ENERGY TRANSITION AND ENERGY SECURITY BULLETIN

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EDITOR'S NOTE

The second issue of the Energy Transition and Energy Security Bulletin continues the analytical agenda established in Issue 1 by examining four interconnected dimensions of the global energy system: investment flows, energy costs, energy security, and the environmental implications of the ongoing energy transition. Taken together, these dimensions provide a comprehensive view of the structural pressures and policy trade-offs that define contemporary energy governance.

Global energy investment has entered a new phase. For the first time in history, annual clean energy investment has surpassed two trillion dollars, reaching $2.3 trillion in 2025 — nearly sevenfold the level recorded a decade earlier. Yet the pace of this expansion, while historically unprecedented, remains insufficient. The International Energy Agency estimates that achieving net-zero emissions by 2050 requires annual clean energy investment to reach $5.6 trillion by 2030. The current trajectory covers only 41 percent of this threshold. This gap is not merely a financial shortfall; it reflects a deeper structural misalignment between stated climate commitments and the allocation of capital in global energy systems.

At the same time, the data presented in this issue reveal a persistent and politically significant asymmetry in energy costs. Industrial electricity prices in the European Union remain approximately 50 percent higher than those in the United States and China, primarily due to the region's exposure to volatile gas markets — a vulnerability sharply exposed by the 2022 energy crisis. This cost differential has direct implications for industrial competitiveness and underscores a critical tension within the energy trilemma: the pursuit of environmental sustainability through the accelerated phase-out of fossil fuels can, in the short term, compromise the affordability dimension of energy policy.

The import dependency analysis reinforces this complexity. Japan and South Korea remain among the most fossil-fuel-dependent advanced economies in the world, with import dependency ratios of 87 and 82 percent respectively. For these countries, energy security is not an abstract policy objective but an immediate economic and geopolitical vulnerability.

Global CO_2 emissions reached a new record of 38.1 $GtCO_2$ in 2025, continuing an upward trajectory despite the rapid deployment of renewable energy. This apparent paradox — accelerating clean energy investment alongside rising emissions — reflects the structural inertia of the global energy system. Emissions growth is increasingly concentrated in emerging and developing economies, where rising energy demand continues to outpace the deployment of low-carbon alternatives.

Finally, the critical minerals section addresses what may be the most underappreciated dimension of the energy transition: the substitution of fossil fuel dependence with mineral resource dependence. The clean energy technologies upon which the transition depends require large and rapidly growing quantities of lithium, cobalt, nickel, copper, and rare earth elements. Under net-zero scenarios, lithium demand could rise ninefold by 2040. Supply chains for these materials are currently concentrated in a small number of countries, raising new concerns about geopolitical vulnerability and strategic competition.

This bulletin aims to contribute to a more informed and evidence-based discussion on these issues, drawing on the most recent available data from the International Energy Agency, BloombergNEF, the Global Carbon Project, and other authoritative sources. Readers are encouraged to consult Issue 1 (March 2026) for the foundational analysis of global electricity generation trends, Türkiye's energy mix, and the energy trilemma framework that underpins the present discussion. A note on investment figures: the $2.3 trillion figure cited in this issue (BloombergNEF, 2026) refers to clean energy investment specifically, whereas the broader global energy investment total — including fossil fuel sectors — reached approximately $3 trillion in 2025 according to IEA estimates; both figures are accurate and measure different scopes.

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GLOBAL CLEAN ENERGY INVESTMENT (2015–2025)

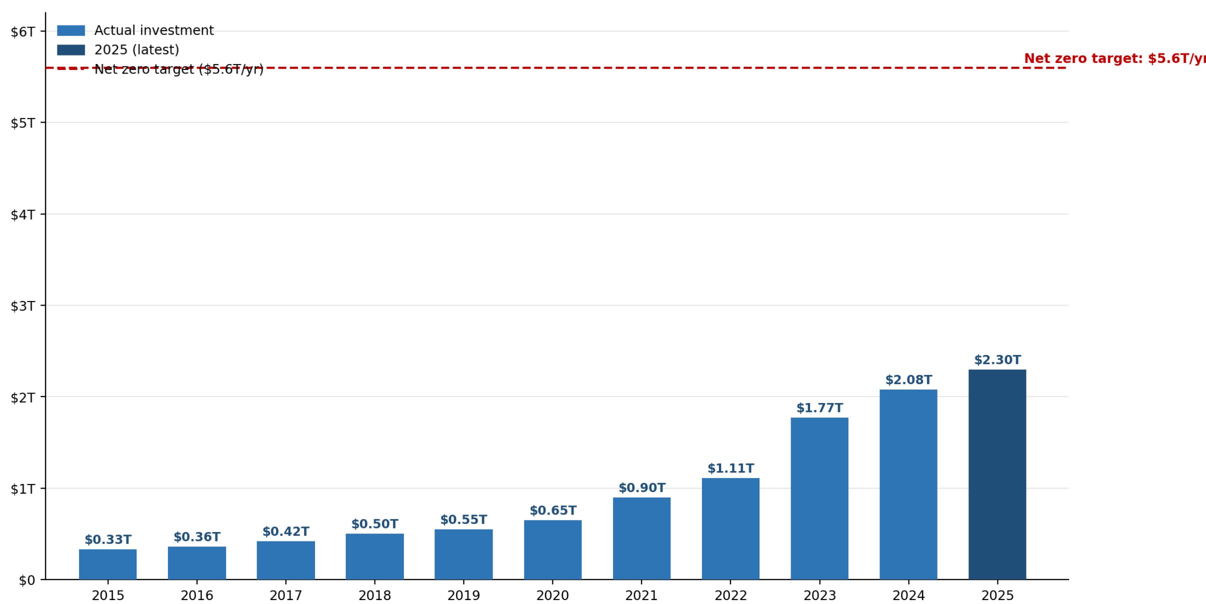

Figure 1. Global clean energy investment (2015–2025, USD trillion)
Source: BloombergNEF Energy Transition Investment Trends 2026; IEA World Energy Investment 2025

Figure 1 illustrates the evolution of global clean energy investment between 2015 and 2025. Over this decade, annual investment has grown nearly sevenfold — from $330 billion to $2.3 trillion — reflecting a fundamental reorientation of capital flows within the global energy system. The most significant acceleration occurred after 2020, driven by post-pandemic fiscal stimulus programmes, the implementation of major clean energy legislation in the United States and the European Union, and the rapid decline in the cost of solar photovoltaic and battery storage technologies.

Despite this remarkable expansion, the data reveal a persistent and widening gap between current investment levels and those required to meet internationally agreed climate objectives. The IEA's net-zero scenario requires annual clean energy investment to reach approximately $5.6 trillion by 2030. At present, the world is investing at less than half this rate. The dashed line in Figure 1 illustrates this gap visually, reinforcing that the current pace of investment — while historically unprecedented — remains structurally insufficient.

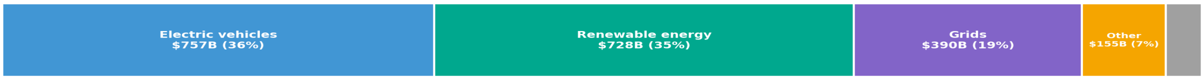

Figure 2. 2024 clean energy investment by sector (USD billion)
Source: BloombergNEF Energy Transition Investment Trends 2025

The sectoral breakdown of 2024 investment (Figure 2) reveals that electric vehicles and renewable power generation together account for approximately 71 percent of total clean energy spending. Grid infrastructure, representing 19 percent, has emerged as a critical bottleneck: without commensurate investment in transmission and distribution networks, the expanding capacity of wind and solar generation cannot be effectively utilised. Energy storage, though growing rapidly, still represents only 3 percent of total investment.

Key Insights

1 **Investment momentum is real but insufficient**

Global clean energy investment reached $2.3 trillion in 2025 — a historic high. Yet this represents only 41% of the $5.6 trillion annual investment required by 2030 to put the world on track for net-zero emissions by 2050.

2 **Sectoral imbalances threaten transition speed**

Electric vehicles and renewables dominate investment flows, while critical enabling technologies — grids, storage, hydrogen, and carbon capture — remain significantly underfunded.

3 **Geographic concentration creates systemic risk**

China alone accounted for approximately 38% of global clean energy investment in 2024. Emerging and developing economies outside China received only 18% of global flows over the past decade.

GLOBAL ELECTRICITY PRICES AND ENERGY COSTS (2015–2025)

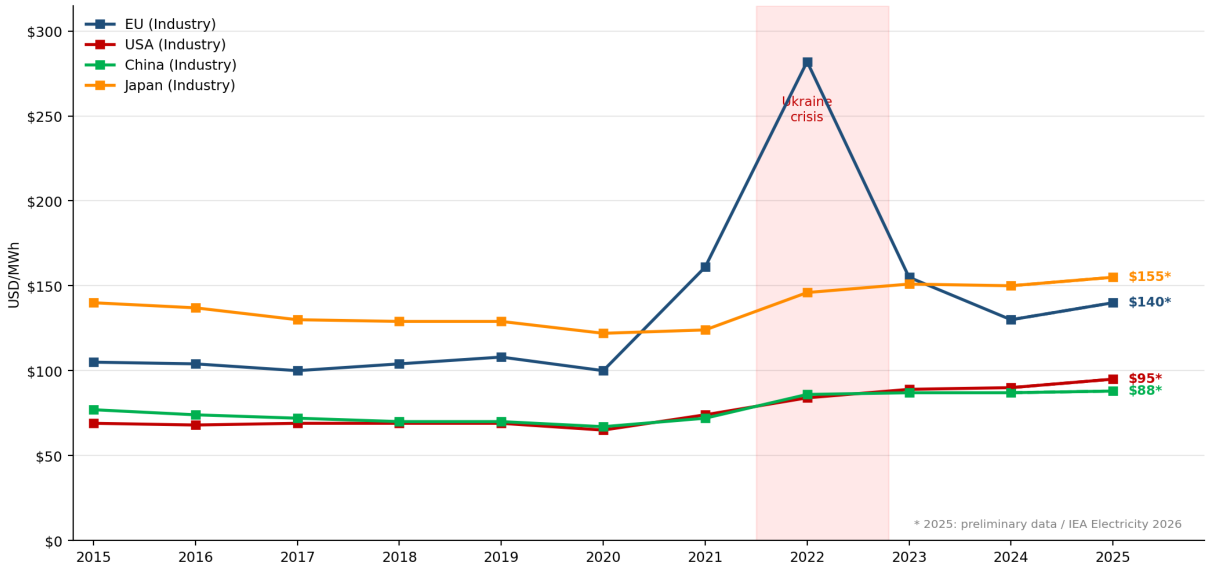

Figure 3. Industrial electricity prices by region, USD/MWh (2015–2025)
Note: 2025 figures are preliminary estimates. Source: IEA Energy Prices 2025

Figure 3 presents the evolution of industrial electricity prices across four major economies between 2015 and 2025. The data reveal a striking divergence in energy cost structures that has intensified significantly over the past decade. European industrial electricity prices peaked at approximately $282 per MWh in 2022 — the direct consequence of Russia's curtailment of natural gas supplies following the invasion of Ukraine — before declining to around $130–$140 per MWh by 2024–2025. Despite this partial correction, EU industrial prices remain approximately 50 percent higher than comparable prices in the United States and China.

This cost asymmetry has important implications for industrial competitiveness and for the political economy of energy transition. Energy-intensive industries operating within the European Union face a structural cost disadvantage relative to their counterparts in North America and Asia. The United States, benefiting from abundant domestic natural gas supplies unlocked through the shale revolution, has maintained comparatively stable industrial electricity prices throughout the period. China's price trajectory has remained broadly stable due to a combination of coal availability and administered pricing mechanisms. Japan, despite its high import dependency, has seen prices moderate somewhat following investments in LNG import infrastructure and energy efficiency improvements.

Key Insights

1 **The 2022 energy crisis exposed Europe's structural vulnerability**

EU industrial electricity prices tripled between 2020 and 2022, driven by gas market disruption. Despite partial recovery, prices remain approximately 50% above pre-crisis norms.

2 **Energy cost asymmetries undermine industrial competitiveness**

The persistent gap between EU and US/China electricity prices creates a structural challenge for energy-intensive industries and complicates the political economy of climate policy.

3 **Affordability is the trilemma's most politically sensitive dimension**
Rising energy costs disproportionately affect households and industries in import-dependent economies, reinforcing the need to integrate affordability into energy transition frameworks.

ENERGY SECURITY AND IMPORT DEPENDENCY (2024)

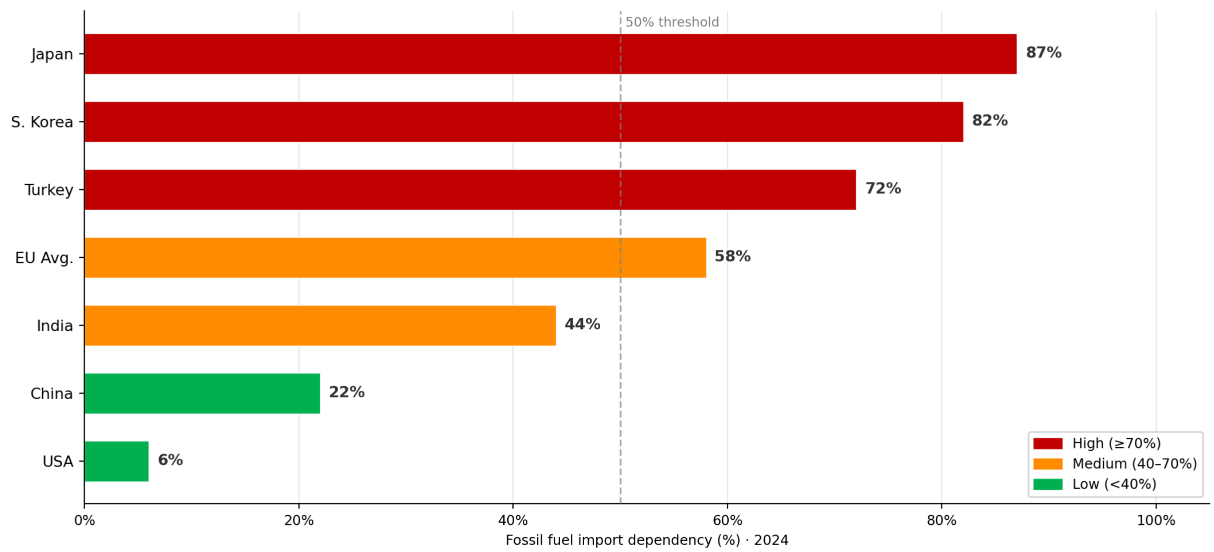

Figure 4. Fossil fuel import dependency by country, % (2024)
Source: IEA World Energy Balances 2024; Eurostat 2025; METI Japan 2024

Figure 4 illustrates the fossil fuel import dependency ratios of seven major economies based on the most recent available data for 2024. The variation across countries is striking and reflects fundamental differences in natural resource endowments, geographic location, and the structure of national energy systems. Japan and South Korea, lacking significant domestic fossil fuel reserves, remain the most import-dependent advanced economies in the world, at 87 and 82 percent respectively. For both countries, energy security represents a permanent structural constraint that shapes virtually every dimension of energy policy.

Türkiye's import dependency of 72 percent places it among the more vulnerable economies in the analysis, particularly given its reliance on imported natural gas for both electricity generation and heating. The European Union's average of 58 percent masks considerable variation among member states and reflects the significant reduction in Russian gas imports achieved since 2022 — a reduction that has been costly in terms of both energy prices and industrial output. China's relatively low dependency ratio of 22 percent reflects its large domestic coal base, while the United States has achieved near-energy independence through domestic shale oil and gas development.

Key Insights

1 **High import dependency creates acute geopolitical exposure**
Japan, South Korea, and Türkiye each source more than 70% of their fossil fuel needs from abroad, making them highly sensitive to supply disruptions, price shocks, and geopolitical instability.

2 **Renewable energy is increasingly framed as an energy security tool**
Domestic renewable resources offer a pathway to reduce import dependency. Japan's technical wind and solar potential exceeds current electricity demand tenfold, yet remains largely untapped.

3 **The geography of energy security shapes transition strategies**
Countries with high import dependency face stronger incentives to accelerate domestic clean energy development — but often lack the financial resources to do so at the required pace.

GLOBAL CO_2 EMISSIONS TREND (2015–2025)

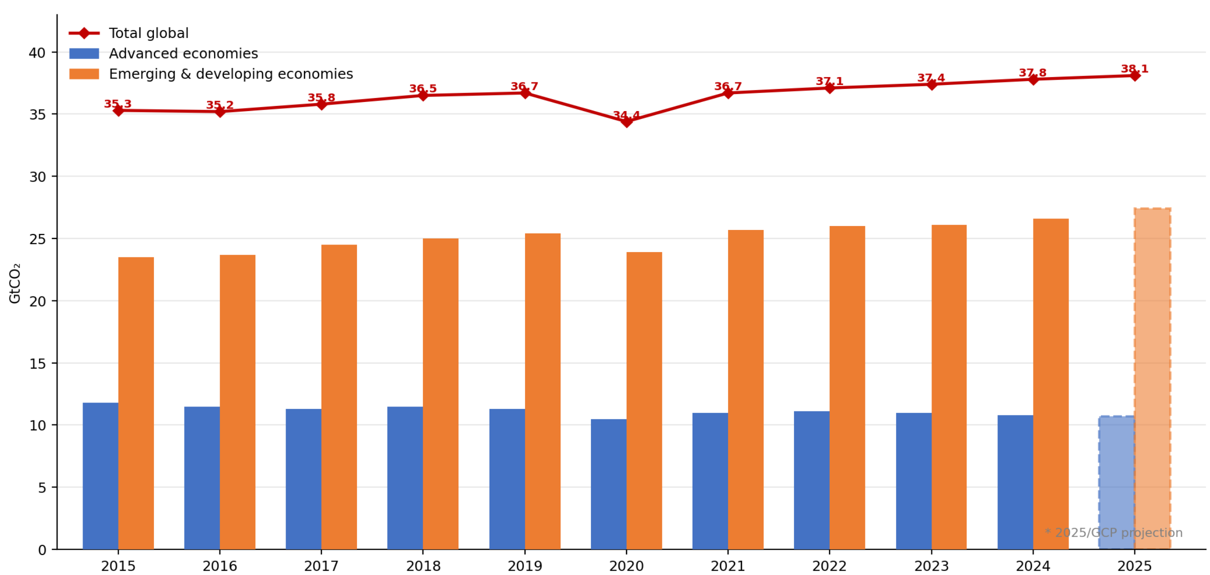

Figure 5. Global energy-related CO_2 emissions by economy group ($GtCO_2$, 2015–2025)
Note: 2025 figure is a Global Carbon Project projection. Source: IEA Global Energy Review 2025; Global Carbon Project 2024

Figure 5 presents the trajectory of global energy-related CO_2 emissions between 2015 and 2025, disaggregated between advanced economies and emerging and developing economies. The data reveal a paradox at the heart of contemporary climate policy: despite the largest and most sustained expansion of clean energy investment in history, global emissions have continued to rise, reaching a new record of 38.1 $GtCO_2$ in 2025.

Two structural dynamics drive this outcome. First, energy demand growth in emerging and developing economies continues to outpace the deployment of renewable energy capacity, resulting in increased reliance on fossil fuels. Second, the absolute volume of fossil fuel consumption globally remains high even as its share of total energy supply gradually declines. In other words, a growing energy system can generate more clean energy in absolute terms while still consuming more fossil fuels than the previous year. This dynamic explains why rising renewable investment and rising emissions are, paradoxically, not mutually exclusive in the current phase of the energy transition.

The divergence between advanced and developing economies is particularly notable. Emissions in advanced economies have continued to decline, driven by structural changes in their energy mixes and the phase-out of coal in electricity generation. In contrast, emissions from emerging and developing economies have increased each year since 2020. This divergence has profound implications for the global architecture of climate policy and for the equity dimensions of the energy transition.

Key Insights

1 **Global emissions reached a new record in 2025**

Energy-related CO_2 emissions rose to 38.1 $GtCO_2$ — the highest level ever recorded — driven primarily by energy demand growth in emerging economies.

2 **Advanced economies are decoupling growth from emissions**

Emissions in OECD countries continued to decline in 2025, reflecting structural changes in energy systems and the accelerating deployment of renewables and energy efficiency measures.

3 **Emission growth is increasingly concentrated in developing economies**

Rapidly industrialising economies face a structural tension between expanding energy access — a development imperative — and limiting emissions, underscoring the need for differentiated transition finance.

CRITICAL MINERALS DEMAND AND THE ENERGY TRANSITION

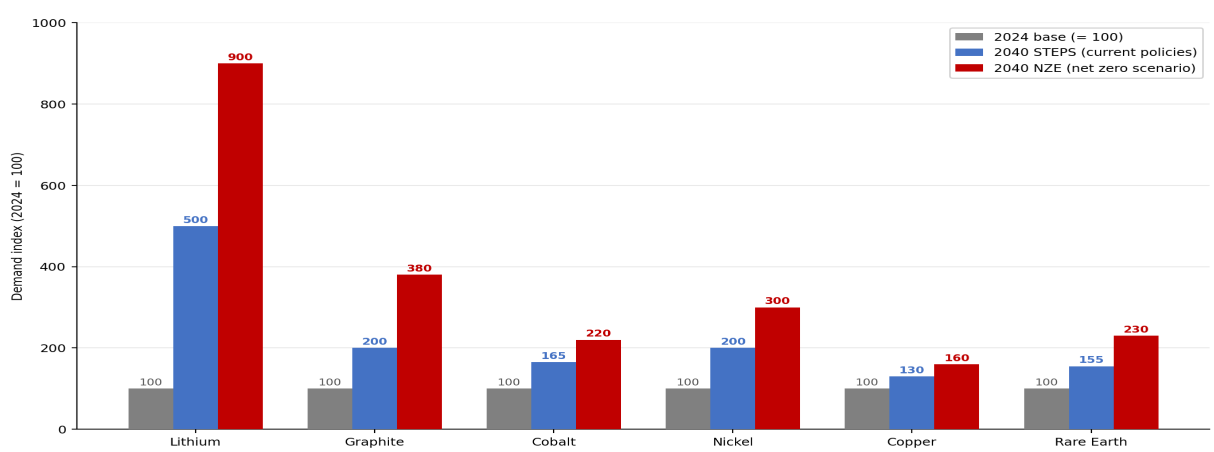

Figure 6. Critical minerals demand index (2024 = 100), STEPS and NZE scenarios, 2040
Source: IEA Global Critical Minerals Outlook 2025

Figure 6 illustrates the projected demand trajectories for six critical minerals under two scenarios: the Stated Policies Scenario (STEPS), which reflects the impact of currently implemented policies, and the Net Zero Emissions scenario (NZE), which describes the pathway required to limit global warming to 1.5°C. The scale of projected demand growth is significant. Under the STEPS scenario, lithium demand is projected to increase fivefold by 2040 relative to 2024 levels; under the NZE scenario, the increase reaches approximately ninefold. Similar trajectories apply to graphite, nickel, cobalt, and rare earth elements.

Beyond the volume challenge, the geographic concentration of critical mineral production and refining represents a distinct and growing geopolitical risk. Refining capacity for several key minerals is heavily concentrated in China, which accounts for approximately 50 to 90 percent of global refining capacity across these commodities. China's decision in late 2024 and early 2025 to impose export restrictions on gallium, germanium, antimony, and seven heavy rare earth elements has directly demonstrated the strategic leverage that mineral export controls can generate. This has accelerated efforts by the European Union, the United States, Japan, and others to develop domestic and allied supply chains for critical materials.

The IEA's Global Critical Minerals Outlook 2025 estimates that approved mining and refining projects are currently sufficient to meet only 60 to 70 percent of projected demand under the STEPS scenario by 2035, implying a significant structural supply gap that must be addressed through accelerated investment, permitting reform, and international cooperation on supply chain resilience.

Key Insights

1 **The clean energy transition creates new resource dependencies**
Decarbonisation substantially increases demand for lithium, cobalt, nickel, copper, graphite, and rare earth elements — minerals with highly concentrated and geopolitically sensitive supply chains.

2 **Supply gaps threaten transition speed**
Approved mining and processing projects are insufficient to meet projected mineral demand under even the most conservative scenarios. New investment and permitting reform are urgently needed.

3 **Mineral geopolitics is reshaping energy security**
Export restrictions on critical minerals by major producing countries introduce a new dimension of supply risk into the global energy system — one increasingly recognised in national security strategies.

EXPERT OPINION

Oil, Inflation, and Geopolitics: The Iran Crisis and the Global Economic Crossroads

Prof. Dr. Oytun Meçik | Eskişehir Osmangazi University

The global economy in 2026 has once again been shaken by geopolitical tensions centred on Iran, pushing energy markets and inflation expectations into renewed uncertainty. Even without a full-scale supply disruption, the risk surrounding critical transit routes has been enough to drive oil prices sharply upward. Markets, acting on anticipation rather than realised shortages, have priced them at a significant geopolitical premium. This underscores a persistent reality: energy remains one of the most sensitive transmission channels through which geopolitical risks translate into macroeconomic instability.

Rising oil prices quickly extend beyond energy markets into the broader economy. As a key input in transportation, production, and agriculture, higher energy costs feed directly into consumer prices. This creates a widespread inflationary effect, particularly in economies already facing fragile price dynamics. Emerging markets are especially vulnerable, as energy import dependence amplifies both external imbalances and domestic inflationary pressures.

After a period of easing inflation, this new oil shock has forced central banks to reassess their positions. Policymakers now face a familiar dilemma: tightening monetary policy to contain inflation risks slowing growth, while a more accommodative stance could undermine inflation expectations. Because this inflation is largely driven by supply-side factors, conventional policy tools have limited effectiveness, making the trade-offs even more complex.

Inflation expectations add another layer of risk. Sustained increases in energy prices can alter the behaviour of firms and households, leading to higher wages and pre-emptive price adjustments. Once such dynamics take hold, inflation can become self-reinforcing, complicating stabilisation efforts. Early signs suggest that this risk is becoming more pronounced, particularly in economies where expectations had only recently stabilised.

At the same time, the crisis highlights the fragility of global energy security. Despite ongoing efforts toward decarbonisation, the world remains heavily dependent on fossil fuels. This dependence creates structural vulnerabilities, as geopolitical developments in key regions can have immediate global repercussions. For energy-importing countries, this is not only an economic challenge but also a strategic one.

The relationship between this crisis and the energy transition is inherently paradoxical. On the one hand, higher oil prices strengthen the case for renewable energy and reduce the relative cost advantage of fossil fuels. On the other hand, they increase the cost of investment and strain public finances, potentially slowing the transition. Thus, the same forces that accelerate the urgency of change can also hinder its implementation.

The distributional consequences of the shock are uneven. While some energy-exporting countries may benefit from higher revenues, oil-importing economies face worsening trade balances, rising inflation, and tighter fiscal constraints. Within countries, lower-income households bear a disproportionate burden, as energy and food expenditures constitute a larger share of their budgets.

Looking forward, much depends on the trajectory of the geopolitical conflict. A rapid de-escalation could stabilise energy markets and ease inflationary pressures. However, a prolonged crisis would likely sustain high oil prices and increase the risk of stagflation — a combination of weak growth and persistent inflation. In a more severe scenario, broader disruptions could extend beyond oil, intensifying global economic stress.

Ultimately, this episode is not merely a temporary shock but a reflection of deeper structural interdependencies. Energy markets, geopolitics, and macroeconomic stability remain tightly intertwined. The policy challenge, therefore, operates on two fronts: managing short-term inflationary pressures while accelerating the long-term transition toward a more resilient and diversified energy system. Decisions taken in this period will shape not only the trajectory of inflation and growth but also the future of global energy security.

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