sold worldwide, representing more than one in five sales compared to just 1% of sales in 2015.

Nearly two-thirds of these sales took place in China, while Europe and North America followed with respective shares of 18% and 11% of total EV sales. While EV penetration remains significantly lower in emerging market and developing economies (excluding China), EV sales in these markets grew at more than twice the rate of sales in advanced economies, reaching to 55% in 2024.

In China EV sales nearly doubled in 2024 compared with 2022. To sustain this momentum, China has extended its vehicle trade-in policy into 2025. As a result, it is expected that around 60% of new car sales in China in 2025 will be electric – a milestone that was originally targeted as 50% for 2035 in the country's 2020 roadmap.

In Europe, despite EVs accounting for one-fifth of total car sales, EV sales declined for the first time in a decade due to the reduction of subsidies, especially in Germany. Germany experienced a sharp drop in EV sales following the removal of purchasing incentives in late 2023. France also progressively reduced grants in 2024, with plans to lower them further in 2025.

Clean transport investment, which includes EVs, and rail electrification, is estimated to reach USD 35 billion by 2025 in emerging market and developing economies (outside China). By comparison, oil subsidies for the transport sector in these regions have averaged more than USD 110 billion annually over the past decade.

In 2024 United Kingdom advanced as Europe's largest EV market with a sales increase of around 20%. While many European countries continue to offer incentives for EVs, their terms vary widely. For instance, changes to company car taxes in Belgium significantly boosted EV sales, which nearly tripled in 2024 – the largest increase in any EU member state over the past two years. The European Commission plans to encourage member states to overhaul their tax regimes to incentivise companies to prioritise purchasing EVs, with the aim of electrifying the transport sector, further boosting EV adoption and enhancing the competitiveness of European car manufacturers.

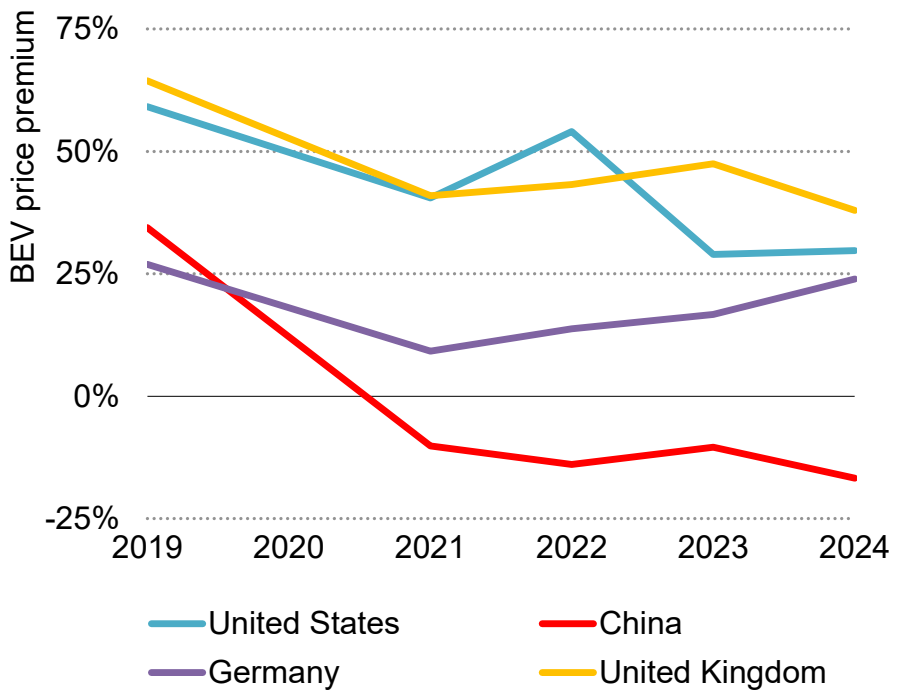
In the United States 1.6 million EVs were sold in 2024, accounting for 10% of total car sales. While EV sales nearly tripled compared with 2021 levels, growth rates have begun to moderate. Year-on-year increases were 56% in 2022 and 42% in 2023; EV sales grew by only about 11% in 2024. This slowdown can be attributed to higher interest rates, which have made financing more expensive, and the limited availability of affordable EV models.

EV sales in emerging market and developing economies (excluding China) quadrupled in 2024 compared with 2022, but sales in these markets still account for a small share of the global EV market.

In Latin America EV registrations more than doubled year-on-year in 2024, with almost two-thirds concentrated in Brazil, where affordable Chinese EV imports boosted sales. In India EV registrations exceeded 90 000 units in 2024 – almost double the number recorded in 2022. This surge has been driven by government incentives such as the FAME II scheme, the PM E-Drive initiative and additional subsidies offered through state-level policies.

Affordability remains a key factor in EV adoption. In China small and affordable models have made electric cars cheaper than conventional vehicles, fuelling mass-market uptake. In contrast, EVs remain around 40% more expensive than conventional cars in the United Kingdom and about 30% higher in the United States; however, this price gap is gradually narrowing. The limited availability of affordable models remains a challenge in the United States. In 2024 only two battery electric vehicles (BEV) models were priced below USD 30 000, compared with more than 50 ICE models in the same price range. As the cost gap continues to close, more affordable options become available, and the second-hand market expands, EV adoption is expected to accelerate significantly across all markets, particularly among middle-income buyers.

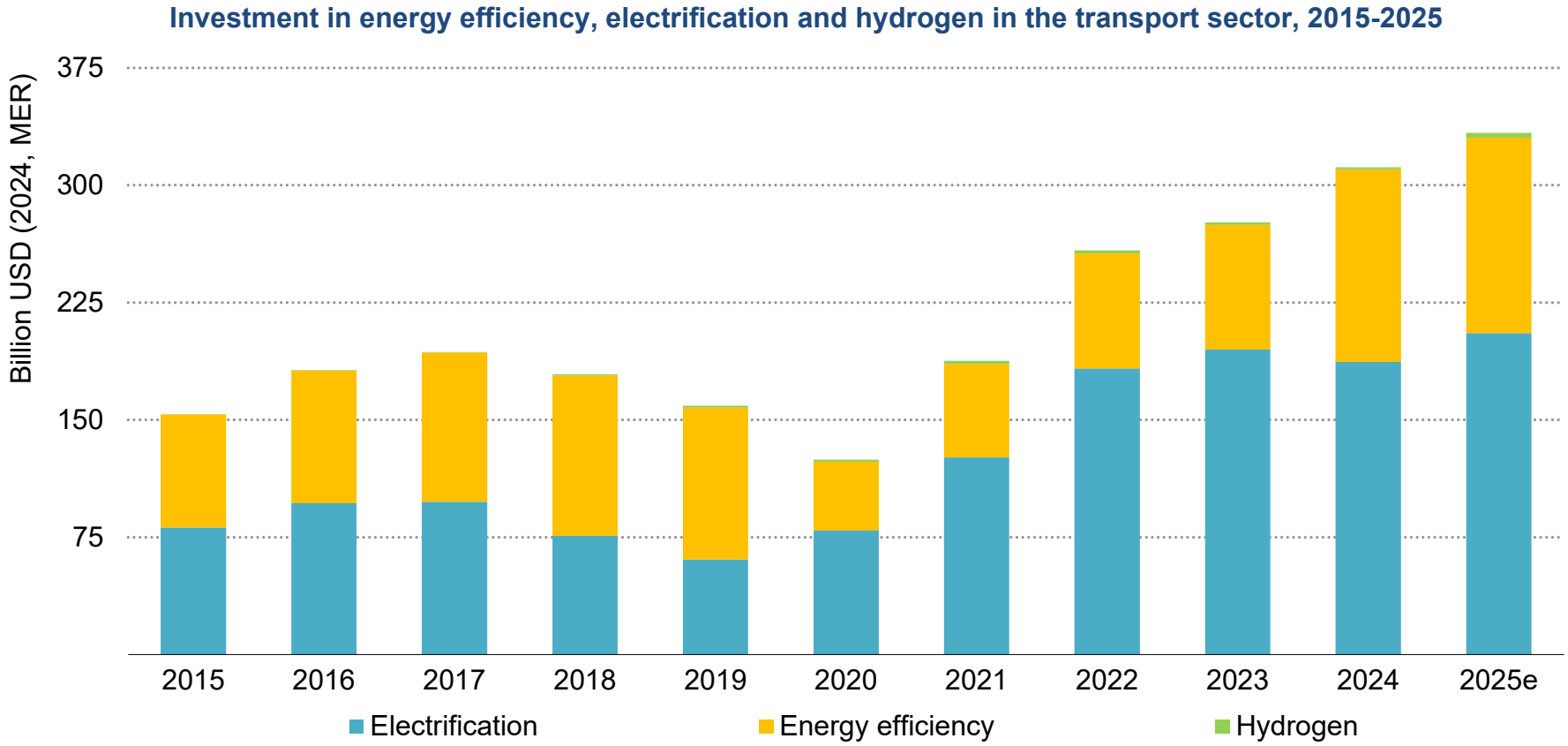
Premium of BEVs over ICE vehicles, 2019-2024



Notes: BEV = battery electric vehicle; ICE = internal combustion engine. 2020 values are average of 2019 and 2021.

Source: IEA analysis based on data from S&P Global Mobility.

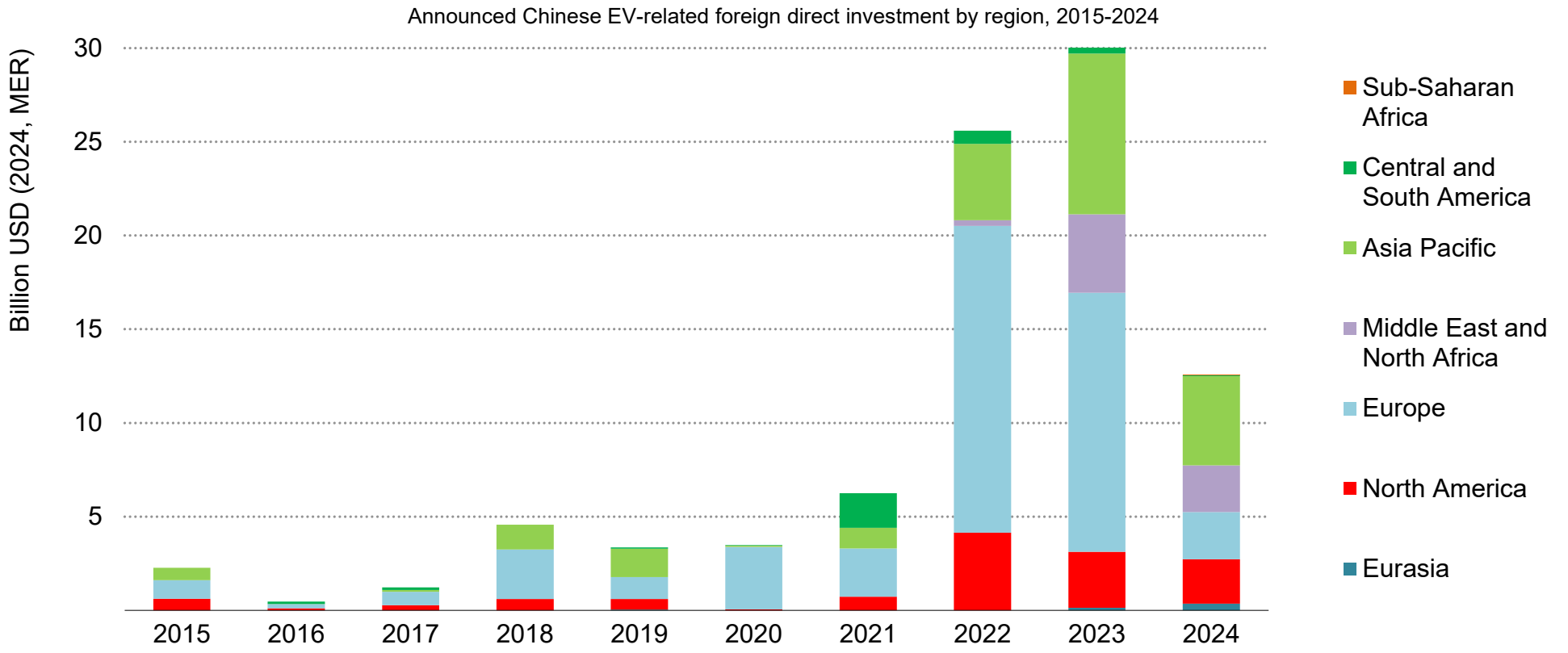
Electrification dominates transport investment and is driving its rapid growth



Although investment in energy efficiency has steadily increased, electrification has seen significantly faster growth, capturing a progressively larger share of total transport investment, especially from 2020 onward.

Notes: Hydrogen spending in the transport sector is low and not clearly visible on the figure; it is included for completeness. 2025e = estimated values for 2025.

Chinese companies are shifting from an export-led EV strategy towards opening overseas factories to mitigate political pushback and secure market access



Chinese EV-related foreign direct investment reached a record high of USD 30 billion in 2023. In recent years, the focus of investment has shifted away from North America towards Europe, Asia, the Middle East and North Africa.

Notes: EV-related investment includes the assembly and manufacturing of EVs (downstream), as well as battery and battery material manufacturing (midstream). Major transactions include investments above USD 5 million only.

Source: IEA analysis based on Rhodium Group (2025), China Cross-Border Monitor.

Global transport investment is set to hit a record in 2025 at around USD 330 billion, with electrification in the lead

Global transport investment has more than doubled in the past decade and is projected to exceed USD 330 billion in 2025. The main driver of this growth is the electrification of transport, particularly EVs, which account around USD 175 billion, followed by rail electrification at almost USD 35 billion. Globally, around 60% of all investment is directed toward electrification, with regional variations: China and Europe attribute almost all their transport-sector investment to electrification, and North America over 75%. Electrification brings inherent improvements in efficiency, but other technical improvements in energy efficiency also contribute to the investment picture, for example an investment in a more fuel-efficient vehicle. The latter energy efficiency investments in the transport sector primarily involve switching to more energy-efficient vehicles in road and rail, by replacing less efficient models with advanced alternatives that provide the same services while consuming less energy.

Increasing trade barriers and tariff hikes could redirect capital flows within major automotive markets. Companies may strategically reallocate investment to navigate trade barriers and maintain competitiveness in key markets.

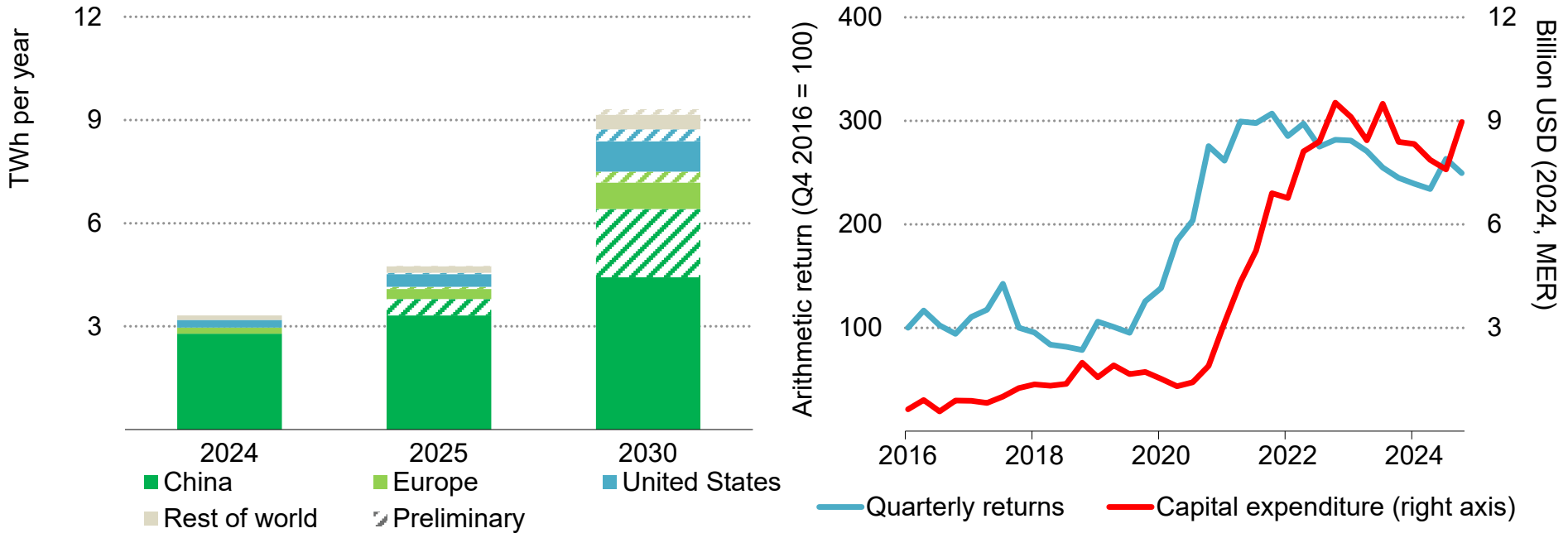
Chinese automakers have already significantly expanded their global manufacturing footprint and announced about USD 80 billion in EV-related foreign direct investment over the past five years with the aim of securing access to markets. Nearly half of this investment is in Europe. More recently, China's focus has shifted to Asia and Latin America, driven by market access strategies and regional incentives. BYD, for instance, has established production facilities in Thailand, Uzbekistan and Indonesia, with plans for Brazil and the Republic of Türkiye (hereafter "Türkiye "). SAIC Motor has invested heavily in Southeast Asia, particularly in Thailand and Indonesia, while also expanding its presence in Mexico with a USD 1 billion EV plant intended to serve the broader Latin American market. A major expansion of battery manufacturing capacity is underway, again led by Chinese firms.

Tariff hikes may also lead to increased car prices and reduced demand, since automotive supply chains are typically global, with vehicle design, component manufacturing and final assembly often occurring in different countries. Such tariff increases may disrupt both manufacturers and their established supply chains, potentially triggering broader ripple effects on global GDP and inflation rates.

Despite shipping's small share of transport investment, new regulations could boost sector investment. In April 2025 the IMO approved draft rules setting a target for achieving net zero emissions by 2050, including a global fuel standard, emissions pricing and support for zero-emission technologies. These rules are set for adoption in October 2025 and implementation from 2027.

Capital expenditure in the battery industry remains high at around USD 9 billion per year, reflecting a focus on long-term capacity building over short-term profitability

Battery manufacturing capacity (right) and financial indicators for listed battery companies (left)



Global battery manufacturing capacity exceeded 3 TWh in 2024, with projections indicating a potential tripling to over 9 TWh over the next five years if all announced projects are completed as planned.

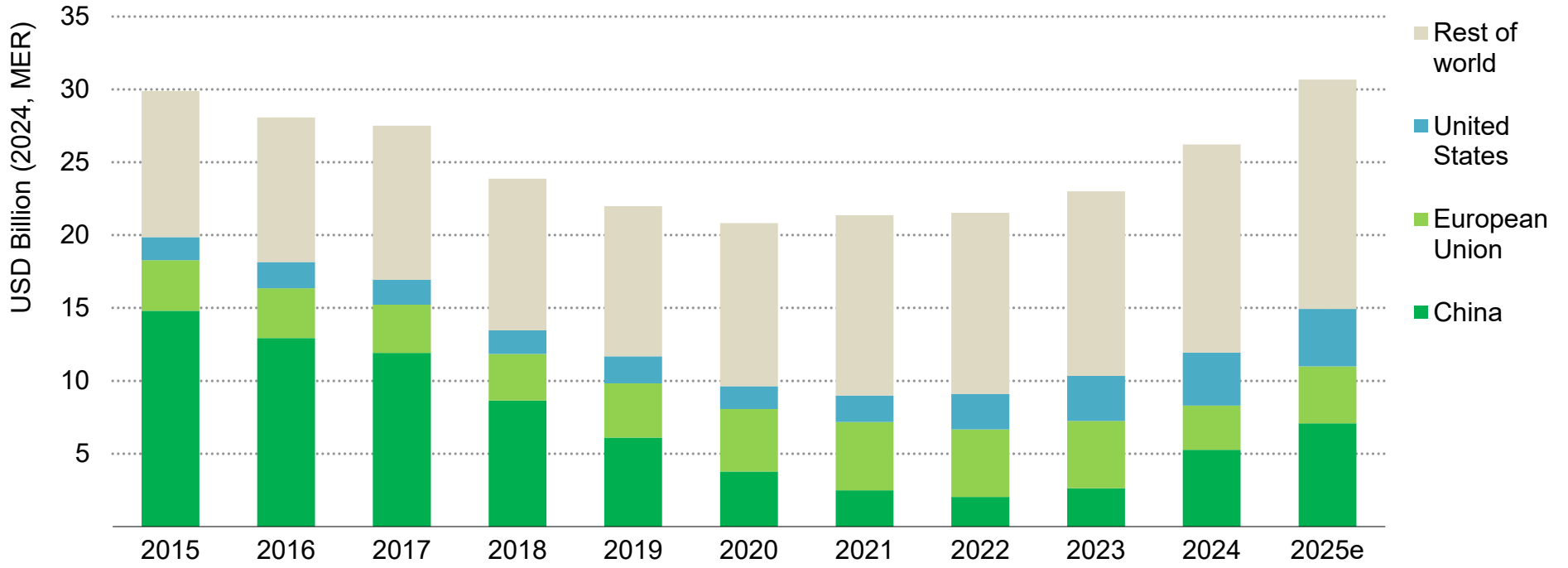
Notes: Quarterly returns based on the total return index of an equal weighted portfolio of listed battery companies. Listed battery companies comprise LG Energy Solution, BYD, Contemporary Amperex Technology, Samsung SDI, Gotion High-tech, Eve Energy and Farasis Energy Gan Zhou. Manufacturing capacity refers to battery cells. 2024 values are based on installed capacity; 2025 and 2030 values are based on installed and committed capacity (full) and preliminary (dashed) manufacturing capacity.

Sources: IEA calculations based on Benchmark Mineral Intelligence; BNEF; Bloomberg Terminal (2025).

Industry

Investment in energy efficiency in the industrial sector rose again in 2024

Investment spending in industrial energy efficiency by regions, 2015-2025



China has rebounded with a threefold increase between 2023 and 2025, the European Union is on track to achieve an unprecedented 30% increase from 2024 to 2025, while the United States maintains steady growth with consistent progress since 2021.

Notes: 2025e = estimated values for 2025

Policy measures in China, technological advances in the United States, and support for reindustrialisation in Europe are driving energy efficiency investment

Following the growth observed in 2024, global investment in industrial energy efficiency is expected to maintain its upward trajectory in 2025. Key drivers of this progress include a weakening of the property market downturn in China and improvements in the country's industrial energy efficiency, strong support for clean industries in Europe, and advances in emerging technologies in the United States, with tariffs taking a backseat to macroeconomic factors.

Energy efficiency investment in China has recovered, reversing the decline seen up to 2022 and building on the modest growth achieved in 2023. In 2024 annual investment reached a notable USD 5 billion, doubling from the previous year. This growth is expected to continue at a robust pace, with investment projected to reach more than USD 7 billion in 2025, representing an average annual growth rate of more than 50% from 2022 to 2025.

A significant factor in this growth is the slight softening of the slump in China's real estate sector, which has historically been a key pillar of the national economy, contributing around one-quarter of the country's GDP. This is because the property market plays a key role in shaping demand for energy-intensive materials such as steel and cement – sectors that are central to industrial activity and often the focus of efficiency upgrades. In recent years, however, the property market has been unfavourable, marked by a severe and prolonged downturn, falling house prices, and declining investment.

Despite persistent headwinds, targeted policy interventions in the property sector have supported a sustained rebound in energy efficiency investment since its 2022 low. Measures such as reduced mortgage rates, increased developer financing and government-backed asset purchases have contributed to a gradual recovery in housing market sentiment. This, combined with some recent signs of stabilisation in the construction activity, although modest, encourage greater utilisation of industrial capacity and provides both the rationale and the capital flow for investing in more efficient production technology.

Similarly, a significant portion of the recent surge in Chinese investment in industrial energy efficiency can also be attributed to ongoing improvements in energy efficiency. In 2024 the National Development and Reform Commission raised its economy-wide energy intensity target, setting a 2.5% reduction in energy consumption per unit of GDP, up from 2% in 2023. This followed the State Council's 2024-2025 Energy Conservation and Carbon Reduction Plan, released in May, which introduced binding targets for the end of 2024, such as a 3.9% reduction in CO_2 emissions per unit of GDP, and a 3.5% reduction in large industrial energy intensity.

Efficiency measures have also been implemented on a sectoral level. For instance, in the cement and building materials sectors, clinker capacity was capped at 1.8 billion tonnes for 2025, and planned

retrofits are expected to deliver savings of 5 Mtce and 13 Mt CO_2. Similarly, under current targets energy savings in the petrochemical and chemical industries could reach 40 Mtce and 110 Mt CO_2.

In the United States, industrial efficiency investment has been consistently rising since 2020, with an average year-on-year increase of 20%. It surged from a little over USD 1 billion in 2020 to nearly USD 4 billion in 2024, positioning the United States as by far the largest investor among advanced economies. The country is also the most advanced innovator and largest market player in industrial software, which is the main driver behind process optimisation - the AI application with the greatest potential to reduce global energy demand. The potential savings are substantial: as digitalization advances, AI-driven process optimisation could deliver around 3 EJ of energy savings by 2035 in energy-intensive sectors, and up to 5.2 EJ in other industries.

A shift in trade policy, including a 50% tariff on steel (as of June 4th), aluminium and related products, has created some uncertainty regarding the US outlook. However, the greater uncertainty for demand in the steel and cement sectors stems from broader economic conditions, such as construction trends and economic growth, rather than tariffs themselves. While tariffs may influence steel prices, the primary driver for demand is the overall economic environment. After 2025 trade barriers could affect manufacturing investment, with financing conditions becoming a critical factor. Cement demand remains largely local, and while trade barriers can affect steel prices, the broader economic outlook will ultimately shape demand more than tariffs alone.

The European Union, conversely, is projected to see a significant rebound in its industrial energy efficiency investment, recovering from a low of USD 3 billion in 2024. Projections for 2025 estimate 30% growth, largely attributed to the European Commission's recent launch of the Clean Industrial Deal, "a business plan to decarbonise, reindustrialise and innovate", which the Commission had already made a first 100-days priority of its mandate back in July last year.

As European industries are said to grapple with "high energy costs and fierce and often unfair global competition", the Clean Industrial Deal aims to increase the competitiveness of energy-intensive industries. To achieve this, the Deal outlines measures to reduce energy costs through accelerated electrification, boost demand for low-carbon products via procurement reforms and carbon labelling, and mobilise over EUR 100 billion for clean manufacturing. It further includes a streamlined State Aid Framework, expanded Innovation Fund, creation of an Industrial Decarbonisation Bank, and InvestEU revisions to unlock up to EUR 50 billion in additional investments, while addressing raw material supply risks and regulatory barriers.

Demand and policy uncertainty is dampening prospects for clean industrial investment in some sectors, notably for steel, although Europe is bucking the overall trend

Projections for the coming years indicate a significant decline in the volume of low-emissions steel capacity expected to come online, with around USD 9 billion worth of projects scheduled to become operational in 2026, a drop of over 60% from the previous year. This points to a substantial preceding underinvestment in these technologies, reversing the upward trend observed until now. This downturn affects all major project types, especially electric arc furnaces (EAFs) and hydrogen-ready direct reduction plants, signalling a sharp reversal from the over USD 160 billion in global commitments made since 2018.

The Asian low-emissions steel market experienced the most dramatic contraction. This decline is primarily driven by reduced commitments to EAF projects in China, and is particularly significant as EAF represent two-thirds of global low-emissions steel. Much of this slowdown can be attributed to the Chinese government decision to suspend approvals for new steel capacity replacements. This policy shift appears aimed at curbing overall capacity expansion, partly in response to mounting international concerns over the oversupply of Chinese exports.

Weaker demand growth, particularly stemming from the construction and automotive industries, filters through to clean industrial investment, particularly in capital-intensive technologies like near-zero-emissions steel. Requiring three to four times more capex than conventional production routes, they present a far less appealing business case than traditional steel production. This becomes particularly true given that profitability in the steel sector has been highly volatile in recent years: both ArcelorMittal and POSCO, for instance, saw average annual EBITDA (earnings before interest, taxes, depreciation, and amortisation) margins decrease by more than 30% over the 2021-2024 period.

In contrast, investment in recycling offers a significantly lower-cost alternative. Recycled aluminium, for example, can require as little as one-tenth of the capital required for primary production, making it an attractive pathway for decarbonisation. However, the potential to scale recycling is fundamentally limited by the availability of secondary materials, a factor closely tied to economic maturity. Emerging market and developing economies, where infrastructure is relatively new and recycling systems less developed, face structural constraints in ramping up recycling rates at the pace seen in more mature economies.

Evolving market conditions and policy uncertainty have presented significant challenges for the sector in the United States, where SSAB decided to withdraw from negotiations for a USD 500 million near-zero-emissions steel award. This initiative was part of a USD 6 billion federal funding package announced in 2024 under the Industrial

Demonstrations Program, aimed at accelerating the decarbonisation of hard-to-abate sectors. However, the long-term outlook for this funding remains uncertain.

Europe stands out as a key exception to the global decline in clean industrial investment, particularly in the steel decarbonisation sector. While global investment in hydrogen-based steelmaking dropped nearly threefold in 2024, Europe continues to dominate, accounting for more than 70% of new investment in this area. Overall, Europe invested nearly USD 15 billion in clean industrial technologies in 2024, with 80% of this funding directed towards steel decarbonisation projects.

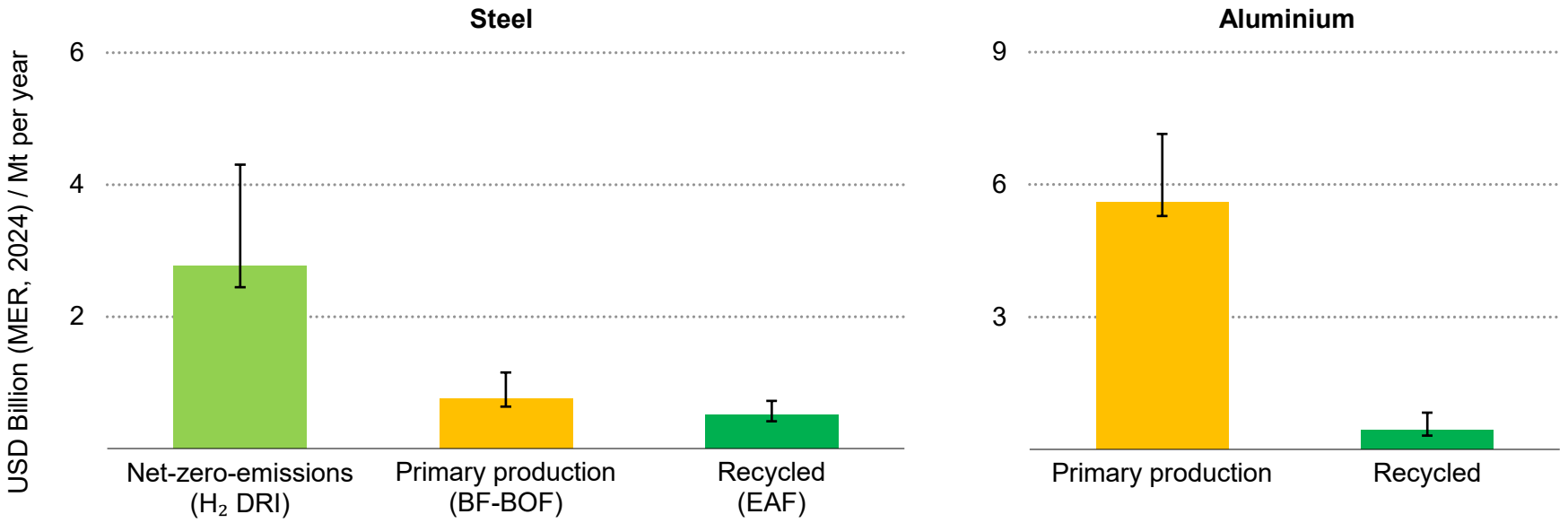
However, while Europe's investment in low-emissions steel remains significant, these technologies - especially hydrogen-based steel production - are still in their early stages and are expensive to implement. To accelerate adoption and make these technologies more viable, the European Union has implemented several supportive measures. For instance, it is tightening carbon pricing and phasing out free allowances by 2026, and additional programmes like carbon contracts for difference (CCfDs) have been introduced to de-risk investment in green technologies.

Looking ahead, the EU Clean Industrial Deal and Action Plan for Affordable Energy are expected to play a central role in supporting investment in low-emissions steel production. Part of this framework, the recently adopted Steel and Metals Action Plan provides more targeted support to address specific challenges facing the sector, including high energy and input costs, carbon leakage risks and limited access to clean technologies. The plan outlines measures such as expanding access to low-cost clean electricity, scaling up hydrogen and recycling capacity, and fostering demand through lead markets for near-zero-emissions steel. These actions aim to reduce cost uncertainties and strengthen the business case for decarbonisation investment. In parallel, the upcoming review of the Carbon Border Adjustment Mechanism (CBAM) may offer further support to domestic producers. Additional measures include reinforced trade defences to address global overcapacity, extended CBAM coverage with anti-circumvention provisions, and new targets to boost circularity and secure access to scrap. A large-scale funding effort – over EUR 100 billion – is also being prepared to support industrial decarbonisation.

A broader look at the sector reveals mixed fortunes across different subsegments. Investment in the circular economy, for instance, was trending downward in 2024. Recycling of plastics accounts for about half of that spending and paper recycling comprises a third, while aluminium recycling stands slightly above 10%. In contrast, clean ammonia projects maintained a robust pace at about USD 3 billion. Bioplastics investment, conversely, shrank dramatically by almost a third, falling to just over USD 1 billion.

Recycled production requires less capex than conventional primary production, while near-zero-emissions primary steel requires significantly more capex

Capex comparison between near-zero-emissions steel (H_2 DRI), conventional primary production (BF-BOF) and 100% recycled steel (EAF); capex comparison between primary aluminium production and recycled aluminium production (post-consumer scrap)



Near-zero-emissions steel continues to face high capital costs, especially due to electrolyser costs (included here), potentially limiting near-term scalability. In contrast, recycled aluminium has a CAPEX less than one-tenth of primary production.

Notes: H_2 DRI = electrolytic hydrogen-based direct reduced iron with electric arc furnace; BF-BOF = blast furnace basic oxygen furnace (based on coal); EAF = electric arc furnace; Estimated capital costs for near-zero-emissions technologies currently under development (prototype, demonstration or early commercialisation) reflect projected costs upon commercialisation. Bars represent the median capex, while error bars indicate the range of costs due to variations in engineering, procurement and construction costs. These error bars also account for uncertainty in the technology. Hydrogen electrolyser costs are included for the H_2 DRI route. All estimates are for greenfield facilities, excluding land costs.

Source: IEA (2024), Energy Technology Perspectives 2024.

Implications

Accelerating energy efficiency and electrification of energy demand, will have major implications for energy security and affordability

Over the past five years, less than a quarter of the growth in spending on clean energy transitions came from efficiency and electrification of energy demand, as countries keep their focus on securing supply in the power and fuel sectors. However, investing in making more efficient use of energy is a crucial lever, available to both importers and exporters of energy, to keep a lid on demand pressures, improve competitiveness and energy security, and limit the environmental impact of energy use.

The continued pace of global EV adoption supported by cross border investment in manufacturing capacity, and the electrification of transport beyond passenger vehicles will have important implications for worldwide oil demand. China illustrates how large-scale transport electrification can lead to substantial reductions in oil import costs. By the end of the decade EVs deployments are set to displace over 5 mb/d of diesel and gasoline globally, and China accounts for half. It turns into an estimated saving of about USD 110 billion per year for the country, assuming a price of USD 60 per barrel.

Investment in energy efficiency in the buildings and industry sectors have fared better than anticipated in recent years, but questions remain about how quickly viable business models can prove their ability to reduce reliance on long-term public subsidies. The example of the slowdown of heat pumps sales, notably in Europe, which have been impacted by the recent reduction of gas prices and the lack of clarity and stability of long-term policy signals, highlights how the immediate return expectations of incumbent technologies can prevail over the decision to invest in longer-term savings. The price premium EVs compared to ICEs has narrowed significantly, due to falling battery prices and the rise of smaller cars, but high upfront costs in other technologies remain a barrier to adoption, especially for EMDEs faced with a higher cost of financing and debt service burdens.

The geopolitical context at the time of writing this report casts uncertainty over how quickly the industrial sector–particularly heavy industries–can transition toward greater electrification and improved energy efficiency. As a cornerstone of global industrial competition, the steel sector faces significant investment demands to decarbonize its production, which may initially be seen as a threat to its international competitiveness.

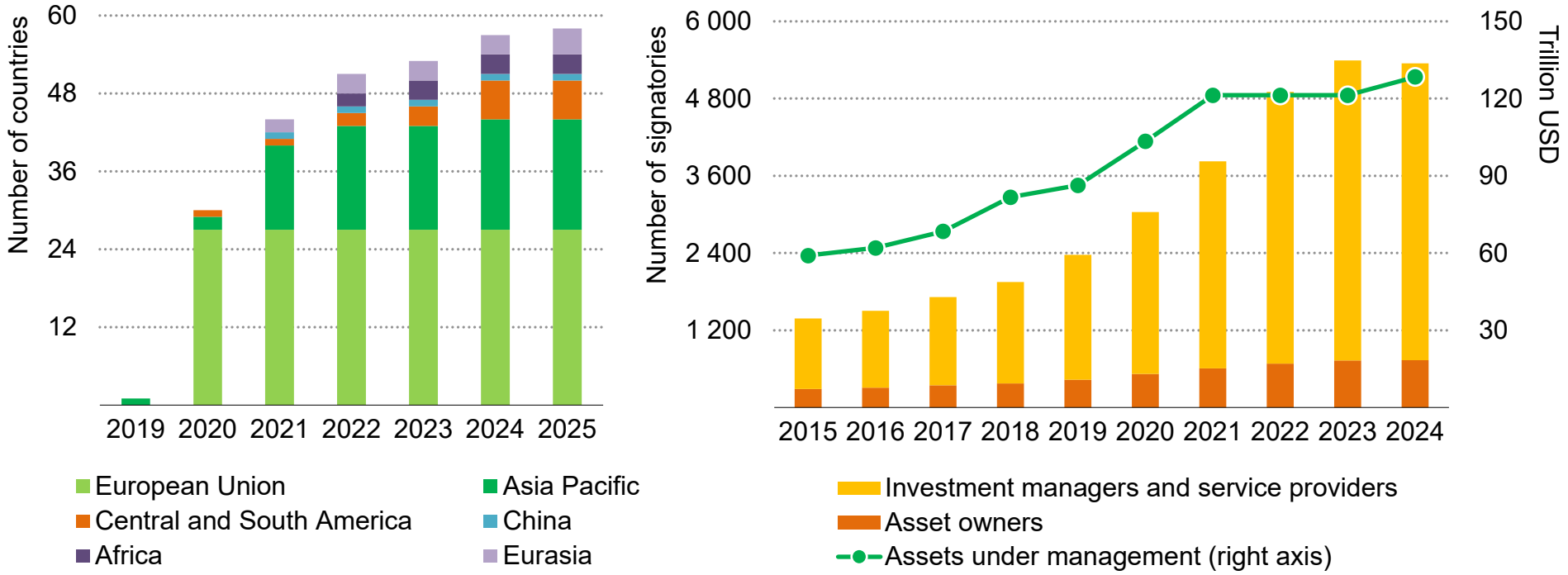
The goals agreed at COP28 included the objective of doubling of the rate of improvement of the world's energy intensity, to reach 4% annually. Last year, achieving this objective required a tripling of annual investment in energy efficiency and electrification by 2030. The increase in spending in 2025 means that the gap is slightly lower today (2.7), but an additional USD 1.3 trillion every year is still needed across the transport, buildings, and industry sectors.

Finance

Overview

The past decade saw the rise of sustainable finance instruments and industry-led initiatives that aligned finance with energy transitions, but they now face strong headwinds

Number of countries with sustainable finance taxonomies (left) and membership of Principles of Responsible Investment (right)



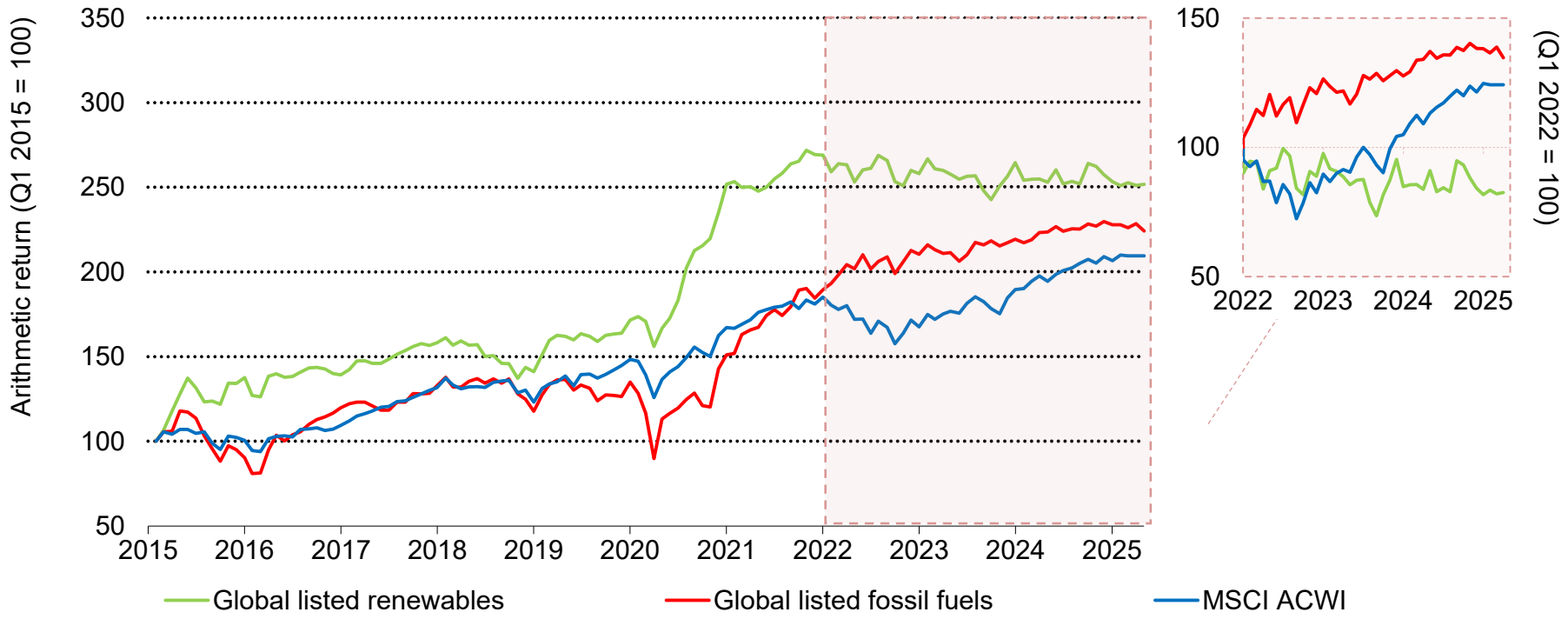
Sustainable finance taxonomies have served as a key regulatory tool to support the growth of green finance, notably green bonds, and to help financial institutions create responsible investment policies and transparent reporting, although much of this remains voluntary.

Notes: PRI = Principles of Responsible Investment. Various state-owned banks and regulatory bodies in China have introduced sustainable finance taxonomies, starting with the Green Bond Endorsed Project Catalogue in 2015. This was updated in 2021, in an effort to consolidate taxonomies.

Sources: IEA analysis based on Sustainable Banking and Finance Network (2024), SBFN Toolkit, Climate Policy in Action (2023), Shaping the Future of Finance, Principles of Responsible Investment (2024), Annual Report.

This boom in sustainable finance practices coincided with a period of strong financial performance for clean energy companies, but this has slowed over the past three years

Monthly returns of energy-related sample portfolios, 2015-2025 (left) and Q1 2022-Q1 2025 (right)



Listed clean energy companies have significantly outperformed both fossil fuel companies and the broader market over the past decade, driven by government support and strong deployment; since 2021, fossil fuel companies have performed better.

Notes: MSCI ACWI = MSCI All Country World Index. The global listed renewables and fossil fuels portfolios are selected based on relevant Bloomberg Industry Classification Standard (BICS) criteria. Within the portfolios, each company is given equal weighting. Further information can be found in IEA and Imperial College London (2021), Clean Energy Investing: Global Comparison of Investment Returns.

Source: IEA analysis based on data from Bloomberg (2025).

Questions over the role of sustainable finance practices and changing market dynamics are creating a more complex financing environment for clean energy projects

Since the mid-2010s there has been increased attention on the role of finance in energy systems – both in terms of financial institutions' contribution to climate change and how policy and regulation can ensure that financing is aligned with energy security and transition priorities. Regulations were created on disclosure of climate-related metrics, integration of environmental, social and governance (ESG) issues into investment decisions, and green or sustainable taxonomies. Such taxonomies – which classify business activities by alignment to sustainability goals – have been introduced in 58 countries, with at least 13 more under development. They often serve as the basis for more complex regulation, as occurred with the European Commission's 2018 Action Plan on sustainable finance.

At the same time, financial industry initiatives such as the Task Force on Climate-Related Financial Disclosures cemented the view that climate change introduces financial risks and investment opportunities. This led to new disclosure guidelines, notably under the International Sustainability Standards Board, and initiatives such as the Glasgow Financial Alliance for Net Zero, which aimed to support financial institutions to align with international and national energy and climate targets. These initiatives have driven net zero target setting: by 2024, 81 asset owners, 264 asset managers and 118 banks had disclosed targets and/or transition plans.

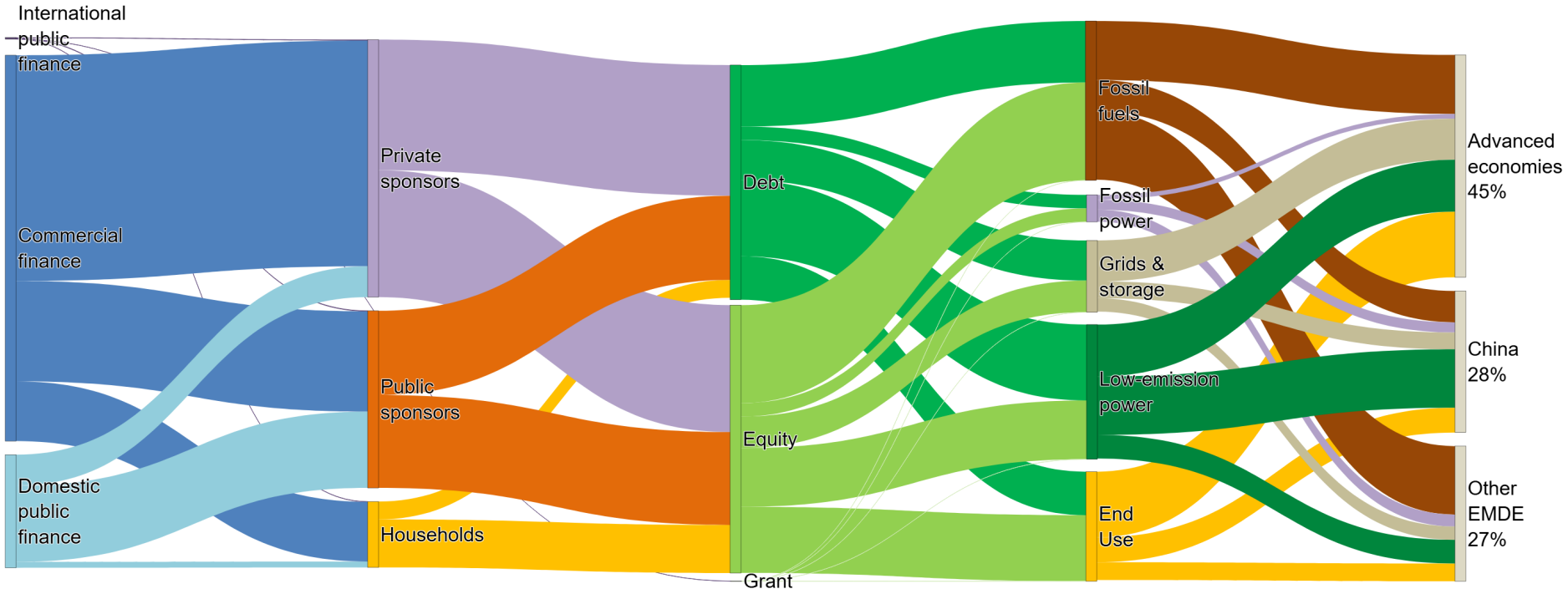
The rise of sustainable finance happened in a low-rate environment, during which time listed renewables companies outperformed the broader market. However, since 2021 the combination of higher interest rates pushing up capital costs, supply chain disruptions after the Covid-19 pandemic, and policy incentive changes has slowed renewables' performance. Simultaneously, corporates, financial institutions and governments began questioning the cost/benefit assumptions that underlie ESG practices. Over the past year financial institutions have faced legal challenges over their membership of net zero or ESG-related initiatives. Meanwhile, concerns over the impact of regulation on productivity have led the European Commission to move forward with plans to streamline key sustainable finance regulations via an Omnibus, which some groups are concerned may result in a watering down of ambitions and transparency.

Most financial institutions have not rowed back on previous climate-related commitments, but evolving regulatory priorities present a degree of uncertainty. Combined with current market dynamics, there is a risk of slower growth in private sector clean energy spending. Equally, international public funds are under pressure, and emerging market and developing economies face record levels of debt. This may worsen the regional disparity in energy spending, threatening both economic development and global energy security needs.

Sources of finance

Most energy investment is supported by commercial finance and made by private sponsors, but the sources of finance vary widely by technology and region

Source, flows and destination of global energy-related investment spending, 2024



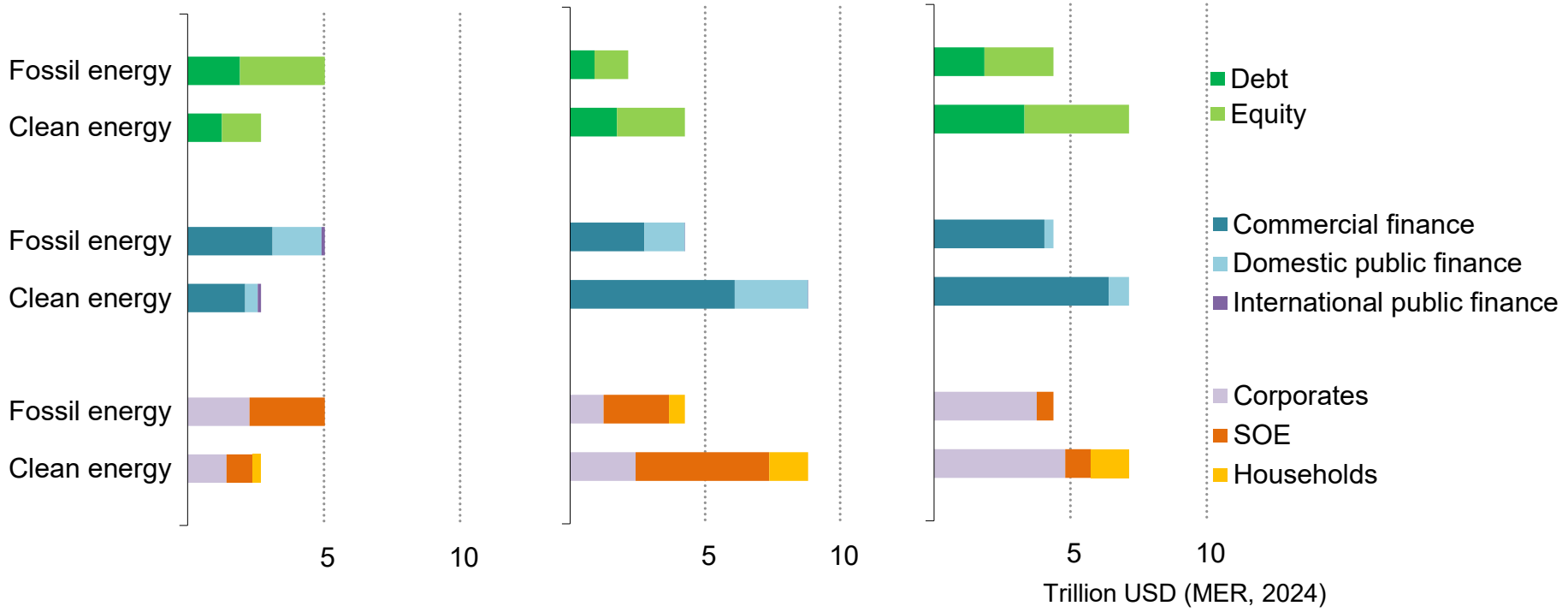
Today, 75% of the available finance for investment in the energy sector is commercial finance, but domestic and international public finance play important roles that vary widely across regions and sectors.

Note: End use outflows do not equal inflows due to energy-related investments into international aviation and shipping, which are not allocated to a given region. EMDE = emerging market and developing economies.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS, AidData (2023) Global Chinese Development Finance Dataset version 3.0.

The energy transition is reshaping who is making investments into the energy system and how these investments are financed

Cumulative historic clean and fossil energy in other EMDE (left), China (middle) and advanced economies (right), 2015-2024



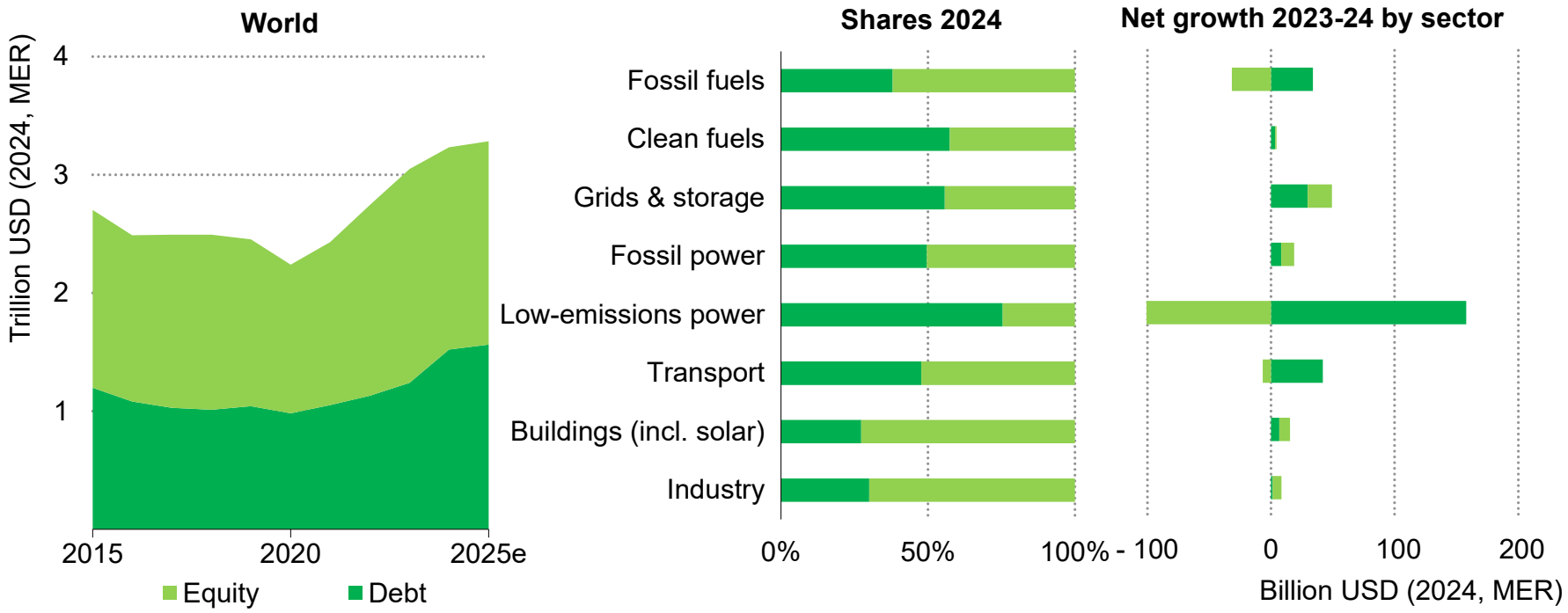
Through purchases such as home solar and battery systems, households are becoming a more important driver of energy investment over time. In general, clean energy also depends more on debt finance than fossil fuels, which typically are financed using more equity.

Notes: SOE = state-owned enterprise. Fossil energy includes fossil fuel supply and unabated fossil power generation.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS, AidData (2023) Global Chinese Development Finance Dataset version 3.0.

More positive debt dynamics emerged in 2024 in response to benchmark rate cuts, creating better conditions for clean energy financing, which is typically sensitive to borrowing costs

Capital structure of energy finance by instrument and sector, 2015-2025



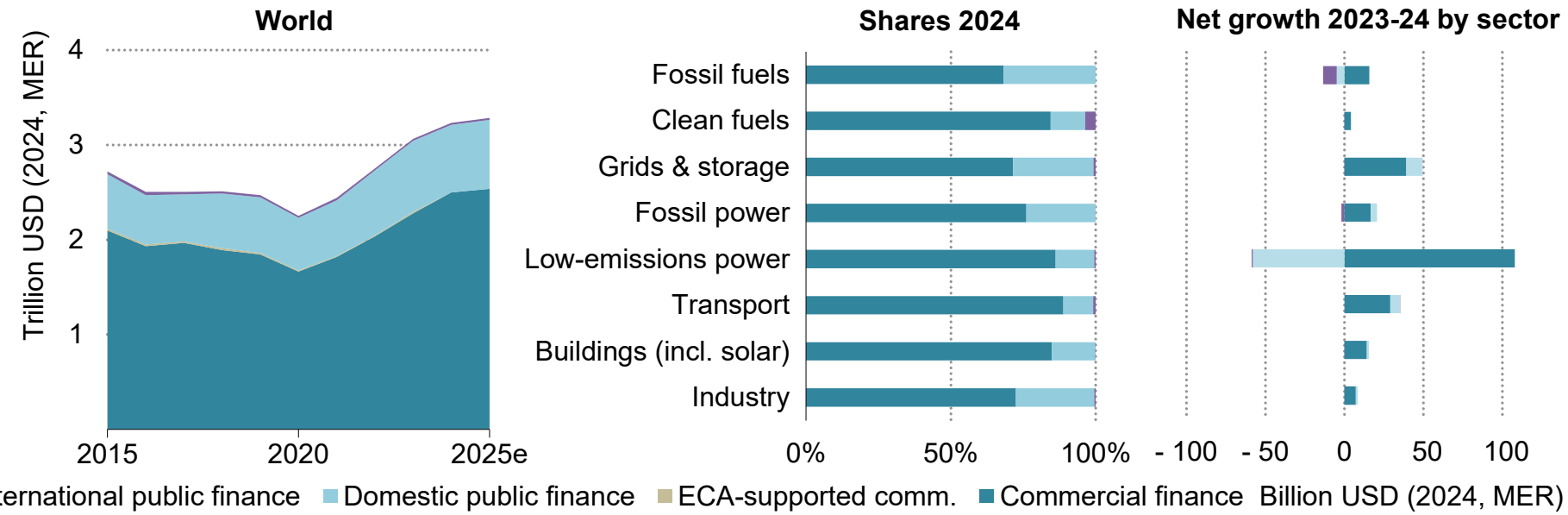
Sectors with high capex and stable cashflows, such as clean power, rely heavily on debt finance and hence benefit from recent rate cuts.

Notes: Building rooftop solar here is grouped with buildings to clearly demarcate differing trends for utility-scale solar and distributed solar. Elsewhere throughout this report, rooftop solar is included in the power sector, not end use. Debt includes both bond issuances and loans for private enterprises, state-owned enterprises (SOEs) and households. Equity includes equity investments made by private enterprises, SOEs, development finance institutions (DFIs) and households, as well as state subsidies and tax incentives, and finance from export credit agencies and central banks. MER = market exchange rates; 2025e = estimated values for 2025.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS, AidData (2023) Global Chinese Development Finance Dataset version 3.0.

Energy investments are primarily financed from commercial sources today, but public finance is a key enabling factor and continued to grow in 2024 except for clean power and fossil fuels

Sources of energy finance by actor and sector, 2015-2025



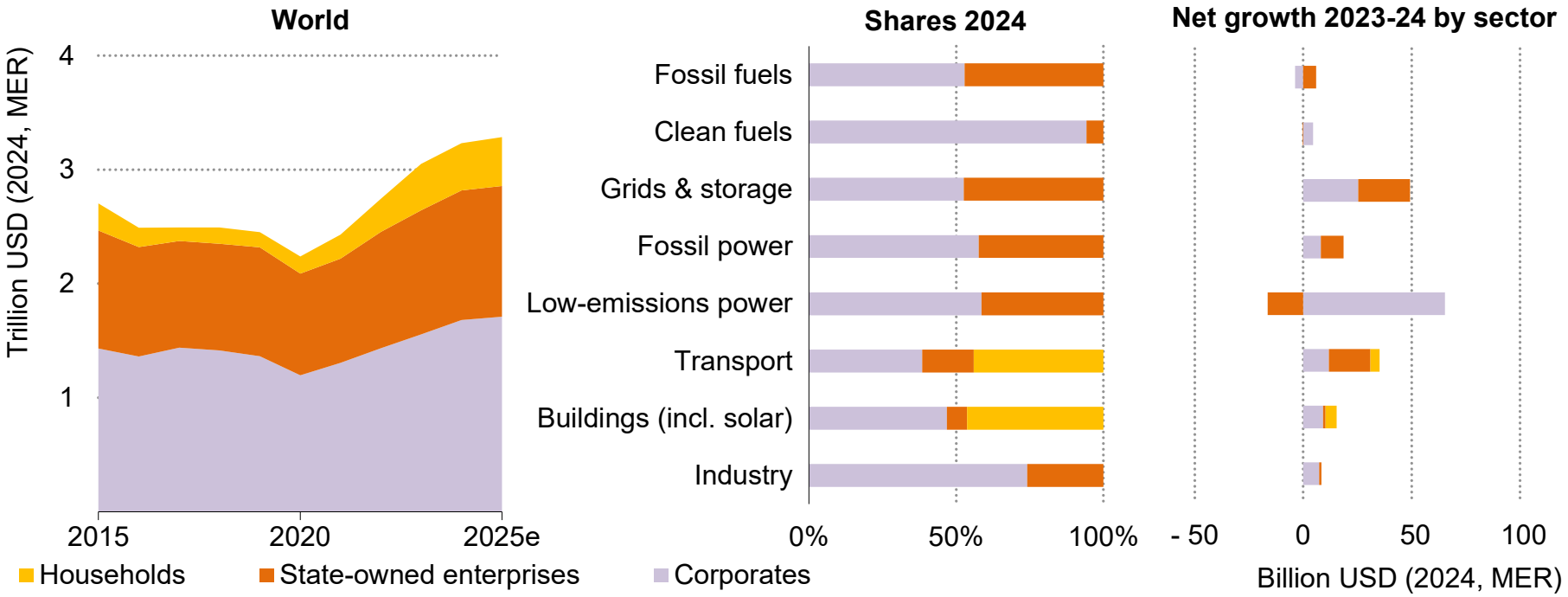
Subsidies and tax credits have catalysed commercial finance for clean power generation. However, domestic public finance to the sector declined from its 2022 highs of USD 142 billion to USD 83 billion in 2024 as governments withdrew support for mature technologies.

Notes: "Commercial finance" includes equity investments made by private enterprises and households (inclusive of self-financing) and debt from financial institutions, and in some cases from state-owned banks. "ECA-supported comm." refers to the portion of commercial finance mobilised by export credit agency (ECA) guarantees and insurance. ECA-supported commercial finance is only available to 2023 and shown in the World figure on the left, otherwise it is included under commercial finance. "Domestic public finance" includes public equity in corporations and SOEs, subsidies, tax incentives and finance from central banks. "International public finance" includes development finance institutions (DFIs), multilateral climate funds (MCFs), government donors, philanthropies and some official export credits directed to emerging market and developing economies offered under the OECD arrangement.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS and Export Credit Group, AidData (2023) Global Chinese Development Finance Dataset version 3.0.

Households spent more on EVs and higher material costs pushed up household energy efficiency investment; meanwhile fossil investment by state-owned enterprises grew in 2024

Sources of energy investment by actor and sector, 2015-2025



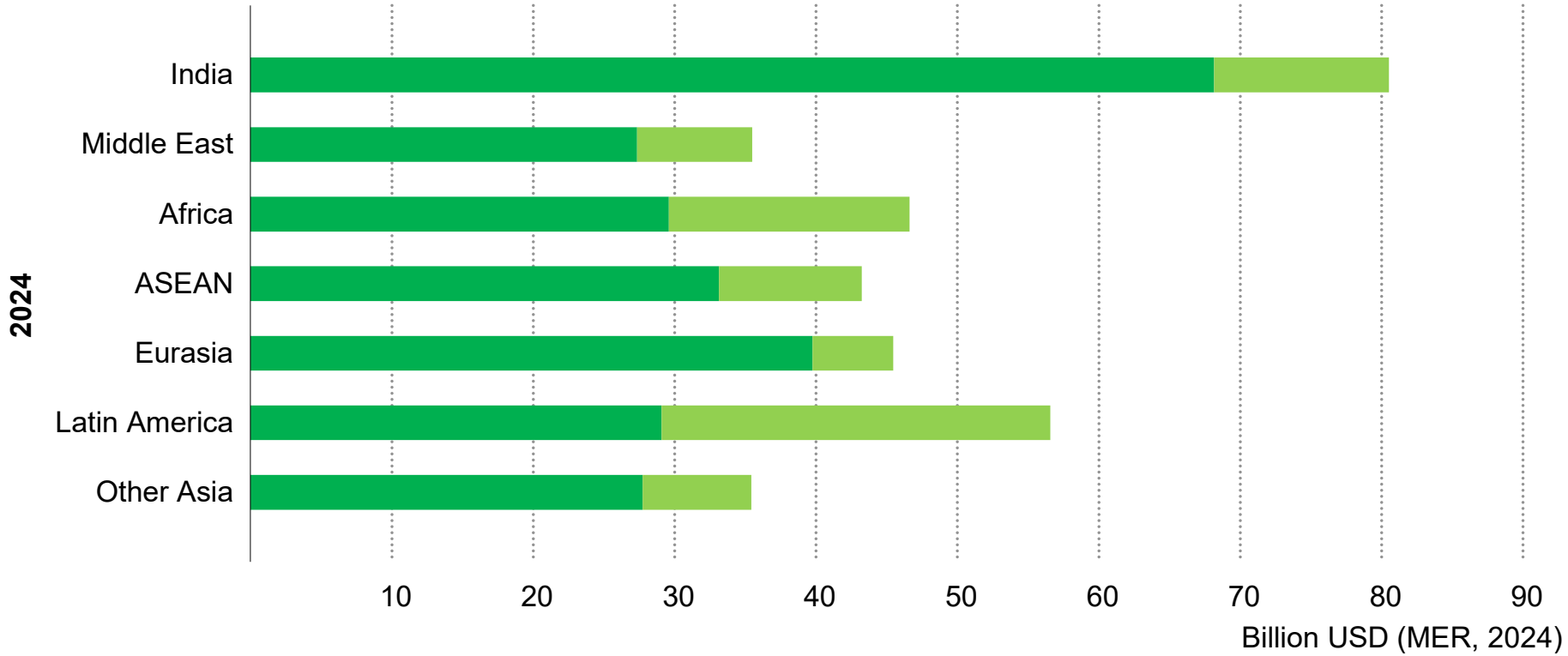
EV investment in China and other EMDEs increased by a respective 7% and 67% in 2024 vs -4% in advanced economies. At the same time, fossil fuel investment by state-owned enterprises also increased from 2023, notably in the Middle East, China and India.

Notes: Building rooftop solar here is grouped with buildings to clearly demarcate differing trends for utility-scale solar and distributed solar. Elsewhere throughout this report, rooftop solar is included in the power sector, not end use. “State-owned enterprises” refers to companies and assets (in the case of buildings, for example) owned by the state. “Corporates” refer to private and publicly listed companies. 2025e = estimated values for 2025.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS, AidData (2023) Global Chinese Development Finance Dataset version 3.0.

While capital markets are growing in EMDE other than China, a widening financing gap means that substantial mobilisation of international capital is required

Domestic and international share of energy-related investment spending in EMDE other than China, 2024



Expanding investment in emerging and developing economies in ways that fully meet their goals will require an expansion of international capital flows, as well as deeper domestic capital markets

Notes: EMDE = emerging market and developing economies; ASEAN = Association of Southeast Asian Nations; MER = market exchange rates.
Sources: : IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS

Debt finance for clean energy is growing, and rate cuts provide welcome relief for EMDE…

Access to long-term and affordable debt is essential for energy transitions given the high upfront costs that are typical for clean energy projects like renewables. Persistent inflationary pressures and high interest rates generally act as an impediment to clean energy finance. Yet recent years have shown the resiliency of clean energy finance, which has continued to grow despite this challenging environment. In 2024, for example, 80% of total investment into utility-scale solar and wind was met through debt financing, compared to 56% in 2015. This trend is visible in EMDE as well, for example, developing Asia and Latin America have both seen a rise in the use of debt financing for utility-scale renewables.

That clean energy projects remained bankable under more difficult conditions for borrowing underscores the effectiveness of public support measures, such as feed-in tariffs and subsidies, and the rapidly growing market for corporate power purchase agreements, all of which have provided developers with predictable and attractive cashflows to offset rising borrowing costs. At the same time, the growing track record of mature technologies has built up investor confidence and experience in structuring renewables financing, also leading to the proliferation of green financial instruments.

The rising share of debt finance should be acknowledged as a welcome development for EMDE given the comparatively lower cost of debt. Notably, project finance (i.e. off balance sheet) has been a driver of debt finance since 2015, particularly in large parts of Africa and Latin America, where these transactions account for 70-80% of financing for solar today. These projects are often structured as special purpose vehicles where leverage is spread between multiple sponsors and financiers, demanding a higher premium as investors have less ability to recoup debt if the project underperforms or defaults and projects are more time- and resource-intensive to execute. As such, concessional finance is often used to improve risk-adjusted returns on these projects in EMDE, and hence new energy investment has leant heavily on DFIs in regions such as Africa, where over one-third of energy projects in 2024 involved DFIs.

Mobilising international finance for EMDE is essential in the years ahead, but developing domestic capital markets is also crucial in EMDE where borrowing is often conducted in foreign currency. 2024 shows encouraging signs in this respect. Having stabilised in 2023, the outlook for sovereign credit ratings significantly improved in 2024 on the back of interest rate cuts, economic reforms, and reduced fiscal and external imbalances. This is especially the case for Africa where credit upgrades for private financial entities should ease borrowing constraints beyond SOEs. Our assessment of EMDE other than China supports this hypothesis: in 2024 clean energy project finance increased by 46% to USD 37 billion and, crucially, domestic finance was the largest driver in many regions.

…however, the rapidly growing finance gap points to a larger role for international sources

Clean energy investment is a multi-trillion-dollar opportunity to foster technological innovation, create new jobs and meet governments' commitments to achieving a clean, affordable and secure energy transition. Although annual clean energy investment has grown from USD 1.2 trillion in 2015 to USD 2 trillion in 2024, EMDE other than the People's Republic of China (herafter "China") have captured less than 10% of this growth and hence their share of global investment has gradually declined over this period.

To meet their energy needs, EMDE other than China need to access larger volumes of finance at more affordable rates, requiring targeted actions to reduce real and perceived risks. Capital also needs to be mobilised from the private sector, particularly international sources, as public and domestic financiers alone are unlikely to be able to meet future needs. Depending on the level of ambition, energy-related financing requirements could rise by as much as 6% of annual GDP in EMDE other than China by 2035, a scale which even well-developed domestic capital markets would struggle to meet. Domestic capital market development in EMDE other than China has been limited and their growth faces a number of challenges (e.g. insufficient regulatory frameworks) that mean the role of international finance is projected to grow over the next decade.

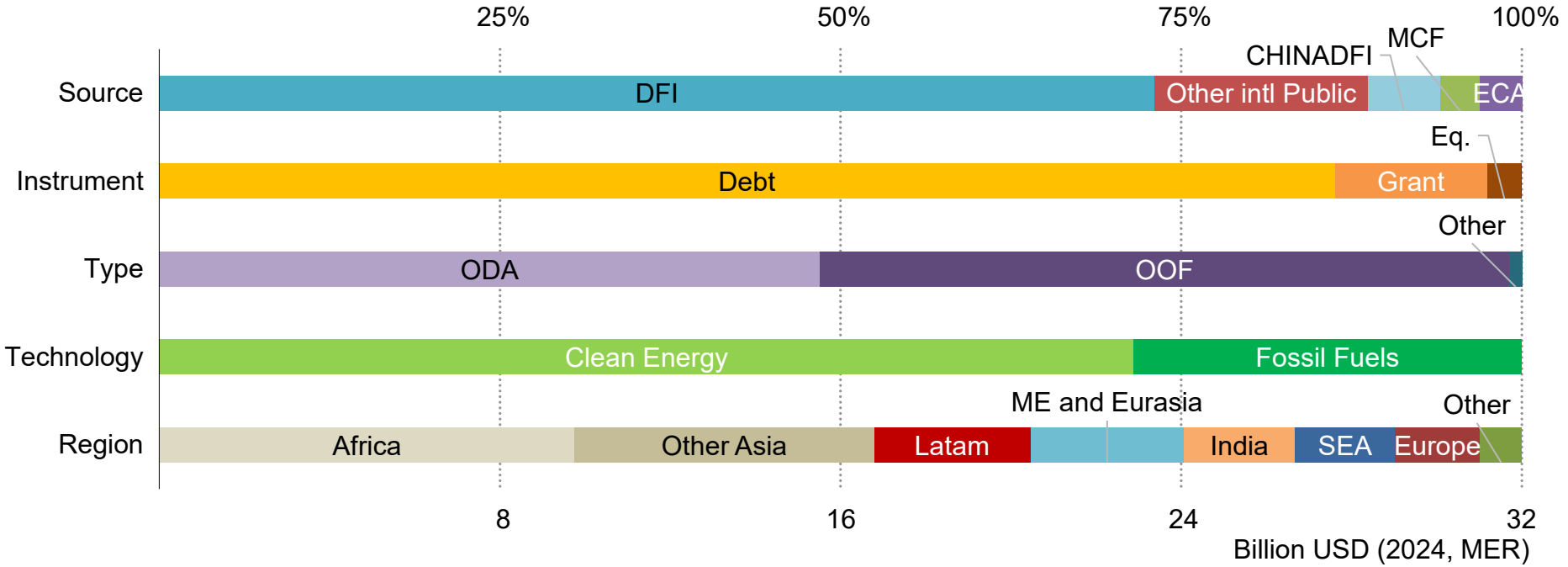
Macroeconomic and currency risks are a principal barrier for international investors, holding back investment flows and contributing to the cost of capital being typically two to three times more expensive in EMDE other than China than in developed countries. Increasing geopolitical tensions, limited project pipelines and prudential financial regulations also hold back international financial flows into EMDE other than China, which only made up 26% of global energy investment in 2024. Nascent capital market development, often-high interest rates and an emphasis on short-term bank lending mean that domestic financing can also be costly. Co-ordinated interventions to develop local capital markets alongside international support, including through guarantees and concessional loans, are key to mobilising finance, with USD 115 billion of concessional finance needed annually by the early 2030s.

The "financing gap" between actual and required energy-related investment is set to increase rapidly, due to rising investment requirements and limited capital market development. At a regional level, international finance plays the largest role in Africa and Latin America. To meet the rising energy-related investment needs in EMDE other than China, the barriers to the mobilisation of international capital discussed above need to be addressed. Targeted policy interventions are needed that not only build a pipeline of projects that meet the risk-return profiles of international investors, but also ensure affordable capital for project developers while shielding them from currency risks.

International public finance

International public financiers are crucial sources of debt and grant financing for EMDE

Breakdown of different sources of international public finance by instrument, type, technology and region, average 2022-2024



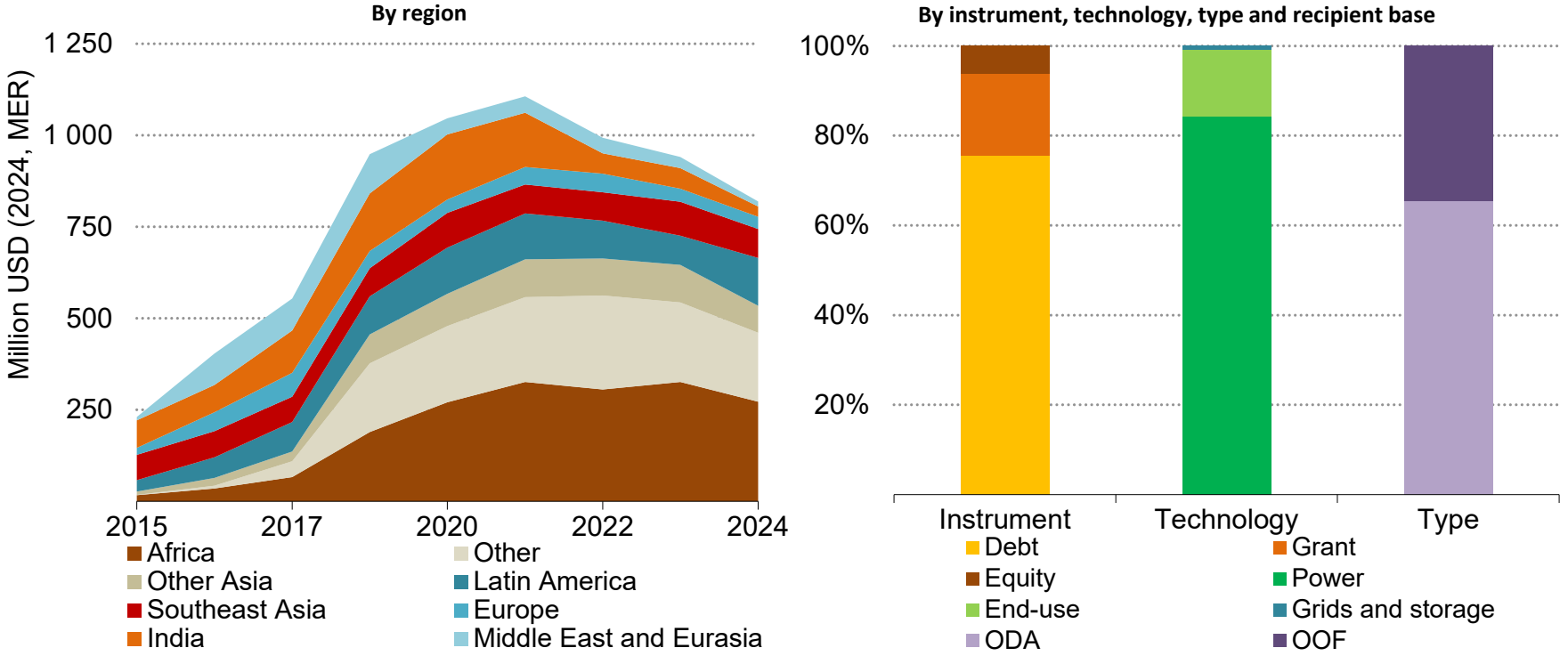
International public financiers provide over USD 32 billion of financing annually, comprising over 7% of clean energy investment in EMDE other than China. These sources of finance are important for regions lacking access to private capital.

Notes: DFI = development finance institutions, excluding China-based DFIs; Other intl Public = government donors and philanthropies; CHINADFI = China Development Bank and the Export-Import Bank of China; MCF= multilateral climate funds; ECA = export credit agencies; Eq. = equity; ODA = official development assistance; OOF = other official flows that do not meet ODA criteria, excluding export credits; Other Asia = Asia other than SEA; Latam = Latin America; SEA = Southeast Asia; ME = Middle East; Other = other projects with no specified recipient region or bilateral support without regional detail. Annual financing was calculated using commitments. Only the portion of ECA financing directed to EMDE via official export credits is captured in this figure. ECA data cover the latest available three years (2021-2023).

Sources: IEA analysis based on OECD (2025), CRS, AidData (2023), Global Chinese Development Finance Dataset, Version 3.0, OECD Export Credit Group.

Multilateral climate funds, while small in size, have huge potential to mobilise finance at scale

Breakdown of MCF yearly financing by region (left) and by instrument, technology and type on average (right), 2015-2024



Highly concessional financing from MCFs plays a critical role in de-risking investments in clean energy across EMDE, but increases in both scale and efficiency to support the ramp up in spending by 2035

Notes: Annual financing was calculated using commitments. MCF = multilateral climate fund; Other = projects with no specified recipient region or bilateral support without regional detail; ODA = official development assistance; OOF = other official flows (excluding export credits). Financing excludes some funding for private sector projects due to data availability issues. MCFs analysed are the Adaptation Fund, Climate Investment Funds (CIF), Green Climate Fund (GCF) and Global Environment Facility (GEF).

Source: IEA analysis based on OECD (2025), CRS.

Different types of international public financiers have distinct roles

International public finance as defined in this report covers funding from development finance institutions (DFIs), multilateral climate funds (MCFs), government donors and philanthropies. Export credit agencies (ECAs) are also covered, although they have a different financing approach. These financiers play a critical role, particularly in higher-risk regions and nascent technologies. By offering concessional loans, grants and specialised instruments, such as risk pooling solutions and first-loss guarantees, they help bridge gaps in commercial financing and accelerate progress on clean energy transitions and energy security and climate goals.

Development finance institutions

DFIs globally are the largest providers of international public finance for energy, having provided around USD 43 billion annually between 2015 and 2024, with nearly 80% directed to clean energy through debt and grant instruments. As both development-driven institutions and financially sustainable lenders, DFIs make concessional and return-generating investments, allowing them to continuously reinvest in new projects and scale their impact over time. In 2023 commitments by DFIs outside China reached USD 33 billion – the highest level since the decline seen in 2017 – suggesting renewed momentum in international public financing. However, whether this trend continues into 2024 and beyond remains uncertain, given political shifts and fiscal constraints that have led to significant aid cuts from major donors such as the United States, the United Kingdom and the Netherlands. At the same time, fossil fuels, especially in upstream oil and gas and retail gas distribution, still accounted for 27% of DFI energy-related commitments in 2023, underscoring the role of these sources in EMDE energy systems.

Meanwhile, Chinese DFIs have sharply reduced overseas financing, making up less than 8% of international public finance from 2022 to 2024 – a stark decline from 2016-2018, when their commitments far exceeded those of all other DFIs combined. Chinese DFIs' project sizes have shrunk: the average commitment per project was around USD 525 million in 2016, while recently announced projects in 2022 and 2023 are less than USD 250 million overall. However, there has been a shift in the types of projects supported. In 2021 over 70% of Chinese DFI commitments went towards oil and gas projects; more recent trends show a pivot to renewables and grids.

Multilateral climate funds

MCFs, while accounting for only a fraction of total international public finance, provide highly concessional funds to EMDE to support climate goals. Playing a complementary role to DFIs, they deploy a greater share of grants and loans at more favourable terms, with a governance structure that ensures equal representation from EMDE, supporting country ownership.

Of the four MCFs' financing of USD 7.8 billion between 2015 and 2024, nearly 70% was provided as official development assistance

on concessional terms, well above the average for international public financiers. The majority of the financing was concentrated in Asia and Africa, accounting for 32% and 25% respectively, followed by Latin America at 12%. In terms of technology, the overwhelming majority went to clean power, followed by end use, demonstrating a firm commitment to align their financing flows with climate goals.

MCFs provided an average of USD 780 million in financing per year between 2015 and 2024. However, spending peaked in 2021, declining 26% by 2024. This sharp drop raises questions about future MCF financing, especially in light of the United States' decision to revoke a USD 4 billion pledge to the Green Climate Fund. Amid uncertainties, MCFs are exploring innovative mechanisms to raise further capital. In January 2025 the Climate Investment Funds' Capital Markets Mechanism, listed on the London Stock Exchange, announced that its inaugural bond raised USD 500 million. This marked the first time an MCF was able to leverage capital markets, bringing in private funds to combine with their own resources.

Another positive sign is efficiency improvements MCF project approvals and disbursements, reflecting their maturity and increasing prominence in the international public finance landscape. Continued enhancements and transparent monitoring, reporting and verification can help increase confidence in the work of MCFs and help attract both public and private finance, while also scaling MCFs' impact.

Other international public finance

Traditional donors' contributions through government institutions and philanthropies can also be key providers of highly concessional funding. OECD donor governments provide an additional USD 3 billion directly to EMDE recipients in addition to their contributions through multilateral or bilateral agencies. Crucially, over 97% of public donor financing is provided as official development assistance for clean energy technologies, primarily as grants and concessional loans, emphasising government donors' primary focus on development rather than financial returns. While philanthropies represent a small share of overall financing, they also do not have to emphasise returns, making them able to fund high-risk projects, such as demonstration projects and innovative new technologies.

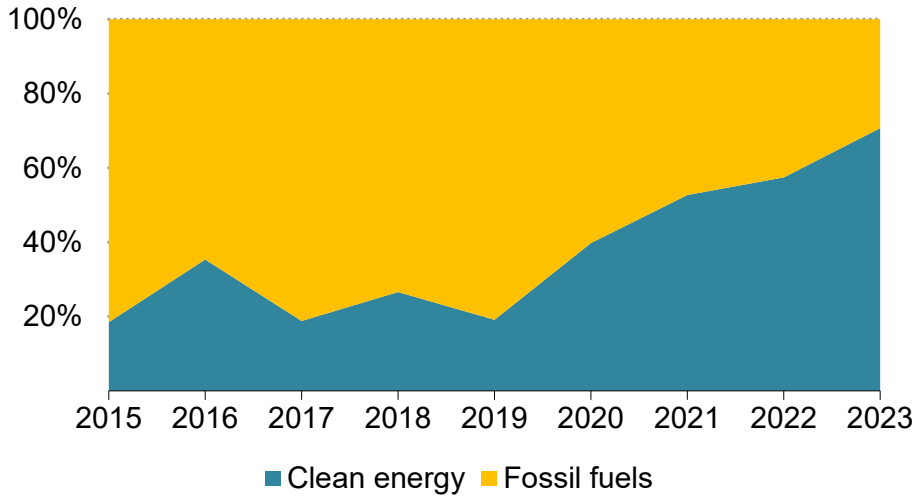
Chinese public institutions have provided an average of USD 11 billion annually towards energy in the past decade, predominantly for fossil fuel projects, unlike Chinese DFIs, which were more balanced across technologies. However, the share of clean energy has been increasing since 2020, reflecting China's pivot toward smaller projects focused on fostering local economic benefits, particularly in sectors like electric vehicles and the digital economy. It also marks a broader transition in China's overseas financing, with large-scale infrastructure lending by DFIs giving way to a more commercially driven approach led by state-owned commercial banks and facilitating the entry of private enterprises in the global market, especially in EMDE through the Belt and Road Initiative.

Export credit agencies are expanding into clean energy while maintaining a structurally distinct, trade-driven role

Export credit agencies (ECAs) play a unique role in enabling cross-border energy investment by providing guarantees, insurance, direct credit and interest rate support. While guarantees, which are crucial for de-risking and mobilising private capital, represent less than 1% of the financing from all international public financiers combined, 84% of ECA financing for energy projects includes this element.

Unlike other facets of international public finance, ECAs are sector and market agnostic – their primary target is supporting the exports of domestic businesses. While energy makes up a relatively small share of ECA activities, between 2014 and 2023 it still accounted for nearly USD 18 billion of commitments for fuel supply and power generation per year under the OECD's Arrangement on Export Credits. ECAs have seen a shift in priorities, with clean energy now surpassing fossil fuels in the share of financing. This change was accelerated by the OECD Export Credit Group's 2021 decision to cease support for unabated coal and the 2023 agreement for more flexible terms for clean energy under the Climate Change Sector Understanding. Wind energy has become the largest recipient of support over the past decade, although fossil fuel projects, especially in upstream and midstream oil and gas, continue to receive backing. In addition to the OECD's actions, the Net Zero Export Credit Agency Alliance also signals growing alignment with net zero objectives.

Energy-related officially supported export credits, 2015-2023



Source: IEA analysis based on data provided by the OECD Export Credit Group.

While 71% of ECA-backed energy finance goes to EMDE, 81% of this supported fossil fuels in the past decade, with clean energy projects more common in advanced economies. However, in 2023 export credits for clean energy in EMDE surpassed those for fossil fuels for the first time, marking an important milestone. ECAs hold significant potential to drive clean energy investment in higher-risk EMDE, where their guarantees and de-risking tools can unlock further private investment.

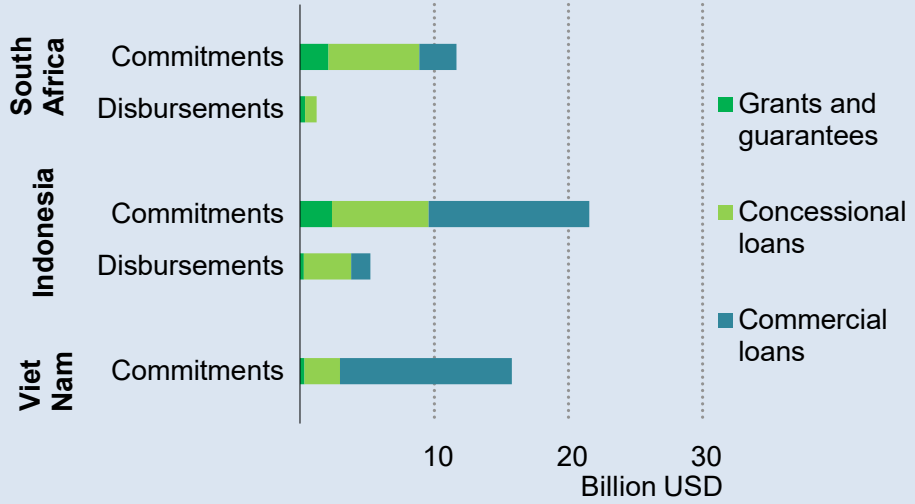
Just Energy Transition Partnerships and the international finance landscape

The first Just Energy Transition Partnership (JETP) was announced at COP26 in 2021, representing a new approach to co-ordinating finance for the energy transition in coal-dependent EMDE. Funded primarily by the G7 and European Union, JETPs aim to mobilise finance for decarbonisation while supporting affected communities. Across the four partner countries (Viet Nam, Senegal, Indonesia and South Africa), JETPs have attracted nearly USD 50 billion in commitments from public and private sources.

Disbursements to date under the JETPs have been drastically lower than committed funding, reaching less than USD 7 billion. Challenges have ranged from intense negotiations over support to a severely limited pipeline of investable projects and difficulties ensuring meaningful stakeholder participation. JETP funding has mainly been offered in the form of debt financing, rather than grants (which make up less than 3% of total committed funding).

In 2025 the United States withdrew its leadership and participation in the JETP programme alongside its over USD 4 billion of funding commitments. While other funding countries have indicated their strong intentions to continue JETP support, they have also made clear their hesitation to enter into new JETPs. Reasons include the slow progress to date and difficulties co-ordinating between different stakeholders. The learnings from current JETPs still serve an important role, with the need for national leadership, stakeholder engagement and co-ordination between financiers informing future efforts to support EMDE through “country-led platforms”.

Commitments and disbursements under agreed JETPs



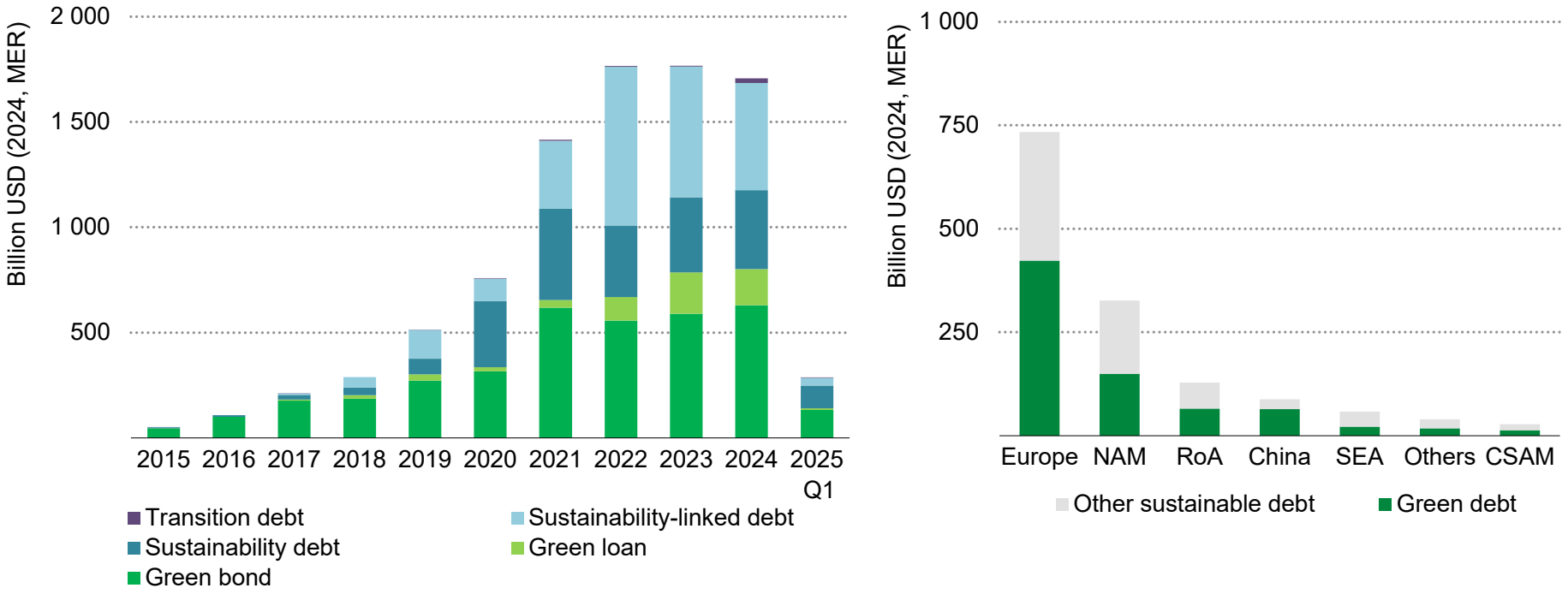
Notes: The JETP investment plan for Senegal is still in development. Disbursement data for Viet Nam are also not available. Data are in nominal terms.

Sources: IEA analysis based on aggregations of reporting from the Presidential Climate Commission 2022, Just Energy Transition Partnership Indonesia, European Commission and Government of South Africa performed by CGEP.

Sustainable finance

The total volume of sustainable debt slightly declined in 2024 compared with 2023, but green debt instruments remained resilient, maintaining a stable level over the past three years

Sustainable debt by type, 2015- Q1 2025 (left) and region, 2024 (right)



The past decade saw a proliferation of green-labelled debt, particularly in the bond market, spurred on by the introduction of sustainable finance guidelines, as well as strong investor interest; however, the market is still heavily concentrated in advanced economies.

Notes: Sustainable debt refers to the combined total of bonds and loans. For categories other than green, only the aggregate amount of bonds and loans is shown as they tend to have smaller volumes. Other sustainable debt = aggregated amount of transition debt, sustainability-linked debt and sustainability debt. SEA = Southeast Asia; CSAM = Central and South America; NAM = North America; RoA = Rest of Asia.

Source: IEA analysis based on data from Environmental Finance (2025).

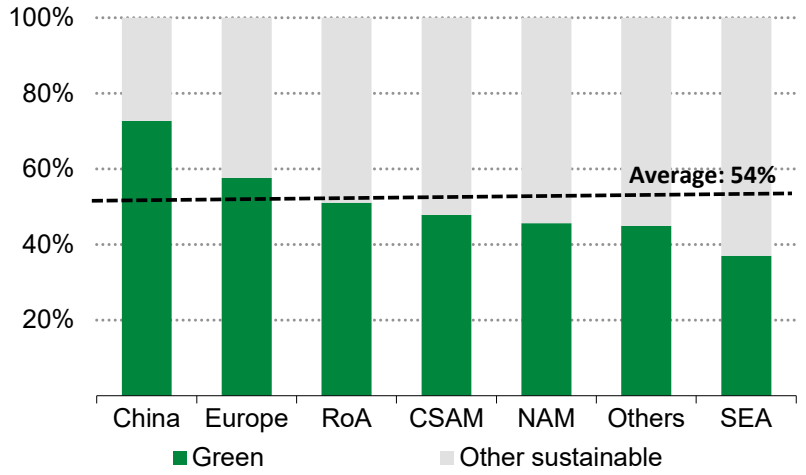
The green debt market has contributed to the energy transition in the past decade, especially in Europe and China; in the coming decade, transition finance for EMDE becomes important

Over the past decade, annual issuances of green debt have risen nearly twenty-fold from USD 45 billion in 2015 to USD 800 billion in 2024. The market remains geographically concentrated, with around 60% of issuances in 2024 being in Europe. In Europe and China, green debt accounts for nearly 60% and over 70% of sustainable debt issuances respectively – above the global average – enabled by the presence of both developed capital markets and a strong pipeline of relevant projects, particularly renewable power.

The rise of green debt in Europe and China serves as a positive example. These two regions comprise 40% of clean energy investment needed over the next decade. This underscores the need to develop finance for other regions, particularly EMDE, where clean energy investment has remained stagnant.

Transition finance is essential to help countries balance energy transitions and energy security. While there is no single definition, transition finance broadly refers to financial activities that support projects and companies aiming to make existing operations cleaner and reduce emissions, but not yet achieving net zero, guided by corporate transition plans or equivalent benchmarks. It helps mitigate the risks of financial carbon leakage, where strict regulations, narrow definitions of Paris Agreement alignment and a lack of clarity on credible hard-to-abate transition pathways lead to divestment and capital shifting to less-regulated regions or sectors, such as private debt markets that are harder to monitor. The creation of local taxonomies or roadmaps can help translate interest in transition finance into rapid progress as they allow investors to design transition commitments, while also mobilising capital from developed markets for EMDE.

Sustainable debt breakdown by region, 2024

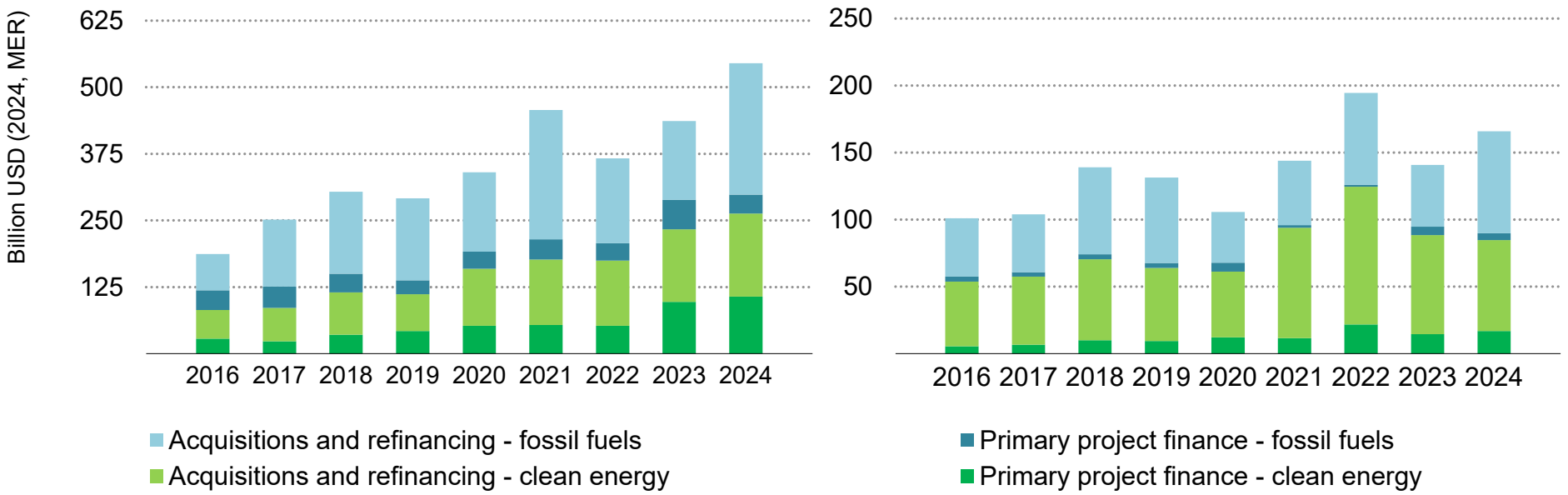


Notes: Sustainable debt refers to the combined total of bonds and loans. SEA = Southeast Asia; CSAM = Central and South America; NAM = North America; RoA = Rest of Asia; Other sustainable = aggregated amount of transition debt, sustainability-linked debt and sustainability debt.

Source: IEA analysis based on data from Environmental Finance (2025).

Clean energy finance from commercial institutions also remained high, especially from banks, which provided more clean energy finance in 2024 than ever before

Energy primary project finance, acquisitions and refinancing among banks (left) and institutional investors (right), 2016-2024



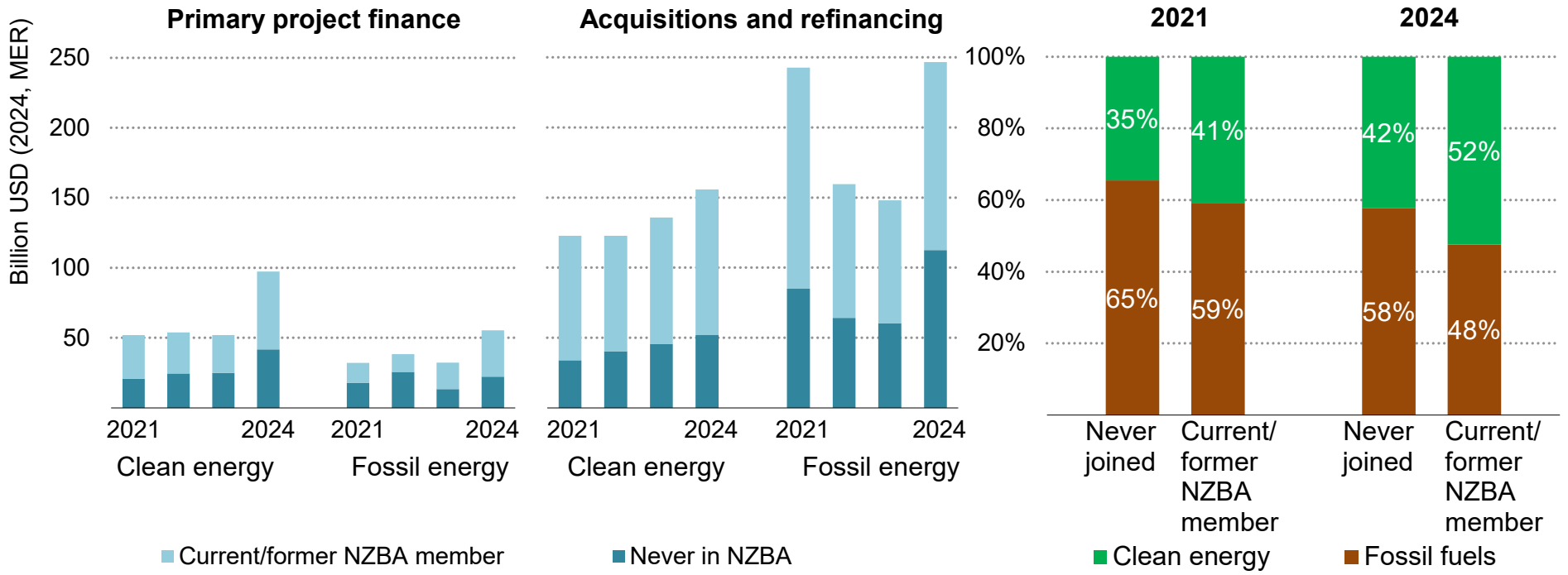
Clean energy finance from banks and institutional investors approached USD 350 billion in 2024. Although institutional investors have become steadily more active, commercial banks are the larger supplier of early-stage credit.

Notes: Does not include corporate loans, bond purchases or equity holdings in energy companies. Institutional investors include asset managers, pension funds, sovereign wealth funds, private equity and venture capital funds, managed trusts, and dedicated energy and infrastructure funds. Clean energy includes clean fuel supply, low-emissions generation, grids, battery storage, and end-use electrification and energy efficiency improvements.

Source: IEA analysis based on IJGlobal (2025).

The banking sector has seen high-profile departures from the Net-Zero Banking Alliance, but clean energy finance is growing irrespective of membership status

Financing trends by banks based on their relationship with the NZBA, 2021-2024



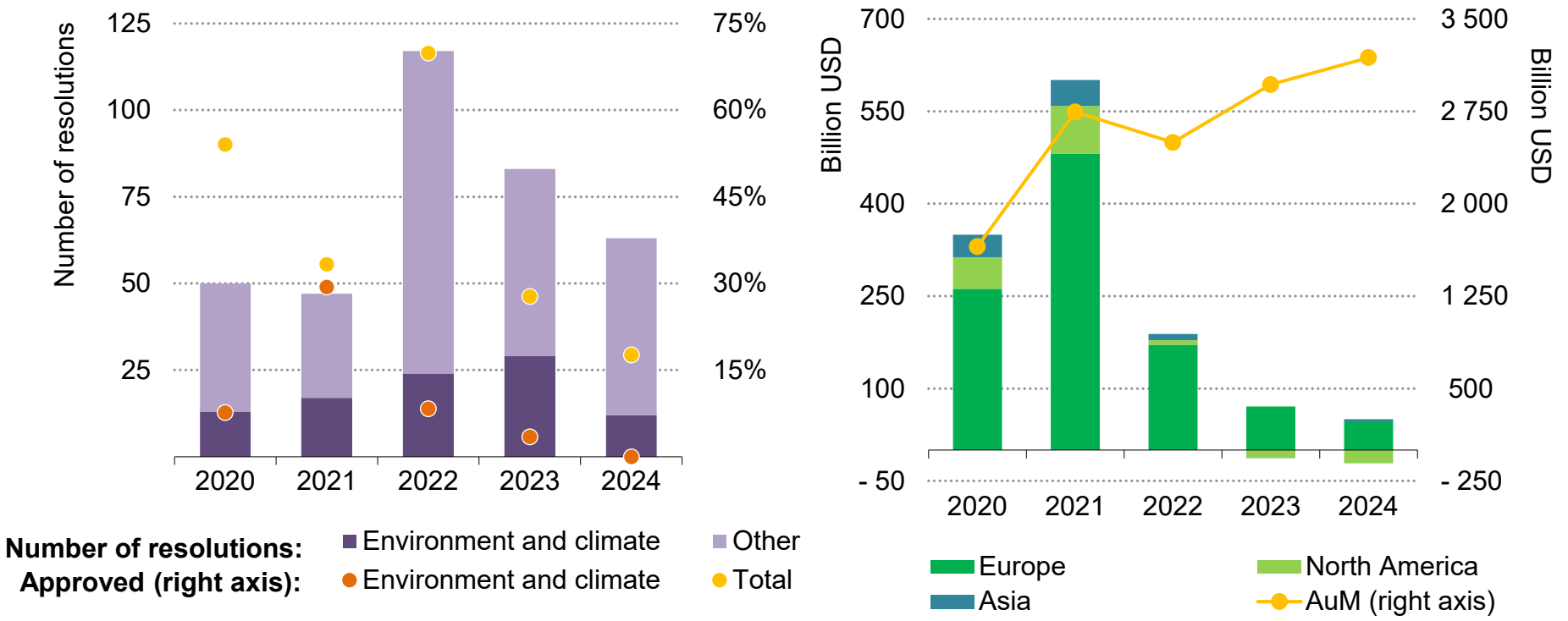
Irrespective of their membership of the NZBA, banks have seen a significant growth in clean energy financing. If interest rates decline and renewables become cheaper, market fundamentals continue to support credit demand in clean energy sectors.

Notes: NZBA = Net-Zero Banking Alliance; MER = market exchange rates. Bank financing analysed here does not include corporate loans, bond purchases or equity holdings in energy companies.

Source: IEA analysis based on IJGlobal data (2025).

The most notable retreat from ESG appears to be in fund flows and company engagement

Proxy voting trends at energy companies, 2020-2024 (left) and sustainable fund flows, 2020-2024 (right)



Since achieving peaks in 2021, both engagement at energy companies and inflows into sustainable funds have fallen, reflecting the broader slowdown in ESG practices as fossil fuel returns rebounded.

Notes: AuM = assets under management. AuM is taken from Q4 of each year, whereas the fund flows show the total across all four quarters.
Sources: IEA analysis based on Bloomberg (2025), Morningstar (2025) and Principles of Responsible Investment (2024).

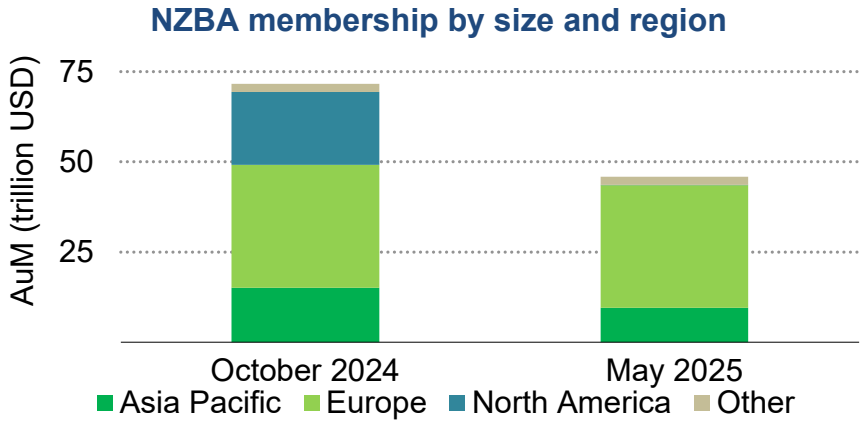
The retreat from climate initiatives is likely to weaken corporate engagement, but market conditions and commitment to existing targets are bolstering bank financing for clean energy

Banks and institutional investors play a major but differing role in energy finance. This report mostly refers to primary finance needs: that is, capital allocated to finance new energy investments. Institutional investors such as pension funds and asset managers typically operate via secondary markets, trading existing equities and bonds. This is largely due to their need for liquidity and credit-rated instruments, which are most readily available in public markets. The relationship between secondary and primary markets is complex, but secondary market activity can still support primary financing. For instance, being listed can improve a company's equity liquidity, making it more attractive to a wider pool of investors. Equally, acquisitions and refinancing via secondary markets allow developers to lock in capital at cheaper rates or to remove liabilities from their balance sheet, thereby freeing up liquidity for new projects. In contrast, banks face fewer such constraints and hence are a crucial provider of primary project finance for new energy investments.

Banks

Since 2016 banks have provided about USD 500 billion of primary project finance to clean energy sectors, compared with just over USD 100 billion from institutional investors. The gap between these actors has widened in recent years as the end of the low-rate environment led investors to allocate more capital to government bonds. Similarly, in clean energy acquisition finance and refinancing, banks have increased their spending by 27% over the past two years, whereas this type of finance from institutional investors remains well below 2022 highs.

Since late 2024 major North American and Japanese banks have left the Net Zero Banking Alliance (NZBA) – an industry-led group overseen by GFANZ – causing the group to shrink by 40% and raising concerns over future capital allocation or corporate engagement.



Note: Other = Africa, Middle East, Latin America and the Caribbean.

Sources: IEA analysis based on NZBA (2024), 2024 Progress Report, Responsible Investor (2025), NZBA.

It is too soon to draw conclusions regarding the impact of these departures, but historical trends in energy finance suggest that

returns and cashflows have been the main driver of allocation choices. Based on the primary and secondary finance analysed in this report, between 2022 and 2024 NZBA member banks increased their financing of clean energy by 53%, whereas banks that never joined NZBA did so by 45%. The relatively small differential suggests that most banks view clean energy as a strategic growth opportunity irrespective of their climate targets. During this period a surge in public financial support for clean energy in the United States and European Union, the declining cost of renewables and, in 2024, a reduction in benchmarking rates created a strong investment case for clean energy. It follows that if cashflows are predictable and returns sufficient, clean energy finance from banks should continue to grow in lockstep with demand.

Membership of the NZBA includes a commitment from banks to decarbonise their lending in line with net zero targets. This presents the risk that departures from the alliance result in a rise in fossil fuel financing. Non-NZBA members saw the largest increase in the secondary financing of fossil fuels, at 88% in 2024, nearly double that among current (and now former) NZBA members (48%). While non-members appeared more willing to finance fossil fuels in 2024, the fact that financing trends for both groups generally move together suggests that broader market conditions – including lower corporate credit risk and better lending terms – continue to play a key role. Indeed, 2024 saw a surge in refinancing and bond issuances linked to mergers and acquisitions among oil and gas companies, which brought in new capital from NZBA and non-NZBA banks alike.

Only one of the banks that left the NZBA has withdrawn previously stated net zero targets or climate ambitions (as of May 2025). Even with targets in place, reductions in bank financing of fossil fuels were always going to be staggered, due to regional considerations and mixed empirical evidence of the impact of divestment. Banks' climate strategies therefore often put an emphasis on engaging with clients on transition plans while simultaneously contributing to the expansion of clean energy supply and reducing fossil fuel financing to new clients. Decarbonisation targets act as an important metric to ensure a comprehensive strategy, and the exits from NZBA, combined with the potential for a lighter touch regulatory environment, reduce the pressure on banks to disclose and achieve these targets.

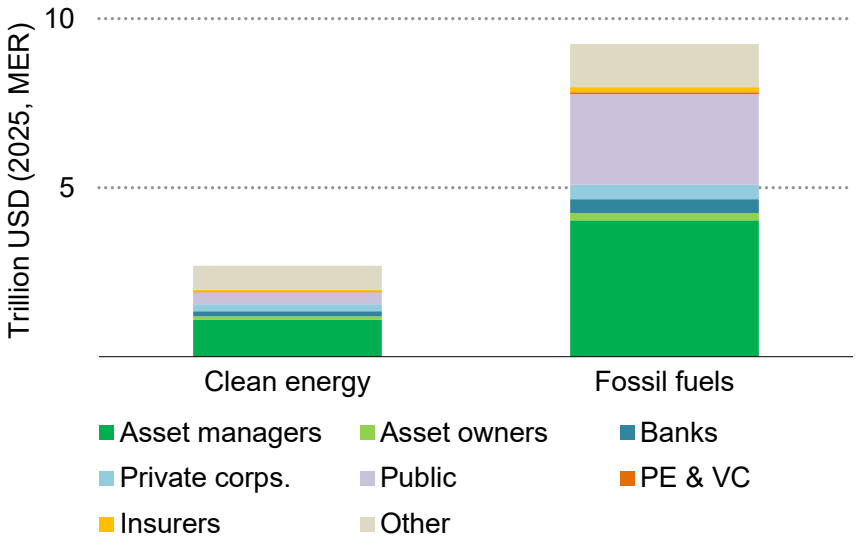
Asset managers and asset owners

Like the banking sector, asset managers have faced legal challenges over membership of the Net Zero Asset Managers initiative (NZAM) and the engagement initiative Climate Action 100+ (CA100+). Early 2025 saw high-profile departures from both initiatives by large US asset managers, leading NZAM to announce in January 2025 that it was suspending activities to undergo a review. This raises the question of whether asset managers will retreat from clean energy financing or slow their engagement with fossil fuel companies.

Sustainable funds, which generally refers to listed equity funds, help drive affordable capital to clean energy companies to support operational expenditure. Flows into sustainable funds have fallen from highs of USD 600 billion in 2021 to USD 30 billion in 2024.

Beyond just the stronger performance of fossil fuels in recent years, sustainable finance regulation and the climate preferences of asset owners and managers also drive these fund flows. Less pressure on asset managers to hit climate targets may therefore act as further downward pressure on sustainable fund flows.

Ownership and estimated value of energy companies, May 2025



Notes: corps. = corporations; MER = market exchange rates; PE & VC = private equity and venture capital.

Source: IEA analysis based on Bloomberg data (2025).

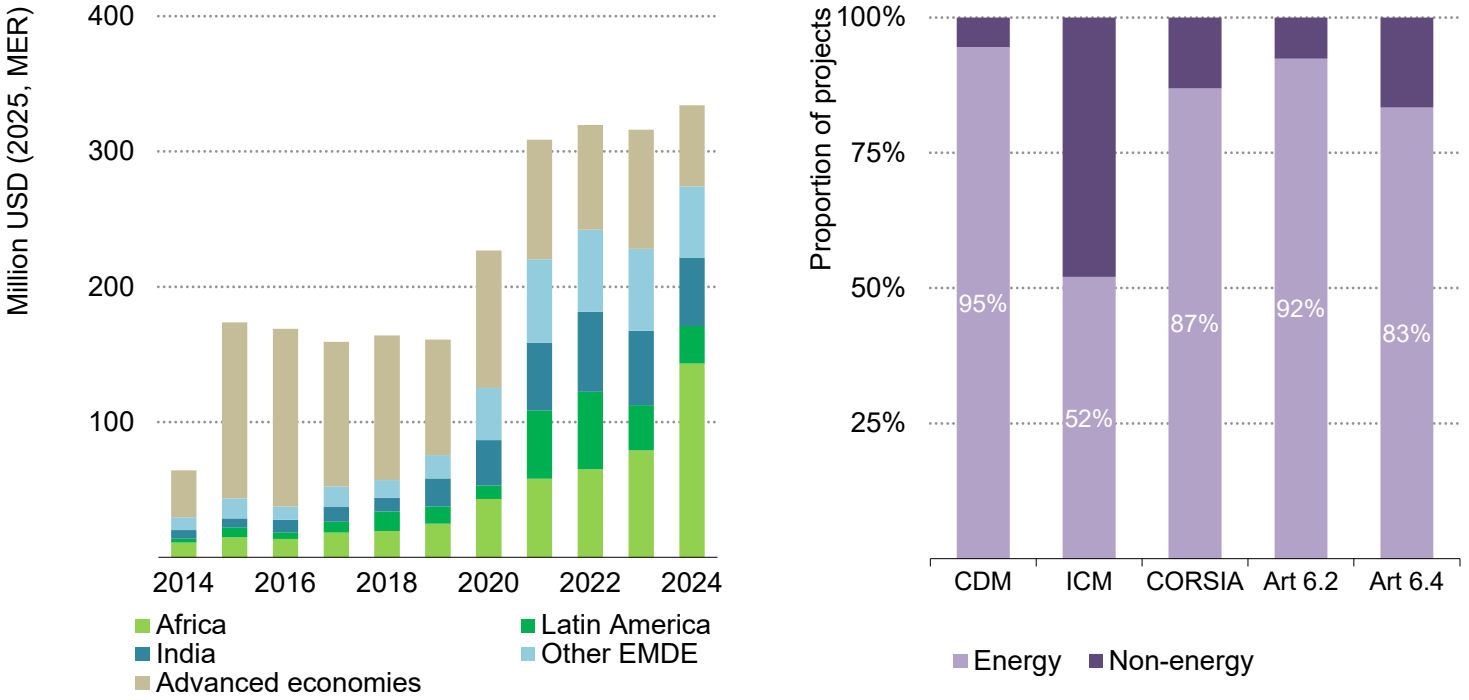
Beyond their role as finance providers, institutional investors can drive energy transitions via stewardship tools – the practice of using their ownership stakes to influence company choices. In 2024 asset managers and owners held just under half the ownership stakes of the largest fossil fuel companies, giving them significant leverage. Voting on shareholder resolutions is a key stewardship tool and has increasingly been used on climate reporting and target setting, as encouraged by CA100+ and NZAM. Measuring the additionality of these initiatives is difficult. They have undoubtedly played a key role in promoting stewardship practices, but in the 2024 voting season NZAM members voted in favour of 64% of climate resolutions, which is only marginally higher than the 61% from managers that were never part of NZAM, indicating membership was not a primary driver.

Departures from NZAM and CA100+ come at a time when support for environmental proposals has fallen. In 2021 around 30% of environmental and climate resolutions at energy companies were approved, whereas in 2024 none were. This drop in support has also revealed a growing split between asset managers and asset owners. Asset owners – such as pension funds and insurance companies – have longer time horizons and are more vocal about climate change as a financial risk. The Net-Zero Asset Owner Alliance has remained broadly intact, and in February 2025 a group of 26 asset owners with assets under management of over USD 1.5 trillion called on managers to strengthen their engagement practices. Going into the 2025 proxy voting season, asset owners appear set to act as the main driver for support of environmental and climate proposals.

Carbon credit markets

Since 2014 carbon credit transaction value has increased fivefold in the energy sector, but has limited impact on overall clean energy investment, despite energy dominating project volumes

Value of energy carbon credit transactions (left) and share of energy projects in different carbon credit markets (right), 2014-2024



The energy share of carbon credit markets represents less than 0.02% of global clean energy investment, but the energy sector is predominant in these markets, except for independent crediting mechanisms, where nature-based solutions play a considerable role.

Notes: CDM = Clean Development Mechanism; ICM = independent crediting mechanisms; CORSIA = Carbon Offsetting and Reduction Scheme for International Aviation; Art 6.2 = Article 6.2 of the Paris Agreement; Art 6.4 = prior consideration notifications submitted to the UNFCCC Secretariat under Article 6.4 of the Paris Agreement. Registries considered: ACR, British Columbia Carbon Registry, Cercarbono (listed on EcoRegistry), Clean Development Mechanism, Climate Action Reserve, COLCX, Global Carbon Council, Gold Standard Impact Registry, Registry Carbon Units, Riverse, Universal Carbon Registry, and Verra.

Sources: IEA analysis based on Allied Offsets (2025), bespoke database on carbon markets data, UNEP CCC (2025), CDM pipeline and Article 6 pipeline databases.

In spite of a low share in overall clean energy investment over the past decade, carbon credit markets have increasingly channelled financing to EMDE, particularly to Africa

Carbon credits, along with carbon taxes and emissions trading systems, are one of the primary mechanisms for carbon pricing. Emissions reduction or removal projects generate carbon credits by comparing actual emissions to a counterfactual baseline – an estimate of emissions that would have occurred in the absence of the project. These credits can come from various types of mitigation activities, with the most common historically being renewable energy and carbon sequestration in forests. While carbon credits can enhance project viability by attracting private capital, some investors view them as an unpredictable revenue source.

The supply of carbon credits comes from different sources: (i) carbon credit standards under international frameworks, such as the Kyoto Protocol's Clean Development Mechanism (CDM) or Article 6 of the Paris Agreement; (ii) independent crediting mechanisms (ICMs), managed by private, non-governmental organisations with independent credit certification systems, such as Verra and Gold Standard; and (iii) domestic government carbon credit mechanisms. Different actors can use carbon credits to claim emissions reductions or removals against different targets. Corporates can use carbon credits towards their own voluntary decarbonisation targets; countries can use Article 6 credits towards their nationally determined contributions; and airlines rely on credits to comply with their obligations under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). The cumulative value of transactions in energy carbon credit markets from 2014 to 2024 reached USD 2.4 billion. In 2024 alone transactions totalled around USD 335 million, with 96% of transaction value coming from ICMs. However, this accounts for under 0.02% of total global clean energy investment in 2024 – a level that has remained almost unchanged for the past decade – indicating that carbon credits have played only a marginal role in financing clean energy.

The size of energy sector carbon credit markets in EMDE has grown over time, with acceleration from 2020, driven by corporate demand. Africa has seen the largest increase, rising from USD 43 million in 2020 to over USD 143 million in 2024. This was primarily due to clean cookstove projects, which accounted for over 80% of the region's transactions over the past decade and are a vital revenue stream for these projects. In Latin America, growth has been driven by renewables, mainly hydropower and wind, while in India and China wind-led renewable energy credits fuelled growth. Advanced economies saw carbon credit revenues peak at just over USD 130 million in 2016, with over 50% of transaction value in the past decade coming from projects related to methane reduction and fugitive emissions, especially in Korea, Germany and the United States.

Energy sector projects are predominant in the CDM, Article 6 and CORSIA to date, and new asset classes are emerging amid growing concerns around quality and environmental integrity

Charting the future of carbon credit markets is challenging due to a range of external factors and differing estimates. Based on energy project shares in ICMs and forecasts on the value of the credit market, the energy carbon credit market could grow to between USD 2.4 billion and USD 12 billion by 2030. While carbon credits constitute a marginal share of overall clean energy investment, the energy sector represents a significant portion in many of the carbon credit markets. In ICMs, energy projects have made up around 52% of credited projects in the past ten years, with forestry and land use projects making up the second-largest category. The proportion of energy sector projects in carbon credit markets under international frameworks is significantly higher. Energy projects account for around 95% of all projects in the CDM.

Early trends suggest a similar pattern for systems that are set to become more relevant, such as Article 6 and CORSIA. Energy sector carbon credits made up 87% of CORSIA-eligible emissions units in the first phase. Additionally, the agreement on the final rulebook of Article 6 at COP29 has brought greater momentum to international carbon crediting mechanisms, and the energy sector is expected to continue playing an important role. Under Article 6.2, 92% of the 118 projects thus far under bilateral agreements are energy sector projects, with 90 energy projects coming from Japan's Joint Crediting Mechanism. The Paris Agreement Crediting Mechanism, established through Article 6.4 of the Paris Agreement, became fully operational at COP29, and 83% of the projects that have applied for prior consideration to participate in it are energy sector projects.

Innovative financing mechanisms can unlock further demand for carbon credits in the energy sector. Insurance companies have started offering solutions to derisk the purchase of carbon credits by safeguarding buyers against losses due to the reversal of emissions reduction outcomes, or host country governance risks. Carbon credit markets are also being applied to new areas of the energy sector. In particular, transition credit initiatives, such as the Monetary Authority of Singapore's TRACTION, have started considering how carbon credits can help monetise emissions reductions from the retrofitting, repurposing or early retirement of coal-fired power plants in EMDE.

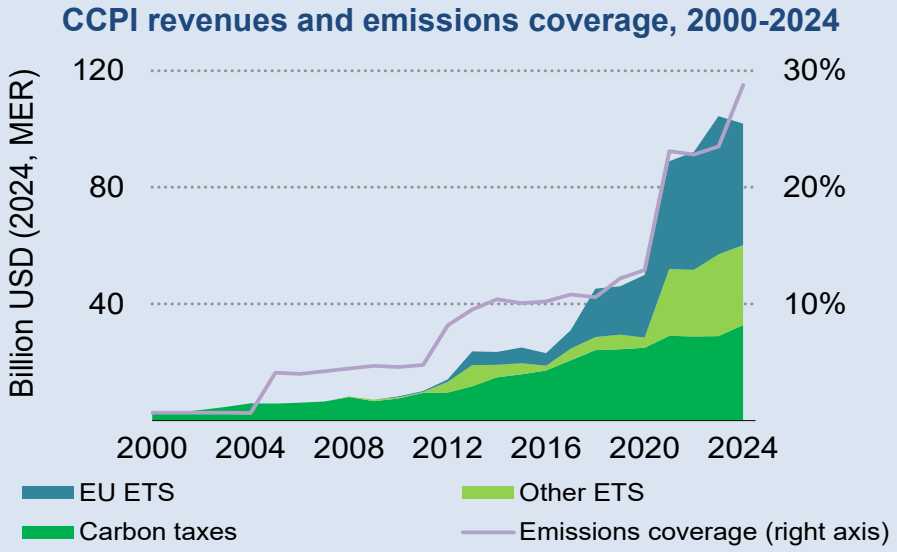
Despite their low share in overall clean energy investment, carbon credit markets have continually been under scrutiny due to concerns of over-crediting, lack of additionality and impermanence of emissions reductions. Market heterogeneity has further complicated efforts to assess project quality. Initiatives to improve market integrity such as the Core Carbon Principles of the Integrity Council for Voluntary Carbon Markets, the CORSIA Emissions Unit Eligibility Criteria and methodologies approved by the Article 6.4 Supervisory Body can also be instrumental in adding confidence to the market.

Compliance carbon pricing instruments can be a source of government revenue, but so far this has been heavily concentrated in advanced economies

Compliance carbon pricing instruments (CCPIs) include carbon taxes, emissions trading systems and hybrids of the two. The main purpose of these instruments is emissions reduction, but they can function as a revenue raising tool for governments. In 2024 revenues from all CCPIs combined delivered just below USD 102 billion, which is slightly lower than in 2023. Revenues can be allocated for general government purposes or earmarked for clean energy. For instance, the EU Innovation Fund uses revenue from the EU ETS to support energy and industrial decarbonisation.

CCPIs are concentrated in advanced economies today, comprising 48 out of the current 80 CCPIs, and constituting 99% of revenues. The EU ETS alone represented around 40% of total revenues in 2024, and it raised a cumulative USD 247.4 billion in 2010-2024, and with plans to further expand to the buildings and road transport sector from 2027 under the EU ETS2.

Other developments are also noteworthy. Japan's pro-growth carbon pricing approach combines upfront investment support through the issuance of climate transition bonds, the Green Transformation (GX) ETS and the GX-surcharge on fossil fuel supply from 2028. The GX ETS is scheduled to transition from a voluntary baseline and credit system to a mandatory cap-and-trade system in 2026. China's ETS, upon its expansion to steel, cement and aluminium, now covers 60% of national CO_2 emissions. Other EMDE are developing new carbon markets. Indonesia launched its ETS covering coal power in 2023, Brazil inaugurated a framework for an ETS, and India adopted detailed regulations for a baseline and credit system to become operational in 2026.



Note: ETS = emissions trading system.

Source: IEA analysis based on data from World Bank (2025), Carbon Pricing Dashboard.

Implications

A turbulent start to the year indicates challenges ahead, but innovative mechanisms and strong project fundamentals can continue driving finance to clean energy

Over the past decade financing practices have supported the rise of clean energy and a stabilisation in fossil fuel spending. The Covid-19 pandemic led to volatility within fossil fuel markets, while the low-rate environment of the late 2010s resulted in cheaper debt – a key enabler of clean energy projects – and increased investor appetite to diversify. Clean energy spending was further incentivised by the rise in government fiscal support and sustainable finance and corporate sustainability regulations. This led not only to a boom in sustainable debt issuances via green bonds, particularly in Europe and China, but also improved environment and climate-related reporting and scenario planning at both corporates and financial institutions.

Many financial institutions have set net zero policies that see a gradual decarbonisation of their portfolios, but how these are applied varies by investor. Asset owners, with their longer time horizons, have been most vocal about climate risks, but other investors are more reactive to market signals such as the strong financial performance of fossil fuels and the changing regulatory environment. Over the last year sustainable finance practices have faced a series of legal challenges, and there is a risk of regulation either loosening or not developing at the pace seen over the past five years. Up to this point, regulation has focused on improving disclosure, but investors would factor the strengthening of this regulation into their risk-return calculations. Without this regulatory pressure, the impetus for financial institutions to decarbonise or reallocate energy spending to clean energy is reduced. That said, the renewed emphasis on energy security has driven more attention towards transition finance, with rapid progress expected in this area in coming years.

Beyond private sector financing, the beginning of 2025 has also seen numerous signs that the role of international public finance may change, with multiple high-profile announcements of cuts to development aid. This type of financing plays a key role in EMDE, particularly in higher-risk countries or technologies. Reductions in the level of financing available have been accompanied by statements about reprioritising the mobilisation role of DFI funding, which also reflects some of the changes seen in external public finance from China, which has shifted towards more commercial activity. This could also mean a larger role for ECAs, who can provide instruments such as guarantees and insurance support, which are tools that can result in high mobilisation ratios.

Innovative solutions that allow for the strategic use of limited resources can prove essential, such as the use of sustainable debt issuances to maximise MCF or other DFI resources. The creation of local transition finance roadmaps and improvements to the credibility of carbon markets can also help channel finance into key areas.

R&D and technology innovation

Overview

Clean energy R&D spending continued to grow in 2024, but innovators have to adjust to higher costs of capital and policy uncertainty, especially those reaching the scale-up stage

Funding for energy innovation – from governments, corporations and venture capital (VC) investors – rose in 2024. The majority of this funding is for low-emissions technologies. However, the growth in available capital slowed compared with previous years. With the exception of Europe, which allocated additional money to clean energy demonstration projects, major national funders of public energy R&D kept their expenditure relatively flat in 2024. Corporate energy R&D grew at the slowest rate since 2020, weakening in all major regions in response to more costly capital and less certain revenue. The amounts of VC invested in energy start-ups declined by USD 8 billion in 2024, as higher interest rates raised the relative risk of equity investment in innovative businesses, reducing the level of VC activity across several sectors, not just energy. In addition, several other headwinds present themselves in 2025, including a more uncertain market outlook for low-emissions technologies amid unsettled trade policies, potential reorientation of national spending priorities, and major announced adjustments to US R&D budgets.

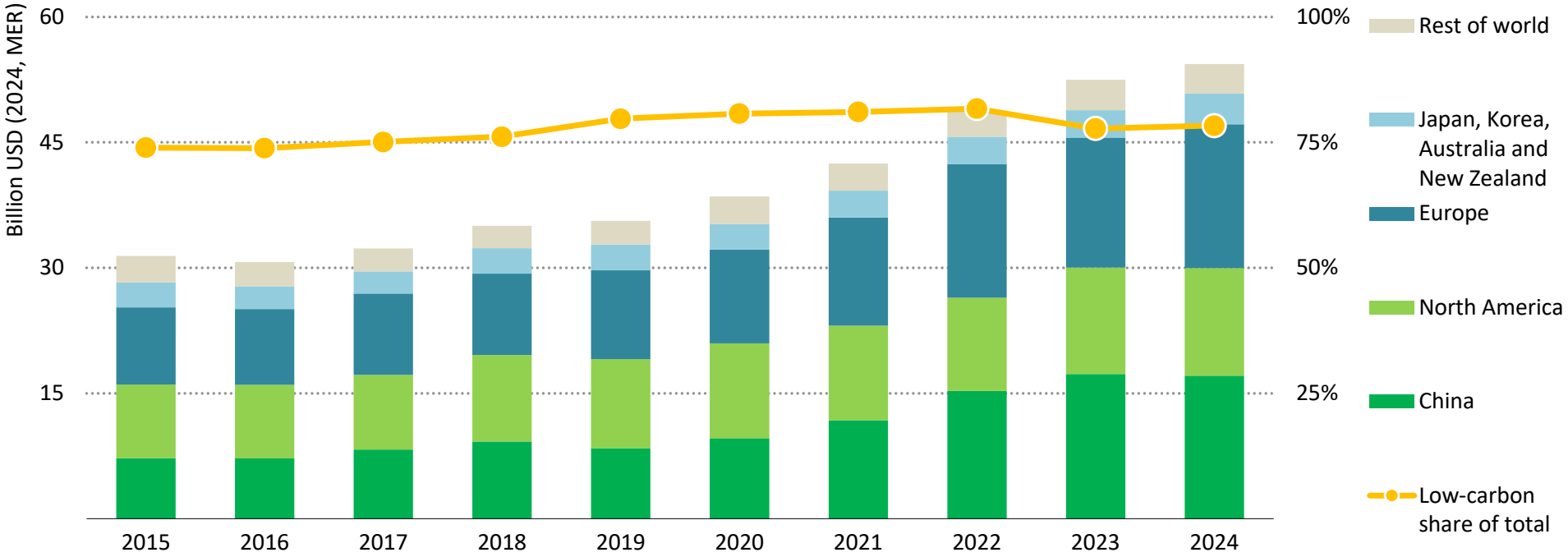
In the context of the high levels of energy innovation activity in the past five years – 1 800 energy start-ups raised equity funding during the peak years of 2021 and 2022, and another 1 400 since then – reduced capital availability for innovators is a concern. This can be especially troubling for entrepreneurs seeking funding to proceed with a large prototype, demonstration project or manufacturing investment. As start-ups typically need to raise more operating capital every few years, and larger funding rounds each time, any reduction in available capital at affordable costs can risk significant delays and, in some cases, bankruptcies. Energy innovators also face greater challenges relative to their peers in other sectors, including high capital costs and often slower payoffs. Maintaining the stability of public innovation funding – including debt and equity, as well as grants – and encouraging partnerships with the private sector, are important government actions to avoid the failure of promising technologies before they have fully tested their potential.

One area that is bucking the trend of slower innovation spending is artificial intelligence (AI). In 2024 it was an outlier as it grew its VC fundraising to USD 84 billion, nearly three times total energy-related VC investment in the same year. The focus on AI brings opportunities for energy innovation, including energy system optimisation and energy technology invention. Innovators developing means of reducing data centre energy consumption or providing firm power may be in greater demand. However, the overall impact will be balanced against the possibility that the surge of capital into the AI field draws public and private funds away from energy-related R&D.

Spending on energy R&D

Chinese growth in public R&D paused in 2024, but expanded budgets for clean energy demonstration projects in Europe kept the global total on an upward trajectory

Government spending on energy R&D, and share of total spent on clean energy, 2015-2024



Government energy-related R&D reached a global total of USD 54 billion in 2024, four-fifths of which went to clean energy technologies.

Notes: Includes spending on demonstration projects (i.e. RD&D) wherever reported by governments as defined in IEA documentation. State-owned enterprise funds comprise a significant share of China's total, which is based on reported company spending, where available. The IEA has estimated United States data from public sources. Europe, Rest of world and North America only contain figures for IEA Member countries.

Source: IEA (2025), Energy Technology RD&D Budgets: Overview.

Growth in public energy-related R&D over the past decade has remained remarkably resilient

Public spending on R&D is essential to energy innovation, funding projects that the private sector is unable or hesitant to support. Total public energy-related expenditure reached USD 54 billion in 2024, a 70% increase in real terms from 2015 and a 4% rise since 2023.

Three regions – The People's Republic of China (herafter, "China"), Europe and North America – make up the majority of public energy R&D, with each representing a similar share of the total. In recent years, China's funding has grown at a faster rate than that of the other two main regions, making it the largest single spender on energy R&D. However, this trend is subject to shorter-term fluctuations and, in 2024, a combination of steady expenditure in China and a larger budget in Europe (notably for the Innovation Fund for demonstration projects) led to Europe occupying the top spot. Growth is likely to continue in 2025 but, without compensatory growth from other countries, proposed cuts to the US budget could lead to a major reduction in US energy R&D spending in the following year and a drop in the global total.

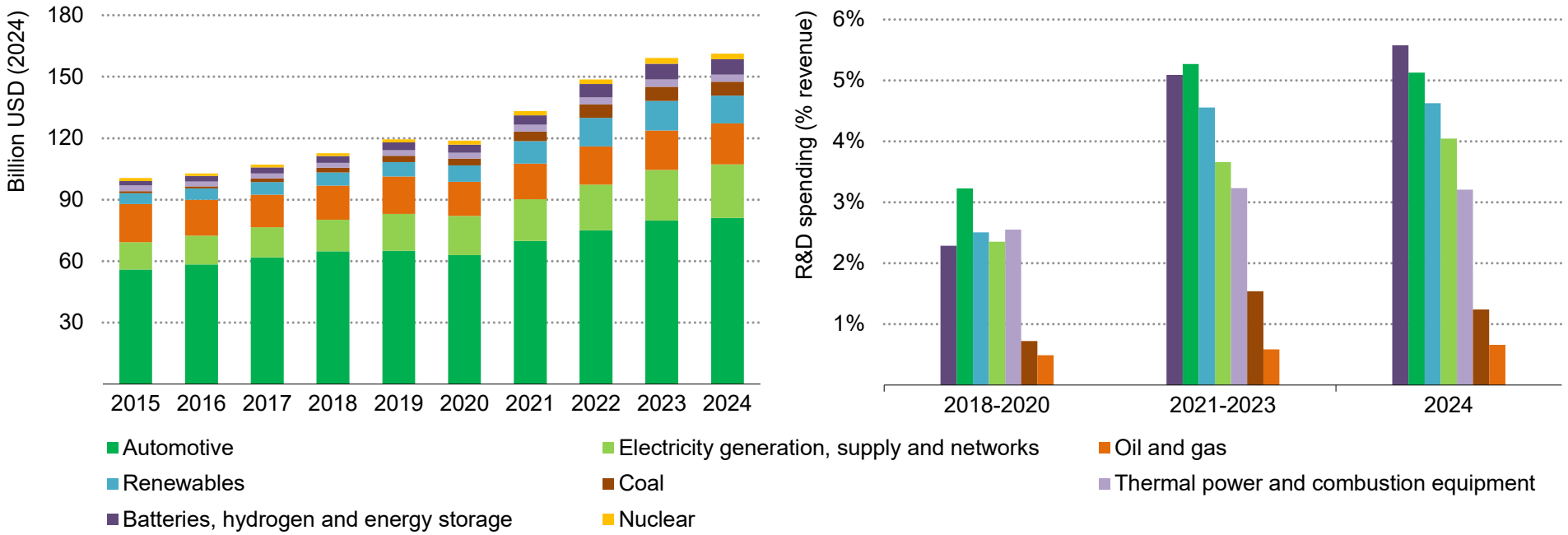
Public energy-related R&D funding spans a range of support across the phases of innovation. Over the past decade the range of mechanisms for public R&D funding has evolved from the traditional grant-based support to include more direct provision of public capital in later phases via venture funds, concessional loans and publicly backed offtake agreements. Examples include the EU Cleantech Co-Investment Facility (which aims to allocate USD 220 million in equity over four years), the Nordic Investment Bank's clean energy transition framework (which intends to provide USD 325 million in loans) and Australia's Hydrogen Headstart programme (which allocated offtake contracts worth USD 2.6 billion in 2023 and 2024). Other energy innovation policies are summarised in the IEA's recent State of Energy Innovation Report.

Since 2015 annual growth in public energy R&D has averaged 6%. This has been spurred by ambitions to deliver clean, affordable and secure energy transitions, but also by the recognition of energy innovation's role in economic growth and the development of emerging industries. For example, China highlighted its aim to establish innovation as a primary driver of its energy transition in the 2025 Two Sessions (its annual high-level political event), indicating that its energy R&D spending is likely to rise further.

Outside these regions, public energy R&D has remained relatively constant, in the range of USD 3-4 billion per year since 2015. Given their more limited financial capacities, emerging market and developing economies (EMDE) are often reliant on innovations developed in other countries, and rising trade barriers also pose a challenge to the future diffusion of energy innovations between countries. To address this, the importance of international innovation co-operation is now recognised in forums such as the G20.

Corporate energy R&D spending continued to increase in 2024, but at a markedly slower rate

Energy R&D spending by listed companies (left), and corporate R&D as a share of revenues (right), by sector of activity, 2015-2024



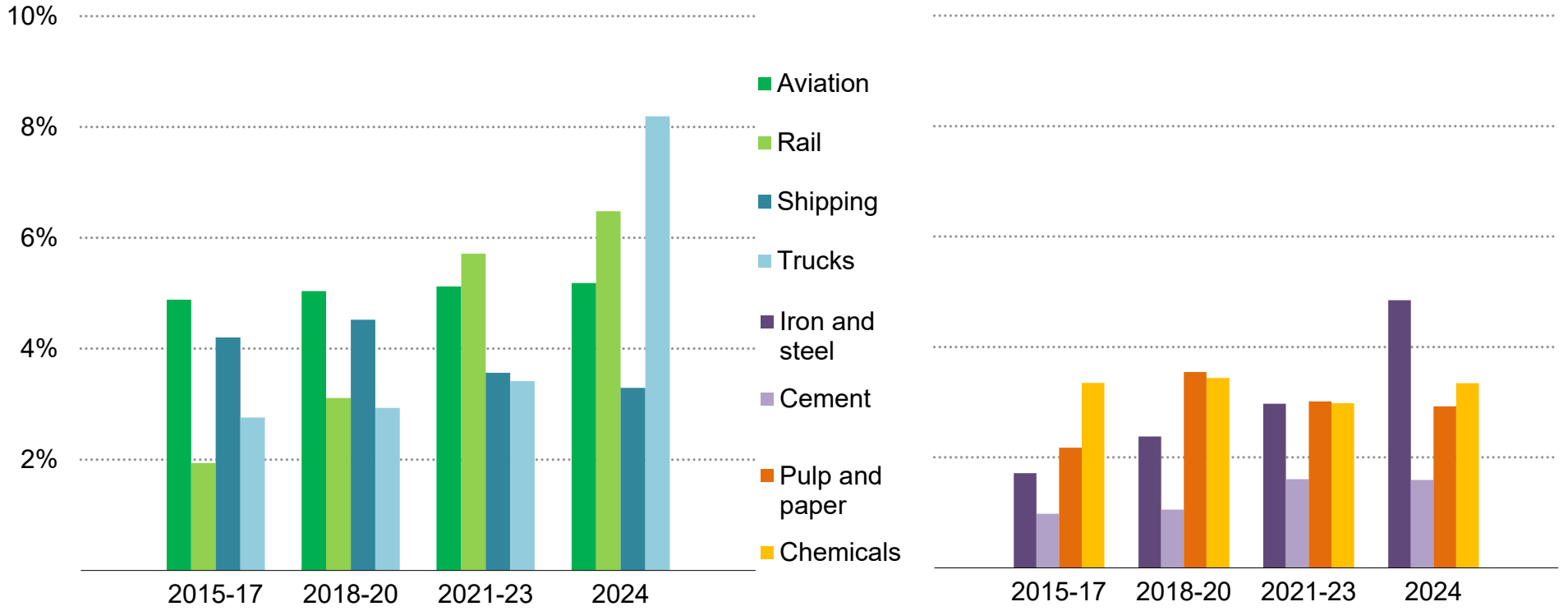
Companies operating in clean energy sectors have spent the highest proportion of their revenues on R&D in recent years.

Notes: Includes only publicly reported R&D expenditure by companies active in sectors that are dependent on energy technologies, including energy efficiency technologies where possible, and based on the Bloomberg Industry Classification System. Automotive includes technologies for fuel economy, alternative fuels and alternative drivetrains. To allocate R&D spending by companies active in multiple sectors, shares of revenue per sector are used in the absence of other information. Values may include both capitalised and non-capitalised costs, including for product development. Right-hand figure considers the average aggregated annual ratios for the top 20 companies earning more than half of their revenues in the sector shown.

Source: IEA analysis based on data from Bloomberg (2025).

R&D spending by corporate sectors under pressure to develop low-emissions solutions has largely increased relative to revenues, though for heavy industry and shipping it remains low

R&D spending as a share of revenue by globally listed companies operating in heavy transport (left) and industry (right), 2015-2024



R&D spending as a share of revenues by corporates operating in heavy transport has risen in recent years (excluding shipping), whilst for heavy industry sectors aside from iron and steel R&D spending has remained flat at a much lower level.

Note: Figures consider the average aggregated annual ratios for the top 20 companies earning more than half of their revenues in the sector shown.
Source: IEA analysis based on data from Bloomberg (2025).

In 2024 energy R&D spending by companies contracted in several energy technology areas, resulting in just 1% growth of corporate energy R&D, the lowest level apart from 2020

R&D expenditure by corporations operating in energy-related sectors continued to grow in 2024, reaching over USD 160 billion. However, at 1%, growth was slower than in any year since 2015, with the exception of 2020 when the Covid-19 pandemic prevented many R&D departments from operating normally. Compared with the year before, there was less spending in 2024 on energy R&D by companies active in areas including batteries, coal, nuclear, renewables and thermal power plant equipment. The automotive sector, which is the largest source of energy-related R&D, raised its energy R&D by only 1%, compared with an average of 9% over the previous three years. This weakening of corporate energy R&D cannot be ascribed to a single country – there was an absolute drop in corporate energy R&D among companies headquartered in Europe and the United States, while those in China raised their level by just 3%, compared with a 20% average over the prior three years.

Slower growth of corporate R&D spending may be linked to the higher costs of capital faced by firms in 2023 and 2024. It is possible that this led to constraints in overall budgets and that they rebalanced spending away from riskier and longer-term research investments as a result. In some areas, such as renewable energy equipment, it appears that cuts were also linked to lower revenues for major suppliers in 2024. In the automotive sector, some corporations may perceive diminishing returns from maintaining high levels of R&D on vehicle electrification as the key technologies have become more settled. However, there is still intense competition among EV makers and suppliers, which provides a strong incentive for companies to invest in gaining an technological edge.

Slower growth nonetheless comes against a backdrop of growth that has lifted corporate energy R&D to a level in 2024 that is 60% higher than 10 years before. Companies invest in R&D to boost competitiveness, develop emerging technologies and adapt to changing market conditions. These drivers, in combination with the significant growth in the size of Chinese companies' balance sheets, have led to the largest expansions of energy R&D spending since 2015 among automotive, power generation, renewables and batteries firms.

Among sectors, companies in the clean energy sector have been spending the greatest share of their revenue on R&D, reflecting pressures to develop emerging technologies and growing markets for their uptake. In 2024 the share of revenue spent on R&D by the largest automotive companies was overtaken for the first time by that for batteries and other energy storage technologies. Higher shares of revenue were also spent by large companies in nuclear, power generation and renewables. In contrast, companies in the fossil fuel sectors spent less than 2% of their revenues in recent years, with limited potential profitability for new innovations and high maturity of current production approaches.

At a regional level, firms headquartered in China now represent an increased share of global corporate energy R&D. Their share rose from 16% in 2015 to 38% in 2025, larger than that of Europe, the next highest, at 27%. Blurred lines between the public and private sectors in China enable the alignment of public and corporate R&D expenditure on energy-related innovation, contributing to China's increasing role in clean energy manufacturing chains through competitive advantages.

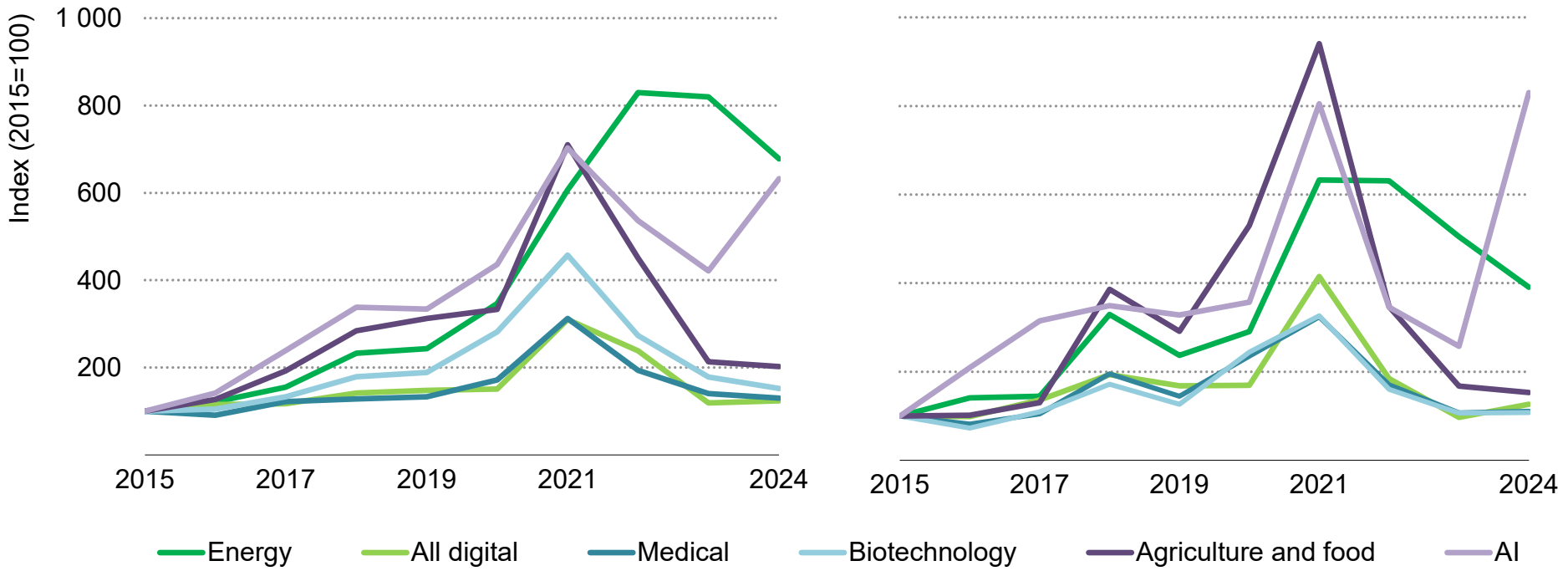
In terms of the largest company spenders on R&D, there have been some notable changes over the decade since 2015. In 2015 the list of the top 20 firms ranked by energy R&D budget was a mixture of US and European automotive companies and oil and gas businesses. The exceptions to this were China State Grid Company and Petrochina. In 2024 the top 20 included a pure-play battery manufacturer for the first time (CATL, a Chinese firm), as well as two EV-focused carmakers (BYD and Tesla). Three other firms that seek to position themselves as equipment suppliers for electrification are also on the list today (Denso, Schneider Electric and Robert Bosch), while the only oil and gas companies are Petrochina, Sinopec and Saudi Aramco.

Corporate R&D expenditure in sectors that are in need of competitive approaches to reducing emissions – heavy industry and long-distance or heavy-duty transport – has risen by an average of 6% each year since 2020, and this rate halved in 2024. The chemicals sector is largely responsible for the majority of R&D spend, with pressure to develop new processes and products, though much of the growth in 2024 also came from the aviation, shipbuilding and iron and steel sectors. Across the hard-to-abate sectors, R&D expenditure by companies operating in sectors with more competition (rail, aviation, trucking and iron and steel) have all consistently increased their R&D expenditure (measured relative to revenues) over the past decade. These trends suggest that these sectors continue to respond to competitive and regulatory pressures to integrate low-carbon production pathways.

Venture capital funding of energy-related companies

Energy-related venture capital activity remained sluggish in 2024 as global macroeconomic challenges restrained investment – except for artificial intelligence

Global venture capital investment by sector of start-up, 2015-2024, for early stage (left) and growth stage (right)

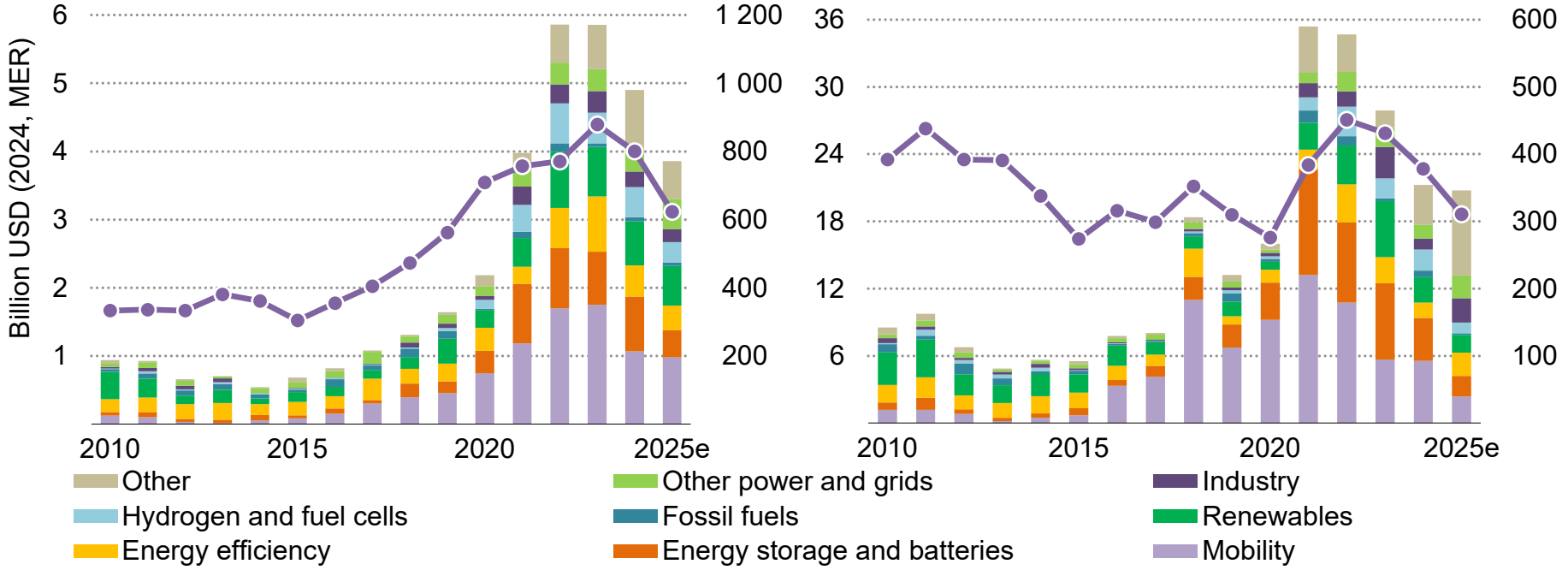


Equity investment in energy-related start-ups has been affected by the broader downturn in venture capital funding, affecting all sectors in 2024 except AI, which grew by 50% in the early stage and over 200% in the growth stage by value.

Notes: AI= artificial intelligence. Early stage comprises Series A and Series B rounds, while growth stage includes Series C and onwards along with direct financing.
Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

After remarkable growth in energy-related VC over the past decade, investment has declined over the past two years across all technology areas and is set to fall further in 2025

Venture capital investment in energy start-ups, by technology area, for early-stage (left) and growth-stage deals (right), 2010-2025

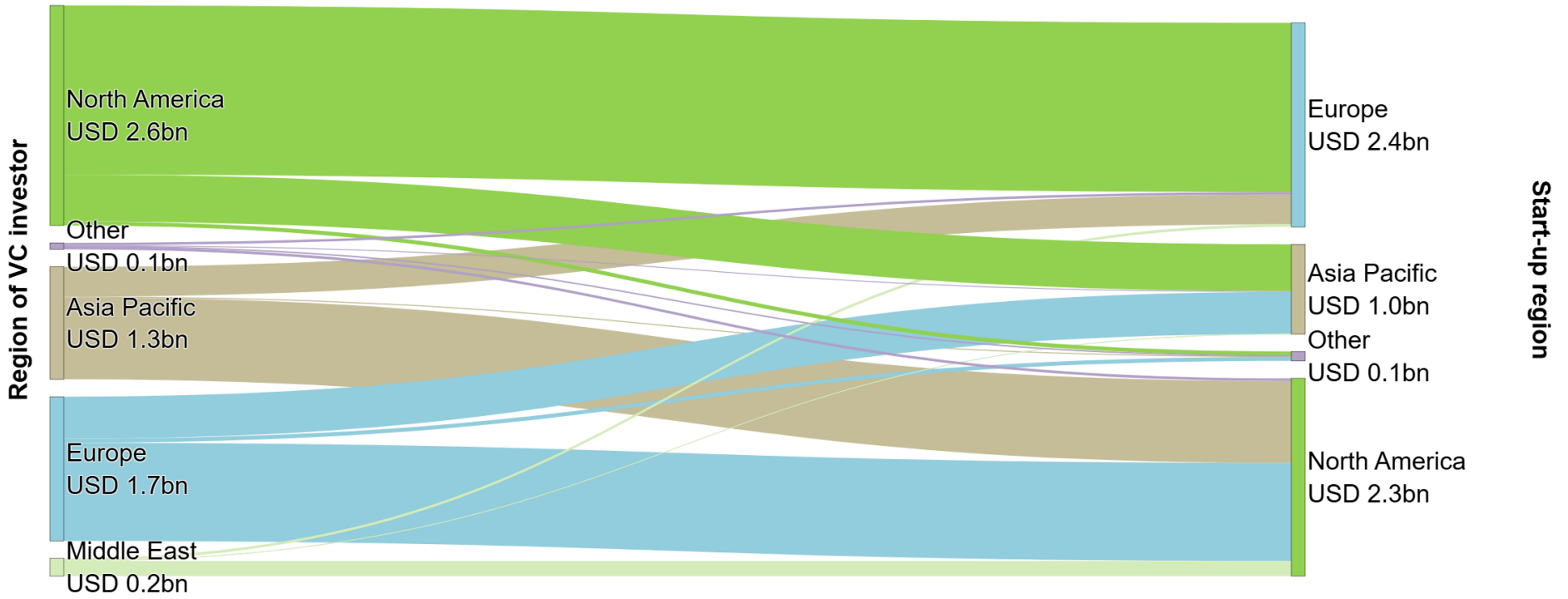


In 2024 VC investment in energy-related start-ups totalled USD 26 billion, a 22% decline from 2023. Early-stage funding decreased by 16%, the first significant year-on-year reduction since 2014, while growth-stage funding fell by 24%.

Notes: 2025e = estimated values for 2025; MER = market exchange rates. Number of deals includes deals for which no value has been reported, meaning that the average deal value cannot be accurately derived from the chart. Industry includes start-ups developing alternative pathways to materials. Mobility includes technologies specific to alternative powertrains, their infrastructure and vehicles, but not generic shared mobility, logistics or autonomous vehicles. "Other" includes carbon capture utilisation and storage (CCUS), nuclear, critical minerals and heat generation. Fossil fuels covers start-ups whose businesses aim to make fossil fuel production and use more efficient or less polluting. Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

Equity investments into energy-related start-ups are predominantly funded domestically, but over the past decade cross-border flows have increased in Europe and Asia Pacific

Flows of energy-related venture capital between regions, 2024



North America invested USD 2.6 billion in energy-related start-ups outside the region in 2024, of which 83% was directed to Europe.

Notes: Shows only inter-regional capital flows from that are not from domestic investors to domestic start-ups. Other includes Africa, Eurasia and South & Central America.
Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

Venture capital investment in energy start-ups fell by 22% in 2024, with a much larger decline in growth-stage fundraising than in early-stage companies that require less capital

In 2024 VC investment in energy-related start-ups suffered a second straight year of decline, falling by 22% to USD 26 billion. Growth-stage funding, which requires investors to commit more capital so that entrepreneurs can build first-of-a-kind projects, fell by 24%. Early-stage VC, which allows innovators to test technologies and build a new business, needs smaller funding rounds, and decreased by 16%, the first significant reduction since 2014.

Our analysis of the USD 4.6 billion already raised up to the end of March indicates that there is set to be a further decline in 2025. However, while our estimate of USD 25 billion for the full year in 2025 is subject to many important uncertainties, it would represent a slowing of the decline.

The outlook is dependent in large part on interest rates, as elevated interest rates were a major factor in the loss of the unprecedented momentum gained in 2021 and 2022. Higher interest rates increase the risk of equity investment in innovators relative to investment in other financial classes, and VC investment has declined across the board in recent years. One of the only sectors to have seen growth in VC investment in start-ups is the AI sector. Among other sectors, VC investment in energy held up relatively well from 2022 to 2024, especially for early-stage start-ups. The policy-driven nature of much energy technology development, combined with continued government commitments to ambitious policies, is a likely reason for this. However, disadvantageous macroeconomic conditions are now combining with policy uncertainty, especially in the United States, the world's largest energy VC market. A possible outcome is a shift of emphasis within VC portfolios there, and early 2025 has shown signs of growing VC investment in areas including critical minerals, nuclear power, power grids and industry in North America.

It is yet to be seen whether VC investors are holding back investment for when conditions improve, or whether the sector is adapting more permanently to a lower appetite for the hardware development risks of energy and climate technologies. However, if energy VC investment does not pick up again, then it may not be possible for the full range of promising technologies that have been funded between 2021 and 2024 to test their potential in the market, unless they can access public funds or find a corporate partner. A boost to market demand for clean energy technologies, spurred by policy, could shore up investment in the medium term, and, with an expanding market outlook, a return to growth in energy VC is realistic.

For early-stage fundraising, the largest energy sector declines in 2024 were related to technologies with lower market certainty – such as hydrogen – and capital-intensive sectors where barriers to entry have been established by first movers, such as EV manufacturing. In contrast, early-stage investment in energy storage and batteries rose, driven by developers of next-generation battery chemistries and

recycling techniques. VRB Energy, a Canadian vanadium redox flow battery developer, received the largest early-stage deal in the sector in 2024, worth USD 55 million. Start-ups developing technologies for the fossil fuel sector saw the largest rise in early-stage fundraising, with over half of funding going towards methane management innovations such as the aerial sensors developed by Insight M (which raised USD 52 million in 2024). Methane abatement has the potential to deliver very high rates of return, with around 30% of current emissions from the oil and gas sector avoidable at rates of return of more than 25%, if emissions are identifiable.

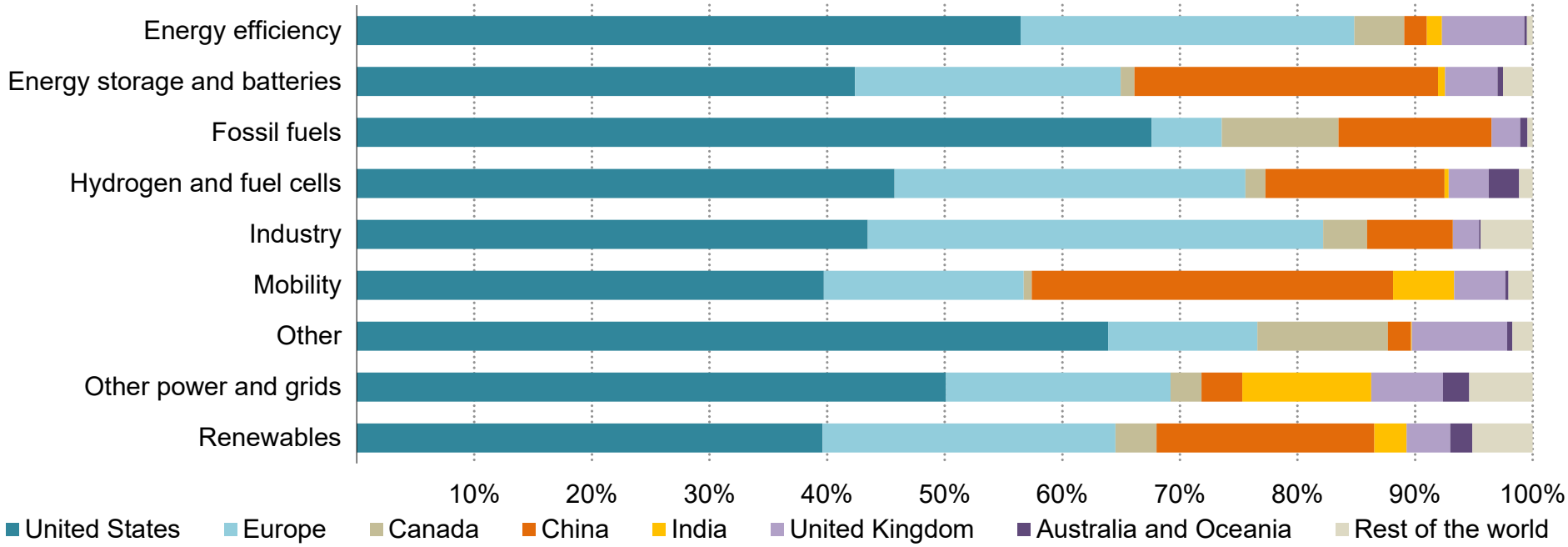
Growth-stage investment in nuclear and CCUS start-ups rose by around 210% and 100%, respectively, potentially driven by interest in the provision of firm power, for example for data centres. The largest growth-stage deals in 2024 were in EVs and nuclear fusion. AVATR, a Chinese electric car maker, secured USD 1.5 billion, while Pacific Fusion, a US developer of a new approach for nuclear fusion raised USD 900 million. A growing focus on AI with energy is exemplified by deals such as USD 255 million for Deep Green, a start-up aiming to use energy from data centre waste heat.

Most energy-related VC investment is domestic, with start-ups raising the majority of their funding from investors based in the same country (or region, in the case of the European Union). Our dataset indicates that 95% of the funds raised by Chinese start-ups were from Chinese investors, and 78% of the funds raised by US start-ups were from US investors in 2024. As China and Europe have expanded their energy VC markets, reliance on overseas investors has diminished.

Flows of capital across international borders are more important in other countries, and, considering the global nature of energy technology challenges, can play an essential role in ensuring that innovations around the world have the chance to scale up. Indian start-ups, and those in EMDE outside Asia, raise more than half their funds from overseas. In 2024 around 30% of the VC raised by start-ups in Africa was from domestic investors, with Central and South America recording 40% and India 37%. Ensuring capital availability for these innovators is therefore reliant on investors' awareness of high-potential entrepreneurs outside their home markets, and, in the longer term, the enhancement of domestic VC ecosystems in countries where they are weaker today. Both of these outcomes can be supported by international co-operation between governments.

US-based start-ups continued to attract the most energy-related VC overall, but Europe's growing share in industry and Chinese momentum in EVs is leading to regional specialisation

Early- and growth-stage equity investment in energy start-ups by region and technology area, 2020-2024

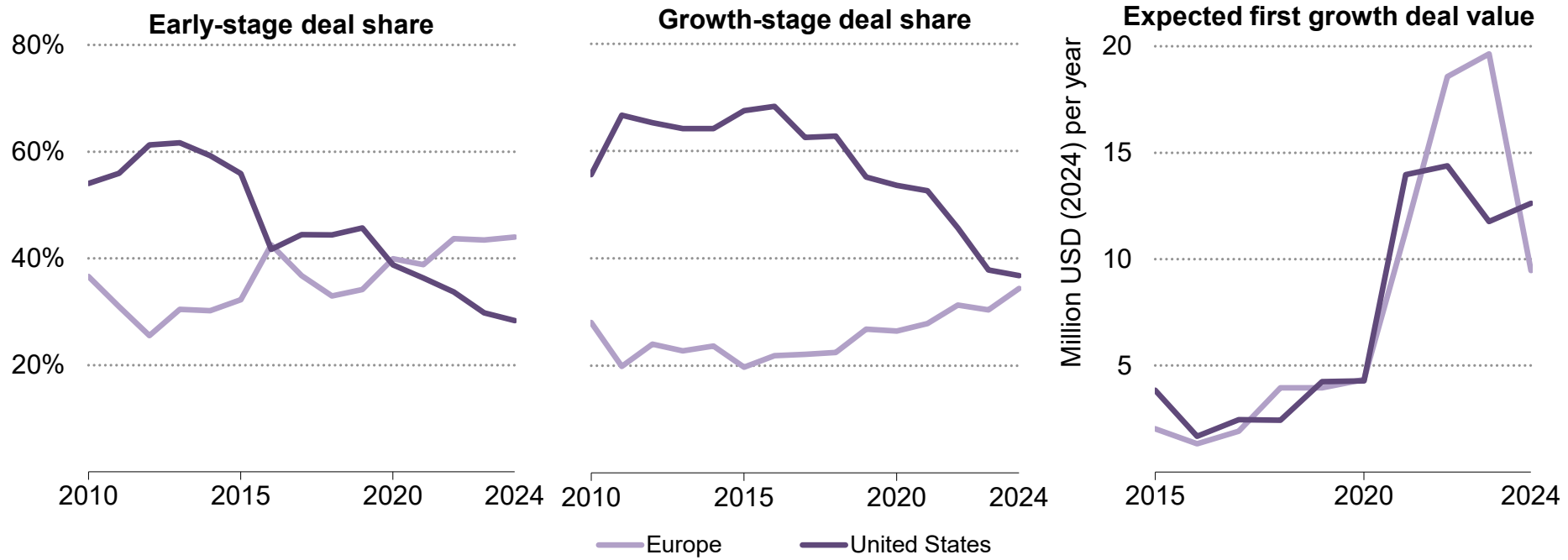


The United States accounted for 46% of all energy-related equity VC investment between 2020-2024, but there is growing regional divergence between technology areas.

Note: "Other" includes carbon capture utilisation and storage (CCUS), nuclear, critical minerals and heat generation. For other categories, please refer to the note in the early- and growth- stage energy-related VC figure above.
Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

Europe outpaced the United States in early-stage energy deals and growth equity conversion in 2022, with rising momentum in recent years

Early- and growth-stage energy venture capital deal counts in the United States and Europe as a share of the global total, and expected first growth deal value, 2010-2024



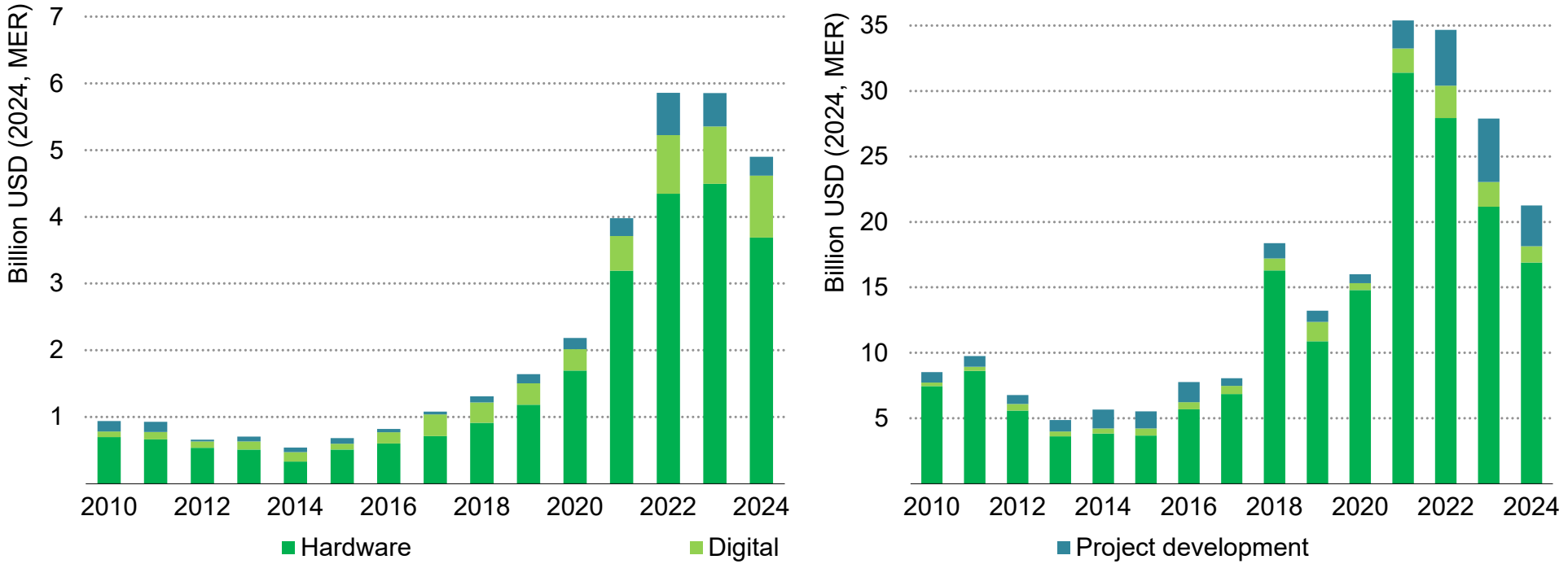
In 2024, 44% of all early-stage deals were in Europe, although the United States maintained stronger momentum in converting more early-stage deals into growth-stage deals, reflecting a more conducive environment for scale-up.

Notes: Expected first growth deal value aims to provide an indicator of the average growth-stage equity raised after a start-up's last early-stage deal, accounting for development time and start-up failure rates and given on a yearly basis. It is calculated as the mean value of all first growth-stage deals of known value for energy-related start-ups in the previous five years (to represent the likelihood of successful fundraising).

Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

While hardware dominates VC investment, the easier scalability of digital investment in a high-interest rate environment and an increasing focus on AI have kept investment resilient

Breakdown of venture capital investment in energy start-ups by category for early- and growth-stage, 2010-2024



Venture capital investment in start-ups developing hardware innovations made up the majority of early- and growth-stage deals over the past decade, although hardware funding has been less resilient to the macroeconomic conditions of recent years.

Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

In 2024 energy-related venture capital remained concentrated in the United States, but higher growth in Europe and China is driving regional specialisations for certain technologies

Start-ups in the United States continue to attract the largest share of global energy-related VC, accounting for 46% of all investment since 2015. Europe, China and India's combined share of energy-related VC has increased over the past decade, rising from 33% in 2015 to 47% in 2024. However, EMDE excluding India and China still only make up a small proportion of energy-related VC, reaching just 4% of global investment in 2024.

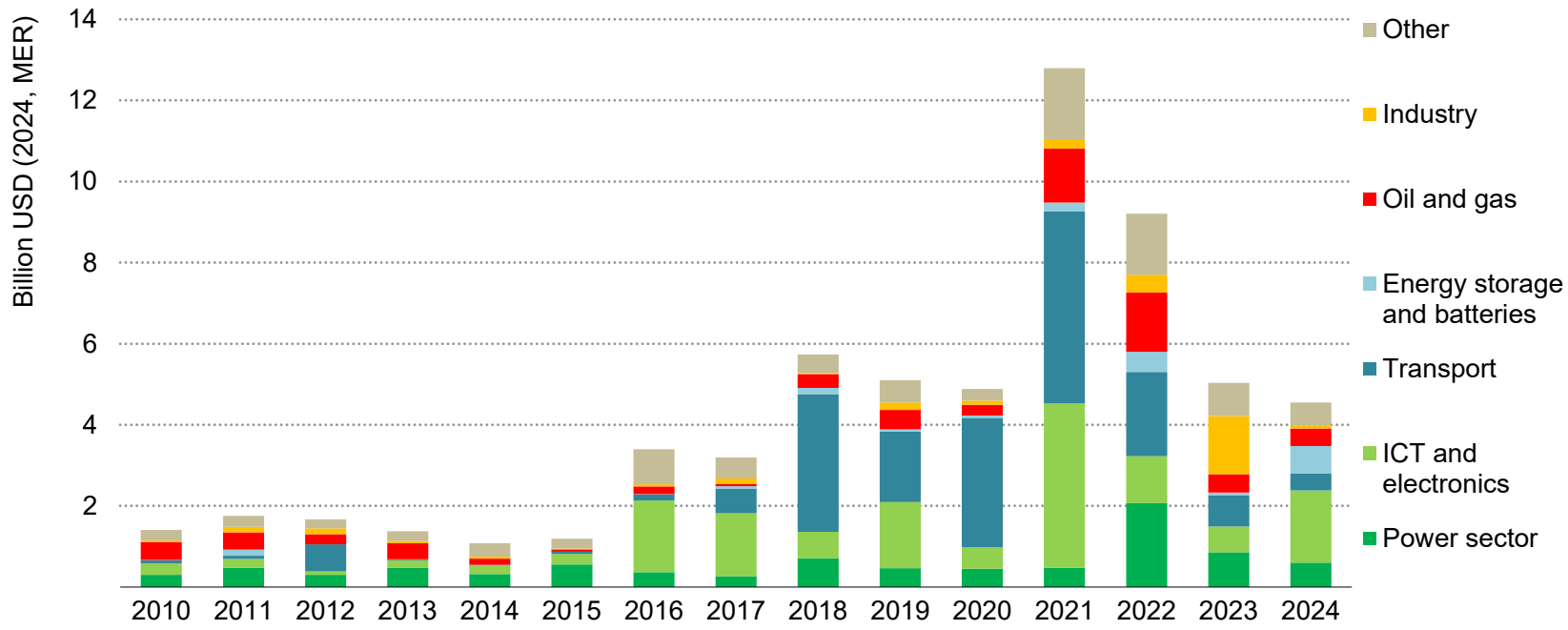
The growing share of global VC investment going into Europe, China and India is not uniform with respect to technology. In Europe, solutions to decarbonise heavy industry represent a relative regional specialisation, accounting for 35% of global investment in this area during 2020-2024, and Europe also has a strong share in hydrogen and energy efficiency, attracting 30% of the total in these areas. In China, mobility has attracted around half of the country's energy-related VC investment since 2020, which also accounted for 30% of global VC mobility investment. China is also active in energy storage and batteries (26% of global investment in the sector since 2020) and in renewables (19%). In India, over 60% of VC was directed to mobility.

Among other trends visible in recent data are shifts in the relative performance of Europe and the United States. In 2021-2024 European energy sector start-ups signed more early-stage deals than their US counterparts and nearly as many at the growth stage. Contrary to common perceptions, we find little difference in the expected size of first growth-stage deals for the two regions, with European start-ups realising higher average values in 2021 to 2023. To track this, we calculate the mean value of all first growth-stage deals each year divided by the number of years since a start-up's last early-stage round, and then adjust this by a factor reflecting the proportion of start-ups that did not raise any further funding in the previous five years (a proxy for the failure rate). It is therefore a composite indicator of the ability of start-ups to raise timely follow-on scale-up funding, the availability of capital in a region, and the failure rate between the critical early and growth stages.

While energy-related VC investment is largely focused on hardware, digital solutions among early-stage deals and project developers among growth-stage deals have remained resilient in recent years, indicating potential investor preferences for shorter development and lower capital intensity in an environment of higher interest rates.

Corporate venture capital investment in clean energy start-ups has dropped since 2023, with the exception of companies operating in ITC and electronics, and energy storage and batteries

Corporate venture capital investment in energy start-ups, by corporate investor sector, 2010-2024



Corporate VC investment fell to USD 4.5 billion in 2024, driven mainly by reductions in investment by corporations in the industrial sector.

Notes: ICT = information and communications technology. “Other” includes categories such as other energy (such as coal and low-emissions fuels), built infrastructure (including appliances, construction and real estate), food and agriculture, forestry, waste and water.

Sources: IEA analysis based on Cleantech Group (2025) and Crunchbase (2025).

Equity venture capital investment by large corporates continued to decrease in 2024, with the year-on-year fall mainly caused by the industrial sector reducing its investment

Equity investment by large corporations in smaller energy-related start-ups has risen significantly over the past 15 years, to a high of USD 13 billion in 2021 from below USD 2 billion in 2010. This use of corporate venture capital (CVC), as it is known, to widen internal knowledge and intellectual property complements internal R&D and has grown substantially since the financial crisis of 2008. It also offers corporations the opportunity to expand into emerging business areas, as internal R&D often relates to innovations for existing products.

For start-ups, CVC offers an important source of funding as it comes with opportunities for strategic collaboration and access to industry experience. However, CVC funding going to energy-related start-ups was not immune to the wider VC trends in 2023 and 2034 – strategic corporate investors reduced their VC investment by just as much as VC funds with a purely financial motive. As a share of all energy-related VC, CVC declined from an average of 27% during 2015-2023 to 17% in 2024. Total CVC stood at USD 4.5 billion in 2024, a drop of 64% from the high point of 2021, reflecting the relative ease of scaling back CVC in response to changing economic conditions compared with internal R&D budgets. In some cases, CVC trends match wider VC trends because not all CVC funds have a strong strategic mandate from their corporate parent.

Energy CVC may be affected by a softening of corporate environmental, social and governance commitments, but the effect is likely to be milder than in other areas discussed in WEI 2025. CVC investments typically align with a company's long-term strategic technology priorities and is reduced or reoriented only when market fundamentals for technologies in their sector and region change.

While the transport sector has been the largest CVC investor since 2018, driven by rising EV sales and the growing role of digital technologies in vehicles, its level of investment fell by 90% between 2021 and 2024. In some cases, this reflects an increasing focus among automotive manufacturers on boosting internal R&D. CVC investment by ICT and energy storage companies has remained resilient to recent macroeconomic instability, driven by competition among battery manufacturers and rising interest in AI. Several corporations operating in other sectors have also announced dedicated AI CVC funds, including Saudi Aramco.

Energy-related CVC is also heavily concentrated in China and the United States, accounting for 25% and 50%, respectively, of total CVC investment during 2015-2024, by start-up location. All regions saw a fall in CVC funding in 2024, with the exception of North America and Asia Pacific (excluding China), which saw a slight increase year-on-year despite high interest rates impacting capital availability.

Implications

Lessons from the past provide useful guidance for energy innovation policy, but new strategic drivers – including AI and supply chain resilience – will also shape the next decade

In the decade since 2015, the year of the Paris Agreement, energy-related R&D spending from public, corporate and VC sources has increased by 75%, with the highest growth rate being in VC funding for energy-related start-ups. Recognising the importance of innovation in meeting public policy goals, Mission Innovation was launched in 2015, an initiative of 24 countries on five continents that committed to accelerating public and private energy innovation, initially by doubling relevant public R&D spending.

Several high-level insights can be drawn from the data and experiences over the past decade.

Energy technology innovation can withstand broader economic cycles, with support from policy and funding bodies. The data on public energy R&D and energy VC do not display the wider dips in investment and activity that were experienced during the global pandemic. For public and corporate R&D spending, the economic destabilisation following Russian Federation's invasion of Ukraine also did not cause a reduction in expenditure. It is possible to draw two tentative conclusions: long-term policy stability that supports expectations of market growth is centrally important to low-emissions energy innovation funding, along with access to affordable capital; and governments can use counter-cyclical spending, including credit lines, to maintain funding stability in periods when limited capital is available (e.g. in periods of high interest rates). For example, the policy-led competition in the automotive sector to secure EV market share has kept R&D spending high in this sector and, in Europe, this was bolstered by R&D loans from the European Investment Bank.

Policies that raise expectations of future market demand spur private energy innovation spending. The automotive sector increased its R&D spending by 45% between 2015 and 2024, largely in support of electrification. In 2024 the iron and steel sector spent a share of its revenue on R&D that was 220% higher than the share in 2015, taking it above the share spent by the chemicals sector. The equivalent rise in the cement sector was 48%, while it was 111% for chemicals and 130% for nuclear. These are all sectors in which rising competitive pressures are shaped by energy security and climate policies.

Among the sources of energy innovation funds, VC is the most responsive to broader macro trends, but it is also a source that governments have sought to cultivate. As a source of innovation capital, VC is highly effective at testing technologies and business models against market realities and growing the most successful faster than would be possible within incumbent businesses. However, VC funding has short time horizons that traditionally made it less compatible with energy hardware than R&D budgets. Through co-financing and other support measures, governments in Australia, Europe and North America have raised the risk appetite of VC investors for energy hardware, but are now learning that capital

can move quickly to other sectors when macro conditions change. This raises questions about how governments can ensure stable access to operational and scale-up capital for promising energy innovators, while accounting for the cyclical nature of VC funding.

Delivering people-centred and affordable future energy systems is partly an innovation challenge. EMDE have a major stake in technological change in the energy system, including through the innovations needed to underpin it. In recent years, energy, climate and development policies in many emerging economies have included ambitious innovation objectives for energy technologies. The economic opportunity is large, and strengthening energy innovation systems in these countries is important for achieving secure, affordable and sustainable energy systems globally. However, EMDE outside China accounted for just 6% of global public R&D spending in 2023 and 3% of corporate R&D, as well as only 4% of energy-related VC.

In the first half of the decade since 2015, climate change mitigation was the single major driver of growth in energy technology innovation, but this is changing. More recently, new policy drivers have emerged that have broadened the scope of energy technologies – the sourcing of critical minerals and yield improvement in battery manufacturing are now key areas of energy R&D. Other important drivers include: industrial competitiveness, energy security, supply chain resilience, securing leadership in AI technologies, provision of firm power to industrial consumers, and energy access. For VC investors, the growing markets for clean energy technologies and their increasing cost competitiveness are also a significant driver, with the majority of VC funding coming from non-corporate investors motivated by commercial interests. These drivers are already affecting capital allocation, but the extent to which they will reinforce or compete with the existing climate-led imperative is unclear. In 2023 and 2024, USD 3.8 billion of VC was invested in start-ups working on critical minerals supplies, 45% more than in the previous five years. In 2024 growth areas for VC funding amid a general decline in the sector included nuclear, geothermal, CCUS and AI.

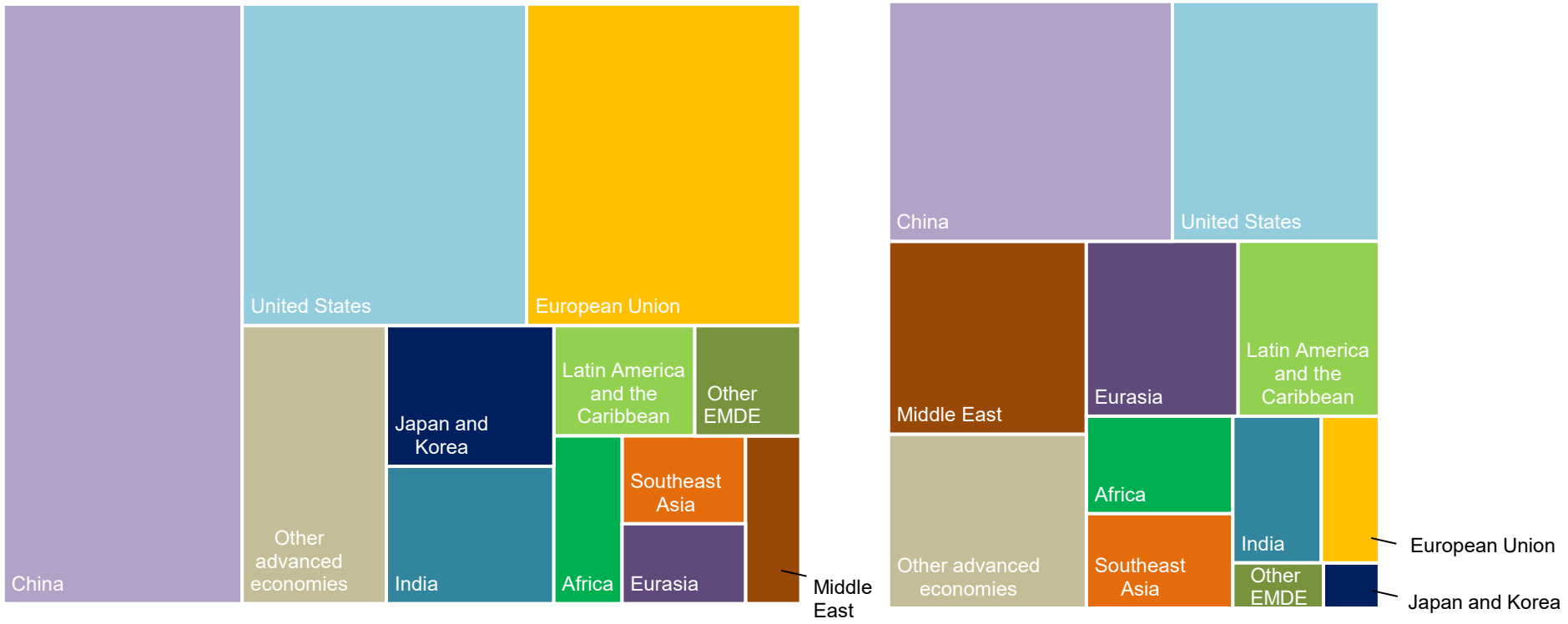
For energy technology innovation, the next decade will be shaped by the ways in which these new strategic drivers interact, the extent to which international co-operation can enhance the rate of technology learning across borders, and how governments use the full range of financial tools to allocate capital efficiently across different priorities. Above all, growing the overall level of public and private capital accessible to energy innovators will be critically important, even as policy makers learn from one another about how to make available funds go further

Regional deep dive

Regional overview

Global energy sector investment is expected to exceed USD 3.3 trillion in 2025

Global clean energy investment (left) and fossil fuel investment (right) by composition and region, 2025e

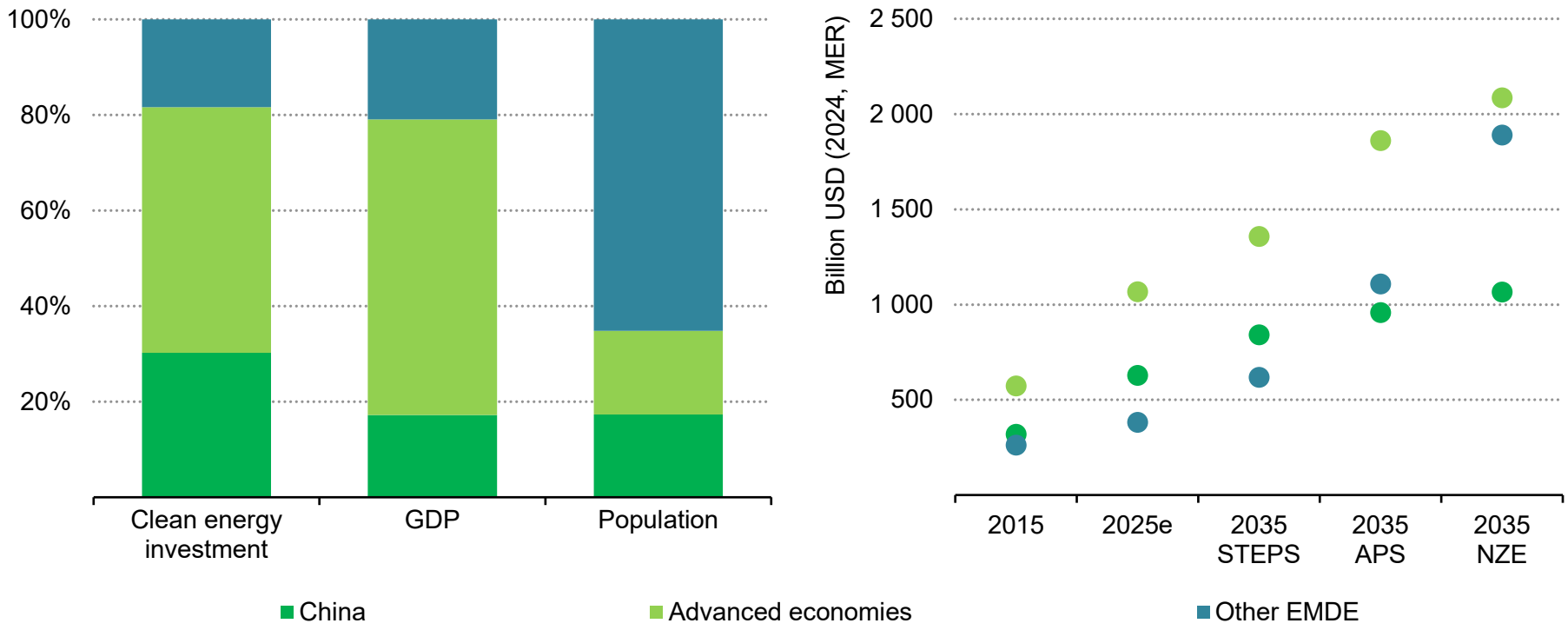


China leads clean energy investment in 2025 at USD 630 billion, while all advanced economies together invest USD 1 trillion. China is also the largest investor in fossil fuels, followed by the United States and the Middle East.

Notes: 2025e = estimated values for 2025; AE = advanced economies; EMDE = emerging market and developing economies.

In 2015 China accounted for a quarter of total annual clean energy investment, whereas today it accounts for almost a third

Key metrics, 2025e (left), and clean energy investment, 2015-2035 (right)

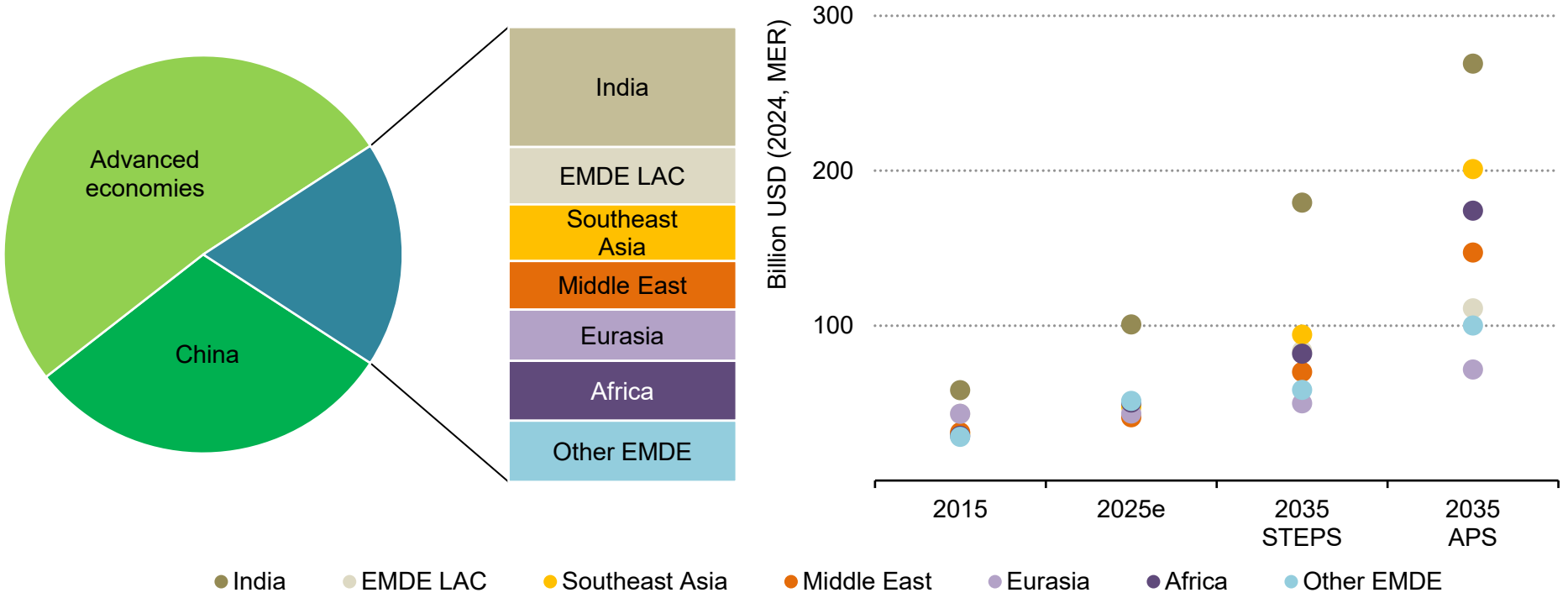


China's clean energy investment has doubled since 2015, compared with an 85% increase in AE and a 45% increase in other EMDE.

Notes: STEPS = Stated Policies Scenario; APS = Announced Pledges Scenario; NZE = Net Zero by 2050 Scenario; MER = market exchange rate; 2025e = estimated values for 2025.

The imbalance of investment is most acute in Africa, which accounts for only 2% of clean energy investment despite having 20% of the world population

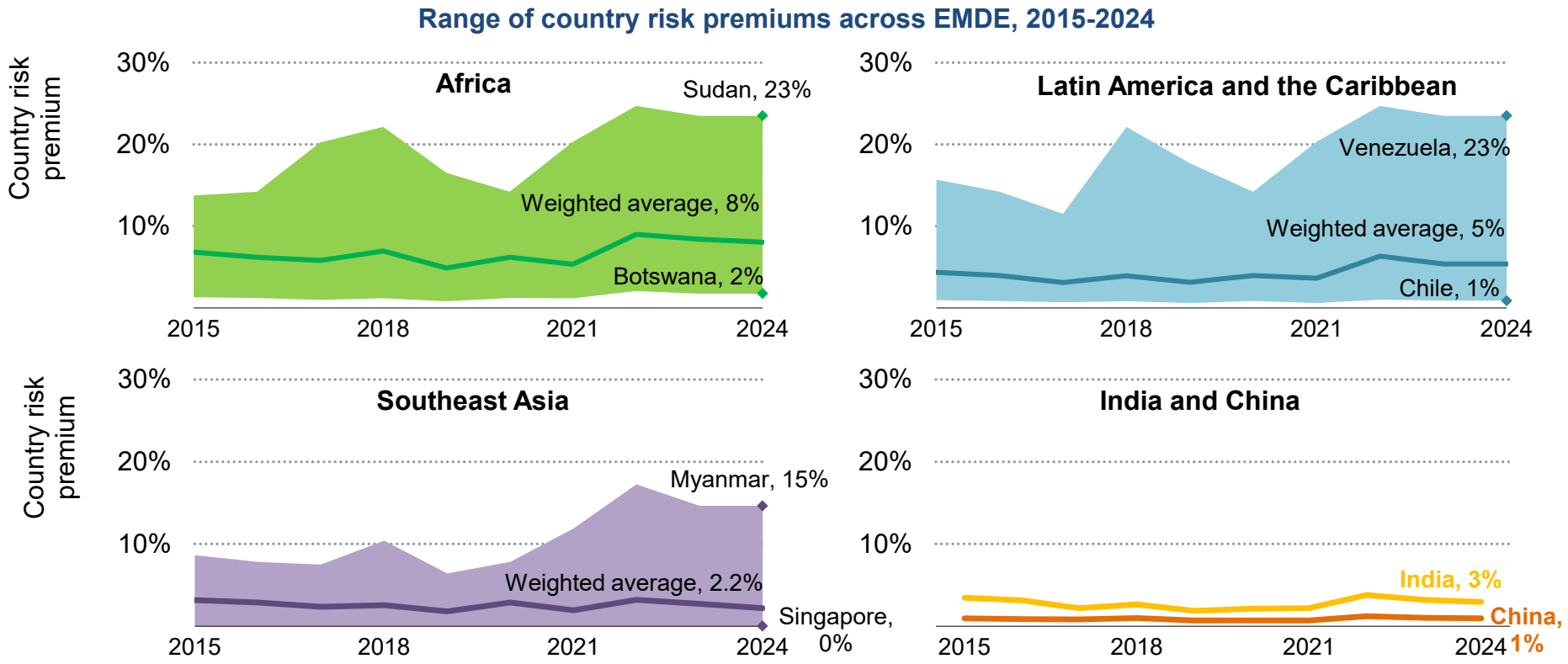
Clean energy investment share, 2025e (left), and clean energy investment in selected EMDE countries and regions (right), 2015-2035



Under STEPS, India continues growth of the last decade in clean energy investment to 2035 with an over 75% increase, while under APS growth almost triples. Under APS, Africa and Southeast Asia invest USD 373 billion in 2035, nearly quadrupling their 2025 investment.

Notes: LAC = Latin America and Caribbean; EMDE LAC refers to EMDE countries in the Latin America and Caribbean region; 2025e = estimated values for 2025.

Macroeconomic trends over the past ten years, including elevated country risk premiums, have been a driver of variations in energy investment across regions



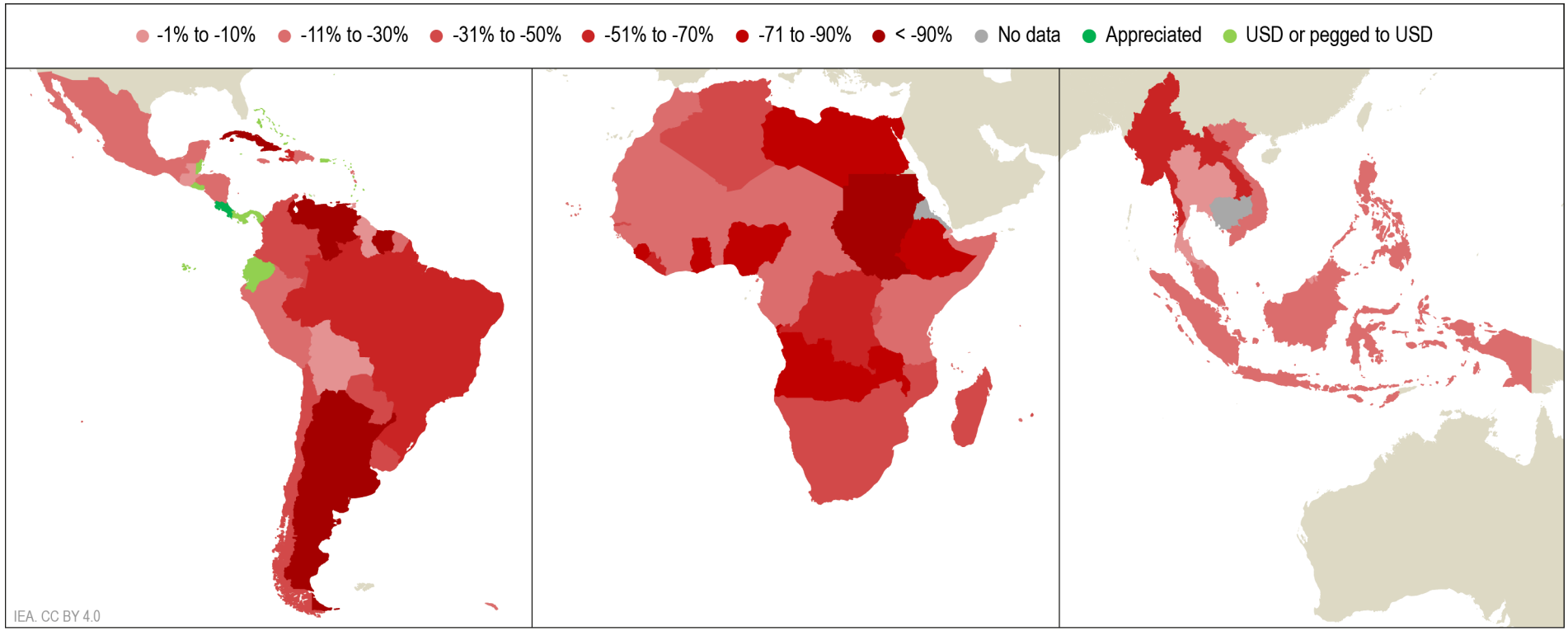
High country risk premiums in EMDE result in increased cost of capital and reduced access to finance for energy investment.

Notes: Country risk premiums refer to the bond spread above US government bonds in a particular country. The weighted average figures for Africa, Southeast Asia and Latin America are calculated by aggregating the risk premium of each country in the region for which data are available, weighted by their 2025 GDP.

Sources: IEA analysis based on IMF (2025), World Economic Outlook, Country Default Spreads and Risk Premiums database (2025).

Since 2015 EMDE currencies have depreciated by double those of AE, creating challenges in accessing and servicing debt, and funding imported energy and technologies

Exchange rate depreciation against the US dollar in selected regions, 2015-2025

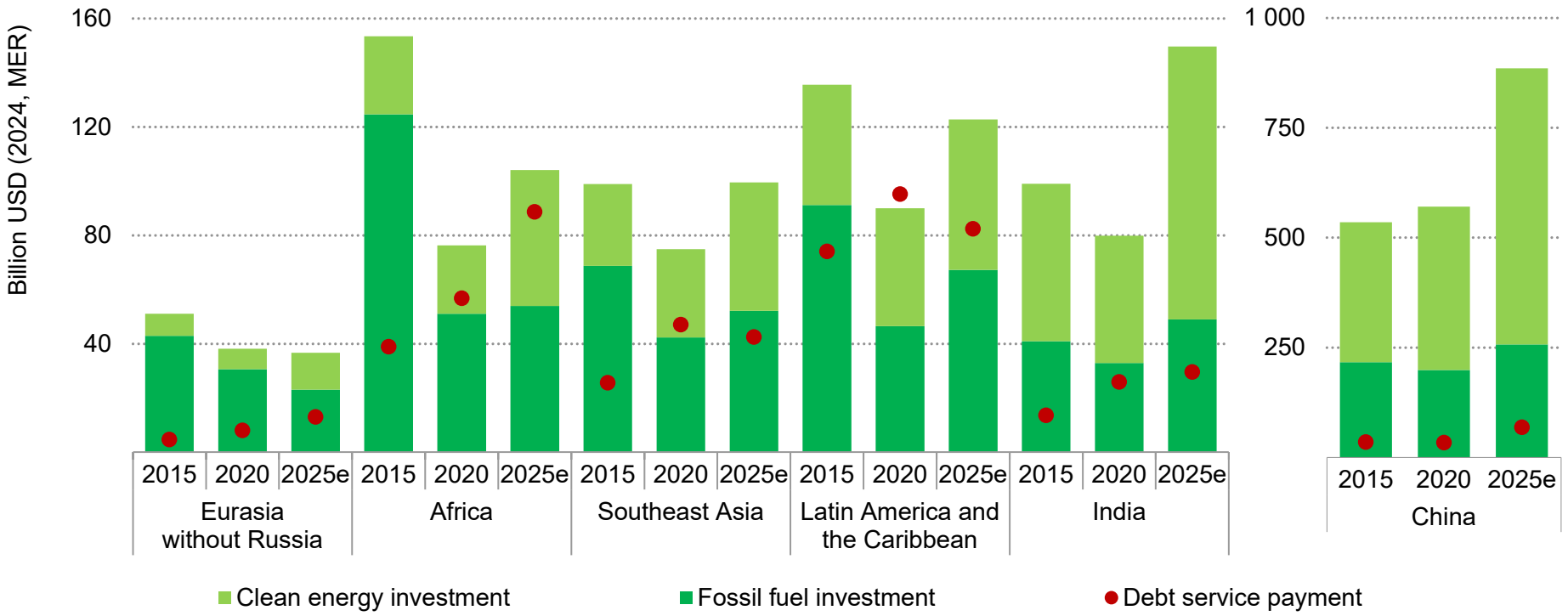


Access to foreign capital has become more costly, resulting in downward pressure on energy investment levels across EMDE. Expanding local capital markets and using currency hedging products are important to shield against depreciation and volatility.

Notes: Depreciation from January 2015 to January 2025.
Source: IEA analysis based on S&P (2025).

Public debt servicing costs in EMDE add strain to scarce government resources, especially in Africa where they are equivalent to over 85% of total energy investment in 2025

Energy investment and public debt service in selected regions and countries, 2015-2025e



China's public debt service to total energy spending is the lowest at 8% in 2025, while India is at 20% and LAC at nearly 70%. Africa's has increased from 25% in 2015 to 85% in 2025, where half of debt is owed by four countries: Egypt, Angola, South Africa and Morocco.

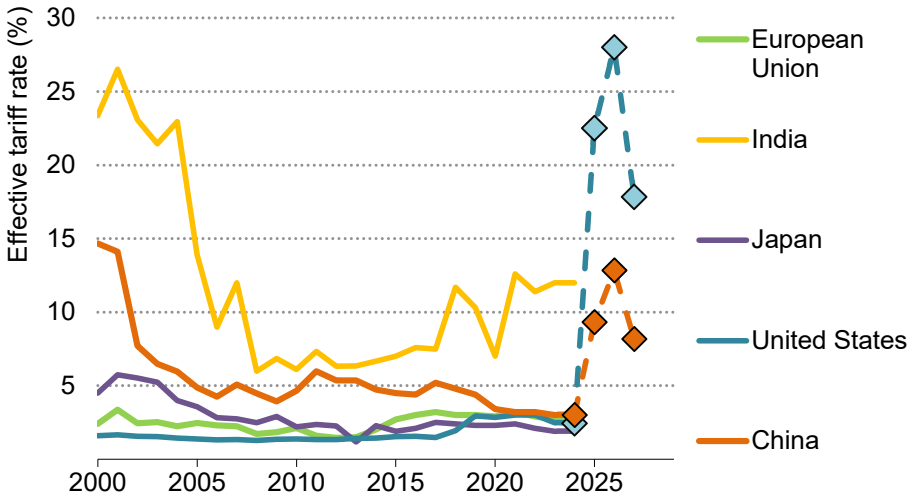
Notes: See methodological section for full definitions. Debt service on external debt, public and publicly guaranteed (PPG) (total debt service, current USD) taken from January 2015 to January 2025; 2025e = estimated values for 2025.

Sources: IEA analysis based on World Bank (2024) International Debt Statistics, and for Chile, Ex-Ante (2024), Database.

Rising barriers to trade and the associated uncertainty around tariffs are likely to drive shifting regional trends in energy-related investment

Over the past decade, increasing integration of energy supply chains globally has reduced costs and increased investment, accelerating the pace of energy transitions. While international trade as a share of GDP has remained roughly constant since 2015, exports of certain energy technologies have increased substantially (up to twenty-fold). Effective tariff rates were at their lowest in decades for major markets until 2025; they have since risen due to US announcements, although the situation remains very fluid.

Effective tariff rates for major global markets



Sources: World Bank (2025), Tariff rate, The Budget Lab (2025), The Fiscal and Economic Effects of the Revised April 9 Tariffs.

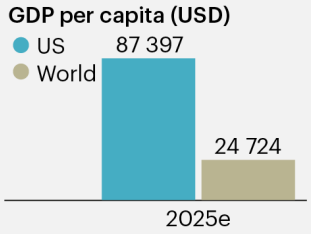
International trade has helped to address regional energy supply–demand imbalances. However, relying on a handful of suppliers for imports of fuels and energy technologies is an energy security risk, a point underscored by the European Union's reliance on gas imports from Russia and the vulnerability this exposed in the global energy crisis of 2022. This is also an area of concern for critical mineral supply chains, which are strongly geographically concentrated.

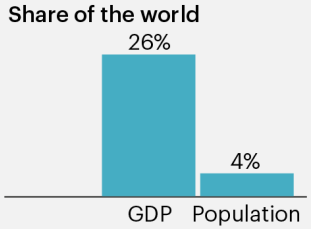
Imports of Chinese energy technologies have largely been the focus of recent tariffs, including in the United States, India and the European Union, citing alleged unfair levels of state support. While tariffs provide protection for domestic manufacturers, they add cost and complexity to globally integrated supply chains. The sharp rise in China-US tariffs in 2025 and subsequent Chinese export controls on critical minerals put economic pressure on exporting and importing companies alike. Prolonged uncertainty with rapidly evolving trade policy and retaliatory measures could result in companies adopting a "wait and see" approach to major new investments, particularly those dependent on international supply chains. In Q1 2025, some USD 9 billion of new clean manufacturing investments in the United States were announced, but almost USD 7 billion were cancelled (rising to 9 billion with early-stage cancellations), mainly battery projects which rely on imports of critical minerals.

United States

Key statistics for the United States

Economic and financial indicators





Sovereign debt rating
AA+

Debt to GDP ratio
123%

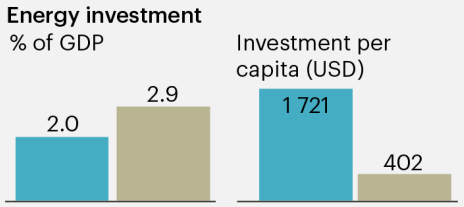
Change in 10-year government bond yield since 2020
+270 bps

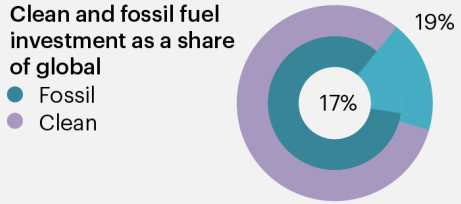
Currency value against USD (2015-2025)
N/A

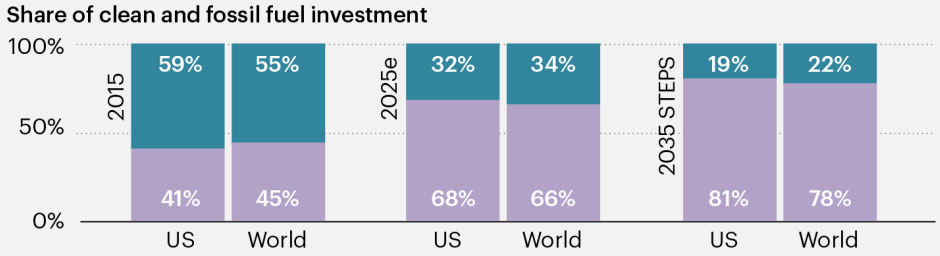
Country risk premium
0.0%

Countries with NZE commitments
N/A

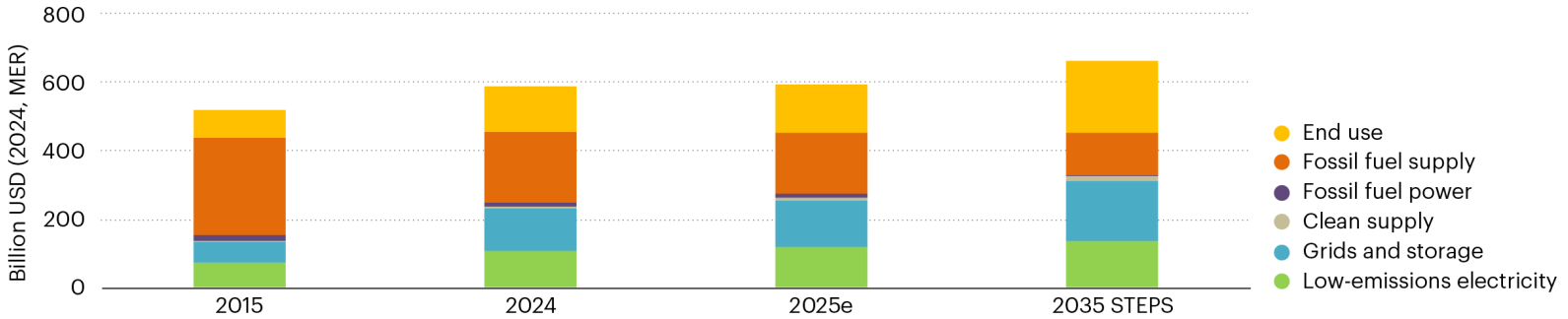
Energy investment indicators







Energy investment trends



Notes: bps = basis points; Change in 10-year government bond yield compares bond yield between January 2020 and March 2025; The United States issued its withdrawal from the Paris Agreement through an Executive Order on 20 January 2025; 2025e = estimated values for 2025; The STEPS projections are from the WEO 2024 and do not reflect policies announced by the new administration.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

The United States is a major investor in all fuels and all energy technologies

The United States has made substantial energy investment over the past decade as part of a broader effort to establish itself in new value chains and supply international markets. It became a net energy exporter in 2019, a remarkable turnaround from its high previous reliance on imports.

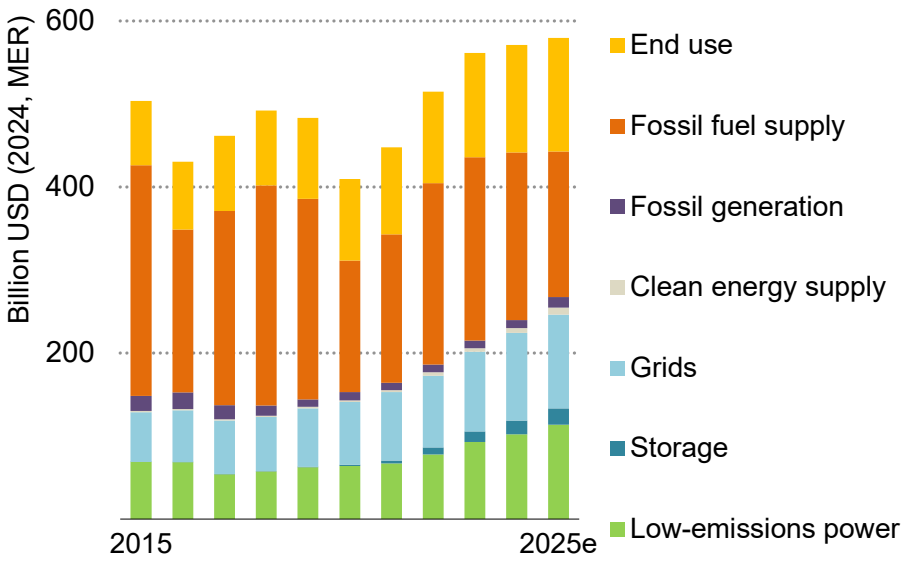
In 2024 it remained the world's largest producer of oil and gas (20%) and a major investor (25%), buoyed by rising investment in LNG export projects, mainly targeting Asian and European buyers. The new administration in 2025 has promised supportive policies for oil and gas extraction as part of a broader drive for US energy dominance, that encompasses supplies of uranium, coal, biofuels, geothermal heat, hydropower and critical minerals.

Between 2015 and 2024 the share of annual energy investment going to fossil fuel supply and fossil fuel-based electricity generation declined from 60% to just under 40%. Supply costs for fossil fuels have fallen over this period, but other sources of investment, notably in low-emissions power, grids and end use, have grown rapidly. New investment in manufacturing has been underpinned by competitively priced energy and assisted by policies boosting domestic competitiveness and foreign direct investment.

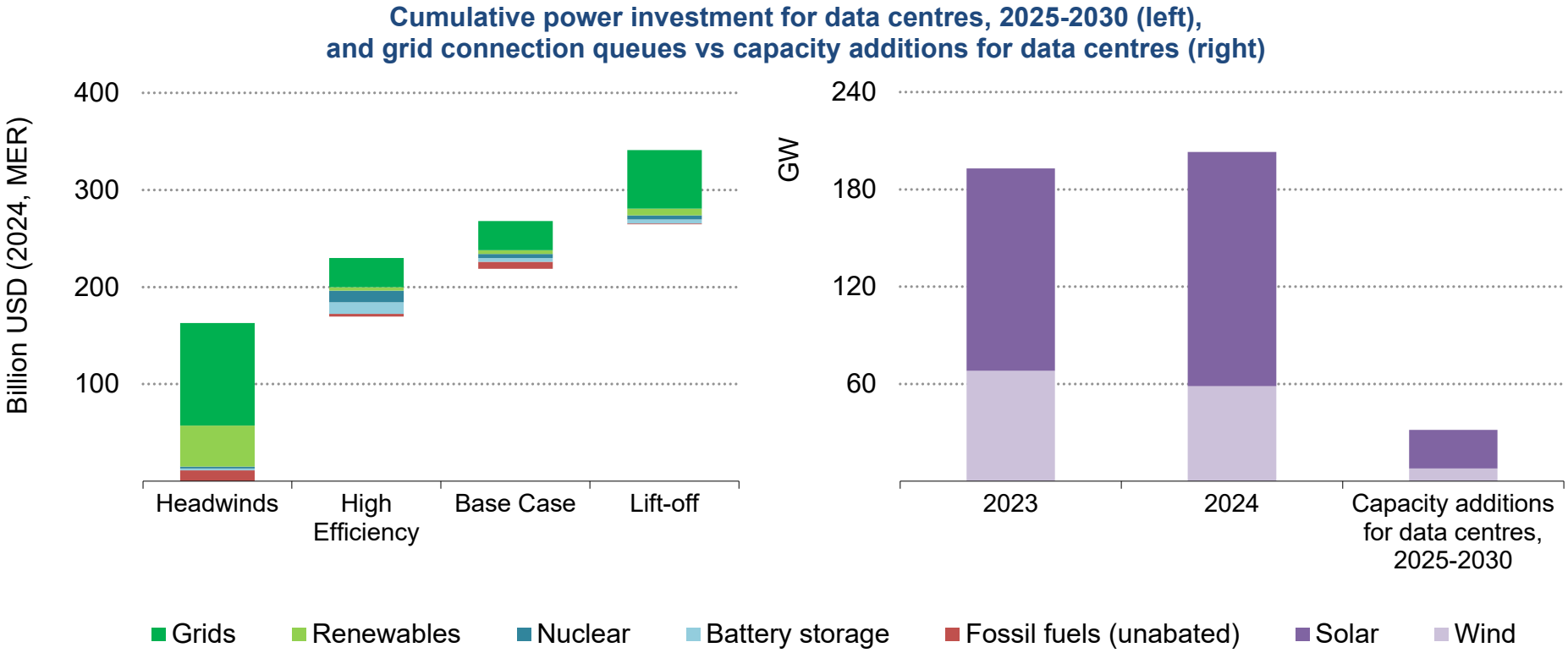
Annual investment in clean technology manufacturing grew from USD 2 billion in 2018 to USD 60 billion in 2024. The United States is now home to 8% of global lithium-ion battery production and 2024 saw solar PV module manufacturing capacity nearly triple to 42 GW.

However, the country has welcomed only one new solar cell plant since 2019, whereas imported cells, primarily originating from Southeast Asia, more than tripled in 2024. This example is reflective of the broader challenges of onshoring clean technology manufacturing and efforts to diversify global supply chains for renewables, critical minerals and battery manufacturing.

Annual energy investment in the United States, 2015-2025e



As the world leader in artificial intelligence, the United States could see additional investment worth USD 170-340 billion in generation capacity, grids and storage by 2030 for data centres



New electricity demand for data centres will require significant investment in both generation capacity and grids. However, the connection queue in the United States remains a significant bottleneck and could slow access to energy for new data centres.

Notes: See IEA (2025) Energy and AI report for scenario descriptions. Right figure captures projects in advanced stages of the grid connection application process as of Q3 2024. Only solar and wind considered given some gas-fired generation for data centres is likely to be captive power and new nuclear reactors are not expected before 2030. Some future capacity additions for data centres may already be waiting for connection and hence may not be purely additive to the queue. 2025e = estimated values for 2025.

Sources: IEA (2024), Renewables 2024, IEA (2025) Energy and AI Report.

The AI-led acceleration in data centre investment could have far-reaching consequences for the power sector, and underscores the importance of deploying timely grid infrastructure at scale

Cumulative US data centre (DC) investment could reach over USD 2.1 trillion in the next five years, and companies are racing to secure sources of clean electricity while also delivering on their corporate decarbonisation targets. This has led to a boom in the US corporate power purchase agreement (PPA) market with technology and DC companies being responsible for procuring 86 GW of renewable capacity since 2015 to secure power for their investments and obtain renewable energy certificates.

US technology companies' ambitious plans have the potential to materially affect the power sector in various ways. DCs are creating demand for next-generation energy technologies by forming a dedicated market for small modular reactors (SMR) and advanced geothermal plants. As of Q4 2024 about 26 GW of nuclear – mostly SMR – and 265 MW of advanced geothermal agreements have been reached between US technology companies and developers. This has been enabled by deep financial markets and a domestic venture capital ecosystem, which have helped drive early-stage growth of new technology developers such as TerraPower, X Energy, Fervo Energy and many others. Given its long history with nuclear power, as well as technology and workforce spillovers from its oil and gas sector, the US could emerge as a leader for these technologies with DCs creating a domestic market for innovation and commercialisation.

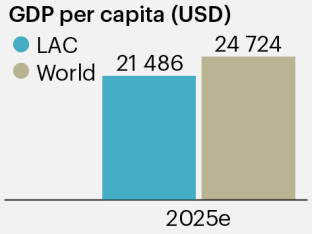
Surging DC investment also has the potential to exacerbate existing challenges relating to grids. Over 90% of DC operators now cite power availability as their top concern and nearly half place upgrading grid infrastructure as the most important mitigator. New grid infrastructure often takes between 5 and 15 years from planning to completion compared with 3 to 6 years for a DC. In 2024 the wait time for a grid connection was 1 to 3 years (up to 7 years in DC hotspots) with 205 GW of advanced-stage solar and wind waiting.

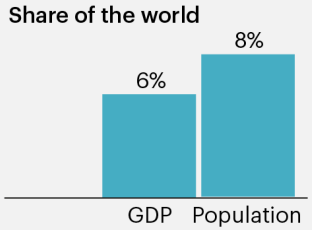
In the Base Case from our recent IEA report on Energy and AI, DCs account for nearly 10% of the country's electricity demand by 2030, up from 4% today. This would require over USD 16 billion of new investment in grids, and could intensify strains on supply chains for electrical equipment, transformers in particular. Suppliers have been unable to keep up with new demand, leading to wait times as long as six years for utility-scale transformers, and prices subsequently increased by 26% in 2024. Three sensitivity cases (Lift-Off, High Efficiency and Headwinds) capture uncertainties in AI uptake, efficiency improvements in hardware and software, and energy sector bottlenecks. Our analysis emphasises that the success of recent grid reforms may prove critical to enable the growth of this strategically important industry.

Latin America and the Caribbean

Key statistics for Latin America and the Caribbean

Economic and financial indicators





Sovereign debt rating
CCC to A+

Debt to GDP ratio
26% to 155%

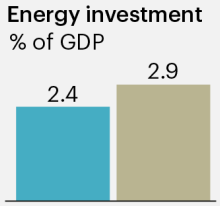
Change in 10-year government bond yield since 2020
+271 bps to +837 bps

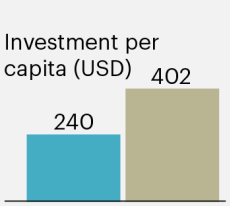
Currency value against USD (2015-2025)
5.4% to -99%

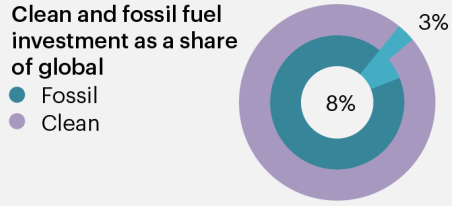
Country risk premium
0.8% to 23%

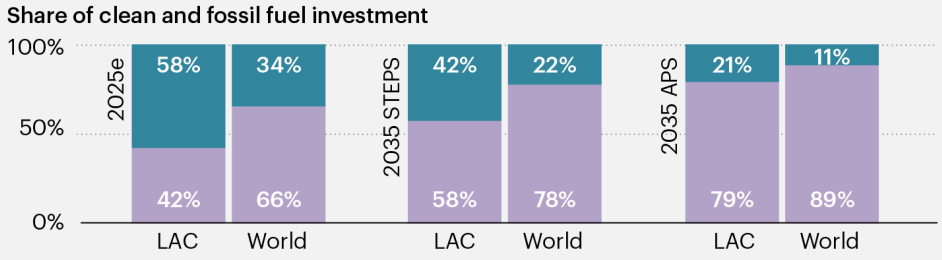
Countries with NZE commitments
32%

Energy investment indicators

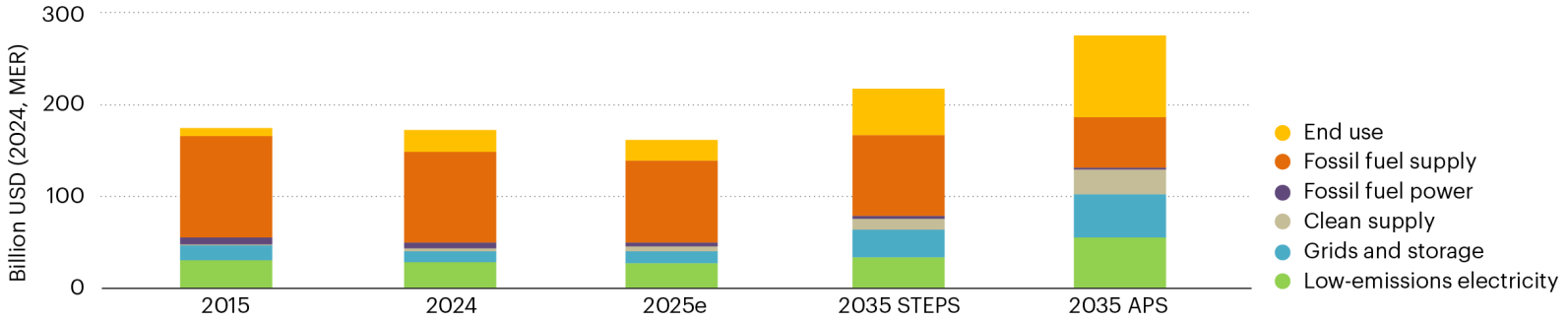








Energy investment trends



Notes: LAC = Latin America and the Caribbean; Change in 10-year government bond yield compares bond yield for Peru (+271 bps between January 2020 and March 2025) and Brazil (+837bps between January 2020 and February 2025); Currency data for Venezuela is omitted from analysis on currency depreciation; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

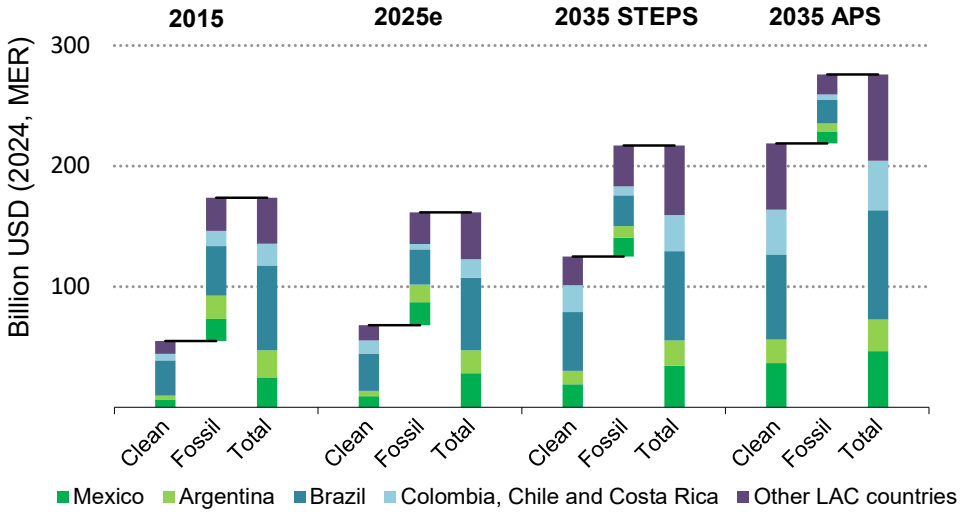
Clean energy investment in Latin America has grown by nearly 25% in the past decade, highlighting regional progress despite diverse country contexts and transition pathways

The economic landscape varies significantly across Latin America, with similar diversity in the political and energy arenas (e.g. net exporting vs net importing countries). This context is further reflected in changes in currency valuation against the US dollar since 2015, which range between -99% and +5.4%, and contrasts in sovereign debt ratings between CCC and A+.

Between 2015 and 2025 regional GDP has grown by 15%, driven mainly by Mexico, Colombia, Chile and Costa Rica, which experienced increases of between 10% and 40%. Over the same period, clean energy investment increased by nearly 25%, reaching USD 70 billion in 2025, with Chile, Colombia and Costa Rica accounting for the largest increase, given the doubling of renewable investment flowing into the three countries. Brazil played a significant role in building momentum behind clean energy investment thanks to the country's enabling environment for investment in solar PV, wind and bioenergy, further accelerated by the enactment of the Future Fuel Law in 2024.

Over the same time horizon, fossil fuel investment has decreased by more than 20%, to over USD 90 billion a year, with Brazil, Argentina and Mexico accounting for almost 70% of this investment. In the STEPS, total energy investment by 2035 increases by around USD 55 billion from 2025, with lower fossil fuel investment offset by an increase in clean energy investment. An even greater shift in investment trends is needed to align with the APS, including significant additional spending on renewables. In the lower fuel demand environment of the APS, fossil fuel investment experiences a decline, while clean energy investment triples from today – including an almost threefold increase in wind generation.

Total investment in LAC selected countries, 2015-2035



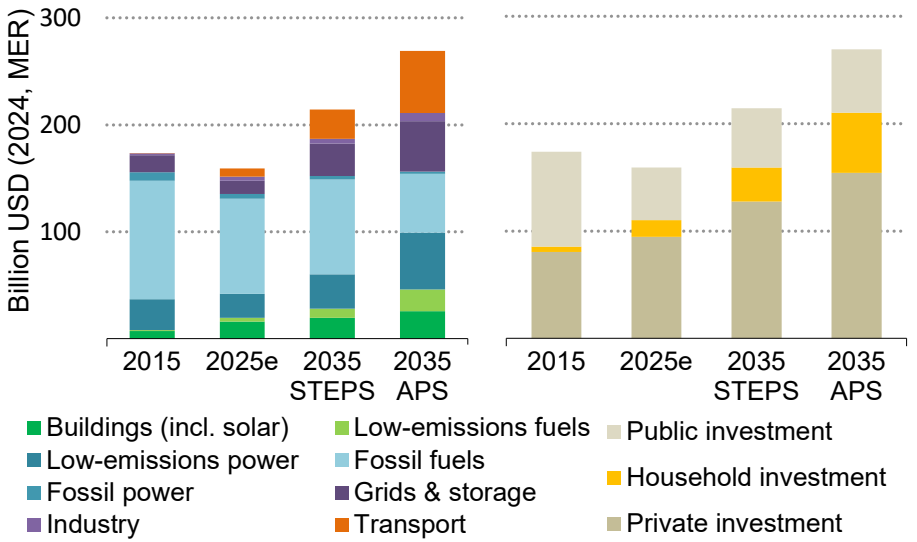
Latin America needs to more than double grid investment over the next decade to support growth in electricity demand and ensure resilience against extreme weather events

As in many other countries and regions, the resilience of grid infrastructure is a crucial variable for Latin America's energy future, particularly given the increasing intensity and frequency of extreme weather conditions. The rise in weather-related incidents, which disproportionately affect the most vulnerable households, combined with the projected annual increase in regional electricity demand of 3% to 2050 under the STEPS, underscores the need for enhanced investment and policies to diversify energy resources and establish a reliable and interconnected transmission grid.

An integrated electricity network, such as SIEPAC (Central American Electrical Interconnection System), enhances resilience by spreading the risks and impacts of extreme weather events. In support of the creation of SIEPAC, the International Development Bank provided USD 170 million in ordinary and soft loans to power utilities and USD 70 million in concessional finance.

Brazil has implemented almost 350 independent power transmission (IPT) projects, whereby the private sector wins the right to build, own and operate a transmission line. Brazil auctioned over 10 500 km of transmission line rights in 2024, securing nearly USD 4 billion at a 40% discount to the maximum price the regulator was willing to pay. Peru and Chile have also implemented IPTs, with the Peruvian government awarding 14 projects worth over USD 2 billion and Chile tendering over 20 projects valued at over USD 900 million. By 2035, in the STEPS, annual investment in grids needs to more than double to USD 30 billion, with almost USD 20 billion expected from the private sector. Under the APS, investment reaches USD 47 billion. For every dollar of public finance, an estimated USD 4 is mobilised from the private sector.

Historical and projected capital investment by sector (left) and source (right) in LAC, 2015-2035

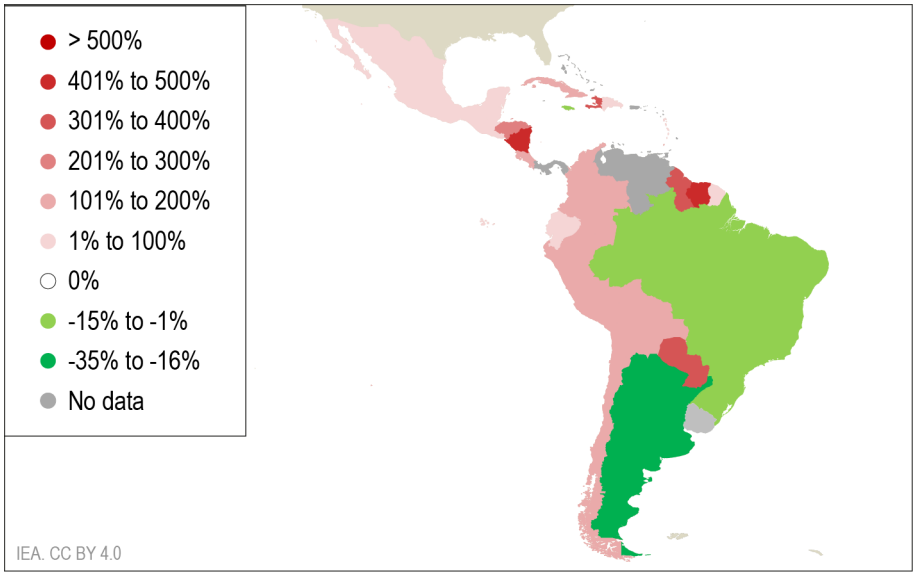


Despite growing investment, Latin America only accounts for 5% of global clean energy investment from private finance due to high costs and limited capital markets

Addressing investment and financing challenges in Latin America will be essential for the region's infrastructure development and the prospects for energy transitions. As things stand, Latin America only accounts for 5% of privately financed global investment in clean energy. This reflects several constraints, including high interest rates that governments have introduced to contain inflationary pressures, which deter the financing of capital-intensive clean energy projects. This is also reflected in the lack of long-term finance, with average sovereign debt maturity of 4-6 years in Honduras, Trinidad and Tobago, Venezuela and Bolivia, and an overall increase in public debt servicing costs. These have increased fivefold over the past ten years in Nicaragua and Suriname, while Brazil and Mexico alone account for more than USD 55 billion dollars per year in debt servicing compared to nearly USD 90 billion in total energy investment.

The region's market capitalisation to GDP ratio is around 36%, compared to 65% in OECD countries. Private investment is mostly concentrated in larger businesses, with development banks playing a crucial role in financing. The region has made strides in Green, Social, Sustainable and other labelled bonds (GSS+) debt issuance, surpassing a cumulative total of USD 250 billion by the end of 2024, led by Chile, Mexico and Brazil. The region successfully issued USD 20 billion in green and sustainable bonds in 2024. Main issuers include Brazil, Mexico, Chile and Colombia, while the Dominican Republic issued its first green bond of USD 750 million in 2024, achieving a rate of 6.70%, 15 basis points lower than non-thematic financing instruments.

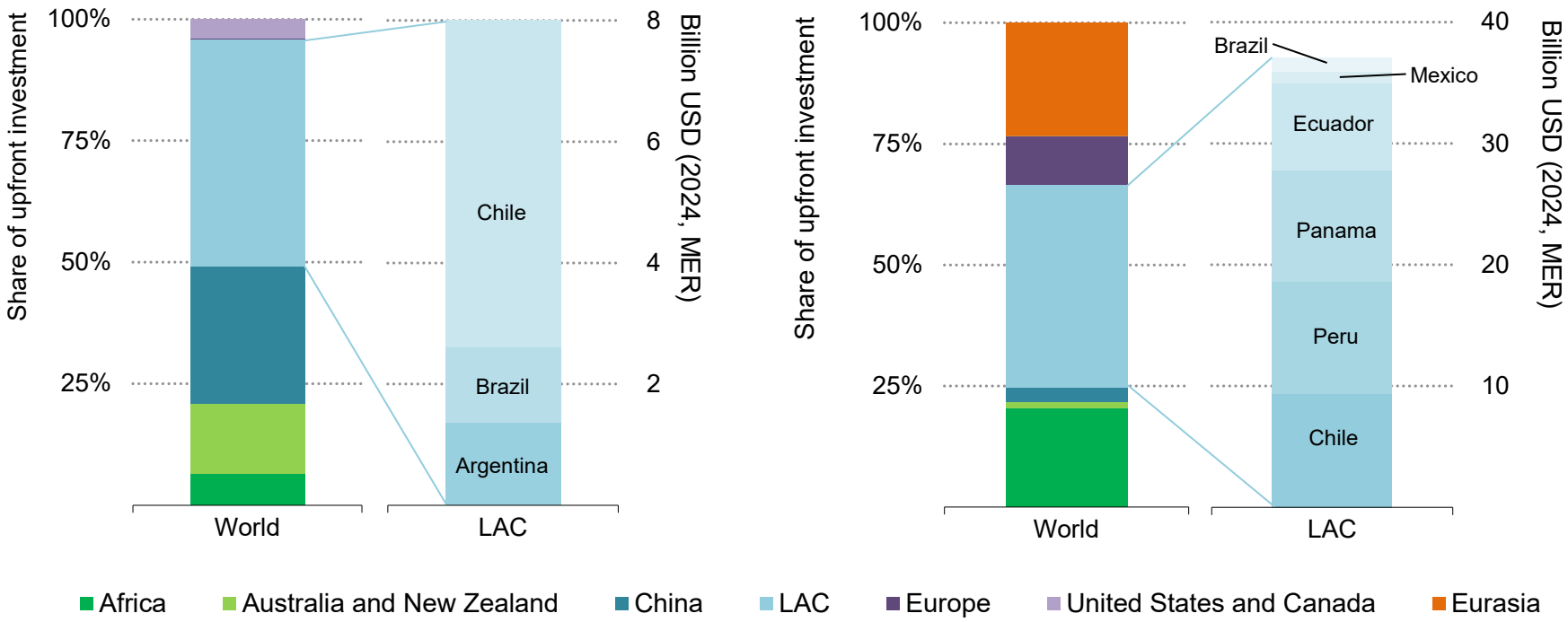
Increase in public debt service in LAC, 2015-2025



Sources: IEA analysis based on World Bank (2024) International Debt Statistics, and for Chile, Ex-Ante (2024), Database.

Latin America ploughed more than USD 45 billion in upfront investment into greenfield mining between 2015 and 2024; however, higher investment is required to move up the value chain

Share of upfront investment and total regional investment in mining of lithium (left) and copper (right), 2015-2024



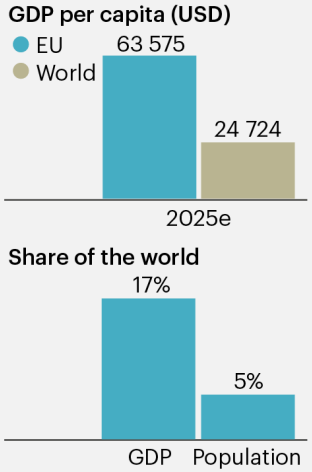
Investment can help enhance the value chain. Argentina's Y-TEC inaugurated the region's first lithium battery cell factory, valued at USD 770 million. Meanwhile, Peru and Mexico are exploring investments in copper smelters to reduce reliance on offshore processing.

Notes: Upfront investment in the past ten years is calculated from the increase in production and the capital cost. Due to historical investment, Chile remains the main producer of copper.

European Union

Key statistics for the European Union

Economic and financial indicators



Sovereign debt rating
BBB- to AAA

Debt to GDP ratio
19% to 169%

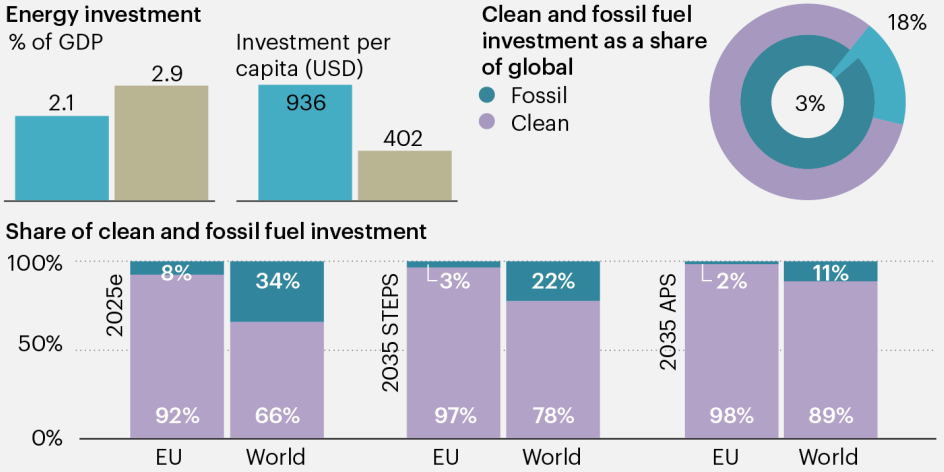
Change in 10-year government bond yield since 2020
+317 bps

Currency value against USD (2015-2025)
-15.0%

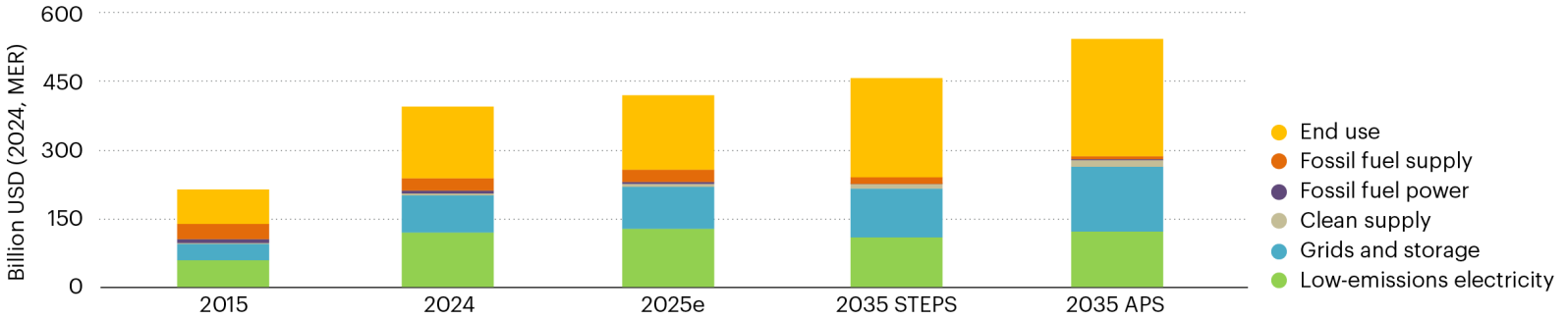
Country risk premium
0.0% to 3.3%

NZE commitments
2050

Energy investment indicators



Energy investment trends

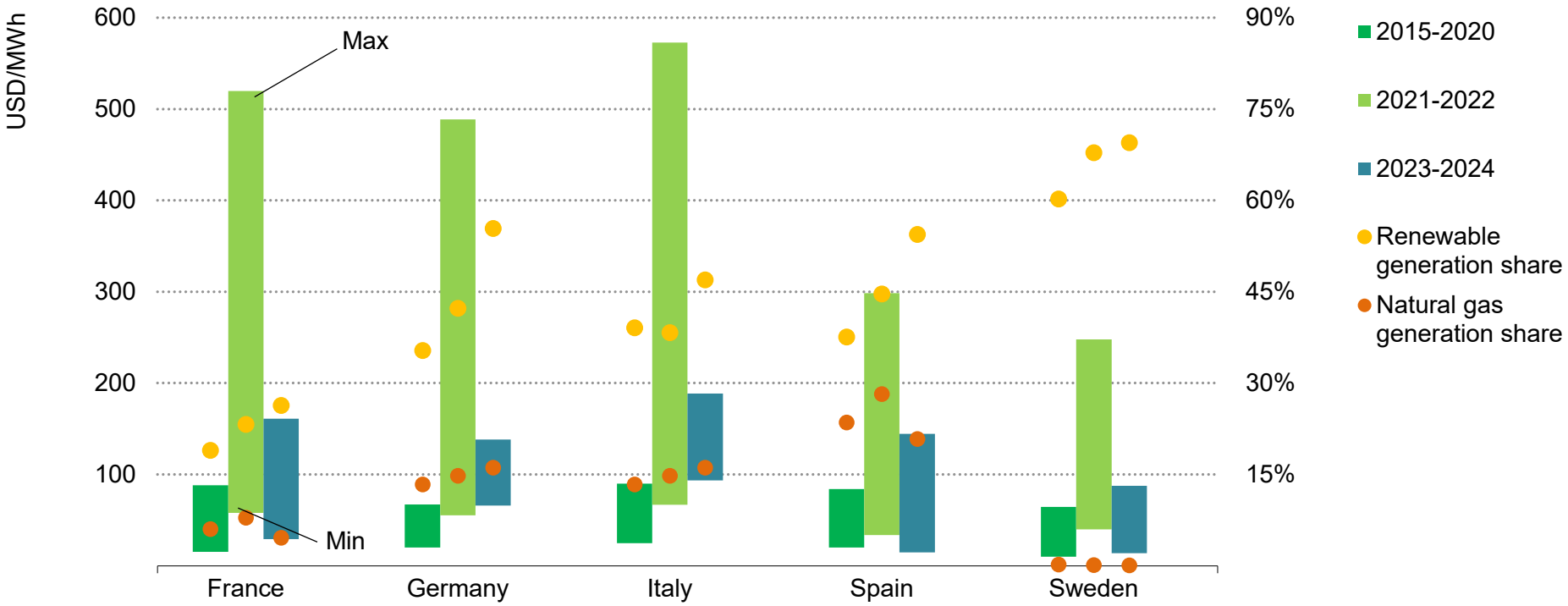


Notes: EU = European Union; Change in 10-year government bond yield compares bond yield for the European Union between January 2020 and March 2025; EUR is used for the currency value against USD; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

After natural gas-driven spikes in electricity prices during the energy crisis, EU electricity prices have fallen; efficient investment in renewables and grids can bring them down further

Spread of wholesale electricity prices in selected EU countries and generation share, 2015-2024



Increased use of low-emissions electricity coupled with enhanced investment in grids and storage is central to the EU's energy security and climate goals.

Source: Ember (2025), European wholesale electricity prices - monthly.

Energy investment in the European Union has shifted over the past decade to low-emissions generation as a means of ensuring the region's energy security

Over the past decade the European Union has increased its commitment to clean energy, with investment reaching almost USD 390 billion in 2025, the third-largest globally. In 2015 the investment ratio of renewable generation to unabated fossil fuel power was 6:1; in 2025 this ratio is close to 35:1. Investment in low-emissions electricity has been driven by the global energy crisis that followed Russia's invasion of Ukraine, subsequent favourable policy incentives and the declining cost of renewable technologies.

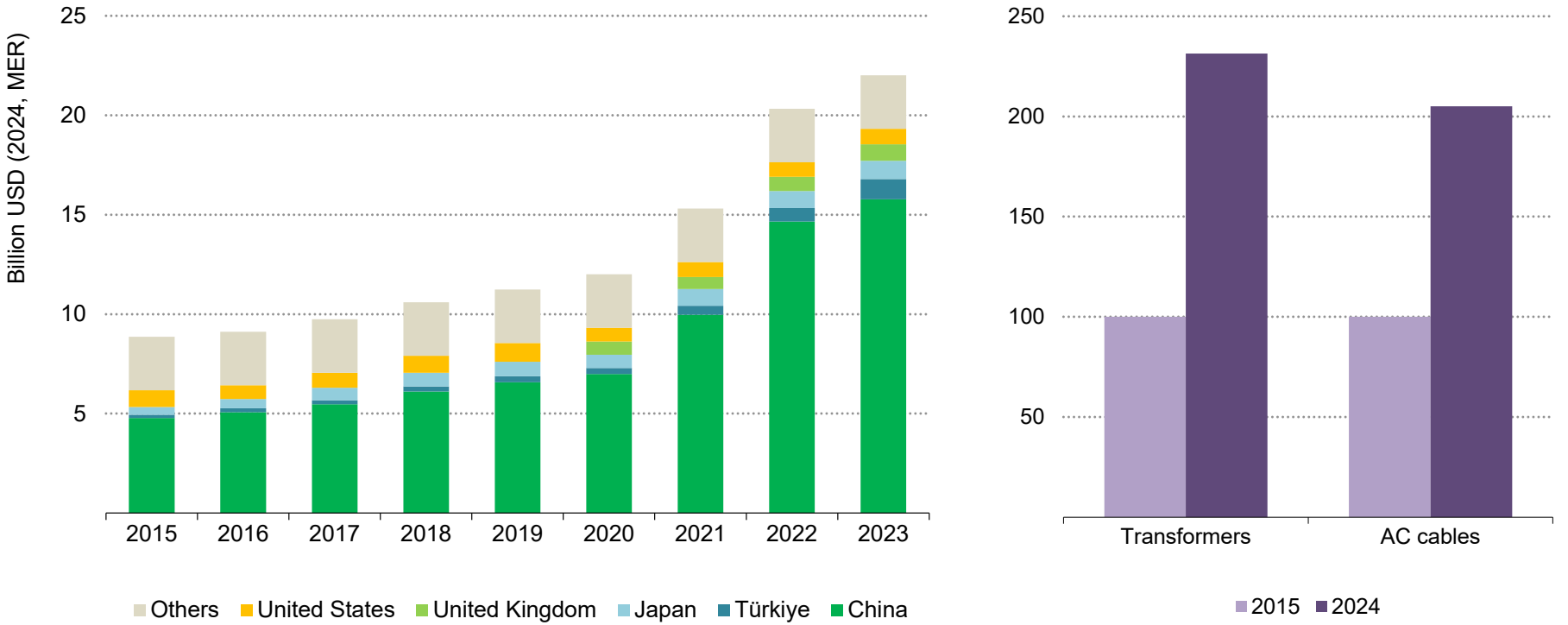
Since 2015 prices for solar PV have decreased by more than 50% for rooftop PV and about 40% for utility-scale, making them a cost-effective option, with investment reaching close to USD 95 billion in 2024. Renewables generated 50% of EU electricity in 2024, while fossil fuels accounted for just over 25%, nearly half their share a decade ago. Investment in buildings energy efficiency has nearly doubled over the past decade to USD 100 billion, and the region is a leader in sustainable debt issuance for green buildings. Investment in the buildings sector increases to over USD 160 billion by 2030 to align with the APS, that achieves the COP28 commitment to double the pace of global energy efficiency improvements.

Clean energy investment has been a bright spot for Europe, but obstacles remain that have affected project implementation, including surging costs, higher interest rates and supply chain issues. For instance, Denmark's recent offshore wind power tenders failed to attract any bids, and other auctions were under-subscribed as developers found that the business case resulting from certain auction designs was unattractive in a high-inflation environment, either because ceiling prices were too low or contracts offered were not indexed to inflation. The European Union faces further challenges from supply chain constraints on grid components and electricity price divergence across member states. In response, it has strategically shifted emphasis toward industrial competitiveness, affordability and supply chain resilience, reflected in the February 2025 Clean Industrial Deal.

The 2022 Russian invasion of Ukraine sharply reduced Russian gas exports to the European Union, leading to a supply crisis and driving prices to record highs. In response, aside from ramping up support for renewables and energy efficiency, EU countries have also diversified gas supplies, notably by increasing LNG imports from the United States. This has contributed to a stabilisation in prices, but prices remain elevated compared to pre-crisis levels. Looking ahead, the European Union continues to navigate the complexities of reducing gas dependency while ensuring energy security.

Supply chain constraints on grid components could hinder progress, as EU component prices have more than doubled over the past decade

Trade value of EU transformer imports, 2015-2023 (left), and EU transformer and cable price indexes, 2015 and 2024 (right)



The trade in transformers is becoming increasingly important for the European Union, particularly due to its growing dependence on Chinese imports, which now account for over 60% of the total.

Notes: In right graph 2015 = 100. AC = alternating current.

Sources: United Nations Comtrade (2024), UN Comtrade Database, IEA Survey (2024).

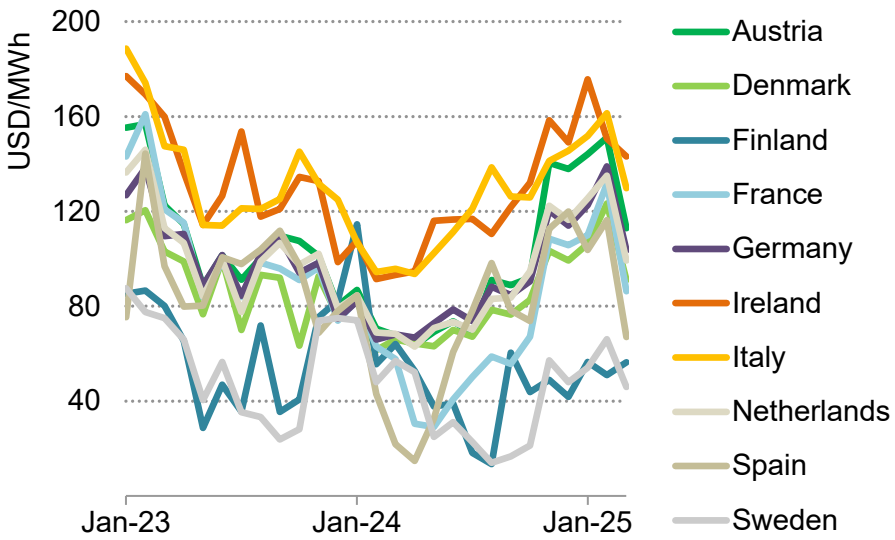
Grid investment holds the key to EU price convergence and market stability

To get the most out of its investments in renewable energy, the European Union now faces the challenge of deeper market integration. Despite significant investment in low-emissions technologies, average energy prices in Europe are higher than in other major economies. Affordable energy, energy efficiency and a well-integrated and connected energy system are key for Europe's competitiveness.

Investment in grids is set to grow to more than USD 70 billion in 2025 with annual spending now double the amount from a decade ago. More effort is going into digitalising the distribution grid, improving efficiency and helping with the adaptation to variable resources. However, investment in grid infrastructure has not kept pace with low-emissions generation expansion, leading to inefficiencies such as long connection queues and an inability to transmit cheap renewable electricity from the southern parts of the European Union to high-demand areas.

The EU energy market has experienced notable disparities in spot prices among member states. As EU market prices rose in 2024, Spain experienced near-zero and even negative spot prices, resulting in the curtailment of renewable energy sources. These fluctuations are largely attributed to the rapid expansion of renewable energy without corresponding upgrades in storage and grid infrastructure. In April 2024 11% of variable renewable output was curtailed in Ireland due to insufficient capacity to transport or store electricity when demand was low. The volatility in electricity prices underscores the need for a more integrated energy system and substantial investment in grid infrastructure and storage. This should encompass the planning and delivery of projects, streamlined permitting, increased digitalisation and improved visibility on the need for various supply chain components.

EU wholesale electricity prices, 2023-2025 Q1



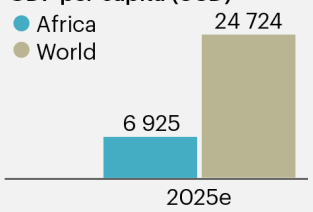
Source: Ember (2025), European wholesale electricity prices - monthly.

Africa

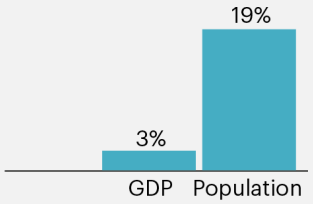
Key statistics for Africa

Economic and financial indicators

GDP per capita (USD)



Share of the world



Sovereign debt rating
SD to BBB+

Debt to GDP ratio
14% to 252%

Change in 10-year government bond yield since 2020
-1 256 bps to +166 bps

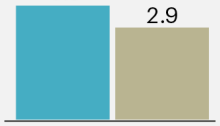
Currency value against USD (2015-2025)
0% to -99%

Country risk premium
1.6% to 13%

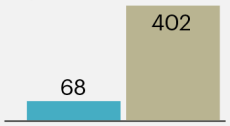
Countries with NZE commitments
26%

Energy investment indicators

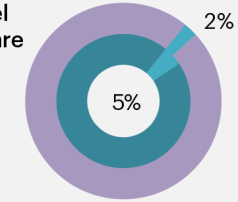
Energy investment
% of GDP



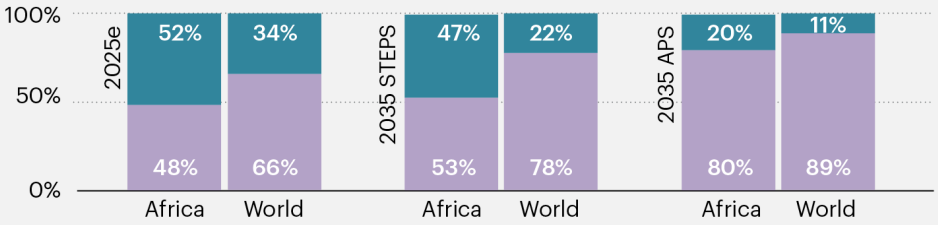
Investment per capita (USD)



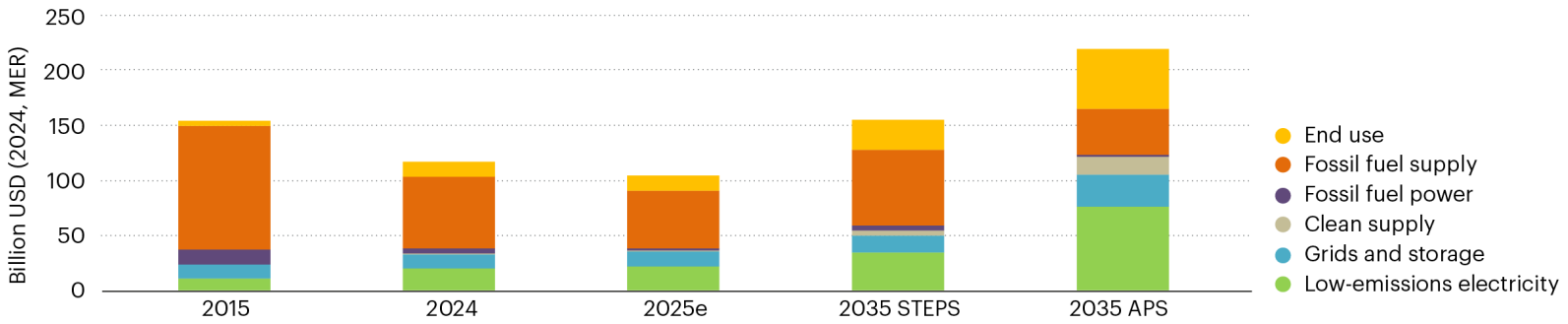
Clean and fossil fuel investment as a share of global



Share of clean and fossil fuel investment



Energy investment trends

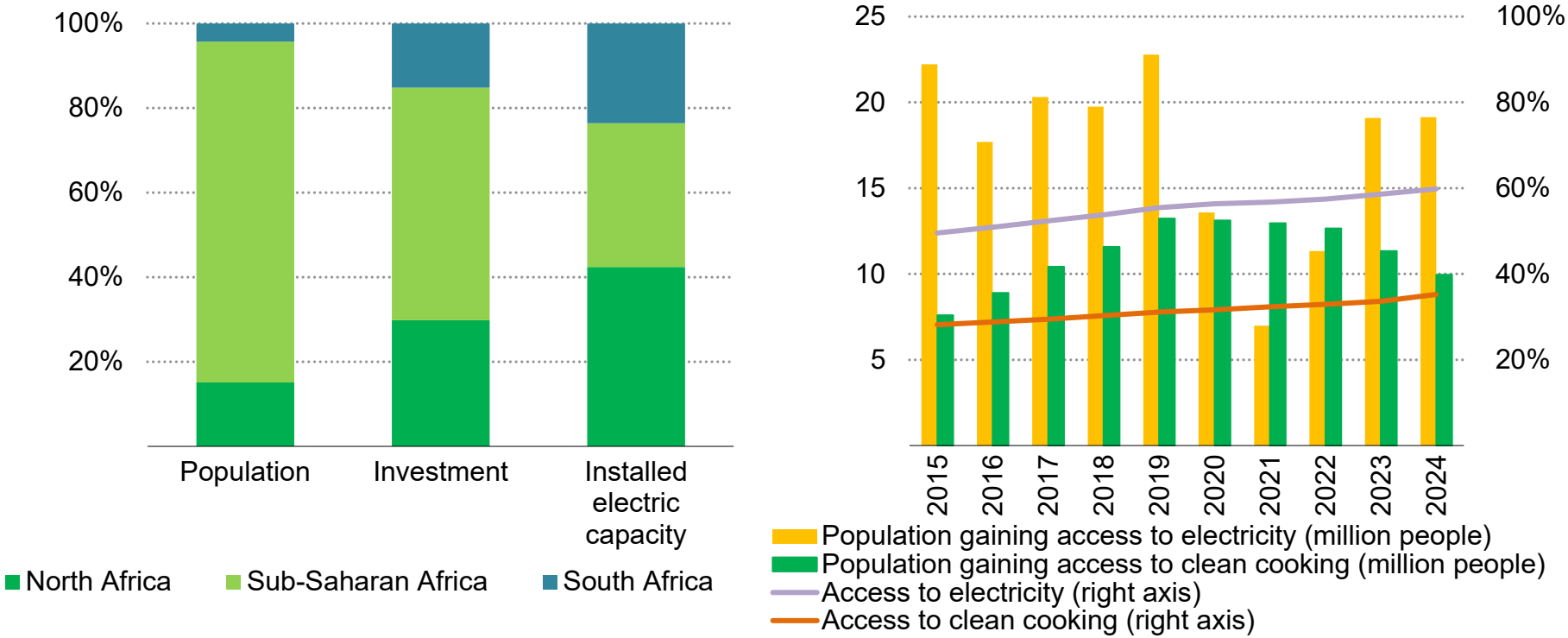


Notes: Change in 10-year government bond yield compares bond yield for Zambia (-1256bps between January 2020 and March 2025) and South Africa (+166bps between January 2020 and January 2024); SD = selective default; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025) and Trading Economics (2025), Government Bond Yields

Regional imbalances in the continent's energy sector remain, with 600 million people lacking access to electricity and nearly one billion people without clean cooking in sub-Saharan Africa

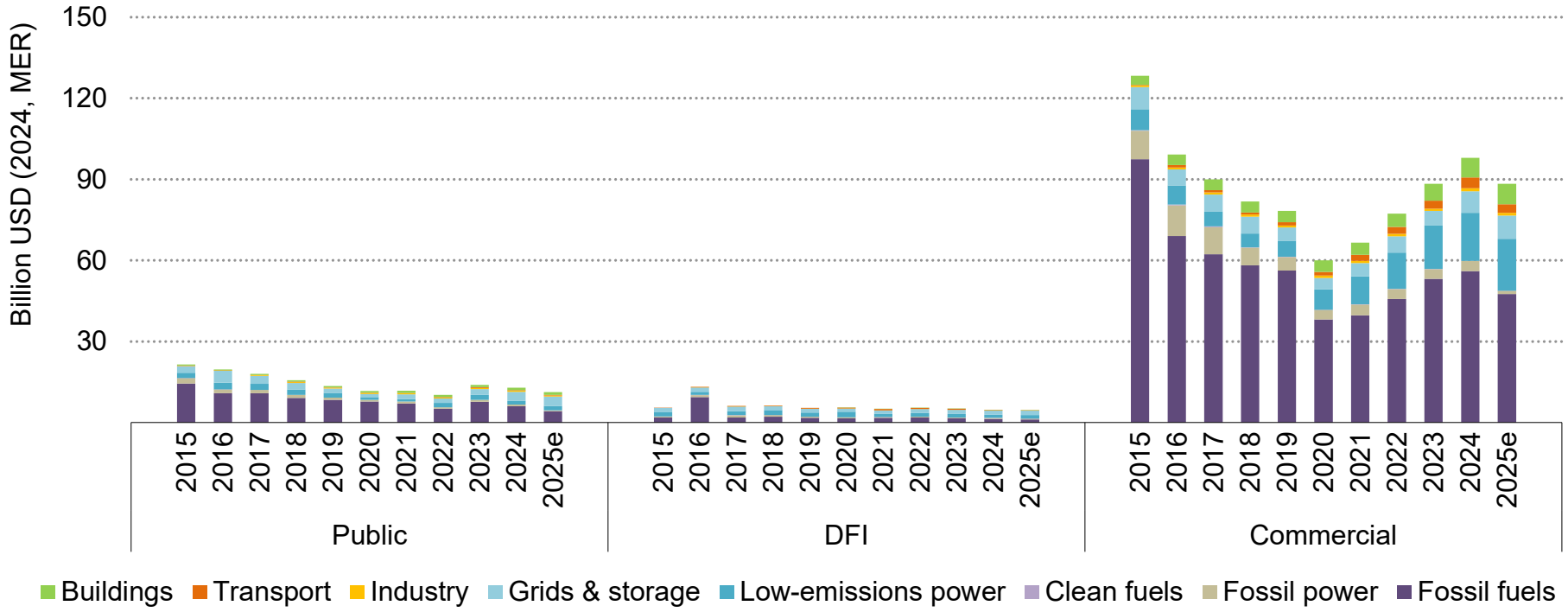
Key metrics by region, 2025e (left), and energy access rates in Africa, 2015-2025e (right)



Installed capacity and investment flows in sub-Saharan Africa are still comparatively low given the region's size. New connection rates have steadily increased over the past decade but remain well below the universal access target set for 2030.

Lower investment levels are linked to a slowdown in both fossil fuel and Chinese DFI spending, but private clean energy investment has more than doubled over the last five years

Investment by sector and finance provider in Africa, 2015-2025e



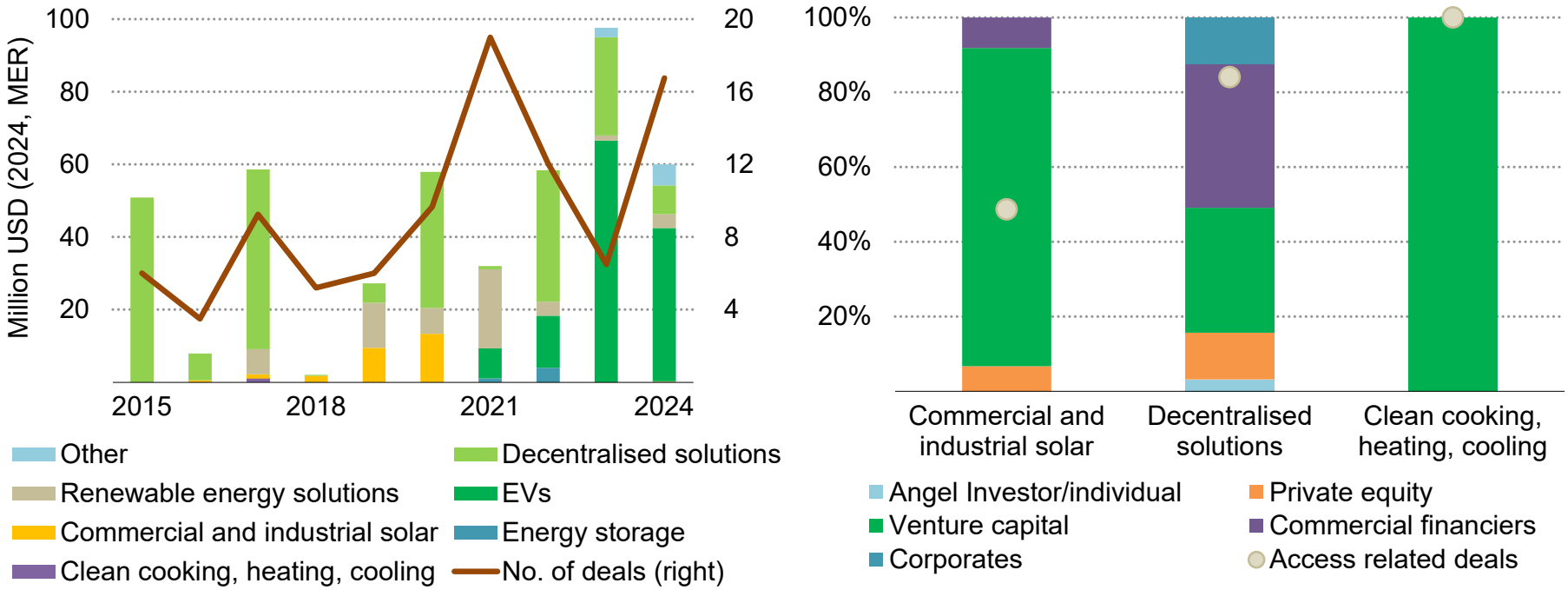
While fossil fuels account for 70% of total spending, private sector interest in renewable power, supported by derisking capital from DFIs, has helped drive up clean energy investment.

Notes: DFI = development finance institutions; 2025e = estimated values for 2025.

Sources: IEA analysis based on data from S&P Capital IQ (2025), IJGlobal (2025), Rystad (2025), World Bank (2025) PPI, OECD (2025) CRS.

Private equity and venture capital are key sources of capital for smaller-scale and early-stage investments, such as in energy access, but spending can be volatile

Private venture capital in early- and growth-stage deals by sector, 2015-2024 (left) and within energy access, 2015-2024 (right) in Africa



Over the past decade, risk-tolerant capital providers have predominantly funded early- and growth-stage start-ups active in off-grid solar and EVs, signalling appetite for decentralised and clean energy solutions.

Notes: EVs = electric vehicles. Decentralised solutions cover mini-grids, solar home systems, and supporting services. Commercial financiers include commercial banks and family office investment funds. Renewable energy solutions cover deals in renewable power, wind, biogases, biorefining, grid optimisation and hardware. Other covers energy efficiency, industry, and carbon capture, utilisation and storage.

Source: IEA analysis based on Cleantech Group (2025).

Africa is faced with new challenges and opportunities as the composition and source of investment flows in the continent shift

Over the past decade roughly half of energy investment in Africa has been in oil and gas, primarily made by private companies with a view to export. After the oil price declines in 2014-15, spending in this area fell back, although it has rebounded somewhat since 2021 with major developments in Senegal, Mauritania, Namibia and Mozambique.

Meanwhile, spending on clean energy remained relatively flat at less than USD 30 billion per year up until 2021. Since then, growth has intensified, driven by low-emissions power, which accounted for about 40% of clean energy investment in 2024. As global technology cost reductions have improved the competitiveness of solar, it now represents the least-cost source of power in many African countries. This improved competitive landscape has also led to a more than doubling of private sector clean energy investment, rising from around USD 17 billion in 2019 to almost USD 40 billion in 2024.

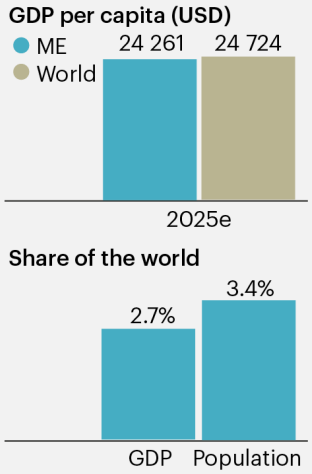
Public and DFI funding for energy projects in Africa has fallen by approximately one-third over the past decade, from USD 28 billion in 2015 to USD 20 billion in 2024. This was largely due to a reduction in spending by Chinese DFIs, which declined by over 85% between 2015 and 2021. While representing a small share of overall spending, the public sector and DFIs are particularly important for projects in nascent markets, using new technologies or in commercially unviable areas. For example, sub-Saharan Africa includes 32 least developed countries (LDCs) and is home to almost all the households without access to energy in the continent. Both LDCs and many of the poorer communities without access can be challenging for private sector investment and rely on concessional funds to ensure affordability.

Against this backdrop, private equity and venture capital play a key role in financing early-stage businesses, especially in energy access, given their ability to invest in smaller-scale, higher-growth companies. Over the past decade, 40% of the private investment into early- and growth- stage energy access start-ups has been provided by dedicated venture capital firms – the group that often take on the highest risk. Meanwhile, private equity funds, who tend to invest in larger deals, have mainly focused on decentralised energy solutions, which have proven business models. However, the average size of deals in the off-grid solar sector remains quite small at USD 7 million. Due to concerns about profitability, both venture capital and private equity firms have begun directing attention away from pure-play residential energy access. Instead, there has been a move towards nascent areas such as EVs, where spending reached almost USD 70 million in 2023, an eightfold increase since 2021, and commercial and industrial solar companies where offtake is considered less risky than residential consumers.

Middle East

Key statistics for the Middle East

Economic and financial indicators



Sovereign debt rating
SD to AA

Debt to GDP ratio
3.2% to 123%

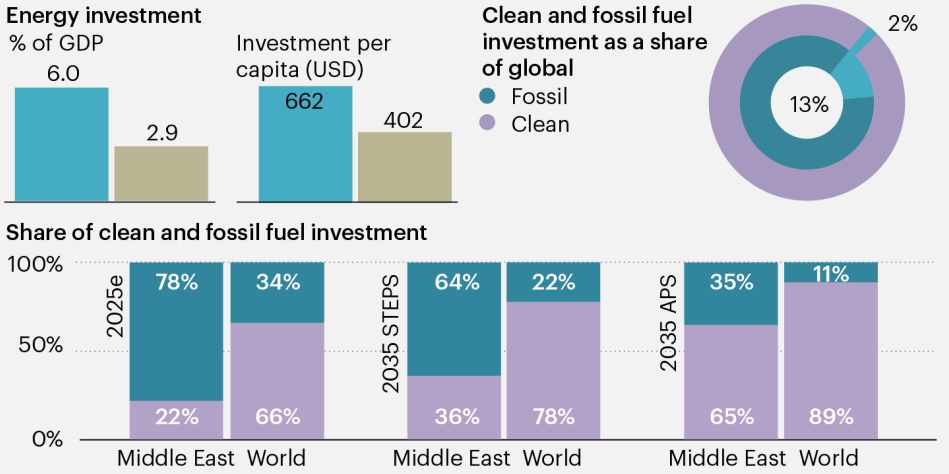
Change in 10-year government bond yield since 2020
No data

Currency value against USD (2015-2025)
0% to -98%

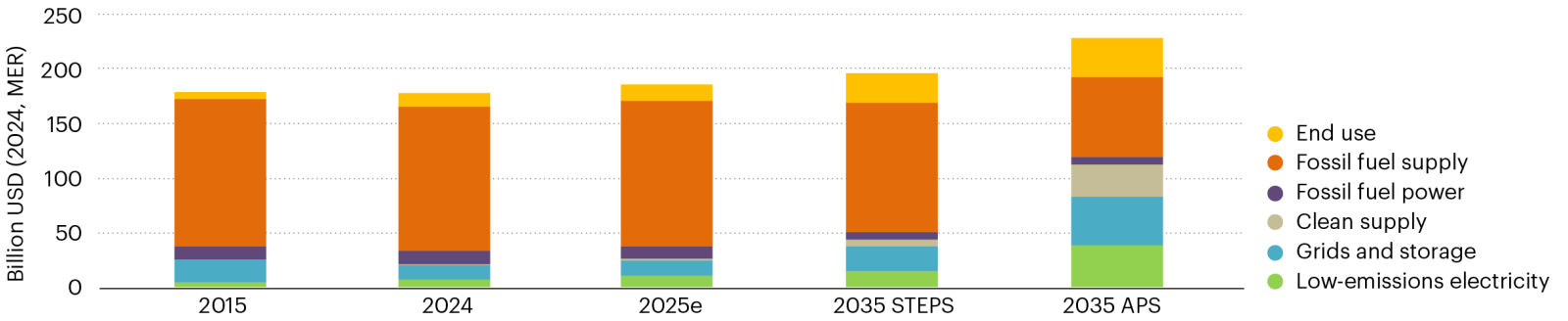
Country risk premium
0.7% to 24%

Countries with NZE commitments
17%

Energy investment indicators



Energy investment trends



Notes: ME = Middle East; There is no data on government bond yields; The currencies of Jordan, Saudi Arabia, Qatar and the United Arab Emirates are pegged to USD; SD = selective default; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025)

The Middle East is rich in a wide range of energy resources, which it is looking to develop with a mix of foreign and domestic sources of investment

The Middle East holds some of the lowest-cost oil and gas resources globally, and in 2024 provided around 30% of global oil production and 17% of global natural gas production. Saudi Arabia's upstream oil and gas investment is the highest in the region, and is set to reach about USD 40 billion in 2025, nearly 15% higher than in 2015. Overall, the Middle East is set to invest about USD 130 billion in oil and gas supply in 2025, around 15% of the global total. Middle Eastern and Asian national oil companies now account for about 40% of upstream investment, up from 25% in 2015.

Upstream oil and gas investment in Saudi Arabia and Kuwait is almost entirely sourced from their national oil companies, while Qatar, the United Arab Emirates, Oman and Iraq have seen greater proportions of foreign investment. In Qatar, domestic investment has ramped up sevenfold since 2015 with the accelerated development of the huge North Field, while foreign investment has quadrupled in the same period. In the United Arab Emirates and Oman, about 40% of upstream investment is consistently drawn from foreign sources. In Iraq, about 70% of upstream investment comes from foreign sources and is increasing with the country set to award 30 new oil and gas projects in the latest two licensing rounds.

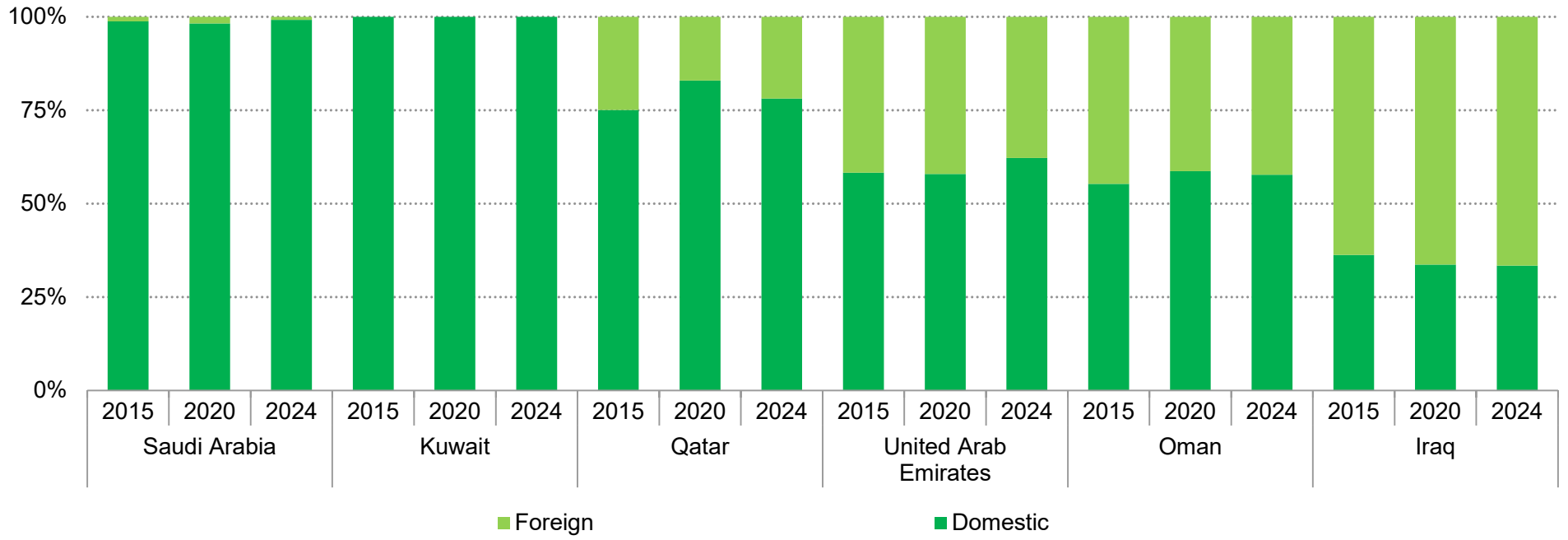
Saudi Arabia and the United Arab Emirates have also stepped up investment outside their home countries. Saudi Aramco recently acquired equity in Port Arthur LNG on the Texas coast, and also in downstream operations in the Philippines, among other examples. Some of the region's large companies, including Saudi Aramco and ADNOC, are also investing more in low-emissions fuels.

In the power sector, natural gas provides two-thirds of the region's power, and the Middle East – together with the United States – accounted for nearly half of all new natural gas-fired FIDs in 2024. The region also has growing contributions from renewables and nuclear, which have doubled their share since 2015 to reach almost 15% around in 2024. Overall clean energy investment for generation is set to amount to around USD 9 billion in 2025.

Mineral development is gaining momentum with higher domestic exploration of lithium, copper and rare earth elements, but Middle Eastern countries are also focused on leveraging their energy advantages to securing international offtake agreements and developing processing capabilities for critical minerals. Planned and announced investments in foreign mining projects by Middle Eastern companies total more than USD 20 billion, led by Saudi Arabia and the United Arab Emirates.

Foreign involvement in upstream oil and gas projects varies across the Middle East, with higher engagement in Qatar, the United Arab Emirates, Oman and Iraq

National and foreign upstream oil and gas investment by country in the Middle East, 2015-2024

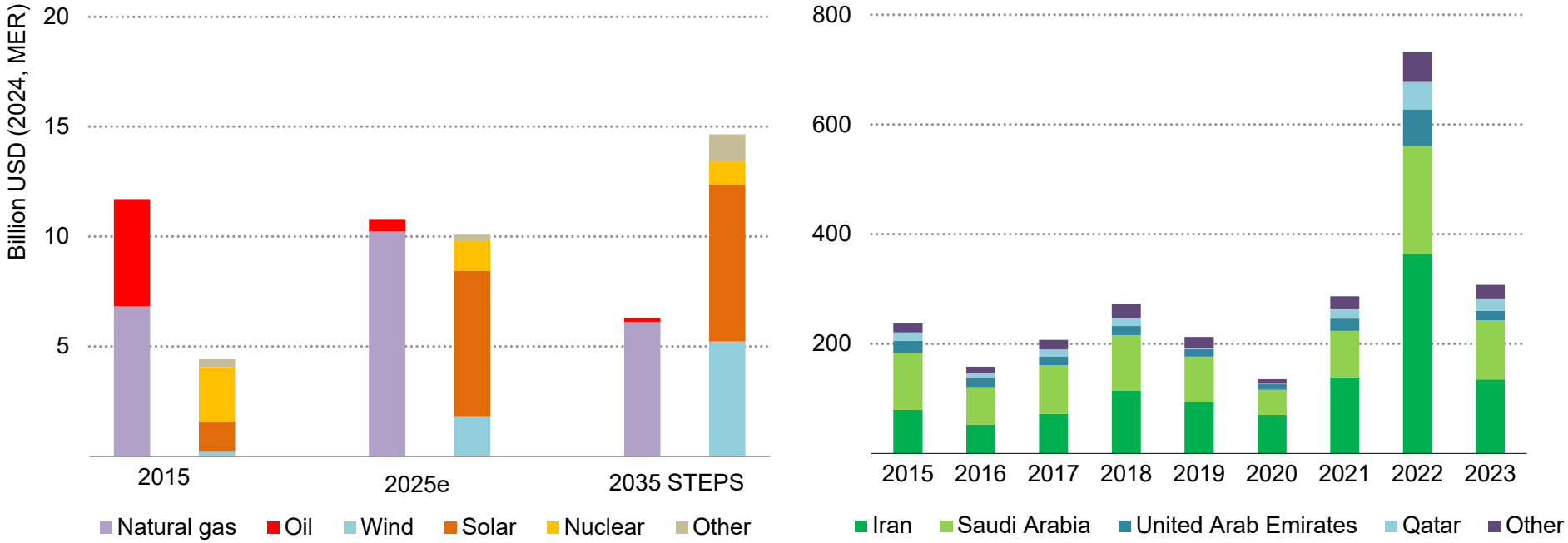


Upstream investment in the Middle East varies from 100% in-country investment in Saudi Arabia and Kuwait to less than 35% in Iraq, signalling different levels of available funding and foreign involvement in resource extraction.

Source: IEA analysis based on Rystad (2025), Rystad energy cube browser.

Low-emissions power investment has soared in the past ten years and is now close to fossil-fuelled power investment levels, yet power investment is still a fraction of fossil fuel subsidies

Investment in power generation in selected Middle Eastern countries, 2015-2035 (left) and fossil fuel subsidies, 2015-2023 (right)



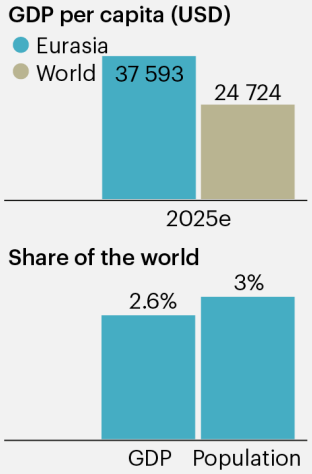
Low-emissions power investment is set to increase by 45% in the next decade, driven by wind investment, to twice the investment in fossil power. The region is also responsible for the majority of global fossil fuel subsides, which dwarf its total power investment.

Notes: Other in left chart = hydro, bioenergy and waste. Other in right chart = Bahrain, Iraq, Kuwait and Oman; 2025e = estimated values for 2025.

Eurasia

Key statistics for Eurasia

Economic and financial indicators



Sovereign debt rating
B to BBB-

Debt to GDP ratio
4.7% to 51%

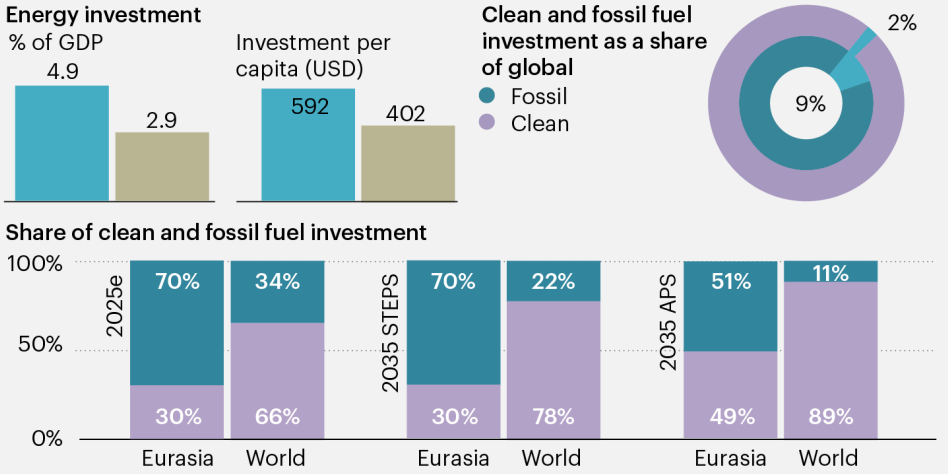
Change in 10-year government bond yield since 2020
+972 bps

Currency value against USD (2015-2025)
19% to -81%

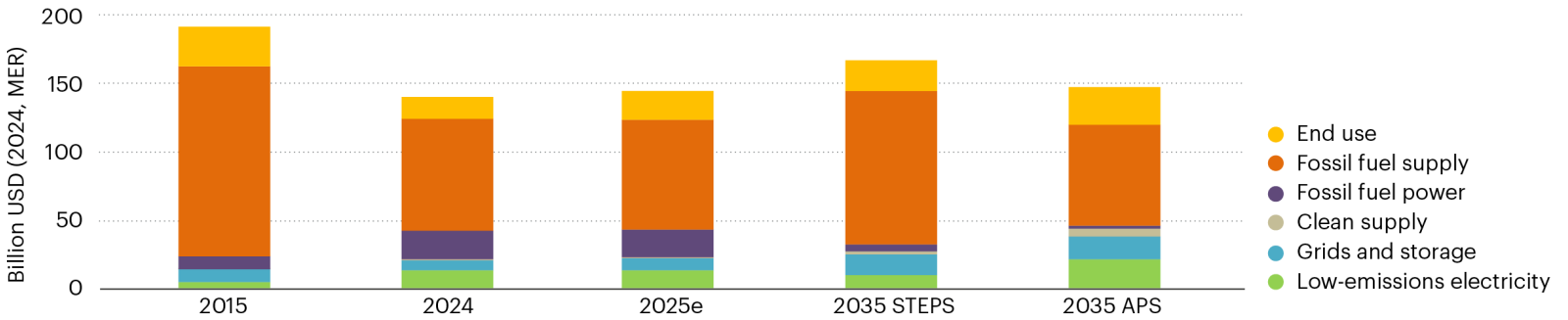
Country risk premium
2% to 9%

Countries with NZE commitments
33%

Energy investment indicators



Energy investment trends

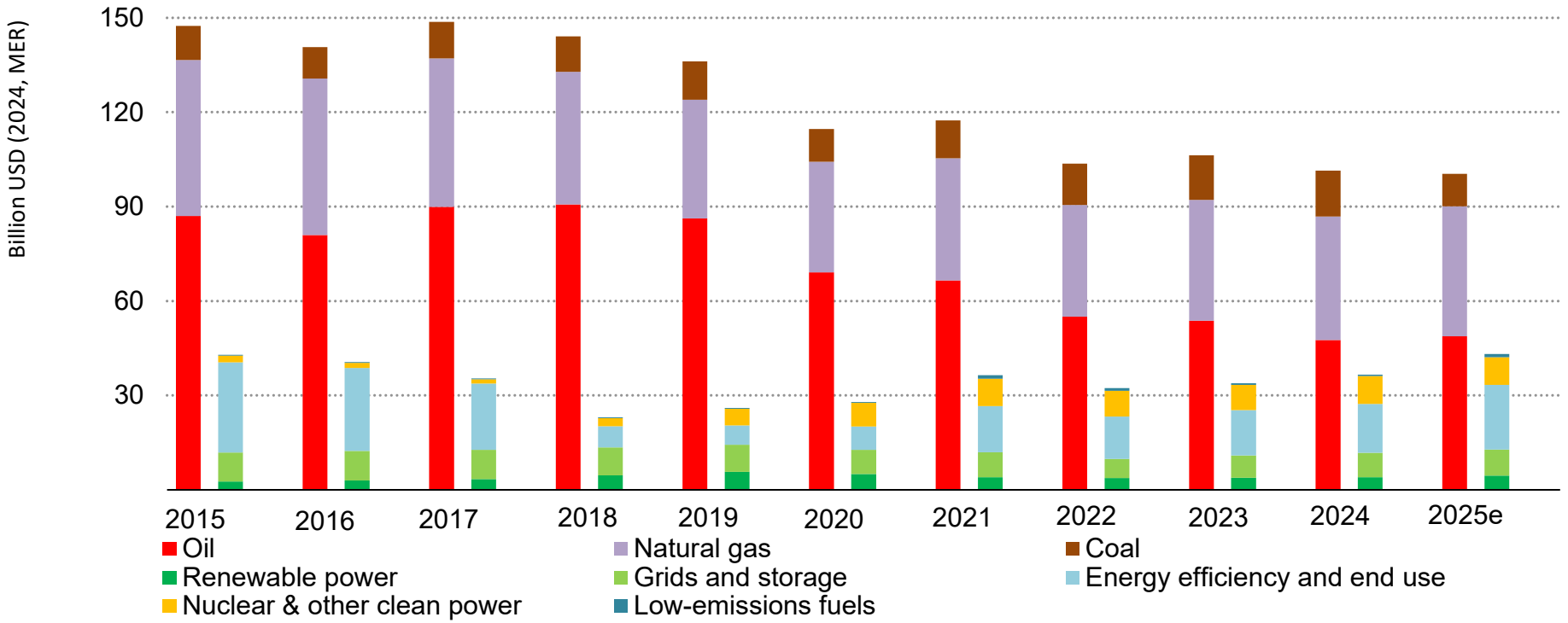


Notes: Change in 10-year government bond yield compares bond yield for Russia between January 2020 and February 2022; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

Eurasia has seen a significant decline in oil investment since 2015, although fossil fuels maintain their dominance in the region's energy mix

Energy investment by major category in Eurasia, 2015-2025e



Despite clean energy investment accounting for a smaller share of total energy investment, over the past decade investment in renewable power nearly doubled and in nuclear power it quadrupled, while grid investment decreased.

Notes: Other clean power = fossil-fuelled power with carbon capture, utilisation and storage (CCUS), hydrogen, ammonia and large-scale heat pumps. Low-emissions fuels = modern bioenergy, low-emissions H2-based fuels and CCUS associated with fossil fuels including direct air capture; 2025e = estimated values for 2025.

Lower Russian spending dampens Eurasia's oil and gas investment, while nuclear makes a comeback

Fossil fuels continue to dominate the overall energy production and investment mix in Eurasia, which includes Russia and the Caspian region. Eurasia faces some common challenges, including significant temperature swings from harsh winter conditions to warm summers, ageing infrastructure and often inefficient patterns of energy use: the energy intensity of Eurasia's GDP is around 70% higher than the global average. However, there are important distinctions to be made across a heterogeneous group of countries that have different resource endowments and national circumstances.

Annual energy investment in Eurasia was almost USD 190 billion in 2015, but has since followed a downward trend, reaching its lowest point in the past decade – around USD 135 billion – in 2022. Declining costs for oil and gas supply partly explain this trend, but it has been exacerbated by the decline in Russian spending after the invasion of Ukraine and the loss of most of its European export markets. However, investment has picked up in other markets, notably in Kazakhstan with the launch of the USD 48 billion expansion of the Tengiz oilfield, Central Asia's largest oilfield, which is operated by Tengizchevroil. This Future Growth Project was commissioned in January 2025. Investment in 2025 reaches a level similar to that of 2020, at an amount of around USD 143 billion. Under today's policy settings, investment levels are projected to rise to USD 165 billion by 2035, with approximately 70% directed toward fossil fuels.

Investment in renewables has remained low in Eurasia, despite a generally favourable resource base for wind and solar. However, there are some signs of change. Uzbekistan, for example, is looking to install more than 20 GW of renewable capacity by 2030, and there are also export-oriented initiatives under discussion for renewables-based electricity via a Green Energy Corridor (a memorandum of understanding was signed between Azerbaijan, Kazakhstan and Uzbekistan in April 2025).

The region is also an important centre for nuclear power, with Russia a leader in nuclear energy design and construction. Since 2017, 45% of the nuclear reactors under construction worldwide use Russian designs. Kazakhstan and Uzbekistan are planning their first nuclear power plants (1.2 GW and 0.33 GW, respectively), while Kyrgyzstan is considering deploying an SMR with a capacity of 110 MW. Uzbekistan signed an agreement with Rosatom in 2024 for the construction of small-scale nuclear reactors. However, Kazakhstan is exploring multiple international partnerships for its nuclear ambitions, reflecting a diversification strategy that reduces reliance on Russian technology.

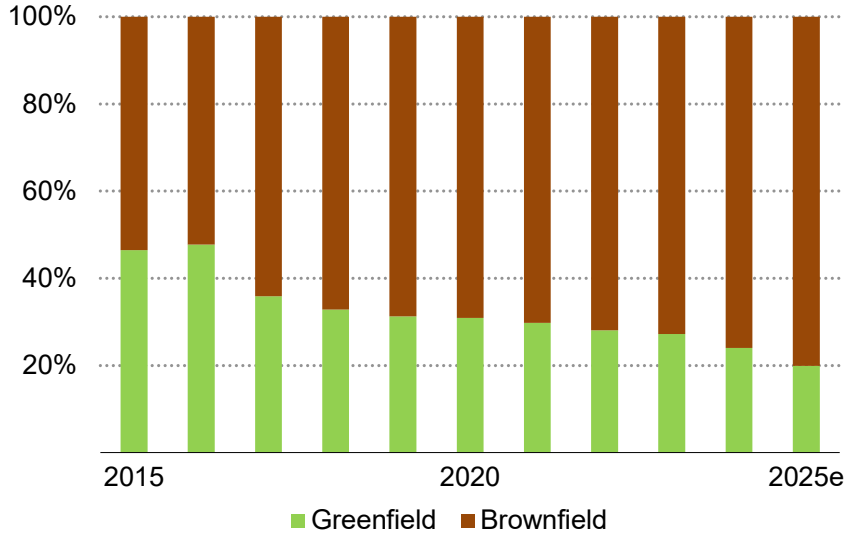
Eurasia's greenfield oil and gas capital expenditure has fallen significantly, dropping from almost half of oil and gas upstream capital expenditure in 2015 to around 20% in recent years

Despite fossil fuel investment maintaining a significant share of overall energy investment, Eurasia's upstream oil and gas investment is projected to be around USD 54 billion by 2025 – around half of 2015 levels. This decline is particularly evident in greenfield projects, where investment has fallen from around 50% in 2015 to less than 20% in 2025. Around 75% of oil and gas upstream investment in the region is made by Russia.

Low oil prices have pushed Russian companies to cut costs and focus on cheaper brownfield projects over new developments. International sanctions against Russia have significantly affected the energy sector by limiting access to advanced drilling technologies, foreign capital and technical expertise from Western companies.

Additional measures announced in January 2025 by the United States targeted Gazprom Neft and Surgutneftegas operations (2.5 million bpd combined output), 183 "shadow fleet" vessels, Russian insurance companies and LNG export facilities. The Russian oil and gas sector has proved to be quite resilient but faces multiple challenges from higher taxes and lower prices (the Russian state budget envisages Urals at just under USD 70/barrel in 2025). This prompted Rosneft to announce that it may postpone some investment plans: first production from its flagship Vostok project has been pushed back by two years to 2026 because of market conditions, sanctions, the departure of international partners, and lack of access to equipment and technology. Information about Russian energy companies is often incomplete and unreliable: most were granted presidential waivers from disclosure requirements. Nonetheless, it is clear that Russian companies have cut back on new field developments.

Oil and gas upstream capital expenditure in Eurasia, 2015-2025e



Source: IEA analysis based on Rystad (2025), Rystad energy cube browser.

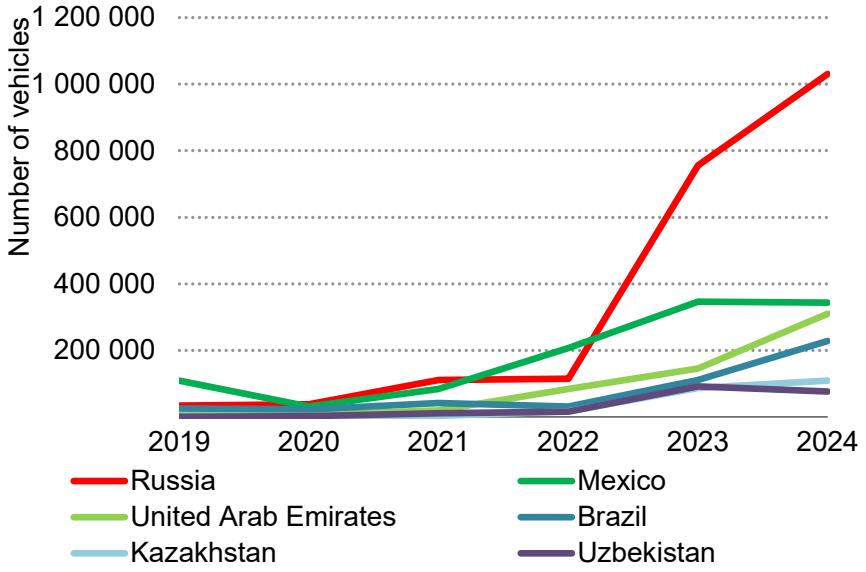
China’s car exports to Russia have skyrocketed in recent years

Russia’s full-scale invasion of Ukraine not only created turbulence on global energy markets but has also shifted regional co-operation and investment trends in the region. Given its loss of Europe as a key export market, Russia has turned towards its Central Asian neighbours. Bilateral trade between China and Russia reached a new record high of USD 245 billion in 2024, growing significantly from USD 64 billion in 2015. One of the key sectors was Russia's automotive market, in which China became a major player, benefitting from the exodus of Western car manufacturers.

In 2024 Russia became China’s largest export market for passenger vehicles, accounting for around 20% of total exports, with more than 1 million vehicles shipped to Russia. In response, Russia has increased recycling fees (akin to a tariff) on Chinese imports.

Russia’s position in Eurasia’s automotive industry is also being challenged. Chinese EV maker BYD, through its joint venture with Uzbekistan’s state-owned automaker, opened a factory in the country and began mass production in 2024. The factory aims to ramp up production to 500 000 units annually, positioning itself as a major automotive hub in Central Asia. In contrast, Russia manufactured approximately 540 000 vehicles in 2023, down by nearly 60% of its pre-2019 production levels.

China’s vehicle exports to selected countries in selected countries in Eurasia, 2019-2024

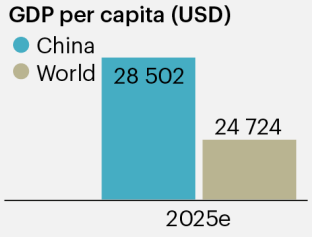


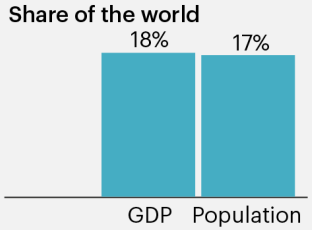
Source: IEA analysis based on General Administration of Customs of the People's Republic of China (GACC) (2025), Trade Tables.

China

Key statistics for China

Economic and financial indicators





Sovereign debt rating
A+

Debt to GDP ratio
84%

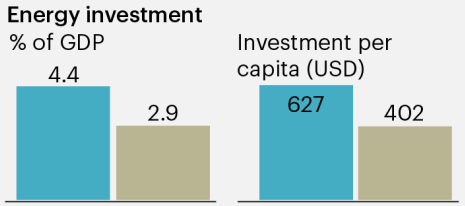
Change in 10-year government bond yield since 2020
-118 bps

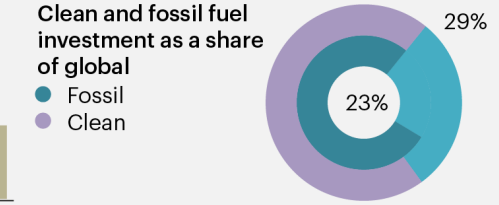
Currency value against USD (2015-2025)
-15.0%

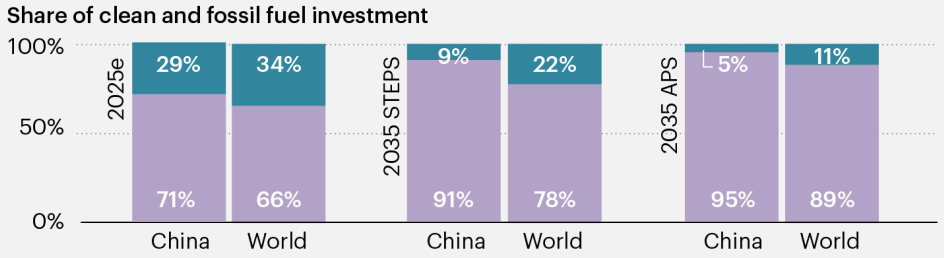
Country risk premium
0.9%

NZE commitments
2060

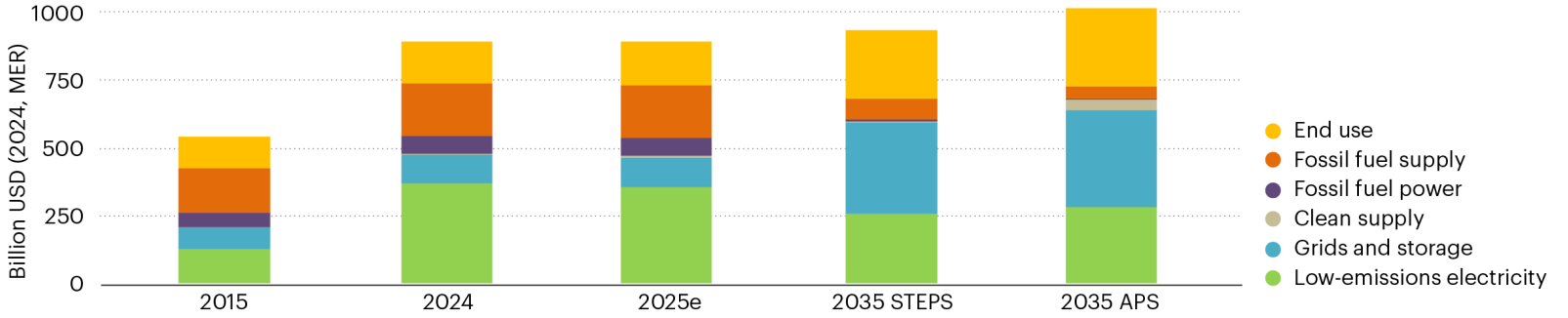
Energy investment indicators







Energy investment trends



Notes: Change in 10-year government bond yield compares bond yield between January 2020 and March 2025; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

A decade of record-breaking renewables investment in China continues, advancing in tandem with sustained spending on coal

In the ten years since the signing of the Paris Agreement and five years since the announcement of the dual carbon goals, China has seen a precipitous rise in clean energy investment, particularly in renewables. In 2024 China's clean energy investment was over USD 625 billion, almost doubling since 2015. 2024 was also a milestone year, as China achieved its 2030 wind and solar capacity target six years ahead of schedule. While renewable installations are set to continue, investment growth is expected to slow in 2025 and – in the case of solar PV, even to fall back slightly.

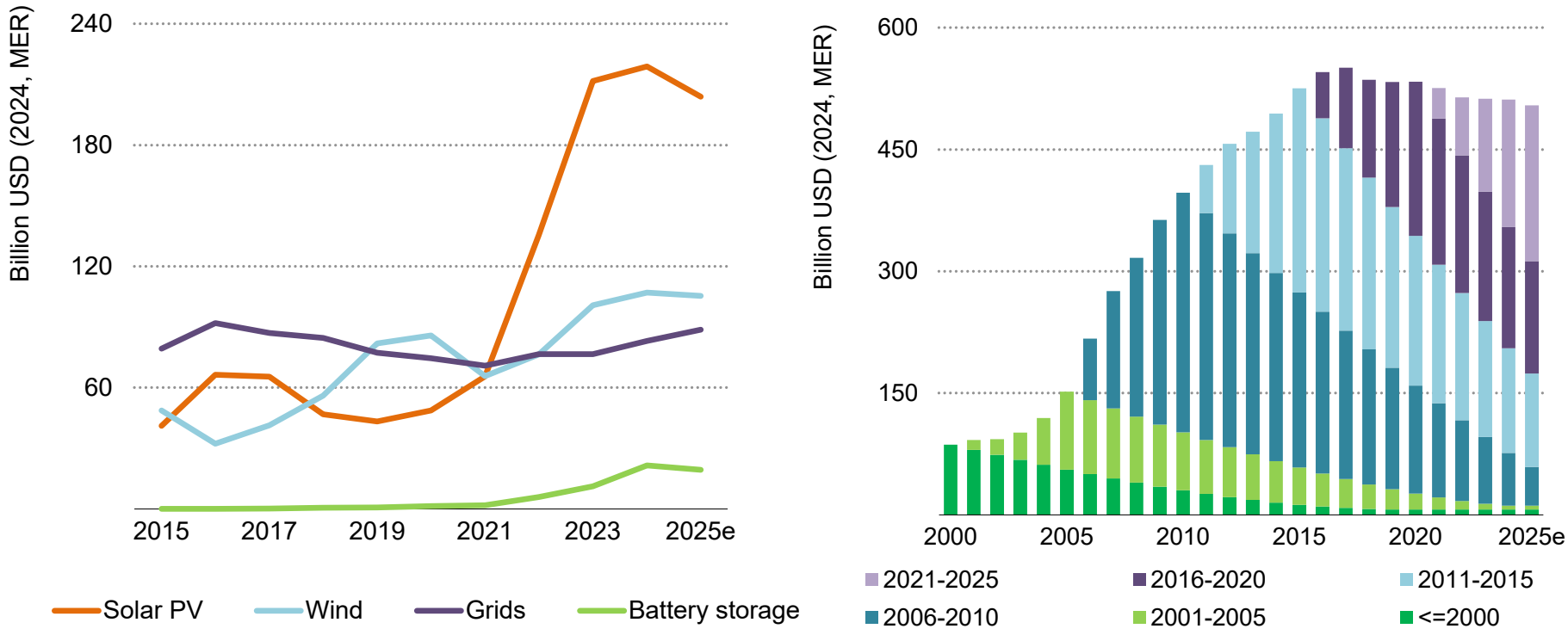
The pace of growth in renewables investment is set to be influenced by policy shifts such as a new pricing mechanism. These also reflect China's evolving macroeconomic priorities, which have long shaped its approach to energy investment. While China met its 5% GDP growth target in 2024, the economy faced mounting pressures from weak domestic consumption, deflationary risks and a deepening real estate crisis. The 2025 Government Work Report reaffirmed the 5% target, but made clear that achieving it will require substantial effort, such as strong fiscal intervention and increasing domestic consumption. Against this backdrop, energy security and reliability have become even more critical. After years of expanding energy supply, focus has shifted to ensuring that this capacity is effectively utilised and stable enough to meet new and evolving demand while sustaining industrial competitiveness. These priorities have materialised in two major investment trends.

The first is the significant push for grid, storage and smart infrastructure. Heatwaves and industrial demand spikes have exposed weaknesses in China's grid, while rapid renewable deployment has outpaced grid expansion, leading to higher curtailment rates and ineffective transmission to areas of high energy demand in the east. To address these bottlenecks, State Grid Corporation of China, which covers nearly 90% of China's power demand, has announced record high investment of CNY 600 billion (USD 83 billion) in 2024 and an additional CNY 650 billion (USD 89 billion) in 2025. While China is already allocating over USD 88 billion to transmission and distribution annually, under the STEPS this figure rises to USD 262 billion by 2035.

The second trend is the continued expansion of coal. Coal remains central to China's energy security strategy, with investment in coal power generation expected to exceed USD 54 billion in 2025. While coal generation could serve as a supplementary backup to renewables, the scale of investment points to a deeper reliance on thermal power, driven by persistent concerns over electricity security.

China’s power sector investment is surging to enhance reliability – expanding grids and storage for renewables while keeping coal in the mix, also as a source of flexibility

Investment in selected clean energy sectors in China, 2015-2025e (left), and capital yet to be recovered from historical investment in coal plants, categorised by year of investment in China, 2000-2025e (right)



Investment in transmission, distribution and battery storage has increased to integrate greater renewable capacity. Coal power plants are the primary source of electricity, providing flexibility, and account for more than USD 500 billion of capital yet to be recovered in 2025.

Notes: 2025e = estimated values for 2025.

China is ushering in a new era of energy investment, fostering increased private sector participation in key domestic projects

China's energy investment has traditionally been dominated by state-owned enterprises and characterised by large-scale infrastructure projects backed by government financing. Projects of relevance to energy security and the energy transition have in recent years been incorporated within the two types of major projects of strategic importance – one focused on infrastructure development and the centred on critical resource management and security. These projects, known for their dual focus on economic resilience and national security, have been prioritised as part of broader efforts to stabilise investment, with around USD 120 billion allocated in 2025.

However, the landscape in China is beginning to shift. In recent years the government has increasingly encouraged greater private sector participation in energy development. As part of its evolving strategy, China has explicitly encouraged the involvement of private enterprises in the energy sector beyond the fields of export-oriented clean energy manufacturing into areas of more strategic domestic importance, such as nuclear power, new energy storage and even into upstream oil and gas and mining. The Chinese government has facilitated private participation in more than 8 000 recommended projects in 2024.

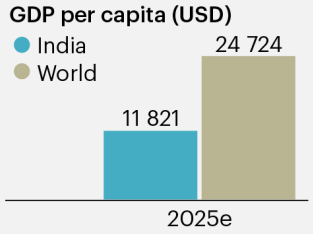
One significant example of this shift is in China's nuclear power sector, a critical pillar of the country's energy security. For years, nuclear projects in China were controlled by a few state-owned enterprises with local governments taking on minority roles. However, in 2024 China approved five new nuclear projects that introduced private capital into the sector for the first time, with private enterprises allowed to hold up to 10% equity. This move demonstrates China's willingness to allow private sector involvement to complement the state's traditional role as a financier and operator.

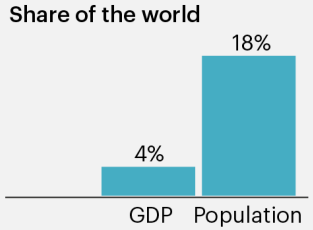
Globally, the energy transition requires significant private investment, and China is aligning with this trend by gradually opening up strategic sectors to private participation. In April 2025 the National Energy Administration introduced new measures to support private firms across a wide range of areas – from renewables and storage to digitalisation and traditionally state-dominated infrastructure, such as hydropower and transmission. While the state continues to lead in core energy investments, its evolving role as a facilitator reflects a longer-term shift towards a more diverse and dynamic investment environment – one in which private capital plays a growing role in advancing China's green and secure energy future.

India

Key statistics for India

Economic and financial indicators





Sovereign debt rating
BBB-

Debt to GDP ratio
83%

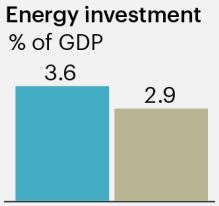
Change in 10-year government bond yield since 2020
+58 bps

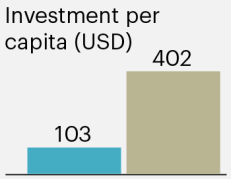
Currency value against USD (2015-2025)
-26.0%

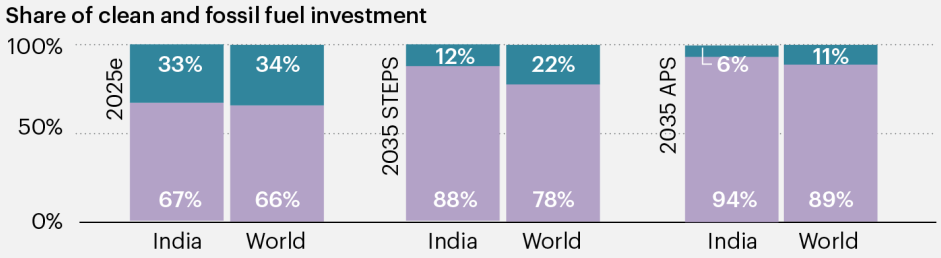
Country risk premium
2.9%

NZE commitments
2070

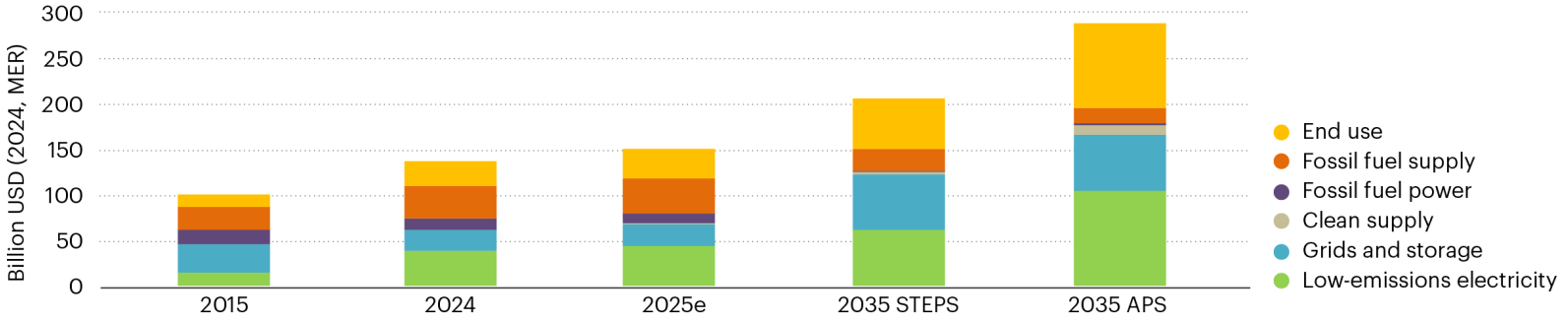
Energy investment indicators







Energy investment trends

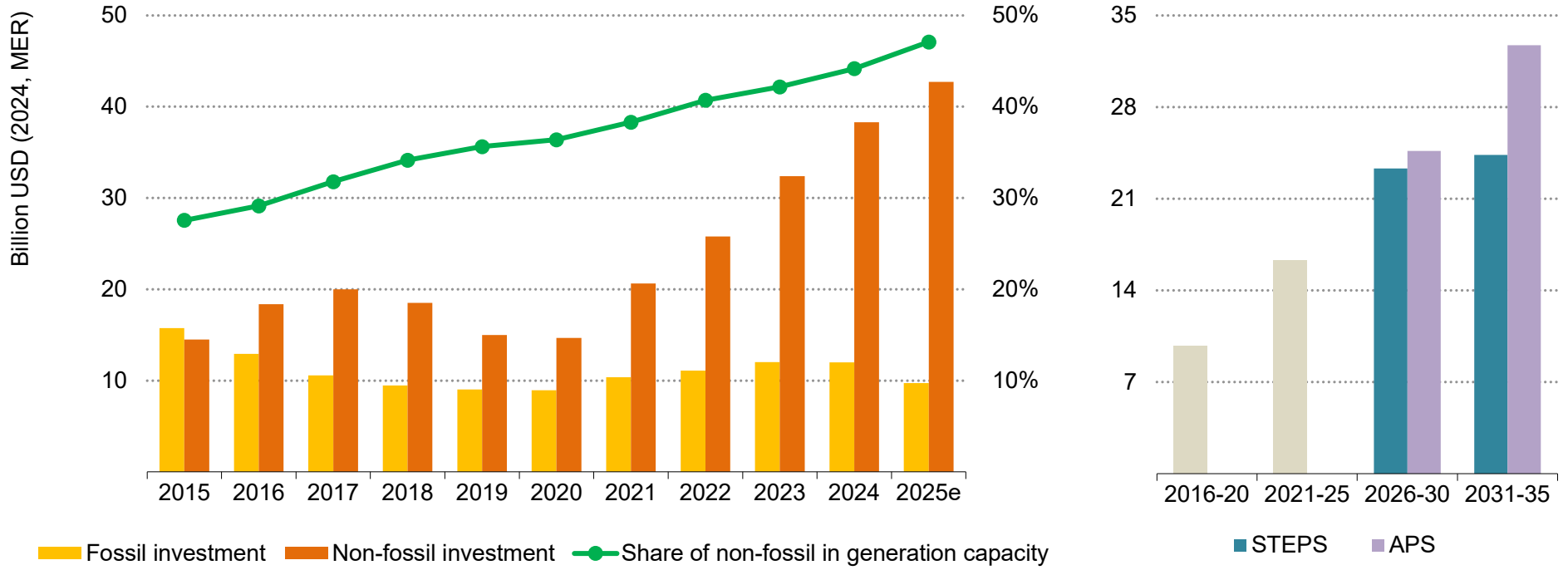


Notes: Change in 10-year government bond yield compares bond yield between January 2020 and December 2024; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

India is on track for 50% of its power generation capacity to be from non-fossil sources, ahead of its target year of 2030, on the back of surging solar PV investment

Investment in power generation capacity in India, 2015-2025e (left), and annual average solar PV investment in India, 2016-2035 (right)



Solar PV investment has accounted for over half of non-fossil power generation capacity investment in recent years. To stay on track with India's net zero by 2070 ambition, India would need USD 1.3 trillion in cumulative investment in clean power to 2035.

Notes: 2025e = estimated values for 2025

As a part of a broader strategy to meet sharply rising electricity demand, India is working to diversify its power generation mix by promoting investment in renewables and nuclear

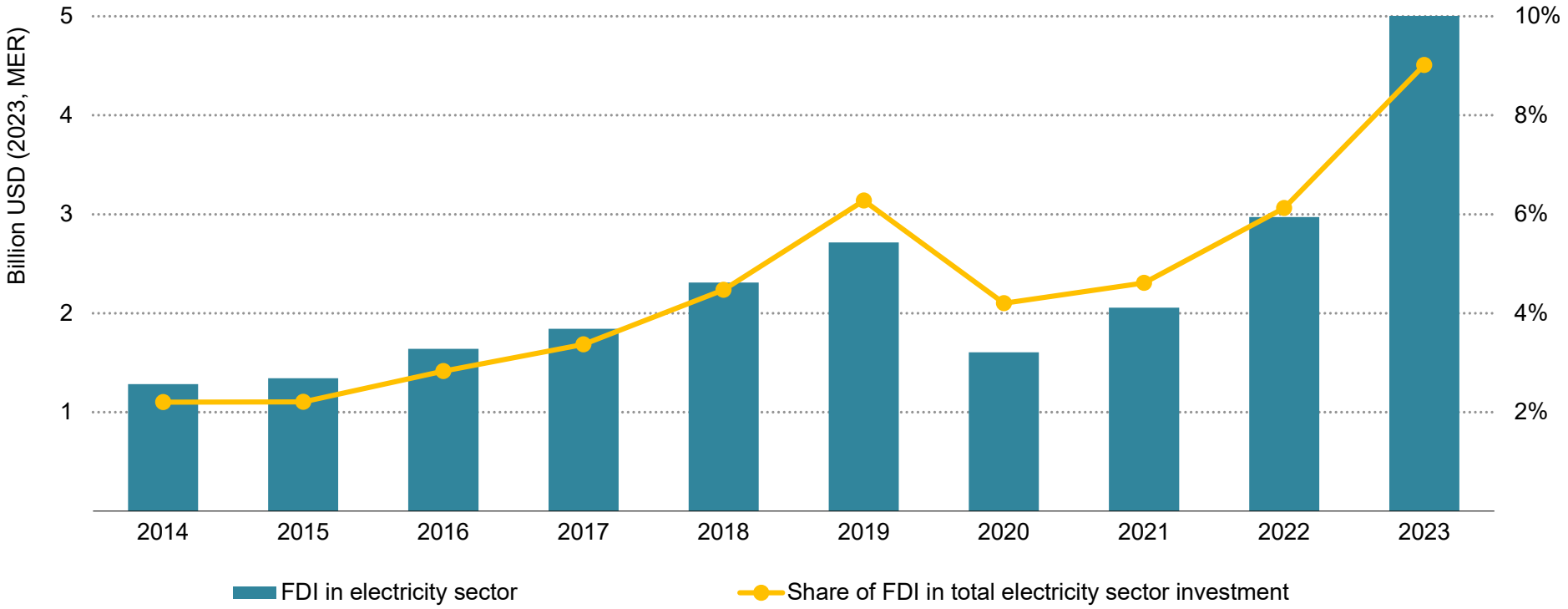
Electricity demand in India has been rising sharply owing to several factors, including increases in commercial and residential space, a surge in ownership of air conditioners and appliances and rising demand from industry. India has seen the third-largest growth in power generation capacity in the world after China and the United States over the past five years. While growth in power generation has come from all sources, there has been a surge in investment in renewables, led by solar PV, which constitutes over half of total non-fossil investment over this period. In 2024, 83% of power sector investment went to clean energy. India was also the world's largest recipient of DFI funding in 2024, receiving around USD 2.4 billion in project-type interventions in clean energy generation.

This has helped bring the share of non-fossil power generation capacity to 44% in 2024, approaching India's target of 50% by 2030. To meet these targets, and to stay on track to meet net zero by 2070, India will cumulatively need to invest USD 1.3 trillion in non-fossil power generation capacity to 2035. This is 16% higher than the amount in the STEPS in this period, signalling a shortfall in total investment under today's policies. India has announced a range of measures to facilitate and support investment in power generation and its network. Notably in 2024 and 2025 India allocated over USD 3.5 billion in the PM Surya Ghar Muft Bijli Yojana, which has a target to install solar rooftop power generation systems in 10 million households by March 2027. For the current financial year, India has also committed USD 245 million to nuclear power projects, with the long-term vision of 100 GW of nuclear capacity by 2047, up from less than 10 GW today. These are among the recently announced measures that support longer-standing initiatives, such as the Production Linked Incentive scheme that encourages the domestic manufacturing of key energy components such as batteries and solar PV modules, the solar park initiative that promotes investment in utility-scale generation, and the Green Energy Corridor that has led to the investment of USD 2.6 billion in India's transmission network to help evacuate electricity generated from renewable sources.

While a large share of the investment in India's power generation capacity and transmission networks is met by domestic sources, foreign direct investment (FDI) has been growing steadily, reaching USD 5 billion in 2023, nearly double the pre-pandemic levels. This is promoted in part by rules permitting 100% FDI across electricity generation sources (with the exception of nuclear) and transmission infrastructure. However, foreign portfolio investment (i.e., investment into financial assets such as stocks) in energy has taken a hit in the past two years due to a range of macroeconomic and sectoral factors, even as the longer-term trend has been one of steady growth.

FDI in India's electricity sector has doubled since pre-pandemic levels to reach USD 5 billion, but there is scope to accelerate further

Foreign direct investment in the electricity sector in India, 2014-2023



The share of electricity sector in total FDI has been gradually increasing, reaching 9% in 2023.

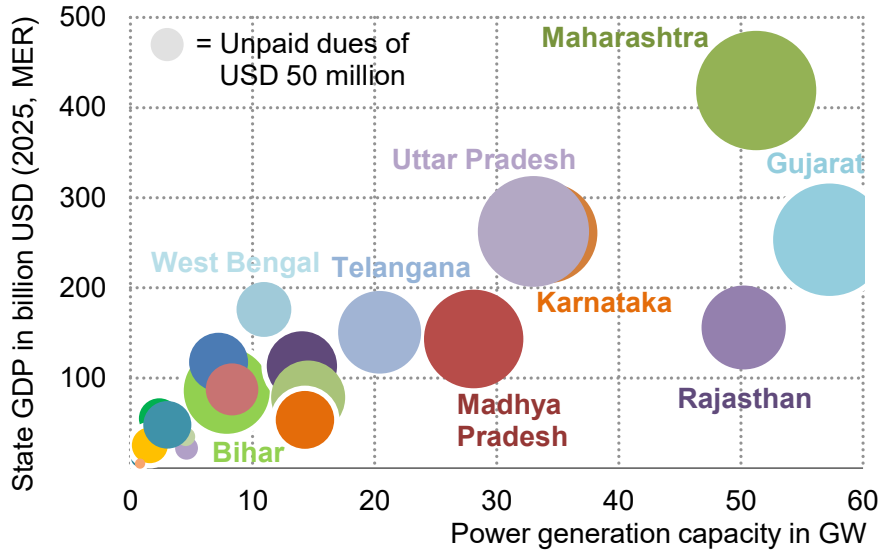
Notes: Energy FDI is taken from the category "Electricity and Other Energy Generation, Distribution & Transmission".
Source: Reserve Bank of India (2025), RBI.

India has been pushing through reforms to improve the attractiveness of renewable power generation investment, including innovative mechanisms to address payment risks

While India's cost of capital for grid-scale renewable energy is one of the lowest among its emerging market and developing economy counterparts, it is still 80% higher than in advanced economies. These higher financing costs affect the financial viability of projects, leading to higher energy prices. Real and perceived risks affect the attractiveness of projects to investors, both domestic and international. These include risks related to land acquisition, offtaker risk and risks arising from the inadequacy of transmission infrastructure, which has impeded 60 GW of renewable capacity in India.

Offtaker risk arising from the inability of distribution companies to pay generation companies fully and on time is cited as a key risk by investors. As of March 2025, distribution companies in India owed over USD 9 billion in unpaid dues. The accumulated losses of distribution companies in India stood at USD 75 billion in 2023. To address these risks, India has been incorporating a slew of reforms. These include Ujjwal DISCOM Assurance Yojana (UDAY), which seeks to improve the financial health of distribution companies by restructuring debt and promoting operational efficiencies; introducing late payment surcharge rules that penalise distribution companies for late payments to generation companies and provide a framework for clearing legacy dues; and establishing the Payment Security Mechanism of the Solar Energy Corporation of India (SECI), which includes escrow accounts, a payment security fund and state government guarantees in case distribution companies fail to pay developers. These are among the various measures that have sought to mitigate risks and unlock greater investment in the sector.

Distribution companies' unpaid dues to electricity generation companies, by state, March 2025

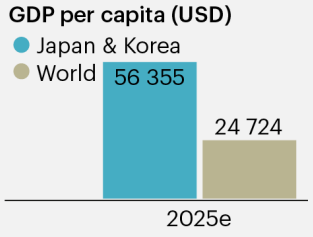


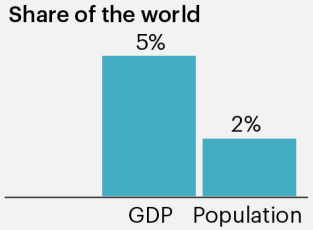
Sources: Ministry of Power; Ministry of Statistics and Programme Implementation (2025), MoSPI.

Japan and Korea

Key statistics for Japan and Korea

Economic and financial indicators





Sovereign debt rating
Japan: A+
Korea: AA

Debt to GDP ratio
Japan: 250%
Korea: 49%

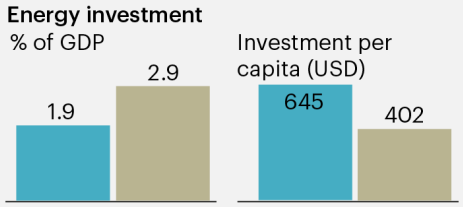
Change in 10-year government bond yield since 2020
Japan: +156 bps
Korea: +121 bps

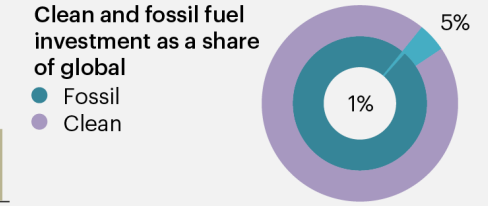
Currency value against USD (2015-2025)
Japan: -24%
Korea: -25%

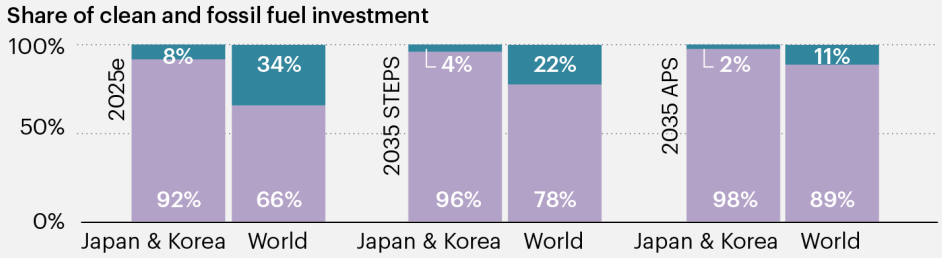
Country risk premium
Japan: 0.9%
Korea: 0.7%

NZE commitments
2050

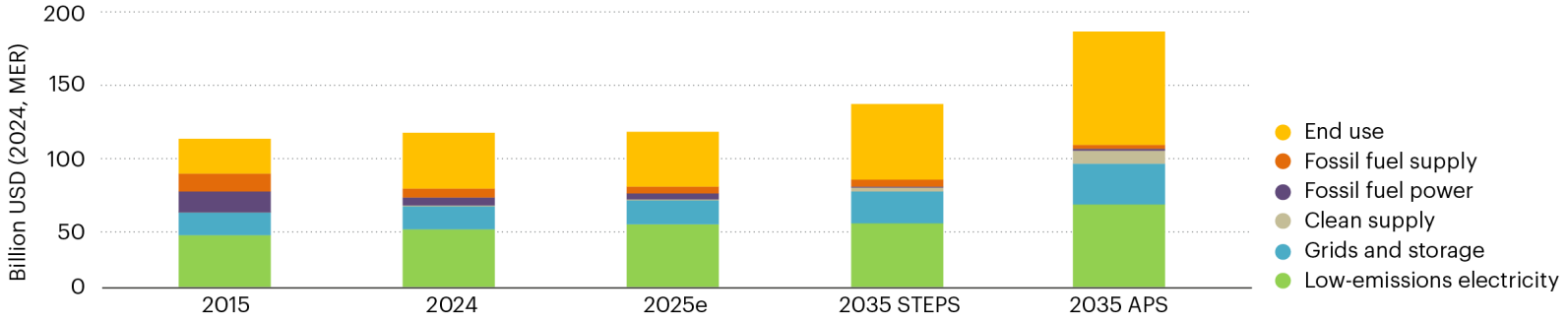
Energy investment indicators







Energy investment trends



Notes: Change in 10-year government bond yield compares bond yield between January 2020 and March 2025; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

Japan and Korea drive the regional economy and energy transition, and place energy security at the heart of their energy transitions

Japan and Korea are two of the most advanced economies in Asia, characterised by a strong focus on trade with a dependence on energy imports to meet demand, equivalent to 4% of the global total. To reduce their reliance on imports and to promote their energy transitions, both countries have made significant investment in clean energy, with 92% of total energy investment going to clean energy compared to a global average of 66%.

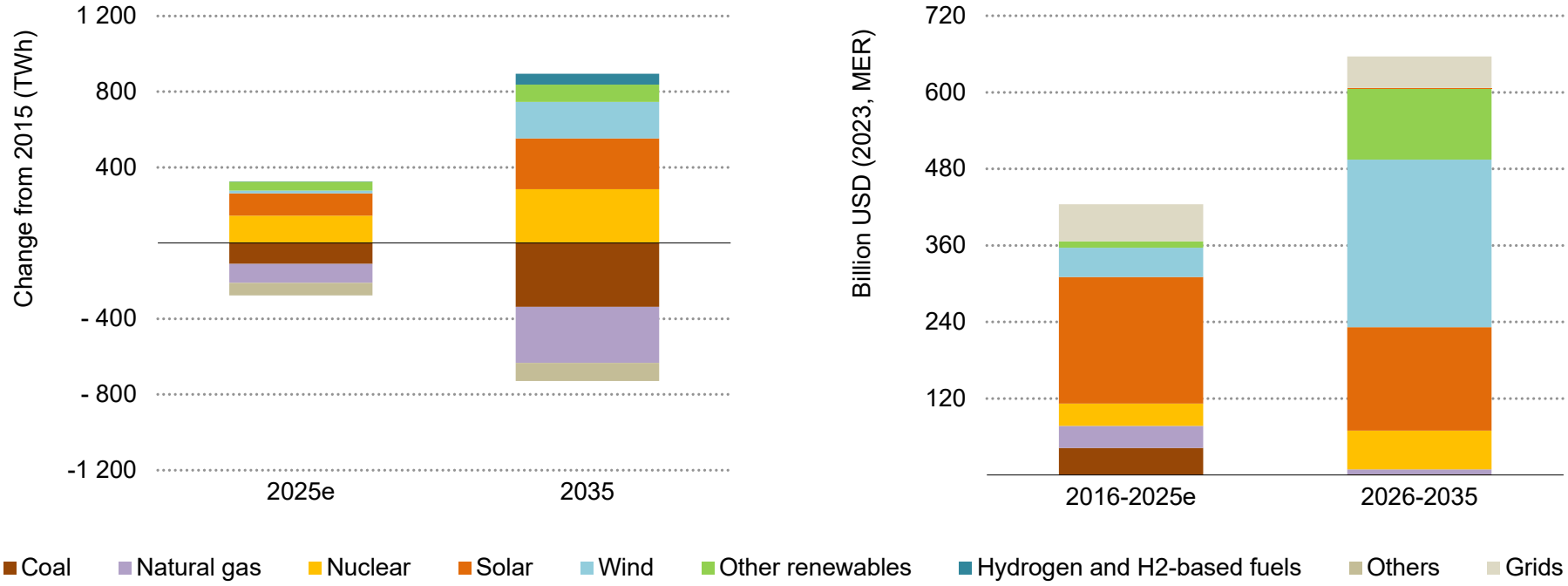
In the past 10 years Japan and Korea's combined GDP grew by approximately 10%, whereas total fossil fuel consumption declined from 15 EJ to 13 EJ, supported by per-capita consumption decreasing by 10%. In contrast, investment in low-emissions electricity has grown by around 10% from USD 38 billion to 42 billion, primarily driven by increased spending on wind power. These investments, and their commitment to carbon neutrality by 2050, show that Japan and Korea are driving the regional energy transition.

2025 is a critical year for energy policy, with the release of new plans to achieve the twin goals of securing stable energy supplies and continuing to accelerate the energy transition. Japan's Seventh Strategic Energy Plan, and outlook for energy supply and demand in FY2040, was announced in February 2025. It emphasised the expectation of increased electricity demand and the importance of maintaining energy security. In the same month, Korea's 11th Basic Plan for Electricity Supply and Demand was finalised, highlighting the importance of energy security to meet the country's rapid increase in electricity demand spurred by advanced industries such as AI data centres, semiconductors and chip and battery manufacturing. Energy security concerns in both countries reflect their low energy self-sufficiency rates, Japan at 13% and Korea at 19%, with a heavy reliance on energy imports contributing to trade deficits.

Over the coming decade, key priorities include reducing emissions and fossil fuel import dependency through power sector decarbonisation via renewables, nuclear and other clean energy sources. Furthermore, Japan and Korea will continue prioritising long-term LNG contracts to mitigate short-term price volatility, while accelerating emissions reductions through proper planning and investing in clean energy towards meeting their 2050 goals. These efforts do not need to remain independent. Given the similarities in their energy mix, co-operation between the two countries will be beneficial over the coming decade. Joint LNG procurement, combined with the emission reduction initiatives already underway, are a positive step in this direction. Also, regional initiatives such as Asia Zero Emission Community (AZEC) are also considered important for broader Asia-wide co-operation.

In the STEPS electricity-related cumulative investment increases to USD 710 billion by 2035 in Japan and Korea, led by increased investment in wind, other renewables and nuclear

Electricity generation by source, 2025e-2035 (left), and electricity-related cumulative investment, 2016-2035 (right) in Japan and Korea



Fossil-fuelled electricity generation has decreased, with the trend expected to continue. Investment in wind, other renewables and nuclear energy will be critical.

Notes: 2025e = estimated values for 2025

Expanding power investment and keeping adequate electricity supply capacity will be crucial to meet rising electricity demand and ensure stable supply for the economies of Japan and Korea

The prospect of renewed growth in electricity demand is creating the need for policy action in Japan and Korea. In the STEPS, electricity demand across buildings, industry and transport increases by 7% between 2025 and 2035, and grows more quickly in the APS due to higher demand from existing energy-intensive industry as well as light industry, and by new sources of demand, such as EVs and data centres.

The increase in demand puts energy security at the forefront of the region's energy agenda, alongside the energy transition. Maintaining an adequate reserve margin is key to ensuring electricity security and achieving this requires long-term planning for the power supply, investment and energy transition. Over the coming decade, policy initiatives such as Japan's capacity market operations and Korea's 20% reserve margin targets, along with public–private co-operation, will play a critical role.

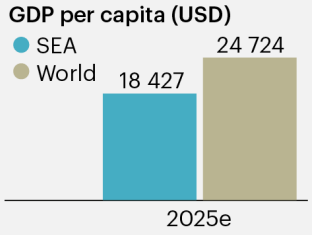
In the next decade promoting renewable power to increase domestic supply will be crucial for securing energy supplies and alleviating pressure on the trade balance. In the STEPS, low-emissions power investment maintains a positive trend, increasing by 8% from approximately USD 65 billion in 2025 to nearly USD 70 billion in 2035. Solar PV and wind power are major investment destinations, accounting for 21% and 30%, respectively. Some renewables, such as offshore wind, face rising material costs and operational challenges. Strong government commitments by Japan and Korea in their basic energy plans can help sustain investment into the future. Additionally, in both countries, where solar PV deployment per unit of land is already among the highest globally, innovations such as perovskite solar PV cells will be key to further expansion. Furthermore, the two countries have a similar energy mix and challenges; strengthening bilateral policies will be crucial for clean energy investment. The continued development of initiatives, such as strengthening the wind power supply chain, advancing hydrogen projects, and co-operation in the field of critical minerals, will contribute to both energy security and the energy transition.

Nuclear, accounting for over 25% of electricity supply in 2035 under the STEPS, will play a key role in diversifying energy sources while ensuring a stable and secure electricity supply. Notably in recent years sustainable bonds for nuclear-related investment have emerged. However, over the next decade, government involvement will be essential for large-scale investments.

Southeast Asia

Key statistics for Southeast Asia

Economic and financial indicators



Sovereign debt rating
BB+ to AAA

Debt to GDP ratio
2.3% to 177%

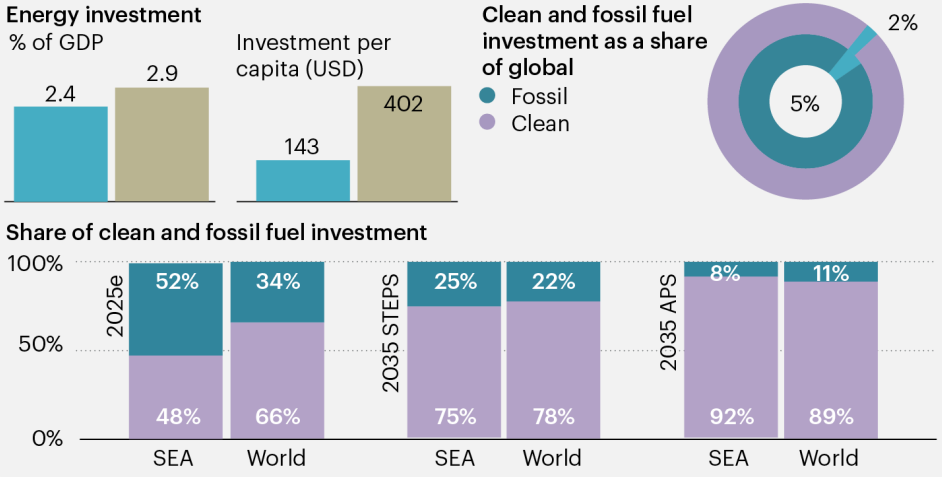
Change in 10-year government bond yield since 2020
+34 bps to +108 bps

Currency value against USD (2015-2025)
1.1% to -62%

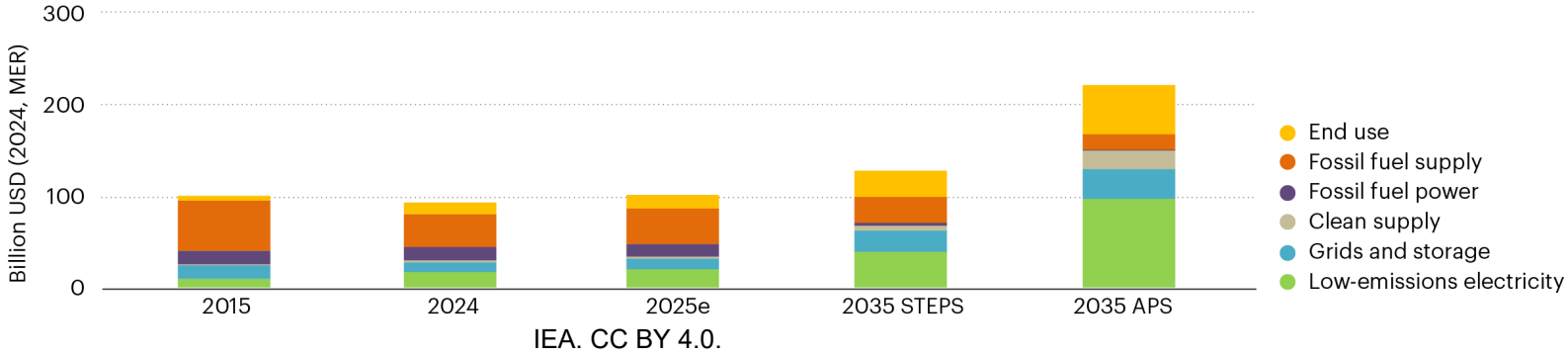
Country risk premium
0% to 13%

Countries with NZE commitments
50%

Energy investment indicators



Energy investment trends



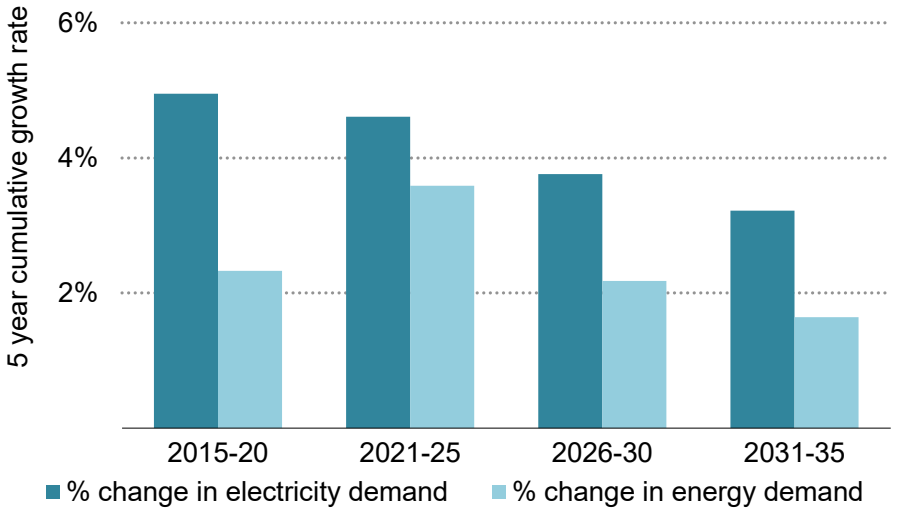
Notes: SEA = Southeast Asia; Change in 10-year government bond yield compares bond yield of Indonesia (+34 bps) and Singapore (+108 bps) between January 2020 and March 2025; 2025e = estimated values for 2025.

Sources: IEA analysis based on S&P (2024), Sovereign Ratings List, S&P Capital IQ (2025), Bloomberg (2025), IMF (2025), Global Debt Database, Country Default Spreads and Risk Premiums database (2025).

Southeast Asia's historic rapid economic growth was mostly driven by fossil fuels; however, clean energy now accounts for almost half of energy investment

Southeast Asia is a rapidly developing region, with GDP per capita increasing by over 30% since 2015. During the last ten years, energy demand has increased by over 35%, driven by a booming industrial sector, with electricity demand rising by over 60%. Driving this is a 12% increase in electricity access rates, growing consumption in industry, urbanisation and rising incomes creating demand for cooling and other appliances. In the coming decade, electricity demand is expected to grow faster than overall energy demand.

Growth in energy and electricity demand in the STEPS in Southeast Asia, 2015-2035

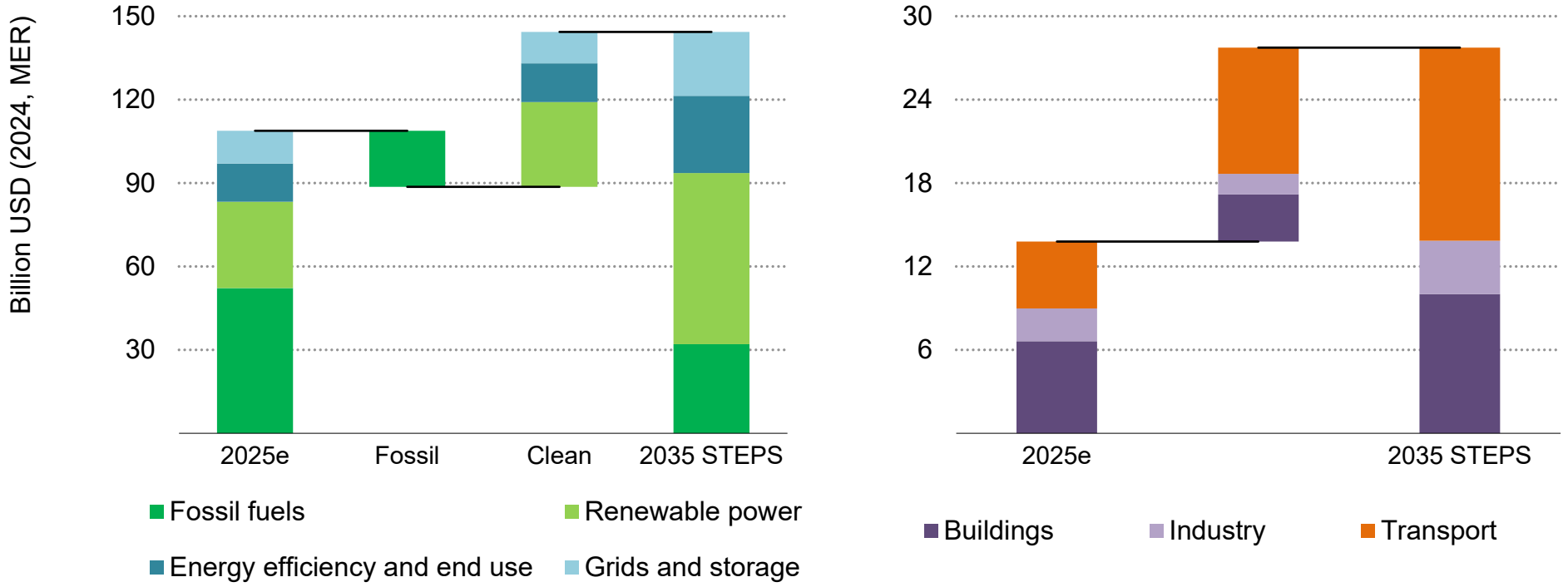


Historically, growth in energy demand has been met by fossil fuels, making up 60% of total energy investment in the past decade. Coal was the main beneficiary, growing from 20% to 30% of the region's energy mix, with USD 110 billion invested since 2015, concentrated in Indonesia and Viet Nam. However, the energy sources that underpin the region's economic development are starting to change. Fossil fuel investment decreased from USD 70 billion in 2015 to USD 50 billion in 2025; clean energy investment reached USD 47 billion, up from USD 30 billion in 2015. Eight out of ten countries have announced target dates for carbon neutrality: Brunei, Cambodia, Lao PDR, Malaysia, Singapore and Viet Nam by 2050; Indonesia by 2060; and Thailand by 2065.

Southeast Asia is playing a growing role in clean energy manufacturing supply chains. In 2023 Viet Nam, Thailand and Malaysia were the world's largest solar PV manufacturers after China. Further, the region holds rich reserves of critical minerals. Indonesia produces over 60% of the world's nickel, attracting over USD 50 billion of investment in greenfield mining during 2014-2023, over 90% of the global total. Chinese investment is driving Indonesia's nickel refinery sector, amounting to USD 30 billion in 2024, and Chinese companies account for around 75% of refining capacity in the country.

Given energy demand growth, Southeast Asia needs to invest an extra USD 47 billion in clean energy annually by 2035, of which USD 14 billion more is needed in end use sectors

Total energy investment (left) and investment in end use sectors (right) under the STEPS in Southeast Asia, 2025e-2035



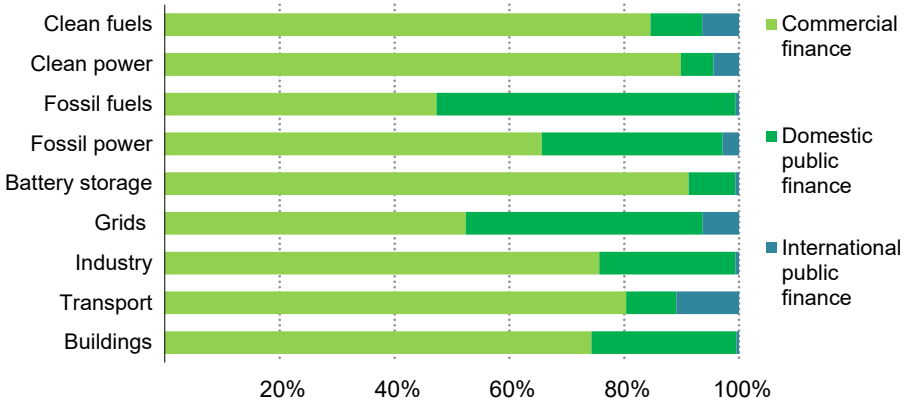
Under the STEPS, annual fossil fuel investment declines by USD 20 billion in the next decade, while investment in renewables, grids and storage and end use sectors all double. Investment in transport needs to increase by nearly 200% by 2035.

Notes: 2025e = estimated values for 2025

To mobilise the USD 95 billion needed for clean energy under the STEPS in 2035, domestic commercial finance flows need to be complemented by international finance and support

Historically, Southeast Asia's capital markets have relied on domestic commercial lending. Domestic finance's share in clean energy investment averaged 75% in 2024, most prominent in end use sectors, comprising 85% of total investment. Commercial finance in clean energy sits above 75%, reaching over 85% in clean power, clean fuels and battery storage. Commercial funding is lowest in grid storage and transmission and distribution at around 55%, with public finance playing a key role at 40%.

Average financing share by source in Southeast Asia, 2015-2025e



Notes: Public = domestic public finance (see methodological section for full definitions).

Several factors have contributed to growing commercial financing in Southeast Asia's energy sector. Firstly, sustainable finance markets are growing in importance, supported by regional frameworks such as the ASEAN Taxonomy for Sustainable Finance. Between 2020 and 2024 the amount of sustainable debt in the region increased from USD 17 billion to USD 60 billion.

Secondly, emerging regulatory reforms have supported increased commercial involvement, such as generous feed-in tariff programmes in Viet Nam and Thailand, which have ushered in private sector involvement. There has also been an increased appetite for corporate clean energy PPAs. However, policy and political inconsistencies create challenges for bankability – retroactive changes to subsidy rules in Viet Nam could affect over USD 13 billion of investment.

Thirdly, catalytic capital and blended finance are emerging instruments for project derisking and to bring technologies to scale in new markets. Although the share of DFI investment has historically been low, where it has been used it has played a crucial catalytic role. For example, a USD 692 million financing package for the 600 MW Monsoon Wind Power project in Lao PDR involved the use of concessional blended finance from DFIs and export credit agencies to mitigate risk, particularly potential curtailment risk, to overcome bankability hurdles and crowd in private capital.

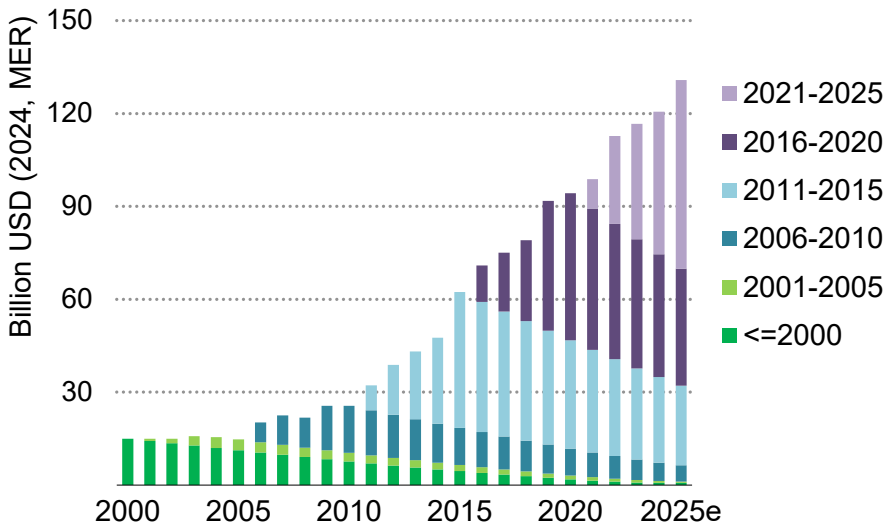
Southeast Asia's diverse energy and economic landscape requires a variety of concessional and transition finance instruments to meet energy goals and reduce reliance on coal

Southeast Asian countries differ widely in their economic structures, resource endowments and market maturity. Singapore ranks fourth globally in GDP per capita, while 31% of the population in Myanmar lacked access to electricity in 2023.

Despite their differences, a common priority for the region is energy security. Southeast Asia faces a deepening supply deficit that will be met by USD 140 billion of fossil imports around 2030 under the APS, increasing exposure to geopolitical instability. Concurrently, coal-fired power has remained a significant component of Southeast Asia's energy mix. Investment in coal plants has steadily risen throughout the past 20 years, reaching 121 GW of installed capacity in 2025. Assuming 25 years of economic lifetime, the capital yet to be recovered from coal plants in 2025 amounts to more than USD 130 billion, which could expose operators to stranded asset risks as energy transitions accelerate. Achieving orderly and just energy transitions would require a combination of financial approaches to scale up clean energy and reduce reliance on fossil fuels, especially the managed phase-out of coal-fired power plants with transition finance.

Transition finance helps overcome the risk-return dilemma involved in the early retirement of coal-fired power plants. TRACTION, led by the Monetary Authority of Singapore, is exploring the use of transition credits, with the first pilot project implemented in the Philippines to accelerate the retirement of a 246 MW coal plant. In addition to early retirement, there also needs to be investment in emissions reduction from coal, such as through repurposing, retrofitting and co-firing.

Capital yet to be recovered from historical investment in coal plants, categorised by year of investment, 2000-2025e



Notes: 2025e = estimated values for 2025

Methodology

Tracking energy investment

The way investment is measured across the energy spectrum varies, largely because of differences in the availability of data and the nature of expenditures. This document highlights the methodology used to ensure that the estimates are consistent and comparable across sectors in the World Energy Investment 2025 (WEI 2025) report and other publications from the International Energy Agency.

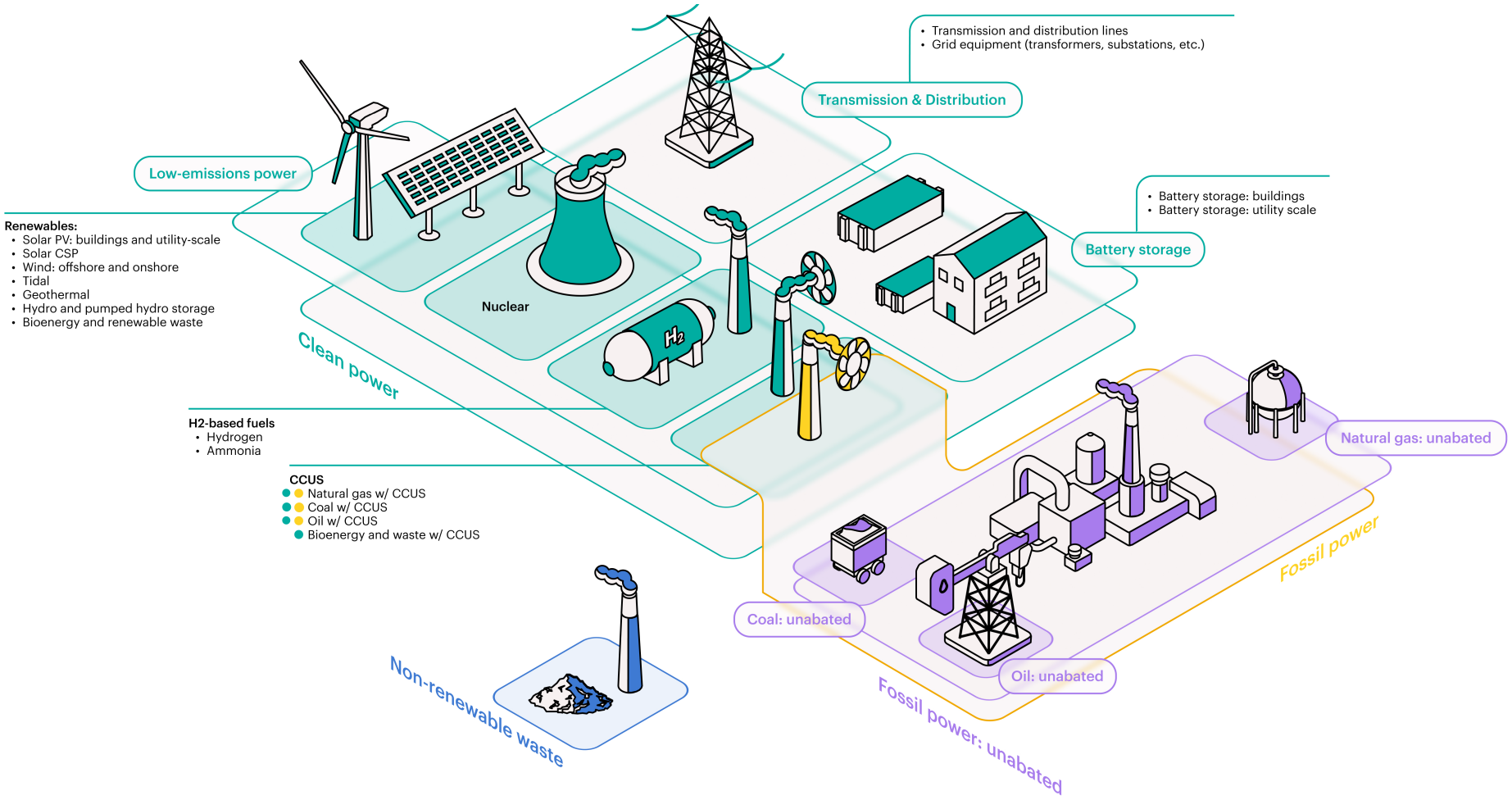
The IEA measures investment as the ongoing capital spending on assets. For some sectors, such as power generation, this investment is spread out evenly from the year in which a new plant or upgrade of an existing one takes a final investment decision (FID), i.e. when a project reaches financial close or begins construction) to the year in which it becomes operational. For other sources, such as upstream oil and gas and liquefied natural gas (LNG) projects, investment reflects the capital spending incurred over time as production from a new source ramp up, or to maintain output from an existing asset**.**

Measuringenergy efficiency is more complex and much of the expenditure is by consumers for whom purchases of more efficient goods are not investments per se. In WEI 2025, as in other recent IEA reports, investment in energy efficiency aims to reflect the incremental spending by companies, governments, or individuals to acquire a piece of equipment that is more efficient than the local market average. Due to the different possible methodologies available, this estimate of energy efficiency investment is not definitive but still included to provide a comparison with the scale of investment in energy supply. Fossil fuel and power sector investments are those that raise or replace energy supply, while investments in energy efficiency are counted as those that reduce energy demand.

Investment estimates are derived from International Energy Agency (IEA) data for energy demand, supply and trade, and estimates of unit capacity costs, analysis of which benefits from extensive interaction with industry. By default, investment data are given in year 2024 US dollars, adjusted using country-level gross domestic product (GDP) deflators and 2024 exchange rates. Unless otherwise stated, all time series and historical comparisons are presented in real 2024 US dollar terms, adjusted for inflation.

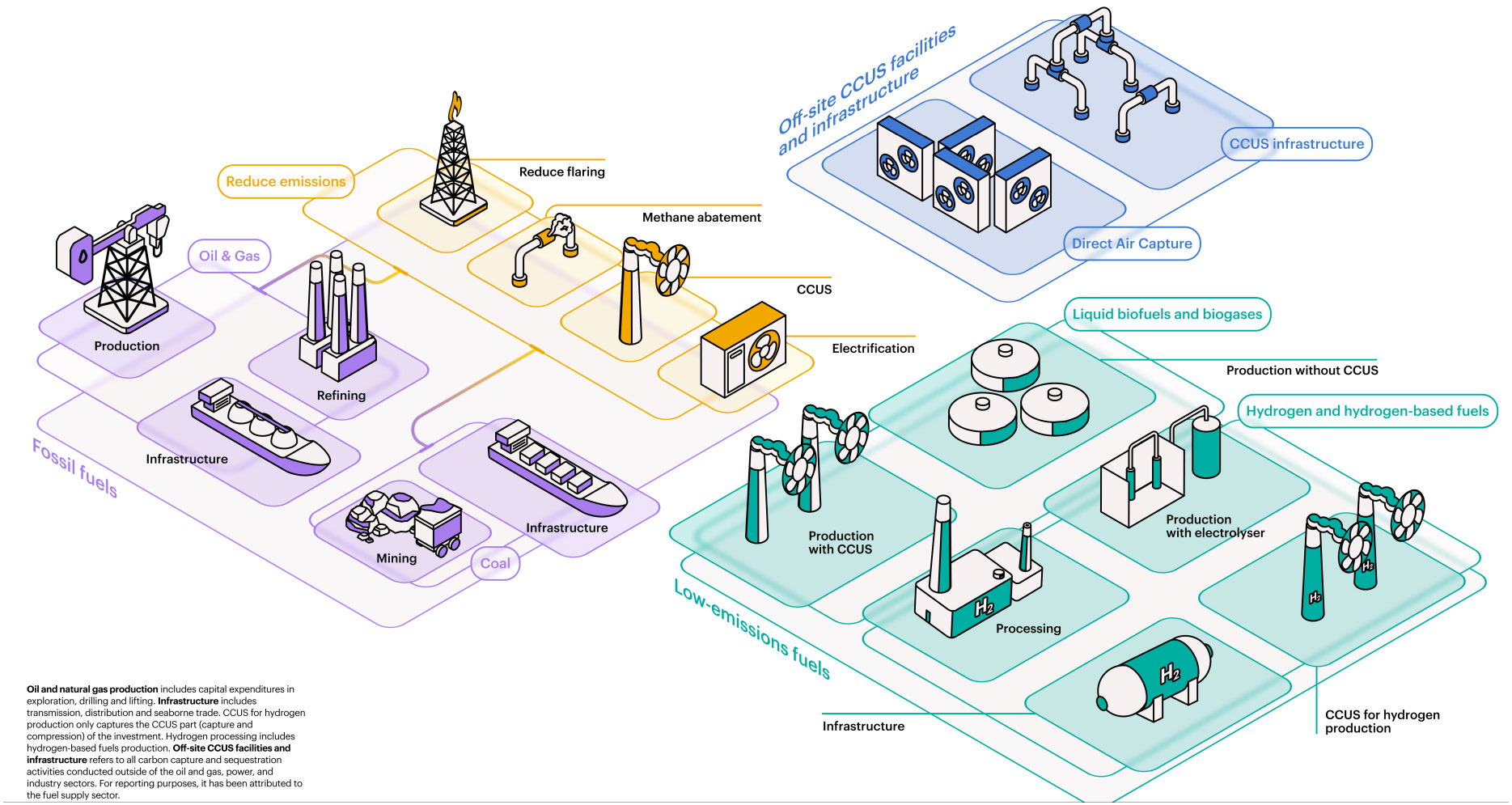
This investment approach mirrors real-world practices and aligns with capital expenditure in financial reporting. In reality, time lags and varied spending occur between FID and project operation. Where possible, financial and energy performance metrics are included to better reflect asset turnover and capital commitment decisions. Other areas of spending – including operating and maintenance expenditures, R&D, financing costs, mergers and acquisitions or public markets transactions – remain important for energy sector development, and are analysed on a standalone basis in IEA investment work, but are not included in the calculations of WEI 2025.

Investment in power



The estimates of electricity investment presented in WEI 2025 correspond to annual capital spending on new power plants, battery storage and grid assets, or the replacement of old assets

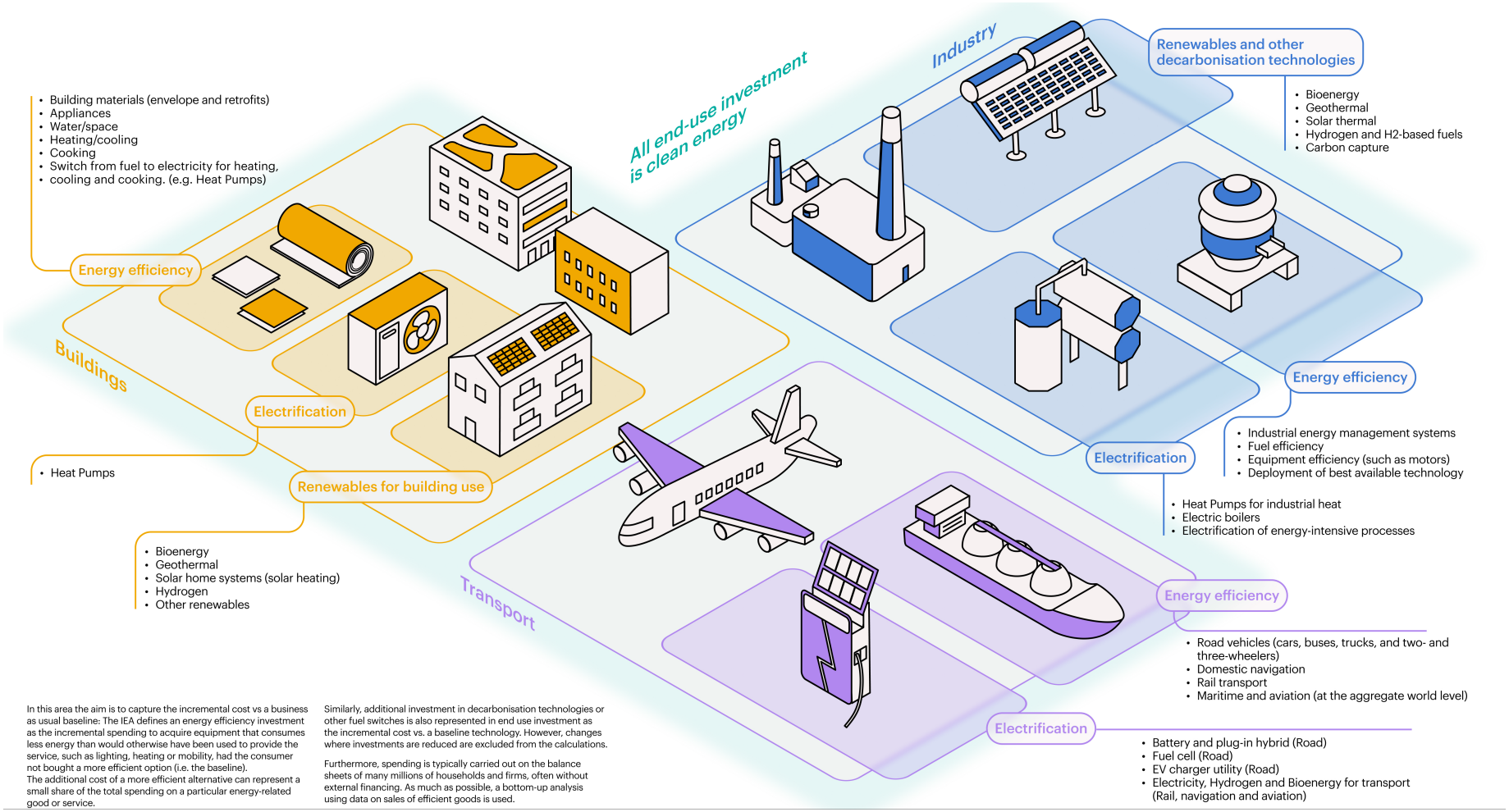
Investment in fuel supply



Oil and natural gas production includes capital expenditures in exploration, drilling and lifting. **Infrastructure** includes transmission, distribution and seaborne trade. CCUS for hydrogen production only captures the CCUS part (capture and compression) of the investment. Hydrogen processing includes hydrogen-based fuels production. **Off-site CCUS facilities and infrastructure** refers to all carbon capture and sequestration activities conducted outside of the oil and gas, power, and industry sectors. For reporting purposes, it has been attributed to the fuel supply sector.

Investment estimates for oil, gas and coal are based on capital spending announcements by some 90 oil and gas majors, independents and national companies, Investment in LNG is based on spending for projects that reached FID between 2000 and 2025

Investment in energy demand and electrification



Investment in energy efficiency incremental spending to acquire equipment that consumes less energy than would otherwise have been used to provide the service, such as lighting, heating or mobility, had the consumer not bought a more efficient option

Methodology used for the regional section

Sovereign debt rating: The long-term foreign currency rating assessed by S&P Global Ratings as of 31 October 2024. Sovereign debt rating as assessed by S&P ranges from D (default) to AAA.

- **Africa**: 24 of the 54 countries have an S&P rating.
- **Latin America and the Caribbean**: 29 of the 44 countries have an S&P rating.

Change in 10-year government bond yield since 2020: Government bond yield data are taken from the Bloomberg Terminal, except for data on Zambia, which are taken from Trading Economics. This indicator compares the 10-yr government bond yield in basis points (bps) between January 2020 and the latest available data. Government bond yield data for regions are as follows:

- **Africa**: data from South Africa and Zambia.
- **Latin America**: data from Peru and Brazil.
- **Middle East**: no data available.
- **Eurasia**: data from Russia.
- **Southeast Asia**: data from Indonesia and Singapore.

Country risk premium: Country risk premium data is taken from the Country Default Spreads and Risk Premiums database by Professor Aswath Damodaran of New York University. Availability of risk premium data from the database is as follows:

- **Africa**: 41 of 54 countries are represented.
- **Latin America and the Caribbean**: 28 of 44 countries are represented.
- **Middle East**: Missing data from Iran, Syria and Yemen.
- **Eurasia**: Missing data from Russia and Turkmenistan.

Currency value against the USD: Exchange rate data are taken from S&P Capital IQ. The rate of depreciation against the USD is calculated in the period between January 2015 and January 2025.

- Latin America and the Caribbean: Excludes Venezuela.
- **Middle East:** Excludes Lebanon and Syria.
- **European Union**: The currency value of the euro is used.

Debt to GDP ratio: IMF data from 2023 are used General government debt is used where available, and where not available, central government debt is used. Here is a list of countries where debt sustainability data are not available:

- **Africa**: No data from Cape Verde, Eritrea, Libya and Somalia.
- **Latin America and the Caribbean**: No data from Anguilla, Aruba, Bahamas, Bermuda, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Cuba, Curaçao, Ecuador, Falkland Islands, Montserrat, Saint Pierre, Sint Maarten, Turks and Caicos.
- **Middle East**: No data from Lebanon and Syria.
- **Eurasia**: No data from Georgia.

NZE commitments: Net zero emissions commitments for the purpose of this analysis include commitments in policy documents, in law, in proposed legislation and in policy documents, while excluding oral pledges and pledges under discussion.

Categories under the sources of finance model:

- **Commercial finance** includes equity investments made by private enterprises and households, alongside debt from financial institutions, including some finance from state-owned banks.
- Domestic public finance includes public equity stakes in private corporations and state-owned enterprises, subsidies, tax incentives and finance from central banks.
- International public finance as defined in this report covers development finance institutions, multilateral climate funds, government donors and philanthropies, and export credit agencies.

Country groupings:

Advanced economies: Australia, Austria, Belgium, Bulgaria, Canada, Chile, Colombia, Costa Rica, Croatia, Cyprus[1], Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Puerto Rico, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom, United States.

Emerging Market and Developing Economies: Afghanistan, Albania, Algeria, Angola, Anguilla, Antigua and Barbuda, Argentina, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Benin, Bermuda, Bhutan, Bolivarian Republic of Venezuela, Bonaire, Sint Eustatius and Saba, Bosnia and Herzegovina, Botswana, Brazil, British Virgin Islands, Brunei Darussalam, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Cayman Islands, Central African Republic, Chad, Chinese Taipei, Comoros, Cook Islands, Côte d'Ivoire, Cuba, Curaçao, Democratic People's Republic of Korea, Democratic Republic of Congo, Djibouti, Dominica, Dominican Republic, East Timor,

[1] Note by the Republic of Türkiye
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Falkland Islands (Malvinas), Fiji, French Polynesia, Gabon, Gambia, Georgia, Ghana, Gibraltar, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hong Kong, India, Indonesia, Iraq, Islamic Republic of Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kingdom of Eswatini, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Lesotho, Liberia, Libya, Macau, Madagascar, Malawi, Malaysia, Maldives, Mali, Mauritania, Mauritius, Mongolia, Montenegro, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nepal, New Caledonia, Nicaragua, Niger, Nigeria, North Macedonia, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, People's Republic of China, Peru, Philippines, Plurinational State of Bolivia, Qatar, Republic of Congo, Republic of Kosovo, Republic of Moldova, Russia, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Sint Maarten (Dutch part), Solomon Islands, Somalia, South Africa, South Sudan, Sri Lanka, Sudan, Suriname, Syrian Arab Republic, Tajikistan, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkmenistan, Turks and Caicos Islands, Uganda, Ukraine, United Arab Emirates, United Republic of Tanzania, Uruguay, Uzbekistan, Vanuatu, Viet Nam, Yemen, Zambia, Zimbabwe

Latin America and the Caribbean: Anguilla, Antigua and Barbuda, Argentina, Aruba, Bahamas, Barbados, Belize, Bermuda, Bolivarian Republic of Venezuela, Bonaire, Sint Eustatius and Saba, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominica, Dominican Republic, Ecuador, El Salvador, Falkland Islands (Malvinas), Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Montserrat, Nicaragua, Panama, Paraguay, Peru, Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Sint Maarten (Dutch part), Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden

Africa: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Côte d'Ivoire, Democratic Republic of Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Kingdom of Eswatini, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Republic of Congo, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Togo, Tunisia, Uganda, United Republic of Tanzania, Zambia, Zimbabwe

Middle East: Bahrain, Iraq, Islamic Republic of Iran, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen

Eurasia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkmenistan, Uzbekistan

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam

Annexes

Abbreviations and acronyms

ADNOC	Abu Dhabi National Oil Company
AE	Advanced Economy
AI	Artificial Intelligence
APS	Announced Pledges Scenario
ASEAN	Association of South-East Asian Nations
BECCS	Bioenergy with Carbon Capture and Storage
BEV	Battery Electric Vehicle
BFBOF	Blast Furnace - Basic Oxygen Furnace
CAPEX	Capital Expenditures
CBAM	Carbon Border Adjustment Mechanism
CCPI	Climate Change Performance Index
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation and Storage
CDM	Clean Development Mechanism
CIF	Climate Investment Fund
CO2	Carbon Dioxide
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRS	Common Reporting Standard
CVC	Corporate Venture Capital
DAC	Direct Air Capture
DC	Direct Current
DFI	Development Finance Institution
DISCOM	Distribution Company
DRC	Democratic Republic of the Congo
DRI	Direct Reduced Iron
EAF	Electric Arc Furnace
ECA	Export Credit Agencies
EERF	Energy Efficiency and Renewable Energy Fund
EMDE	Emerging Markets and Developing Economies
ESG	Environmental, Social, and Governance
ETS	Emissions Trading Scheme
EU	European Union
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
FDI	Foreign Direct Investment
FFP	Fossil Fuel Power
FID	Final Investment Decision
FLNG	Floating Liquefied Natural Gas
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFANZ	Glasgow Financial Alliance for Net Zero
GFMR	Global Flaring and Methane Reduction
GSS	Green, Social, and Sustainability
GW	Gigawatt
H_2	Hydrogen
HEEHRA	High-Efficiency Electric Home Rebate Act
HOMES	Home Owner Managing Energy Savings
ICE	Internal Combustion Engine
ICT	Information and Communications Technology
IMF	International Monetary Fund
IMO	International Maritime Organisation
IRA	Inflation Reduction Act
IRR	Internal Rate of Return
JERA	Japan’s Energy for a New Era
JETP	Just Energy Transition Partnership

LDAR	Leak Detection and Repair
LNG	Liquefied Natural Gas
MA	Merger and Acquisition
MCF	Multilateral Climate Funds
ME	Middle East
MER	Market Exchange Rate
NCQG	New Collective Quantified Goal
NZAM	Net Zero Asset Managers
NZBA	Net-Zero Banking Alliance
NZE	Net Zero By 2050 Scenario
ODA	Official Development Assistance
OECD	Organisation For Economic Co-Operation and Development
OEM	Original Equipment Manufacturer
OOF	Other Official Flows
PACE	Property-Assessed Clean Energy
PPA	Power Purchase Agreement
PRI	Principles for Responsible Investing
PV	Photovoltaic
RD	Research and Development
ROI	Return On Investment
ROIC	Return On Invested Capital
ROW	Rest of the World
SBFN	Sustainable Finance And Banking Network
SD	Sustainable Development
SDG	Sustainable Development Goals
SEA	Southeast Asia
SMR	Small Modular Reactor
SOE	State-Owned Entity
SP	Standard & Poor's
SPV	Special Purpose Vehicle
STEPS	Stated Policies Scenario
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
VC	Venture Capital
WACC	Weighted Average Cost of Capital
WEI	World Energy Investment
WEO	World Energy Outlook
YPF	Yacimientos Petrolíferos Fiscales
YTEC	YPF Tecnología S.A

Units of measure

EJ	Exajoule
g	Gram
GW	Gigawatt
GWh	Gigawatt Hour
kg	Kilogram
mb/d	Million Barrels of Oil per Day
kb/d	Thousand Barrels of Oil per Day
MBtu	Million British Thermal Units
Mt	Million Tonnes
MW	Megawatt
MWh	Megawatt Hour
TWh	Terawatt Hour

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