

Impact Series 15

The global energy race

Barclays Research believes markets may be underestimating the scale of the impact of the next energy demand cycle.





Foreword

Welcome to the fifteenth edition of the Impact Series from Barclays Research, in which we explore one of the defining challenges of the next decade: how the world will power a future shaped by AI, electrification and rising energy demand.

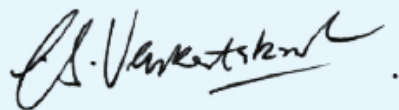
8 September 2026

The forces driving this change are increasingly visible in everyday life. AI is fuelling a rapid build-out of data centres, electrification is transforming transport, industry and heating, and rising living standards continue to increase demand for energy around the world. At the same time, recent geopolitical events have reminded policymakers and investors that reliable and secure energy supplies cannot be taken for granted.

As these trends converge, they are reshaping energy systems, investment priorities and policy decisions around the world. The implications for markets and economies are significant. Meeting future energy needs could require trillions of dollars of investment across energy resources, power generation, grids, storage and infrastructure, making energy one of the most important strategic and capital-allocation considerations of the coming decade. Energy security is playing an increasingly prominent role in policymaking, while access to reliable and affordable energy could become an even more important source of economic competitiveness.

In this report, our research analysts examine the opportunities and challenges emerging from this evolving landscape. From energy demand and inflation to commodities, infrastructure and geopolitics, they explore how the global energy race could influence capital allocation, corporate strategy and investment opportunities in the years ahead.

We hope this report provides a useful contribution to the debate around how economies, industries and markets will navigate the energy addition era.



C.S. Venkatakrishnan
Group Chief Executive Officer
Barclays

Executive summary

The energy transition is increasingly looking less like the replacement of one energy source with another and more like an expansion of the entire energy system. Demand for electricity, oil, natural gas and renewable energy is rising simultaneously, driven by electrification, AI, digital infrastructure, demographics and economic development. At the same time, geopolitical tensions have elevated energy security to a strategic priority. Together, these forces are reshaping investment, policy and capital allocation across the global energy system.

Three structural forces are reshaping energy demand

The current environment differs from previous energy cycles because demand is being supported by three powerful long-term trends:

1. Energy security

Recent geopolitical shocks have made energy security a priority for governments around the world, accelerating investment in energy production and infrastructure.

2. Electrification

Transport, industry and buildings are becoming increasingly electrified, driving sustained growth in power demand and creating significant infrastructure requirements.

3. AI and data centres

AI is emerging as a major new source of electricity demand, increasing the need for reliable generation, transmission and grid capacity.

Our global energy model points to sustained growth

Together, these forces point to a sustained increase in global energy demand over the coming decades. Using our proprietary global energy model, we forecast energy demand growth of 1.9% per year between 2025 and 2050, above the Energy Information Administration's (EIA) current forecast. AI is expected to become an increasingly important driver of energy consumption. By 2040, we estimate data centres could require energy equivalent to Russia's current energy consumption. At the same time, we expect electric vehicles will become much more common, accounting for about 60% of the global vehicle fleet by 2050. As a result, transportation's share of global energy consumption falls to ~14% by 2050 from 17.5% today.

A global race for capital

We estimate annual investment across the global energy system could reach **\$3.6trn by 2027**, more than three times the capital currently required for planned AI infrastructure development. Meeting energy demand will require one of the largest investment cycles in modern industrial history. Capital will be needed across the global energy value chain, but the most acute shortfalls are emerging in the transmission networks, storage systems and grid infrastructure required to make energy usable.

Energy security is increasingly shaping both policy and investment decisions

Against a backdrop of geopolitical fragmentation, ensuring access to reliable, affordable and secure energy has become a central policy objective. Governments are supporting domestic production, infrastructure investment and more resilient supply chains, making energy security an increasingly important driver of both policy and capital allocation decisions.

Increased risk of higher energy-driven inflation

Previous periods of energy underinvestment were often followed by a supply response. This cycle may be different. Rising demand from electrification, AI and energy security initiatives are occurring at the same time as supply constraints, permitting delays and infrastructure bottlenecks. If supply struggles to keep pace, energy markets could remain tighter for longer, increasing the risk of higher energy prices, renewed commodity inflation and a more persistent inflation backdrop than investors currently anticipate.



Barclays Research expects:

1.9% CAGR energy demand to 2050

\$3.6trn annual investment in global energy system by 2027

The global energy race

AI's speed with which it spreads through the world economy, the use cases it generates in industry after industry, its effect on the labour market, the societal implications, etc.: this will be the defining macro theme for the next decade. The global energy race, we believe, will be a close second.

A decade ago, the prevailing narrative about the energy transition was sequential. Renewables would rise, but fossil fuels were supposed to decline. The energy system would transition from one to the other, in an orderly fashion. However, in 2025, the use of every major energy source – oil, natural gas, coal, solar, wind, nuclear – notched new highs. All of them. Oil consumption rose to a record. Natural gas hit a record. Coal hit a record. And renewable capacity additions were the largest in history, with solar power alone meeting more than a quarter of global demand growth for the first time¹. This is not what the consensus predicted. The reality of the energy transition has been messier, more expensive, and hence more consequential for capital markets.

The world is not substituting one energy system for another. It is running both simultaneously, and it does not have enough capital deployed in either. Energy demand is rising at the same time as geopolitical fragmentation is increasing the premium on energy security. The result is a growing race for capital across resources, infrastructure, and power systems – a race that the current level of investment is not winning. Not only has the energy transition not stopped, but the next phase will require significantly more investment across a far broader set of assets than the market currently appreciates. That includes not only renewables and electrification, but also oil and gas exploration, LNG export capacity, power transmission and storage networks, refining resilience, energy services, and other critical infrastructure that keeps the system functioning while it transforms.

The capital misallocation

The energy transition was always going to be expensive. What was underestimated was how long the existing system would need to keep running at full capacity while the new one was being built. Between 2015 and 2022, a combination of ESG-driven capital reallocation, shareholder pressure for returns

over growth, and policy signals favouring clean energy led to a sustained reduction in upstream oil and gas investment. Global upstream capital expenditure is still roughly 45% below peak levels. The industry was told – by investors, regulators, and in some cases its own management teams – that demand was peaking and that new supply investment was stranded capital. The market acted accordingly. But demand did not peak.

We anticipate underlying oil demand growth at over 6 million barrels per day in 2025–2030, driven overwhelmingly by non-OECD economies. At the same time, the industry must replace more than 7 million barrels per day of output annually just to maintain existing supply, before any demand growth is accounted for². It is not investing enough to do even that.

Meanwhile, clean energy investment has surged, reaching a record \$2.3 trillion in 2025, more than double the \$1 trillion flowing into fossil fuels. This is a remarkable achievement. But it has not been sufficient to displace the fossil fuel system it was intended to replace.

The arithmetic is unforgiving: global energy demand grew 1.3% in 2025, and while low-emissions sources contributed nearly 60% of that, the remaining 40% still required more oil, more gas, and more coal³. The world added clean energy at an impressive pace. It just was not fast enough to allow the old system to shrink. The result is a system that is underinvested on both sides. Traditional energy has been starved of the capital needed to maintain supply. Clean energy, while attracting record investment, remains geographically concentrated – roughly 75% of global clean energy investment flows to a small number of markets – and has not yet built the grid infrastructure, storage capacity, or baseload reliability needed to serve as a full replacement. *The capital gap exists everywhere one looks.*

1 <https://www.iea.org/news/global-energy-demand-growth-was-met-by-diverse-range-of-sources-in-2025-led-by-solar-and-then-gas>

2 <https://publications.opec.org/momr>

3 <https://www.iea.org/news/global-energy-demand-growth-was-met-by-diverse-range-of-sources-in-2025-led-by-solar-and-then-gas>

And now come the new demand drivers

What makes the current moment different from previous cycles of energy underinvestment is that demand is being driven by forces that are structural, rather than cyclical. Three in particular deserve attention.

1. Electrification is accelerating globally

Global electricity demand is forecast to grow 3.7% in 2026, more than twice the rate of total energy demand. The International Energy Agency (IEA) projects this pace will continue through 2027 and beyond, driven by electric vehicles, heat pumps, air conditioning, and industrial electrification, particularly in emerging economies where appliance ownership and cooling demand are rising rapidly. Electrification is the mechanism through which de-carbonisation is supposed to work by moving end-uses from direct fossil fuel combustion to the grid, then cleaning the grid. The problem is that the first half of that equation is proceeding faster than the second. Countries are electrifying their economies before the grid – and the generation capacity behind it – is ready.

2. AI and data centres are driving a step-change in electricity demand

Global data centre electricity consumption is forecast to reach 565 terawatt-hours in 2026, up 26% from 447 TWh in 2025. Related power demand is expected to reach 132 gigawatts this year and could hit 290 gigawatts by 2030. AI-optimised servers now account for 31% of total data centre power consumption, up from roughly 20% a year ago⁴. The IEA projects that data centre electricity consumption could double to 945 TWh by

2030, approximately 3% of total global electricity demand. This is not a rounding error. It is a new structural source of baseload electricity demand that did not exist at scale five years ago; that is growing 25–30% annually; and that requires the kind of reliable, continuous power supply that intermittent renewables alone cannot yet provide. It is showing up in the inflation data – AI-related electricity costs are a measurable contributor to the rise in core PCE – and is reshaping utility planning, grid investment, and power procurement across every major economy.

3. Geopolitical shocks have repriced energy security

The war in Ukraine, the conflict with Iran, and the broader fragmentation of the global trading system have fundamentally altered how governments think about energy supply. The assumption that energy could be sourced from the cheapest global supplier, transported through open sea lanes, and priced in transparent commodity markets has been challenged in ways that are not reversible. Europe's forced pivot away from Russian pipeline gas – replacing it with LNG from the United States, Qatar, and a patchwork of alternative suppliers – was the most dramatic example, but it is not the only one. Asia's LNG importers scrambled to diversify supply chains after the Iran conflict threatened critical transit routes. Countries across the Middle East, Africa, and Latin America are positioning themselves as alternative suppliers and competing to attract international capital.

The result is a global energy system that is less integrated, more regionalised, and more expensive to operate, requiring significantly more redundant infrastructure than the pre-2022 model assumed.

⁴ <https://www.gartner.com/en/newsroom/press-releases/2026-06-10-gartner-says-data-center-electricity-demand-to-grow-26-percent-in-2026>



Energy security is reshaping capital allocation

The geopolitical dimension deserves particular emphasis because it changes the investment calculus in ways that standard energy models do not capture. *When energy security is taken for granted, as it largely was in the two decades before 2022, capital allocation optimises for cost.* The cheapest source of supply wins. That logic favoured concentrated production (OPEC, Russia), long global supply chains (LNG tankers, oil tankers through the Strait of Hormuz), and minimal investment in redundancy. It was efficient. It was also fragile. The system that is emerging is different.

Countries are building strategic reserves, contracting for long-term LNG supply, investing in domestic production capacity, and – critically – diversifying not just their energy sources but also their energy suppliers. This is not cost optimised. It is resilience optimised. And resilience requires capital. More LNG regasification terminals. More pipeline interconnectors. More strategic storage. More refining capacity distributed across regions, rather than concentrated in the lowest-cost locations. Global refining is a case in point. Permanent plant closures and war-related damage cut global refinery output an estimated 4.5 million barrels per day in the second quarter of 2026⁵. Crack spreads – the margin between crude oil and refined products – have reached record levels, with the US 3-2-1 crack spread hitting \$64 per barrel and global refining margins touching \$59. These are not normal numbers. They reflect a structural shortage of refining capacity that years of underinvestment and geopolitical disruption have created. Even if both the Ukraine and Iran conflicts were to end tomorrow, it would take years to rebuild the refining capacity that has been lost. The market is telling us, in the clearest possible terms, that the downstream infrastructure is insufficient. The same logic applies across the energy value chain.

Grid investment needs to rise 50% by 2030, from roughly \$400 billion annually to over \$600 billion, just to meet national climate targets, according to the IEA. More than 2,500 gigawatts of renewable energy, storage, and large-load projects (including data centres) are currently stalled in grid connection queues worldwide⁶. The bottleneck is not generation. It is the wires, transformers, substations, and interconnectors that move electricity from where it is produced to where it is consumed. This infrastructure takes years to permit and build, has been chronically underfunded, and is now the binding constraint on both the energy transition and the AI buildout.

Energy addition, not substitution, is the present – and the future

The data support a clear conclusion: the world is in an era of energy addition, not substitution. All major energy sources are growing. The IEA's own Global Energy Review 2026 confirms that oil, natural gas, and coal each reached record consumption levels in 2025. Renewables are growing faster – solar PV contributed the largest single share of demand growth for the first time – but they are growing *in addition to* fossil fuels, not instead of them⁷. This is likely to persist for several years. Non-OECD energy demand is being driven by industrialisation, urbanisation, and rising living standards, forces that are not discretionary and that require energy in all its forms. India's electricity demand is growing 6–7% per year. Southeast Asia is building coal plants alongside solar farms. The Middle East is investing in renewable capacity and upstream oil production simultaneously.

The assumption that the world would transition linearly from fossil fuels to renewables was always an abstraction. The reality is a system that needs more of everything, for longer than the models assumed. This is not an argument against the energy transition. It is an argument for realism about its pace and its capital requirements.

The transition is happening: renewable capacity additions, EV adoption rates, and clean energy investment are all at record levels. But it is happening inside a system where total energy demand continues to grow, where fossil fuel infrastructure is ageing and underinvested, where geopolitical risk demands redundancy, and where entirely new sources of demand (AI, data centres, electrification) are adding load faster than the grid can absorb it.

The net result is that investment is required across resources and infrastructure – traditional and renewable, upstream and downstream, generation and transmission – to maintain a secure, affordable, and resilient energy system. The capital requirements are larger, more diverse, and more sustained than the market is pricing.

Opportunities across sectors and markets

The macro framing is simple. Energy demand is growing. Energy security is being repriced. The capital deployed across the system is insufficient. And the next phase of the energy transition, whether measured in barrels, megawatts, or miles of transmission line, will require more investment, across more assets, for longer than the market currently expects. The question is not whether this capital will be deployed. It is who deploys it, where, and at what return.

5 <https://www.iea.org/reports/oil-market-report-may-2026>

6 <https://www.iea.org/reports/electricity-2026/grids>

7 <https://www.iea.org/reports/global-energy-review-2026/key-findings>

Barclays' global energy model

Rising energy use globally

Global energy use is set to increase, in our base case, ~1.9% CAGR (Compound Annual Growth Rate) over 2025-50, reflective of population growth (+0.7% CAGR), rising real GDP (+2.5% CAGR) and real income growth (+1.8% CAGR). We also expect the global share of electric vehicles to rise to over 50% by 2050 and incremental data centres to reach over 600GW, the bulk of which (400GW) we expect to be in the US. At the same time, we expect carbon emissions growth to be below the rate of global energy use, due to both greater electrification and a growing share of renewables (+15-20pts, to ~50%) in the global energy mix. Our base case is for a more moderate increase in CO₂ emissions per capita (+0.6% CAGR) through 2050.

Emerging markets will drive higher emissions with higher energy use

On a regional level, our base case is for emerging markets to be the key driver of global energy use, with India (+3.8% CAGR) showing the strongest growth. Our base case has China, the largest energy consumer today, growing at a slightly slower pace (+2.4% CAGR) than some emerging economies, but still outpacing the US (+1.5%). We expect China's energy usage to be heavily driven by energy efficiency in industrial and commercial sectors (where we eased the EIA's assumption of significant energy efficiency gains). For CO₂ emissions, we see India (+2.6% CAGR) registering the largest growth in emissions, outpacing both China (2.0% CAGR) and the US (showing about flat).

FIGURE 1

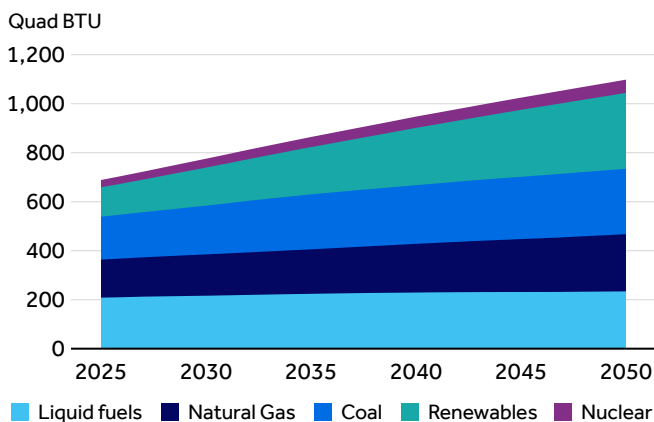
Barclays Research forecasts for energy demand and supply to 2050

	2025	2030	2035	2040	2050	CAGR
Demand (Quad Btu)						
Global Energy Demand	657.60	703.62	752.09	799.97	885.61	1.2%
Global Electricity Demand	265.53	297.68	333.72	371.91	442.93	2.1%
AI / Data Centre Demand	0.21	3.58	7.10	11.18	11.18	17.1%
Supply (Quad Btu)						
Liquid fuels	203.11	205.02	206.68	206.18	200.19	-0.1%
Natural gas	149.85	157.52	164.99	176.60	199.39	1.1%
Coal	162.30	167.33	174.98	177.81	185.61	0.5%
Renewables	113.65	140.49	168.66	200.03	256.98	3.3%
Nuclear	28.85	33.37	36.81	39.33	43.40	1.6%

Source: EIA, Barclays Research

FIGURE 2

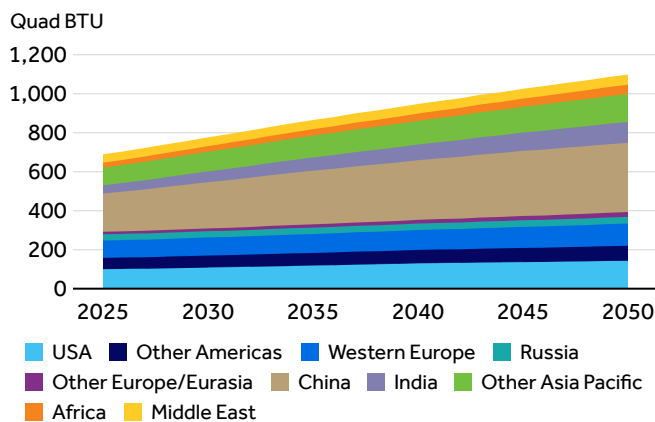
Energy use by fuel source



Source: EIA, Barclays Research

FIGURE 3

Energy use by region



Source: EIA, Barclays Research



Over the past three years, data centres have increased prospective energy needs, while higher EV penetration has reduced it

Our energy model utilizes the EIA's International Energy Outlook 2023 reference scenario, adapted to Barclays house views, particularly for data centres and EVs, where we see key deviations today in terms of the outlook versus 2023. Our base case calculates 32 quad Btu of new data centre energy demand by 2040. For reference, we expect ~950 quad Btu energy usage globally by 2040 (data centres will be ~12% of the increase). Past 2040, we do not model, in aggregate, more data centre additions, given lower visibility.

In absolute terms, data centres will need more energy than entire countries

2040, we estimate more than 600GW of data centre capacity will require ~32 quad Btu of energy (electricity and conversion losses from producing electricity). For context, this is roughly equivalent to 2025 energy use in Russia and slightly lower than in India.

A historic build-out of data centres

We estimate that data centre installed capacity growth will average more than 30% per year in 2026-27, before moderating to about 20% in 2028-29 (new capacity additions could plateau in 2028). The US is expected to be the largest contributor, with installed IT capacity rising from 34GW in 2025 to over 110GW by 2029, implying over 40% growth in the first two years⁸. This represents a very significant acceleration in the US build-out relative to other regions. For the rest of the world, we assume a more moderate growth trajectory, reflecting slower demand progression and infrastructure deployment outside of the US. We assume non-US markets (ex-China) will grow slower, while China is expected to pick up pace in the coming years.

Global installed data centre IT capacity reached some 70GW in 2025. We estimate that capacity additions could increase about 25GW in 2026 and more than 30GW in 2027, with the US accounting for the largest share of incremental capacity, contributing about 15GW and 21GW, respectively.

Beyond 2027, we expect the pace of additions to plateau, with the US adding a further 20GW+ per annum, reflecting a transition from the acceleration phase to a more sustained growth trajectory, as indicated above.

⁸ EIA's International Energy Outlook 2023

We expect hyperscalers to account for the largest share of new capacity additions, representing about 60% of total additions over our forecast period (excluding China). After analysing close to 500 projects, we conclude that a significant proportion of those announced by non-hyperscalers could face clear execution bottlenecks and might not be realised at all. As a result, we believe realised capacity additions are likely to be more heavily skewed towards hyperscalers than announced project pipelines alone would suggest.

Growth in electrical vehicle use

We expect a steady increase in global EV fleet penetration, with EV mix as a percentage of the overall fleet growing at about 15% CAGR between 2020 and 2050, reaching nearly 60% of the fleet in 2050.

China

Among the major markets, China will lead the EV fleet transition by a notable margin. Growth in the EV fleet mix is driven by high EV penetration of new vehicle sales (about 64% in 2026, rising to over 90% by the mid-2040s), as well as government incentives to encourage the transition (such as “scrappage” programs that have been in place since 2024).

Europe

Growth in the EV fleet mix will likely be driven by regulatory policy, as the EU is maintaining its 2035 targets. EV penetration is expected to have a sharp uptick from roughly 30% in 2025 to about 75% in 2035.

US

The EV fleet mix will lag due to slower adoption of EVs, with 2035 new sales of about 38%, roughly half the level expected in China/EU. This reflects the lack of regulatory support for EV adoption, as well as the high mix of large pickup trucks/large SUVs in the fleet, as these segments will likely be the slowest to electrify.

Rest of the World

We see uptake as somewhat contingent on the extent to which Chinese manufacturers continue to export EVs into these markets. The EV fleet transition will be more mixed across countries, with East Asia and Southeast Asia likely leading adoption.



The end-users of energy are categorised into four principal sectors: transportation, industrial, residential and commercial. Fossil fuels (petroleum, natural gas and coal) are the key primary sources, along with nuclear and renewables as non-CO₂ emitting sources. Electricity is interesting in that it

9 EIA's International Energy Outlook 2023

Source

- Petroleum: 35.9 (37%)
- Natural gas: 34.6 (36%)
- Renewable energy: 8.8 (9%)
- Coal: 8.7 (9%)
- Nuclear: 8.2 (9%)
- Total = 96.2 quad Btu (100%)**

End-use Sector

- Transportation: 28.2 (37%)
- Industrial: 26.6 (35%)
- Residential: 11.8 (15%)
- Commercial: 9.9 (13%)
- Total = 33.5 quad Btu (100%)**

Electric Power Sector

- Electricity sales to ultimate consumers: 13.8 (41%)
- Electricity system energy losses: 19.7 (59%)
- Total = 33.5 quad Btu (100%)**

Flows and Percentages:

- Petroleum to End-use:** Transportation (89%), Industrial (33%), Residential (8%), Commercial (8%).
- Natural gas to End-use:** Transportation (5%), Industrial (41%), Residential (42%), Commercial (38%).
- Renewable energy to End-use:** Transportation (6%), Industrial (9%), Residential (6%), Commercial (3%).
- Coal to End-use:** Transportation (<1%), Industrial (3%), Residential (44%), Commercial (51%).
- Nuclear to End-use:** Transportation (1%), Industrial (11%), Residential (23%), Commercial (24%).
- Electricity sales to End-use:** Transportation (1%), Industrial (40%), Residential (11%), Commercial (23%).
- Electricity system energy losses to End-use:** Transportation (1%), Industrial (40%), Residential (11%), Commercial (23%).

Quad Btu = Quadrillion British thermal units

A new era for energy expansion

Transition: A secular capital allocation cycle

We believe the global energy transition is entering a new phase. The first one was defined by climate ambitions, falling clean-technology costs and rapid deployment, helping establish clean power as the dominant source of incremental generation. Increasingly, however, the transition is being driven by secular growth factors beyond climate.

Energy security, competitiveness and sovereignty are becoming transition drivers on a par with sustainability. The transition is now closely tied to AI infrastructure, defence and domestic industrial capacity, with countries pursuing pathways shaped by their resource endowments, industrial priorities and energy-import vulnerabilities. Rising power demand, transmission constraints and geopolitical fragmentation are further reshaping energy and technology flows. In the US, growing power demand and the pursuit of energy dominance continue to support investment despite a less favourable policy backdrop for parts of the clean-energy sector.

Across Asia and Europe, clean energy is increasingly being deployed as strategic infrastructure, broadening the transition's foundations beyond climate policy and making the underlying capital cycle more durable.

We view this as a structurally bullish signal for both clean and conventional energy. Investment across the energy system continues to rise, with clean energy and electrification solutions gaining share of global energy spending. Clean energy investment reached parity with hydrocarbons only in 2019 but is expected to be twice as large in 2026. The IEA expects total energy investment to reach \$3.4trn in 2026, with almost two-thirds directed towards clean energy technologies and infrastructure (Figure 5).

We expect capex across the energy sector, including oil and gas, LNG, power, grids, renewables and electrification, to reach \$3.6trn in 2027. Our forecasts reflect the gap between the supply capacity supported by investment over the past decade and the capacity required to meet future demand. Put simply, above-trend energy demand growth will require above-trend growth in spending.

A multi-decade investment gap, not a temporary capex lift

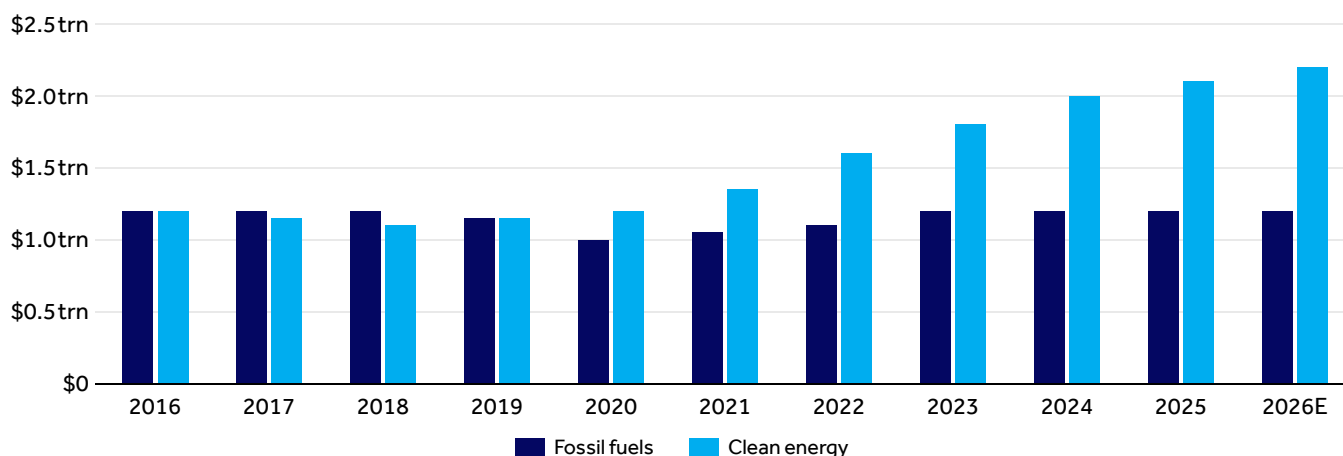
Rapidly rising energy transition capex is still insufficient to meet global energy needs. The energy transition is a multi-decade megatrend. It will require capital not only for greenfield assets, but also for transforming the existing high-emitting capital stock.

In short, the energy transition requires trillions of dollars of investment, and current spending remains insufficient.

FIGURE 5

Global investment in energy, 2016-2026e

2025, MER



MER = Market Exchange Rate. 2026e = estimated. Data are approximated from the IEA.

Source: World Energy Investment 2026, CC BY 4.0, Barclays Research

FIGURE 6

Significant transition capex is required this decade...

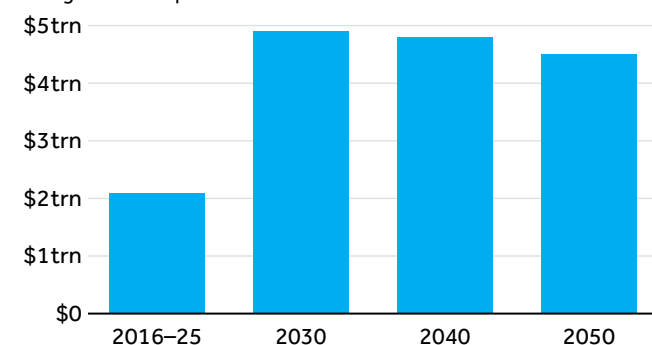
Average annual investment to 2030	Source	Scenario	Scope
\$3.5trn	NGFS	Net Zero 2050	Total transition investment in 1.5 °C scenario.
\$4.5trn	IEA	Net Zero 2050	Broad clean-energy investment requirement across power, grids, EVs, efficiency, low-emissions fuels, CCUS and related infrastructure.
>\$5trn	IRENA	1.5C pathway	Broad annual investment requirement to stay on a 1.5°C-aligned energy transition pathway.
\$5.6trn	BNEF	Net-zero pathway / Paris-aligned transition	Broad low-carbon energy-transition investment requirement to get on track for global net zero by 2050.

Source: NGFS, IEA, IRENA, BNEF, Barclays Research

FIGURE 7

...and will need to be sustained out to 2050

Average annual capital investment



IEA 2021 NZE energy-sector capital investment.

Source: IEA, Barclays Research

The composition of this investment matters as much as the total. As noted above, the first phase of the transition was principally about adding clean generation and lowering technology costs. The next one is likely to be more system-wide and capital-intensive: connecting clean generation, balancing variable output, electrifying final demand, transforming high-emitting industrial assets and protecting infrastructure against physical risks.

We also identify rising system friction, with renewable capacity expanding while grid investment lags, clean-generation costs falling while integration costs rise, and electrification advancing without sufficient clean power or system flexibility. The constraint is shifting from whether clean technologies can scale to the ability of the wider energy system to absorb that scale reliably and economically.

In the new energy equation, reliability is attracting a premium

An increasingly electrified economy raises the value of clean, firm baseload power. While renewables will remain a leading source of new generation, nuclear, hydro, geothermal, long-duration storage and other flexible low-carbon technologies should be viewed as complements rather than competing transition pathways. We are particularly constructive on nuclear, given its role at the intersection of decarbonisation, energy security and AI-related power demand, and believe the sector is experiencing a renaissance. Looking further ahead, nuclear fusion has the potential to transform the energy system and address the energy trilemma.

The broader lesson is that strategic importance does not automatically translate into attractive returns. China's manufacturing scale and technological advances have lowered the cost of solar, batteries and other clean-energy technologies, accelerating deployment but compressing margins across commoditised parts of the value chain.

As a result, being positive on clean-energy deployment is not the same as being uniformly bullish on clean-tech manufacturers. Value may accrue more consistently to developers with contracted demand and route-to-grid advantages or to scarcer enabling assets such as transmission, transformers, storage and grid software. Geopolitical fragmentation further complicates capital allocation as countries balance low-cost equipment against supply-chain resilience and energy security.

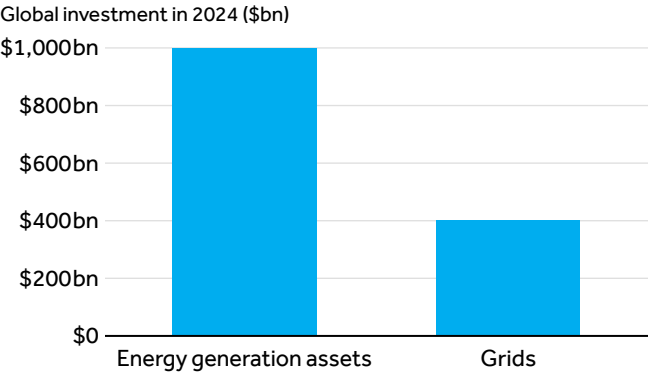
Ultimately, closing the investment gap requires more than identifying the right technologies. Projects need viable revenue models, predictable regulation, manageable execution risk and access to capital. Without these conditions, even economically necessary infrastructure can struggle to attract investment.

Transmission is becoming as important as generation

The most acute shortfall is not necessarily in clean generation itself, but in the infrastructure required to make that generation usable. Cheap generation does not necessarily imply reliable power. Its value depends increasingly on route-to-grid, storage, demand flexibility, interconnection and the ability of the power system to manage changing patterns of supply and demand. The Iberian blackout illustrates the challenge. The Spanish government’s investigation identified insufficient voltage-control capacity as a principal contributor, rather than high renewable penetration or a simple lack of system inertia. Renewable generation was not inherently the problem, but its rapid growth had exposed weaknesses in a power system that had not been modernised sufficiently quickly. The investment is also needed for large renewable adopters such as China and India, evidenced by their latest capex budgets.

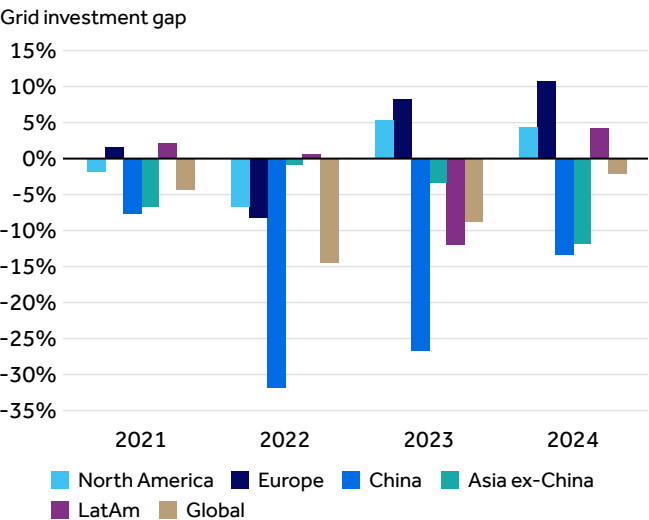
Bringing network investment closer to generation could define the next phase of the transition. Global investment into grids amounted to roughly \$400bn globally in 2024, compared with about \$1trn in generation assets, highlighting the potential scale of the investment opportunity as this ratio moves closer to parity (Figure 8). Our Energy Transition Barometer similarly finds renewable capacity growth outpacing grid investment in several regions, contributing to congestion, negative wholesale prices and greater volatility where network capacity and flexibility have failed to keep pace (Figure 9). We do not view this as a sign that the transition is failing, but rather that it is entering a more infrastructure-intensive phase that will require transmission, distribution, storage, transformers, cables, interconnection and digital grid management.

FIGURE 8
Global investment in grids significantly lags that into energy generation assets



Source: IEA (2025), World Energy Investment 2025, CC BY 4.0

FIGURE 9
Rapid renewables growth has outstripped grid investment growth, particularly in China and wider Asia



Grid investment gap is computed as the difference between grid investment and renewable capacity growth rates.
Source: BloombergNEF, Ember, Barclays Research

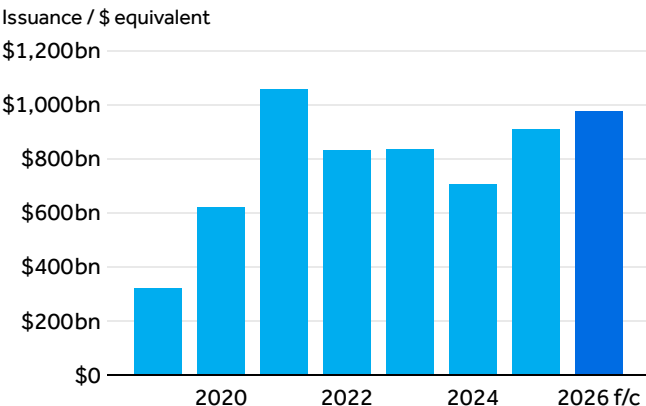
The financing challenge: mobilising capital at scale through ESG bonds

Delivering the next phase of the energy system will require trillions of dollars of investment across generation, transmission, storage, industrial infrastructure and energy-security assets, presenting a significant financing challenge. Mobilising sufficient capital may prove just as important as identifying the technologies needed to deliver the transition.

The ESG bond market is one mechanism through which this capital can be deployed. Over the past decade, green, sustainability and sustainability-linked bonds have evolved into a multi-trillion-dollar market (Figure 10) and an important source of financing for corporates, sovereigns and supranational organisations in particular. To date, however, both issuance and use-of-proceeds have been concentrated in a relatively narrow set of sectors and activities. As a result, labelled debt markets have played an important role in financing renewable energy, clean transportation and green buildings, but have been used less extensively in many of the sectors and activities facing the greatest transition financing needs.

ESG-labelled bonds can also offer issuers benefits beyond financing specific projects. They can help diversify and broaden the investor base, provide a mechanism for demonstrating transition and sustainability commitments, and may offer issuance-related advantages through stronger order books and, in some cases, modest pricing benefits.

FIGURE 10
Total ESG bond issuance across all asset classes



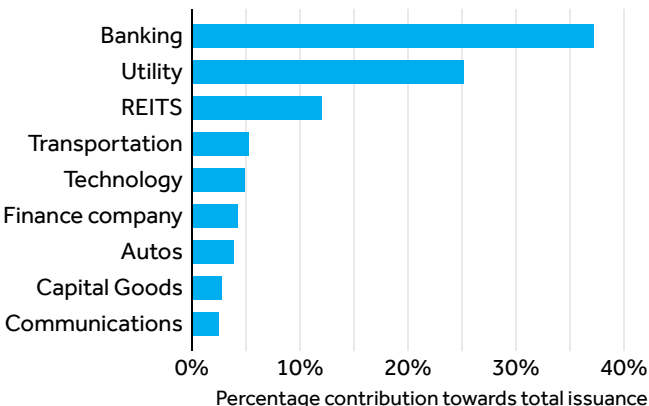
DM hard currency bonds only. Excludes transition bonds.
Source: Bloomberg, Dealogic, Barclays Research

The challenge is that many of the sectors facing the greatest capital requirements in the next phase of the energy transition have made relatively limited use of ESG-labelled financing. This matters because the new energy equation is about more than renewable deployment alone. It requires investment across a broader set of assets, including industrial transformation, energy-security infrastructure and technologies that reduce emissions from existing systems.

This is where transition finance could become increasingly important. Transition bonds have the potential to channel capital towards decarbonisation activities in sectors that cannot easily issue traditional green bonds because their activities are not fully aligned with a low-carbon end-state today. However, adoption remains relatively limited. In our view, further market development will require greater policy and market clarity about what constitutes a credible transition investment.

Electricity networks are becoming one of the most important enablers of the energy transition. While labelled financing has historically focused on renewable generation, growing electrification and energy-security requirements are increasing the need for investment in transmission and distribution infrastructure. Given the role networks play in supporting system decarbonisation and broader energy resilience, we see scope for both green and transition bond markets to play a larger role in financing future grid expansion.

FIGURE 11
H1 26 issuance by sector



DM hard currency corporate bonds only. Excludes transition bonds.
Source: Bloomberg, Dealogic, Barclays Research



Energy in the age of fragmentation

Why energy security matters more than ever

For decades, global energy flows were largely driven by efficiency. Energy was produced where it was cheapest and transported around the world through increasingly integrated supply chains.

That model is now changing.

Russia's invasion of Ukraine, tensions in the Middle East and growing competition between major powers have reminded governments that energy security cannot be taken for granted. At the same time, technological shifts, including AI, electrification and renewable energy are changing how energy is produced and where it is consumed.

The result is a new era of energy geopolitics. Access to energy remains critical, but governments and businesses are increasingly focused on resilience as well as efficiency. So the focus is now not simply if energy is available, it is whether it is secure, reliable and affordable.

Three challenges will shape the next decade

1. Securing Energy Supply

The world still relies heavily on oil and natural gas.

Recent disruptions have highlighted the risks of depending on a small number of suppliers or transport routes. As a

result, countries are diversifying imports, expanding storage capacity and investing in new production, pipelines and LNG infrastructure.

Energy security is increasingly driving investment decisions alongside economics.

2. Meeting Growing Electricity Demand

The rapid growth of AI, data centres, electric vehicles and electrification is creating a new challenge: supplying enough electricity.

Meeting this demand requires far more than power generation alone. It also requires new grids, transmission networks, storage systems and backup capacity.

This means the energy transition is becoming a large-scale infrastructure challenge as well as a climate challenge.

3. Developing New Energy Technologies

Innovation will remain central to energy systems.

Renewable technologies continue to improve, while interest in nuclear power is increasing globally. Further ahead, breakthroughs such as commercial nuclear fusion could transform the economics of energy altogether.

Access to both capital and scientific expertise will increasingly determine which countries lead this next phase.

The return of energy geography

Perhaps the most important consequence of fragmentation is that geography matters again.

For much of the past three decades, economic activity tended to locate where labour was cheapest. In the decades ahead, energy availability may become just as important.

Energy-intensive industries, data centres and future AI infrastructure are increasingly being drawn towards regions with abundant and affordable power. In that sense, energy could play a similar role in the next phase of globalisation as cheap labour played in the last.

The countries best positioned for the next energy era are likely to be those that combine secure energy supplies, infrastructure, technology and access to capital.

Who benefits from the new energy map?

The shift towards electrification is changing the geography of energy.

Historically, economic influence in energy was concentrated among oil and gas producers. In the future, countries with abundant renewable resources, strong electricity infrastructure, critical minerals or advanced technology capabilities could become equally important.

This creates new winners and new dependencies.

The United States

Combines fossil fuel resources, renewable energy potential, technological leadership and deep capital markets.

China

Has established a dominant position in renewable technology manufacturing and critical mineral processing.

Europe

Remains capital-rich but will need major investment in grids, infrastructure and energy security.

The Gulf region

Is likely to remain a major energy exporter while increasingly investing in digital infrastructure and data centres.

Resource-rich economies

Africa, Latin America and parts of Asia may benefit from growing demand for critical minerals and energy supplies.

Australia

Stands out as a rare combination of abundant energy resources, critical minerals and political stability.

Case study 1

Public policy: Can the US build power fast enough?

Meeting rising energy demand will require the rapid expansion of generation and transmission capacity. In our view, policy and permitting constraints could prevent the US from expanding energy infrastructure quickly enough and at sufficient scale to keep pace with demand.

Permitting has become increasingly complex

Permitting is often discussed as a single process, but in practice it involves multiple federal, state and local reviews that can add years to project timelines. For large infrastructure projects, we estimate developers may face more than 60 permits and reviews across numerous agencies.

Delays are common. Across 104 energy-related projects in the federal permitting system, nearly one-third of completed milestones have been late. State and local approvals can further extend timelines, while litigation risk remains significant. Almost 30% of large energy projects have been cancelled or paused¹⁰.

Prior permitting reforms have underdelivered

Congress has repeatedly attempted to streamline permitting, but progress has been modest. The 2023 Fiscal Responsibility Act introduced a two-year deadline for environmental impact statements, yet only 39% have met that target. Meaningful change may prove difficult to achieve quickly.

The Trump administration has sought to accelerate permitting for energy and data-centre projects through executive action, and some permitting metrics have improved. However, it remains too early to conclude that review times for major projects have materially shortened.

More importantly, executive action has inherent limitations: it cannot fully address the federal, state and local constraints that slow infrastructure development. Without broader legislative reform, we believe permitting will remain a significant barrier to expanding US energy infrastructure at the speed and scale required.

10 US Federal Permitting Dashboard Data Portal



Why energy demand could keep inflation higher for longer

Why this cycle may be different

Despite growing EV adoption, global oil demand continues to rise, while supply growth is slowing as US production approaches a peak and investment elsewhere struggles to keep pace. We forecast global oil demand growth of c.1.1mb/d annually between 2027 and 2030, reaching 110.6mb/d by 2030. In our view, current prices underestimate this underlying market tightness, leaving commodity prices vulnerable to renewed upside pressure.

Rising energy demand may increase inflation expectations more than the market expects

For much of the past decade, inflation has been shaped primarily by labour markets, supply-chain disruptions and central bank policy. We believe energy could become a more important driver of inflation than many investors currently expect.

The reason is straightforward. Energy demand is accelerating, while at the same time, supply growth is struggling to keep pace as permitting delays, infrastructure bottlenecks and years of underinvestment limit the speed at which new capacity can be brought online.

This creates an important question for policymakers and investors: could the energy supply-demand imbalance become a more powerful driver of inflation than other disinflationary forces?

Much of today's market narrative assumes that AI will be inflationary in the near term but ultimately disinflationary through productivity gains. While we broadly agree with this framework, it may underestimate the inflation risks associated with the large increase in energy demand required to support that growth.

As such, the next inflation cycle may be driven less by wages and more by commodities, energy and infrastructure constraints.

Three ways energy can increase inflation risk

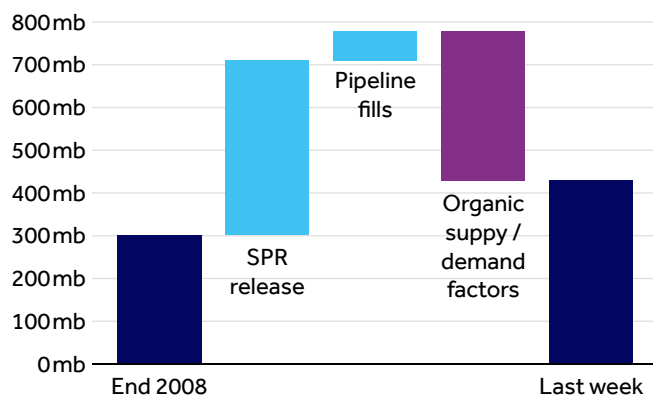
1. Higher Baseline Inflation

The most direct impact is through higher energy prices.

If energy demand continues to grow faster than supply, upward pressure on oil, natural gas and electricity prices is likely to persist. Because energy affects transportation, manufacturing, food production and industrial activity, higher energy costs can flow through to a broad range of goods and services throughout the economy.

FIGURE 12

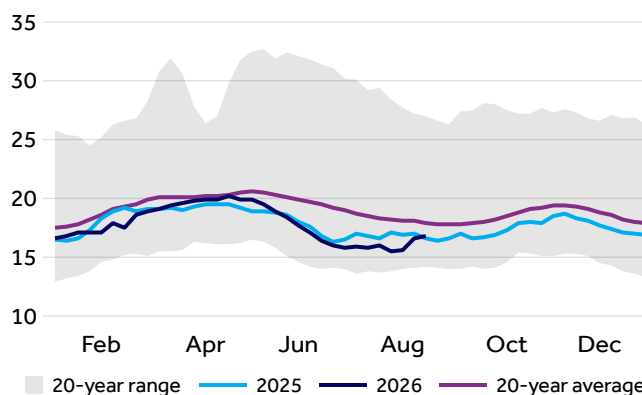
Strategic petroleum reserve releases have cushioned the effect on commercial inventories



Note: Last week - 28 August 2026
Source: EIA, Barclays Research

FIGURE 13

Yet commercial crude oil inventories in the US remain tight...



Source: EIA, Barclays Research

Even if energy prices do not surge dramatically, a structurally tighter energy market could result in inflation settling at a higher level than investors currently expect.

2. Greater inflation volatility

The second effect is increased volatility.

Tighter energy markets are generally less able to absorb unexpected shocks. This means geopolitical disruptions, weather events, infrastructure outages or supply interruptions can have a larger effect on prices.

As a result, inflation may become more volatile and less predictable. For businesses, consumers and policymakers, this uncertainty can be almost as important as the level of inflation itself.

3. More frequent inflation shocks

The final risk is asymmetry.

In theory, higher volatility could produce both positive and negative price surprises. In practice, today's geopolitical environment suggests risks are tilted towards higher prices, rather than lower ones.

Recent years have demonstrated how quickly geopolitical events can disrupt energy markets. Russia's invasion of Ukraine in 2022 and the US-Iran conflict in 2026 both generated large energy-price shocks that fed into inflation expectations worldwide.

As geopolitical fragmentation increases, such events may become more common. This creates a world in which inflation risks are not evenly balanced, but skewed to the upside.

Why it matters

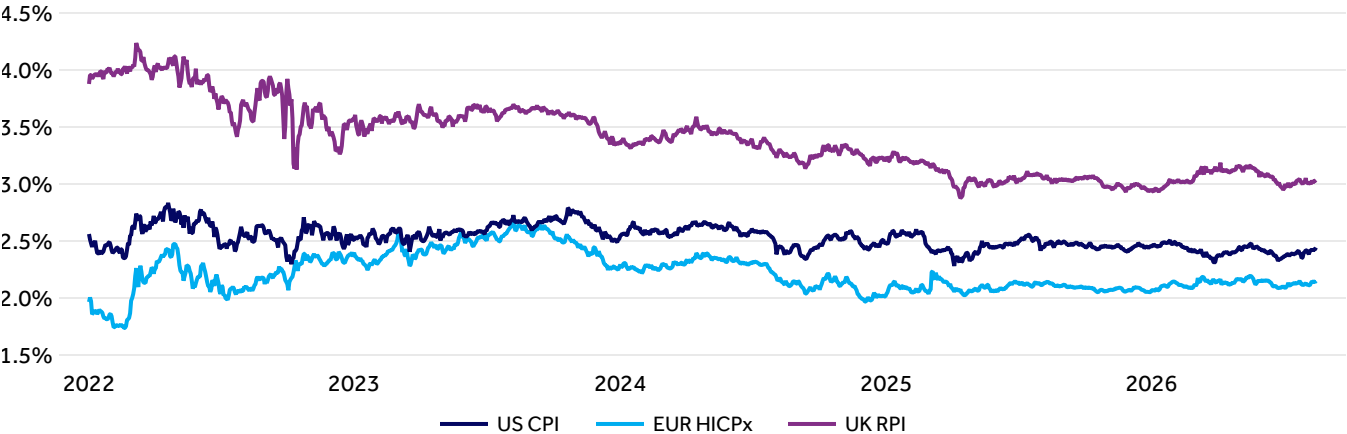
Electrification, AI and energy security are creating powerful new sources of demand at a time when supply and infrastructure are struggling to keep pace. The result is a system that is potentially more inflationary, more volatile and more vulnerable to geopolitical shocks than investors have become accustomed to over the past decade.

If that assessment proves correct, energy may become one of the most important determinants of inflation in the years ahead. Put together, we see the above dynamics as helping to explain why investors are positioning for a rise in inflation risk premium.



FIGURE 14

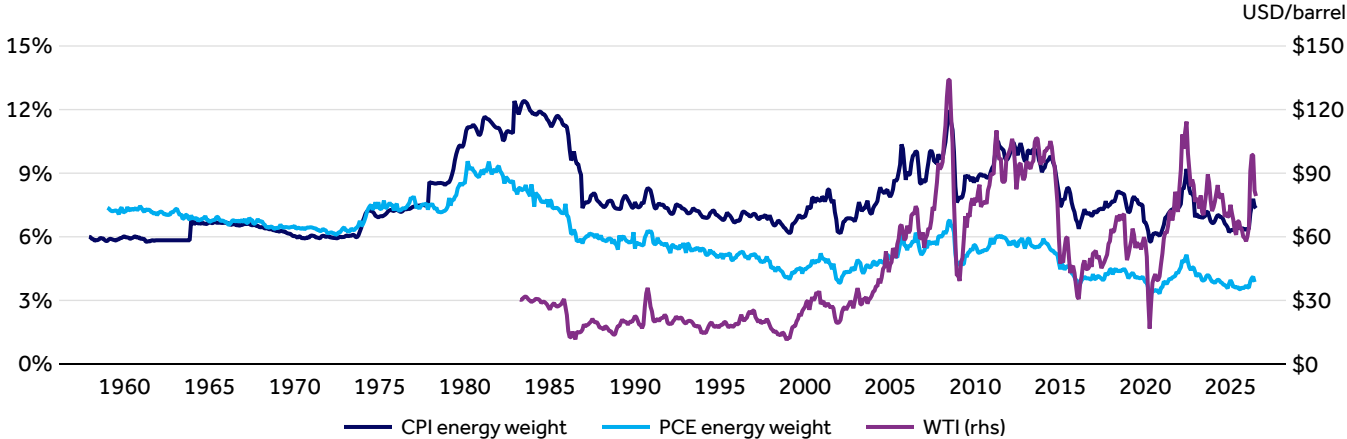
5y5y inflation swaps cross-market



No conversion adjustment made to 5y5y RPI swaps.
Source: Barclays Research

FIGURE 15

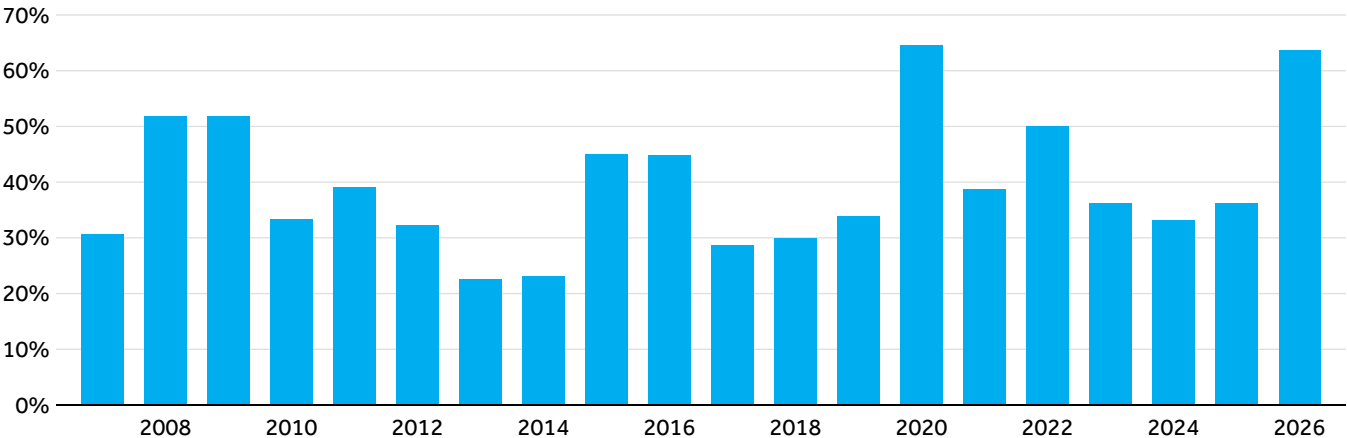
Energy weights in US inflation index baskets vs. WTI futures



Source: BEA, BLS, CME, Macrobond, Barclays Research

FIGURE 16

Crude Oil ETF Volatility Index



Annual average.
Source: CBOE, Macrobond, Barclays Research



Case study 2

Physical AI and energy

AI gets physical, powered by energy

The investment debate about robotics has so far largely focused on chips and AI models. Yet as AI moves from software into the physical world, energy is becoming increasingly important. Every humanoid robot, autonomous vehicle, warehouse robot and drone ultimately converts electricity into movement. As a result, the rise of physical AI could create a new source of electricity demand that extends well beyond data centres and into factories, warehouses and logistics networks. Put differently, physical AI is effectively creating a new category of energy consumer: machines capable of performing physical labour.

Robots are a new category of energy consumer

Physical AI is still a small market today, but our research suggests it could evolve into a \$1trn ecosystem by 2035, spanning humanoids, autonomous vehicles, industrial automation and drones. As deployment accelerates, investors may need to think about robotics as not only a technology theme, but also an energy theme. Unlike traditional software, physical AI creates two-layer energy demand: cloud compute to train increasingly complex models and local power to run robots performing tasks in the physical world.

Training physical AI models is particularly energy intensive because they must learn not only reasoning, but also physics, motion, balance, navigation and manipulation, much of it through large-scale simulations and digital twins. Advanced AI model training currently consumes 100-154 MW of energy, with projections exceeding 4 GW by 2030. While data on physical AI models remain limited, we expect their energy requirements to be even greater, given the added complexity of learning and executing tasks in the physical world.

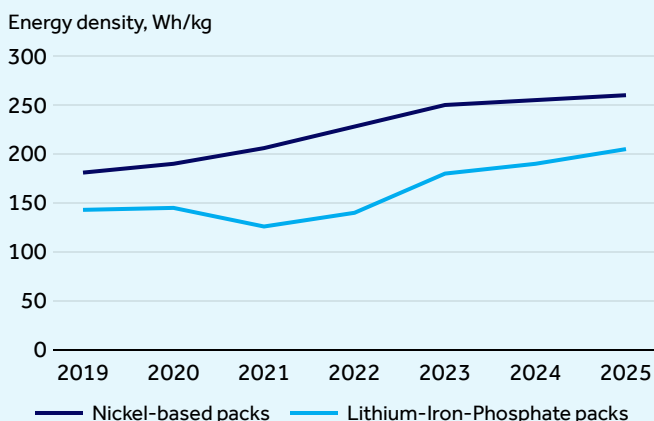
The second layer of energy demand comes from physical execution. Once deployed, robots continuously consume electricity through motors, sensors, processors and communication systems. Unlike large language models, robots must operate in the physical world, overcoming gravity, inertia and friction. Put simply, movement is energy intensive, making batteries, typically lithium-ion, a critical enabling technology.

Batteries are improving but remain a constraint. Battery density has increased about 50% since 2019 (Figure 17), while battery prices have fallen almost eightfold since 2013 (Figure 18). These advances have been critical in making mobile robotics economically viable. Yet batteries remain one of the sector's biggest constraints.

Current humanoids typically operate for only 4-5 hours before requiring recharging or battery replacement. More intensive tasks can reduce operating time further. Even highly advanced

FIGURE 17

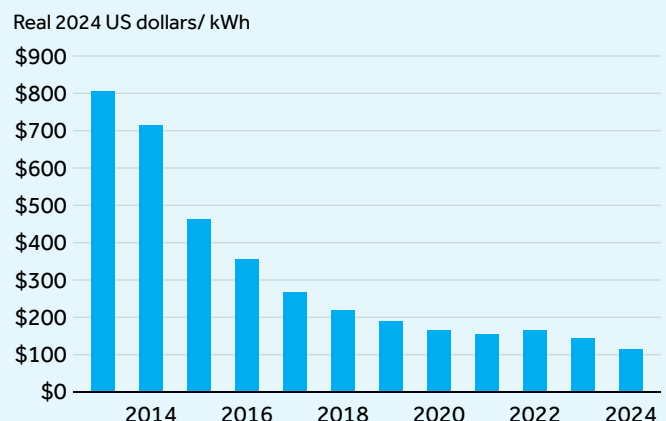
Energy capacity per kg of battery pack has steadily improved



Source: Bloomberg BNEF (Bloomberg New Energy Finance), Barclays Research

FIGURE 18

Lithium-ion battery prices have dropped significantly over the past decade



Source: Bloomberg BNEF (Bloomberg New Energy Finance), Barclays Research



humanoids remain significantly less energy efficient than humans. We estimate that a humanoid such as Tesla Optimus consumes roughly 500 watts while walking, whereas a human performing the same activity is 40-45% more energy efficient (Figure 19).

From labour substitution to electricity substitution

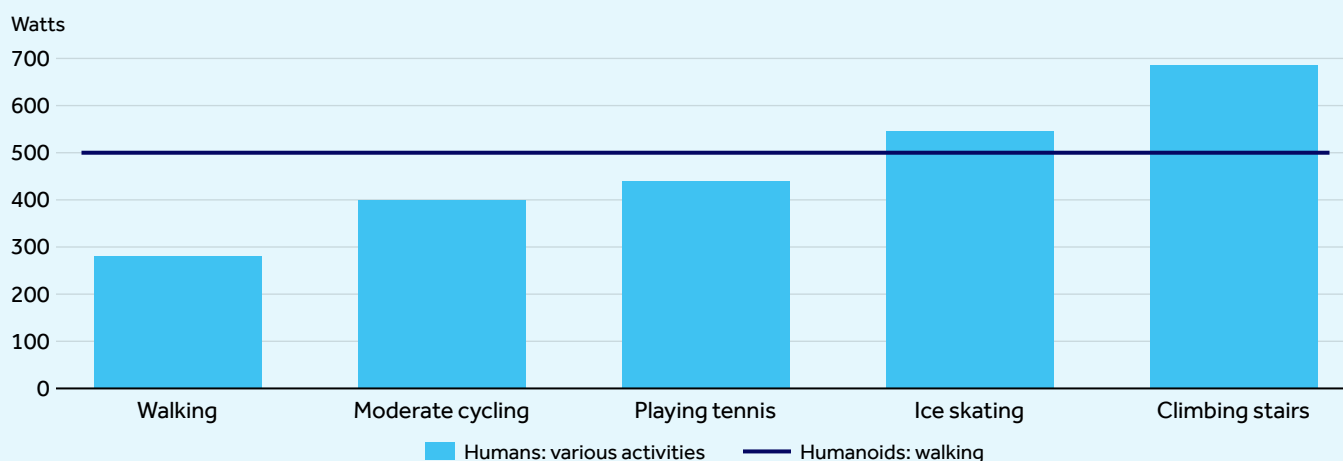
Historically, economic growth has relied on expanding labour inputs. Robotics changes that equation. Our research finds that humanoids could eventually help offset demographic pressures in ageing economies by substituting for labour in

manufacturing, logistics, healthcare and agriculture. In China alone, an upper-bound scenario suggests humanoids could reach the equivalent of 3.8% of labour capacity by 2035, helping offset a significant share of projected workforce declines.

However, replacing labour with robots does not eliminate resource consumption. Instead, it changes its composition. Physical work that was once powered by food and human labour increasingly becomes powered by electricity, batteries and semiconductors. In effect, robotics converts labour demand into energy demand.

FIGURE 19

5y5y humanoids' energy footprint



Source: AlphaSense, Douglas College Physics 1104 Custom Textbook, Barclays Research

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