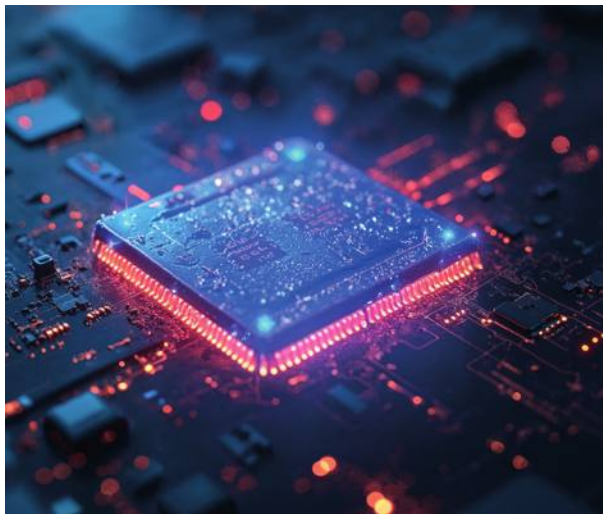

world energy we.

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CHECKPOINT ENERGY







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THE NEW ENERGY ORDER

by **Rita Lofano**

THE MAP OF GLOBAL POWER IS BEING REWRITTEN ON THE PATHWAYS OF ENERGY AND RAW MATERIALS. WITH RETURNS TO MERCANTILISM AND STRATEGIES TO CONTROL SEA PASSAGES, NATIONAL SECURITY ONCE AGAIN DOMINATES THE AGENDAS OF MAJOR POWERS



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ARE WE WITNESSING a shift in the geopolitical order? Yes—that much is certain. But the shape of the new world remains unclear. We glimpse its outlines on the horizon, but for now we sail in an ocean of uncertainty. This issue of WE explores the shifting landscape, rich with both risks and opportunities.

As Francesco Gattei puts it, "the world of tomorrow is no longer flat. It is the time of Jean-Baptiste Colbert, of distrust, of the quest for national superiority—and of 'chaos under heaven.'" In other words, we are leaving behind the era of globalization (the "flat world" of Thomas Friedman's bestseller) and entering one marked by mercantilism (as embodied by Colbert) and a volatile reshuffling of power among great states ("chaos," in Mao Zedong's phrase).

Of all the elements in Gattei's loaded phrase, "distrust" looms largest. It signals a fragile new order, where demand for security grows in a world increasingly dominated by national competition. On the surface, this may look like a return to the 20th century—but history never repeats itself in quite the same way. Instead, we're at the start of something new, marked by recurring shocks and fleeting attempts to predict what comes next.

Consider the "12-day war" between Israel and Iran. As the world braced for a drawn-out conflict, the U.S. abruptly ended the standoff with targeted strikes on Tehran's nuclear sites. In days, forecasts of a closed Strait of Hormuz—one of the most vital energy chokepoints—were upended. Once again, we are reminded: those who control energy—or the routes through which it flows—set the global agenda. From the Strait of Hormuz to the Suez Canal, from the Strait of Malacca to the Arctic Ocean, maritime corridors shape power.

U.S. intervention, combined with backchannel coordination with Israel, averted escalation. Tehran never shut the Strait. It echoed the warning issued by Henry Kissinger in the 1970s: "Control oil and you control nations; control food and you control people." And as Admiral Alfred Thayer Mahan, the great naval strategist, put it: "Whoever controls the sea controls the world." His words ring anew today, as Houthi attacks on shipping flash across the screens, disrupting traffic through the Red Sea and Suez.

Water matters everywhere. In Ukraine, access to the Black Sea—Odessa and the southern ports—is essential for Russia. Without secure southern outlets, Moscow loses influence over the Mediterranean and the trade in grain and gas. The collapse of the Soviet Union, which Vladimir Putin in 2005 called "the greatest geopolitical catastrophe of the 20th century," cost Russia its web of strategic ports across the Baltic, Black, and Caspian Seas, along with the pipelines that connected them.

Now, as climate change opens Arctic sea routes, Putin is pushing for control of the Northeast Passage, positioning it as a secure alternative to Suez.

Energy lies at the core of today's great power rivalries—and it's not just about oil. Rare earth elements, essential for batteries, semiconductors, solar panels, and advanced military technologies, are controlled by a small group of players: China, the Congo, and Russia. Meanwhile, lithium from Chile, Argentina, and Bolivia has become the latest battleground between Beijing and Washington.

In today's geopolitical mosaic, every route matters. Through the Belt and Road Initiative, China has poured investment into ports, railways, and pipelines stretching from Africa to Central Asia. While the Suez Canal and the Strait of Malacca remain crucial arteries, Beijing is actively developing alternative corridors. Iran, by virtue of its geography, is positioned as a strategic junction linking the Gulf, the Caucasus, Central Asia, and the Mediterranean. Tehran has already signed agreements with Russia, India, and Turkey to build out the International North-South Transport Corridor—an ambitious project that could sharply cut travel time between Europe and Asia compared to the traditional Suez route. But how stable is this vision in the wake of the Gaza war, Hezbollah's destruction in Lebanon, the collapse of Syria's regime, and Iran's weakening? We don't know. But we can begin to imagine a new chessboard—move the pieces, simulate, rehearse scenarios, reframe the news, and test our analyses.

The United States, now the world's leading producer of oil and natural gas, nonetheless imports 40 percent of the crude it consumes. This isn't due to a lack of domestic supply, but because national security isn't measured solely in barrels extracted—it also depends on routes controlled, strategic reserves, and military presence across the globe. "We are number one for oil and gas. But we cannot allow Iran, China or others to close the world's channels. We will never be hostages of our enemies," Trump said in 2019, during his first term, at the height of the trade war with China. The strategy is clear: even the most powerful producer must diversify sources and control routes—not out of necessity, but to avoid being trapped in any single geopolitical configuration.

In this delicate balance, the United States remains the principal architect of a global energy order that—though shifting in form—still hinges more on control of transit routes than on control of resources themselves. Power today is measured not at the source, but in the invisible flows beneath the earth and the patrolled waters of the sea.

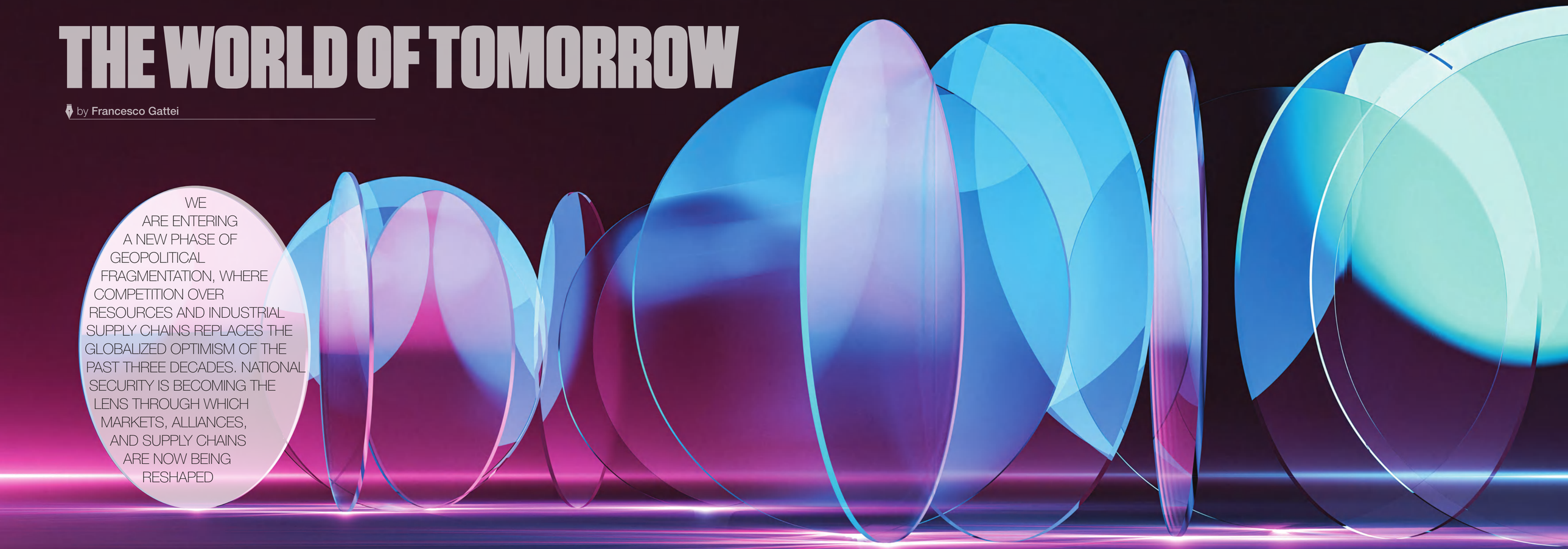


© NASA

The Strait of Hormuz (pictured) is a strategic crossroads of global energy. Around one-fifth of the world's oil passes through here every day.

THE WORLD OF TOMORROW

by Francesco Gattei



WE ARE ENTERING A NEW PHASE OF GEOPOLITICAL FRAGMENTATION, WHERE COMPETITION OVER RESOURCES AND INDUSTRIAL SUPPLY CHAINS REPLACES THE GLOBALIZED OPTIMISM OF THE PAST THREE DECADES. NATIONAL SECURITY IS BECOMING THE LENS THROUGH WHICH MARKETS, ALLIANCES, AND SUPPLY CHAINS ARE NOW BEING RESHAPED

"ALL UNDER heaven is in chaos, and the situation is excellent." Markets are unlikely to share Chairman Mao's sentiment in response to the current U.S. administration's flurry of announcements.

What once served as a rallying cry for revolution now reflects a broader systemic shift: the end of post–Cold War globalization and the beginning of a new era defined by geopolitical fragmentation and competition over critical resources and industrial supply chains.

FROM GLOBALIZATION TO GEOPOLITICAL FRAGMENTATION

For the past three decades, the global order appeared to follow an irreversible path. Economic interdependence was seen as a safeguard against conflict among major powers, and globalization was promoted as a driver of development and convergence across different economic and social systems. Thomas Friedman's *Flat World* envisioned a future of increasing alignment in economic dynamics, propelled by technology, free trade, and expanding multilateral governance to address challenges like climate change. It was the high point of Adam Smith's legacy—laissez-faire economics and the theory of national specialization in full bloom.

Instead, current dynamics point to escalating tensions between the United States and China. At the trade level, the economic winds have shifted—from the breeze of free trade to the gale of mercantilism.

This is not an unfamiliar world—it resembles the one we knew in the 1960s and 1970s. It reflects a cyclical pattern in international relations.

For 30 years, globalization was a positive-sum game. It was so successful it seemed beyond criticism: cheap Chinese goods—enabled by abundant labor, favorable tax regimes, economies of scale, and the world's cheapest coal energy—helped drive inflation down (to the point where pushing prices above 2 percent became difficult) and opened up expanding markets.

At the same time, globalization offered environmental benefits

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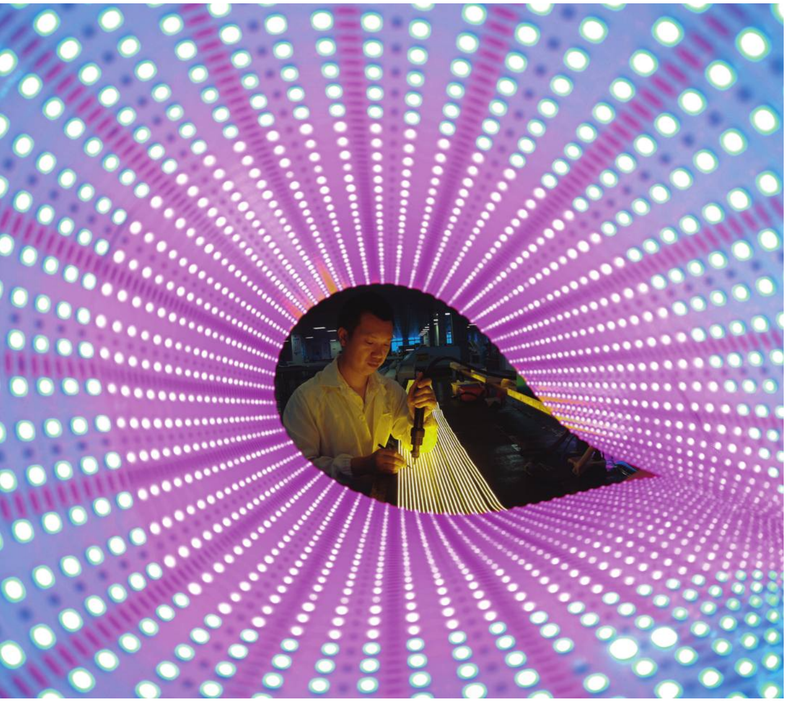

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For the past three decades, China has been considered the factory of the world, given the significant availability of cheap labor, favorable tax regimes and cheap energy. Pictured: an employee at work on the production line of LED lamps for export, at the Jiangxi Jingyuxin Lighting Technology Co. plant in Jiangxi province, China.

to wealthier countries, which outsourced high-impact industrial processes. It was, in short, an ideal arrangement for the West, which assumed its technological edge would remain unchallenged.

Today, that paradigm is beginning to fracture, and the belief in mutual benefit for all players has weakened. In a way, globalization has entered its adolescence: the son—China—challenging the father—the West—asserting its independence in thought and action.

The result is a shift from a unipolar Western-led world, as described in Ian Morris's "Why the West Rules—for Now", to a more contested system in which major powers promote diverging industrial, trade, and political models, each courting less-aligned countries.

The old assumption of the West's enduring supremacy no longer holds. Technological capabilities are spreading more broadly.

And not surprisingly, since 2012, the Thucydides trap has regained relevance in describing the risks of conflict between hegemon and emerging power.

INDUSTRIAL POLICY AS A NEW SECURITY POLICY

Despite the proclamations and provocations of the current U.S. administration, the shift underway appears more than tactical. It signals the emergence of a new order—one that marks the return of national-scale industrial policy for the first time since the fall of the Berlin Wall. It also reflects a renewed focus on "Main Street"—the world of independent small businesses—as a counterpoint to both Wall Street finance and China's rapid technological ascent, sometimes dubbed the "Great Wall Street."

Markets, with their faith in the efficient allocation of capital, tend to downplay the risks of dependency. But today, the world is no longer flat—everything is viewed through the lens of national security.

The United States and China are now competing not just for market access, but for the pillars of value creation: energy and industry, resources and strategic supply chains—from semiconductors to rare earths—and assured access to critical technologies, especially in aerospace and defense.

Alongside the renewed focus on industrial and energy cycles, a trend toward selective exclusion is gaining strength. Tariffs, financial restrictions, and the sidelining of firms from "non-aligned" countries in major projects are becoming tools to reshape supply chains, dependencies, and trade flows.

Industrial policy is once again security policy. Control over resources is becoming an extension of national sovereignty. In this new "cold war," global supply chains are being redrawn according to criteria that go beyond economics. Access to key production inputs can no longer be assumed—it is now shaped by security concerns and alignment within geopolitical blocs.

ENERGY AND TRANSITION IN THE NEW ERA OF COMPETITION

Setting aside other variables, the more fragmented and volatile world now taking shape will have significant implications for the energy sector—shaping how resources are preserved, how value chains for new projects evolve, and how opportunities for international arbitrage unfold.

From an energy standpoint, a new push to secure upstream assets is likely, especially in underexplored regions or areas with untapped potential. This pressure will only grow as production from major U.S. onshore basins begins to decline—a shift many expect within the next few years. Players that had stepped back from international exploration are now likely to return to regions they once left behind. South America, Africa, and parts of Asia offer promising prospects for new resource development.

At the same time, restrictions on financial participation by companies from "non-aligned" countries in strategic projects are likely to increase, aimed at curbing rival powers' access to key resource basins. This renewed scramble for resources will inevitably reshape relationships with major producers in the Middle East, where both the U.S. and China will work to secure exclusive—or at least preferential—alliances.

In a more fragmented global landscape, opportunities for arbitrage and trading are likely to grow. U.S. energy—particularly LNG, with exports reaching about 11.6 Bcf/d in 2024—may become inaccessible to the Chinese market, reshaping global flows and forging new routes and alliances. In a more extreme scenario, industrial components—such as technologies and equipment—could also face mutual restrictions, with direct consequences for project development costs.

Finally, with regard to the energy transition, two parallel trends are emerging. On one hand, there is momentum behind accelerating the development of renewable energy and advanced nuclear technologies to reduce import dependence and enhance national energy resilience. On the other, growing distrust of global supply chains—especially those dominated by less trusted actors—risks slowing project implementation and driving up the costs of transition-related technologies.

The energy transition now seems increasingly shaped by the logic of security. Competition is overtaking cooperation, leading to a transition that is uneven, slow, and fragmented. The vision of a global economic model, coordinated international action, and sustained Western leadership appears to be unraveling.

For the industrial and energy sectors, the implications are significant. Technological asymmetries and arbitrage are emerging as defining features of this new landscape. After decades of downward cost pressure, a new inflationary factor is entering supply chains: the price of security and geopolitical rivalry.

The world is no longer flat. This is a new era—marked by Colbert-style interventionism, mutual distrust, the pursuit of national advantage, and growing disorder. Chaos under heaven, once again.

we

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The quixotic quest for a single source

by Moisés Naím



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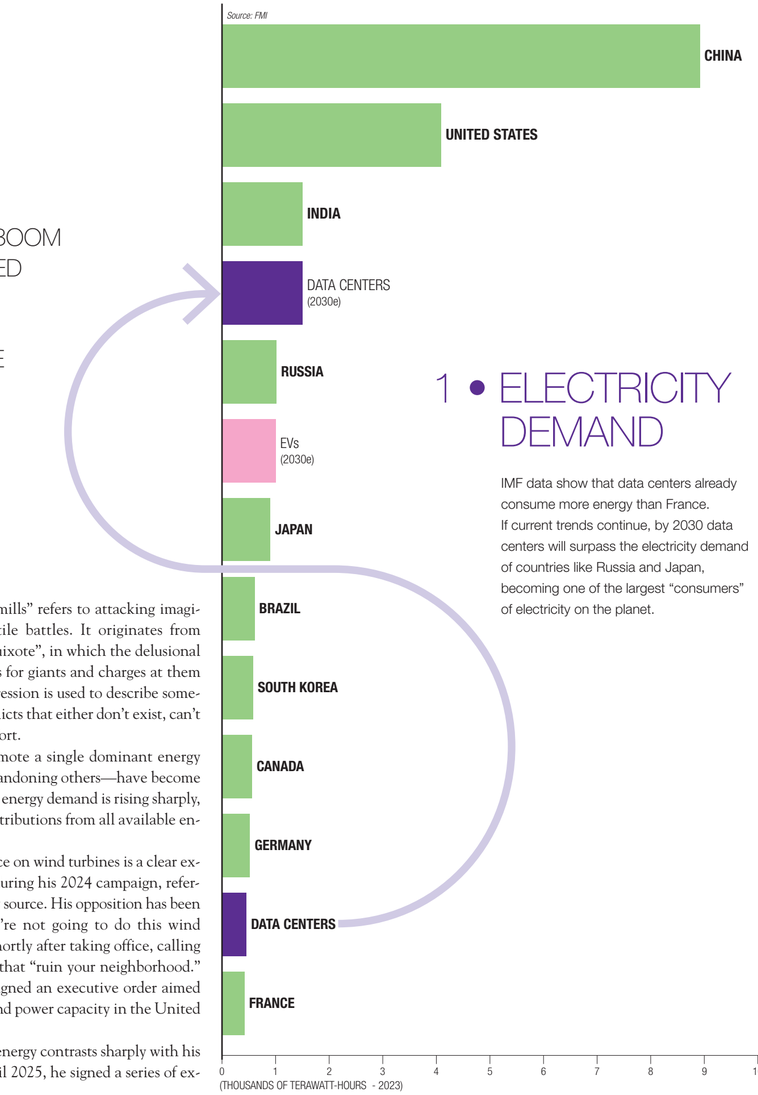
THE ARTIFICIAL INTELLIGENCE BOOM IS FUELING AN UNPRECEDENTED SPIKE IN ENERGY DEMAND, PUSHING GOVERNMENTS TO DRAW ON EVERY AVAILABLE SOURCE — POLITICS ASIDE

THE PHRASE "tilting at windmills" refers to attacking imaginary enemies or pursuing futile battles. It originates from Miguel de Cervantes' "Don Quixote", in which the delusional protagonist mistakes windmills for giants and charges at them with his lance. Today, the expression is used to describe someone who wastes energy on conflicts that either don't exist, can't be won, or aren't worth the effort.

Some of today's efforts to promote a single dominant energy source—while sidelining or abandoning others—have become increasingly "quixotic." Global energy demand is rising sharply, and meeting it will require contributions from all available energy sources.

President Donald Trump's stance on wind turbines is a clear example. "I hate wind," he said during his 2024 campaign, referring to wind power as an energy source. His opposition has been longstanding and blunt. "We're not going to do this wind thing," he declared at a rally shortly after taking office, calling turbines "big, ugly windmills" that "ruin your neighborhood." On his first day in office, he signed an executive order aimed at curbing the expansion of wind power capacity in the United States.

Trump's hostility toward wind energy contrasts sharply with his strong support for coal. In April 2025, he signed a series of ex-



1 • ELECTRICITY DEMAND

IMF data show that data centers already consume more energy than France. If current trends continue, by 2030 data centers will surpass the electricity demand of countries like Russia and Japan, becoming one of the largest "consumers" of electricity on the planet.

ecutive orders aimed at bolstering the coal industry, including measures to protect coal-fired power plants and speed up coal mining leases. "I call it beautiful, clean coal. I told my people, never use the word coal unless you put 'beautiful, clean' before it," the President remarked.

These contrasting positions reflect a broader, long-standing pattern: governments attempting to promote favored energy sources while suppressing others, often driven more by political preference than by practical or technical necessity.

That era is coming to an end.

THE HUGE CONSUMPTION OF ARTIFICIAL INTELLIGENCE

The explosive growth of artificial intelligence is driving a sharp rise in energy demand. This unprecedented surge will compel governments to rely on all available energy sources, regardless of political preference. As former Google CEO Eric Schmidt recently noted, "AI guzzles electricity: a single ChatGPT query requires ten times as much as a conventional web search." Data centers—the facilities that house servers, computers, and network hardware—are now the main drivers behind this accelerating demand for electricity.

According to the Organization of the Petroleum Exporting Countries (OPEC), data centers consumed roughly 500 terawatt-hours of electricity in 2023—comparable to the annual usage of medium-sized countries like Spain or Australia. This figure, which more than doubled compared to 2015–2019 levels, could triple to 1,500 terawatt-hours by 2030.

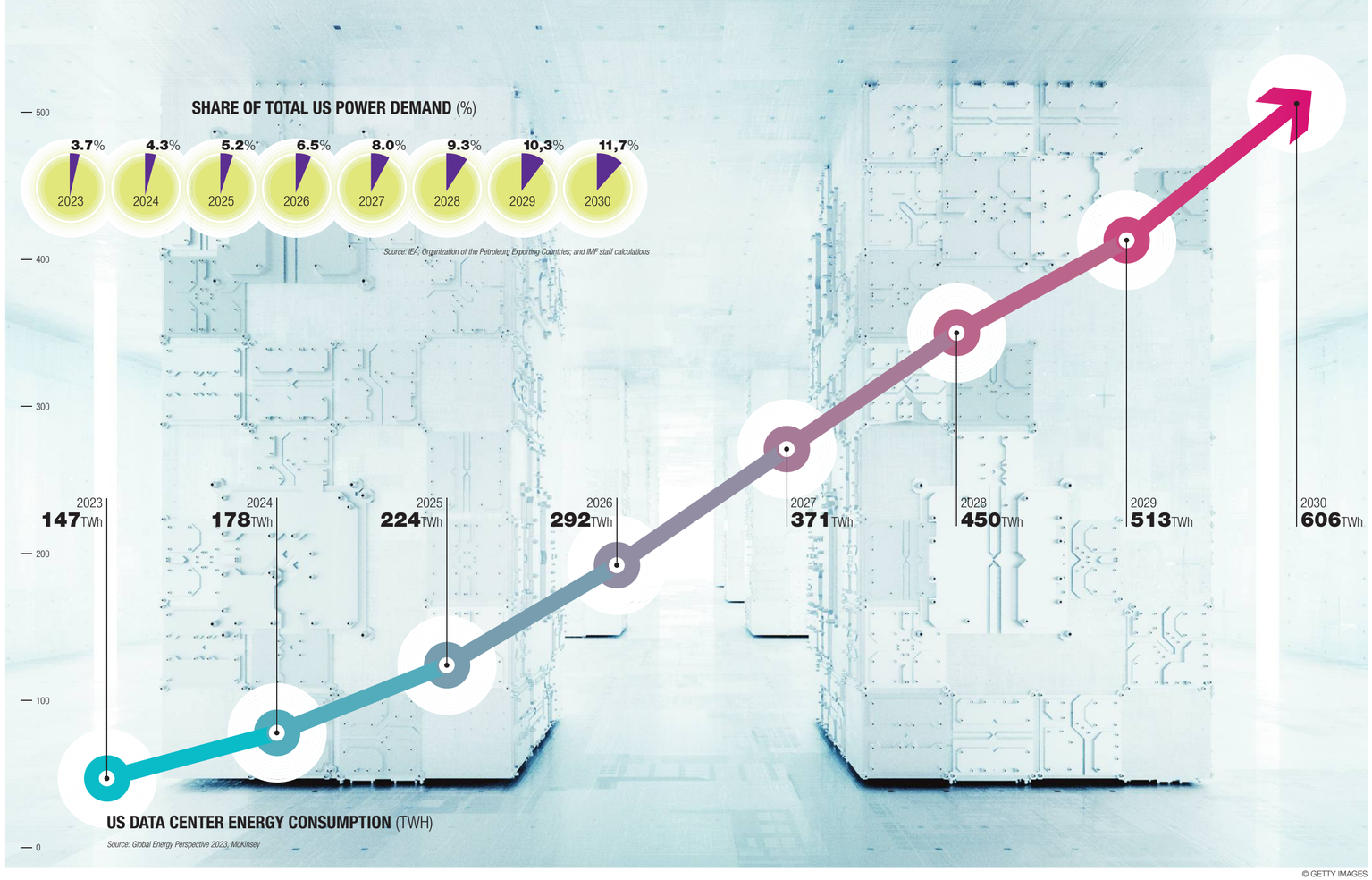
Researchers at the International Monetary Fund (IMF) offer an even starker comparison: data centers already consume as much electricity as countries like Germany or France. By 2030, their energy use could rival that of India. The surge is most pronounced in the United States, which has the highest concentration of data centers. According to McKinsey & Co., power demand from U.S. server farms is expected to more than triple by the end of the decade.

THE NEW PRAGMATISM OF GOVERNMENTS

This unprecedented rise in energy demand is already reshaping energy politics. Early signs point to a fundamental shift: governments that once firmly rejected certain energy sources are now quietly re-embracing them out of necessity.

UK Prime Minister Keir Starmer illustrates this new pragmatism. Despite his party's strong environmental platform, Starmer stated in February 2025, "I'll be open with you, oil and gas are part of the future mix for decades to come." This marks a clear shift from the UK's earlier, more aggressive fossil fuel phase-out plans. Former Prime Minister Tony Blair went further, calling for a "radical reset" of what he described as "irrational net-zero policies that are doomed to fail." He added, "Political leaders by and large know that the debate has become irrational. But they're terrified of saying so, for fear of being accused of climate denialism."

The intensifying competition between energy sources is creating a paradox. In the short term, the urgent need for large-scale new capacity is pushing governments to revisit energy options they had previously rejected—even those they were actively phasing out. Coal plants slated for closure are being granted life extensions. Nuclear power, long a source of political controversy, is seeing a revival as its combination of reliability and low emissions gains renewed recognition.



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2 • POWER DEMAND FOR US DATA CENTERS

The United States, home to the largest concentration of data centers in the world, is the country where energy demand is growing the fastest. According to a McKinsey projection, the energy demand for U.S. server farms is expected to more than triple, exceeding 600 terawatt-hours by 2030.

However, this doesn't mean all energy sources will be treated equally in the long run. Economic pressures and environmental concerns still favor certain technologies. Renewables and next-generation nuclear are likely to retain an edge in regions with the right resources and infrastructure. What's shifting is the absolutist mindset that has shaped government energy policy—ideological rigidity is giving way to pragmatic flexibility.

The fierce competition between energy sources isn't on the horizon—it's already here, and it's reshaping energy politics at a fundamental level. Governments are realizing that ideological preferences in energy policy are becoming unsustainable as AI-driven demand growth outpaces even the most ambitious capacity expansion plans.

What's emerging is a new energy pragmatism. The once-binary political debates over which sources are "good" or "bad" are giving way to more practical conversations about how best to combine all available technologies, tailored to regional needs and resource availability.

A CHALLENGING TRANSITION

This transition won't be seamless. Political leaders who staked their reputations on opposing certain energy sources will resist change. Industry groups with entrenched interests will fight to preserve existing advantages. But the sheer scale of energy demand leaves little room for ideological rigidity.

The next decade will show which countries adapt best to this new reality. Those that adopt a pragmatic, technology-neutral approach are likely to outperform those clinging to inflexible doctrines—whether those doctrines favor fossil fuels or renewables.

In energy policy, as in other domains, necessity is proving to be the mother of reinvention.

we

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SET THE SCENE

by **Francesca Zarri**

ENERGY LOGISTICS IS PLAYING AN INCREASINGLY CENTRAL ROLE IN GLOBAL GEOPOLITICS. EMERGING ROUTES AND INFRASTRUCTURE—FROM EUROPEAN PORTS TO EURASIAN GAS PIPELINES—ARE REDRAWING STRATEGIC BALANCES AND DEMANDING LONG-TERM INDUSTRIAL PLANNING AND VISION



Cargo ships load and unload cargo at the Nansha Port Container Terminal in Guangzhou, Guangdong province, China.

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TODAY, ENERGY logistics is more central than ever—shaped by both geopolitical tensions and global energy and climate policies.

Recent conflicts, especially in the Middle East and the war in Ukraine, have had major impacts on energy flows, disrupting both pipeline infrastructure and maritime routes. A volatile geopolitical landscape adds further uncertainty, shifting trade patterns and forcing constant reassessment by logistics and energy operators.

EUROPE CHANGES DIRECTION

In Europe, natural gas imports from Russia—both by pipeline and as LNG—dropped from 45 percent of total imports in 2021 to 19 percent in 2024. With the expected end of Russian gas transit through Ukraine, projections show a further decline to 13 percent by 2025.

EU sanctions have also sharply reduced Russian oil imports, from 27 percent of total supply in early 2022 to just 3 percent



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today. The European Commission aims to eliminate all Russian hydrocarbon imports by 2027. As of 2025, no new gas contracts with Russia are to be signed, with a phase-out of existing imports to follow.

However, while European measures have clearly reduced dependence on Russian energy, the pipeline export blockade has not achieved its intended strategic effect. Russia has offset the loss of Western customers by deepening energy ties with China, India, and Iran.

In 2024, China became the main buyer of Russian energy exports, including gas and oil. This shift has been enabled by a "shadow fleet" of intermediary traders circumventing Western sanctions, and by new pipeline infrastructure. Since 2019, the Power of Siberia 1 pipeline has supplied gas to China, targeting 38 billion cubic meters per year by 2025—roughly 9 percent of China's gas demand. It will be complemented by the planned Power of Siberia 2 pipeline, with a projected capacity of 50 billion cubic meters annually.

In January 2025, news broke of a Russia–Iran alliance to establish a joint energy hub, starting with plans to build a methane pipeline linking the two countries across the Caspian Sea. Under the agreement, Russia would supply approximately 300 million cubic meters of gas per day, with Iran permitted to resell surplus volumes to third countries.

India—already the world's third-largest oil consumer and importer—has become the second-largest buyer of Russian oil, increasing its share from just 1 percent before the invasion of Ukraine to around 40 percent. In the third year of the conflict, India imported Russian crude worth EUR 49 billion, largely driven by steep discounts relative to international benchmarks.

PORTS AND INVESTMENTS FOR NEW LOGISTICS

Europe's gas import scenario has shifted dramatically. LNG, long underutilized—with regasification terminals operating at just 20–25 percent capacity—has become essential. After the war in Ukraine disrupted Russian pipeline supplies, Europe turned to its next largest suppliers, Norway and Algeria. But neither could ramp up deliveries fast enough to fill the gap. In contrast, U.S. shale gas producers were well positioned to respond, seizing the opportunity to sell at high prices. Their ability to deliver, however, depended on the availability or rapid deployment of receiving infrastructure, particularly floating regasification units.

In 2022, the U.S. exported over 70 billion cubic meters (Gm^3) of gas to Europe, offsetting more than half of the shortfall from Russian supplies and becoming Europe's top supplier—well ahead of Qatar and all African countries combined. This trend continued in 2023, both in Europe and Japan. Global LNG supply is projected to grow by 30 percent by 2030, with 74 percent of that increase coming from projects currently under construction following recent Final Investment Decisions (FIDs). Of this new capacity, 70 percent will come from the U.S. and Qatar. The U.S. response to the energy crisis was not coincidental. For years, it had been positioning itself to shift from energy importer to net exporter, driven by the shale gas boom and sustained investment in liquefaction facilities, port infrastructure, and maritime logistics.



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Pipelines, ports, regasification terminals, power grids: energy infrastructure evolves to ensure security, flexibility and continuity of supply in a rapidly changing geopolitical and environmental context.

The war in Ukraine exposed Europe's industrial vulnerabilities, highlighting its failure to make strategic investments in global energy logistics. The lack of diversified infrastructure left Europe in a weaker position than the U.S. and China.

Today, energy logistics relies increasingly on ports, now functioning as key "energy hubs" for storing and producing LNG, biofuels, and hydrogen. This creates an urgent need—for both Europe as a whole and individual national economies—for coordinated governance. Strategic planning and investment must align around gradually upgrading these hubs, fostering regional synergies and cross-border cooperation between states and industries.

A STRATEGIC VISION

Wars and the pandemic have disrupted and shortened supply chains, shifting globalization toward regionalization. A forward-looking industrial strategy now calls for developing existing infrastructure with the aim of ensuring preparedness across a diversified energy landscape. Europe must take a leadership role, using all available financial and regulatory tools to promote multi-intermodality—particularly in and through ports—as a lever to shape the future of European energy logistics.

The winning strategy is not reactive adaptation to geopolitical shifts, but the proactive development of an independent infrastructure network—ports, terminals, pipelines, and transport routes—underpinned by strategic investment and long-term partnerships.

FRANCESCA ZARRI
Head of Eni Italian Upstream Activities.

THE IMPACTS OF CLIMATE CHANGE

by **Margherita Bianchi** and **Alessio Sangiorgio**

GLOBAL WARMING IS DRIVING MORE FREQUENT EXTREME WEATHER EVENTS, DIRECTLY IMPACTING ENERGY SUPPLY CHAINS AND THE RESILIENCE OF CRITICAL INFRASTRUCTURE. THE EFFECTS INCLUDE POWER SYSTEM DISRUPTIONS, RISING COSTS, AND SERIOUS SOCIO-ECONOMIC CONSEQUENCES. A ROBUST ADAPTATION STRATEGY IS URGENTLY NEEDED



CRITICAL INFRASTRUCTURE continues to expand, with more services—especially digital ones—relying on its reliable operation. These systems now face two types of challenges: deliberate threats and a growing number of disruptions from accidental, natural, and climate-related events. Climate change, driven by human activity, is intensifying extreme weather, directly affecting supply chains, energy production, and the resilience of physical infrastructure. The consequences are broad: power system disruptions, rising operational costs, widening infrastructure funding gaps, and serious societal and economic impacts.

Recent and well-known examples include the massive 2022 power outages in the Buenos Aires region, where a historic heatwave left around 700,000 people without electricity; the 2020 freezing rain in the Russian Far East, which coated power lines

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and cut off power to hundreds of thousands of homes for several days; and summer droughts in Europe that have reduced output from nuclear, hydro, and thermal generation just as heatwaves were driving power demand to peak levels.

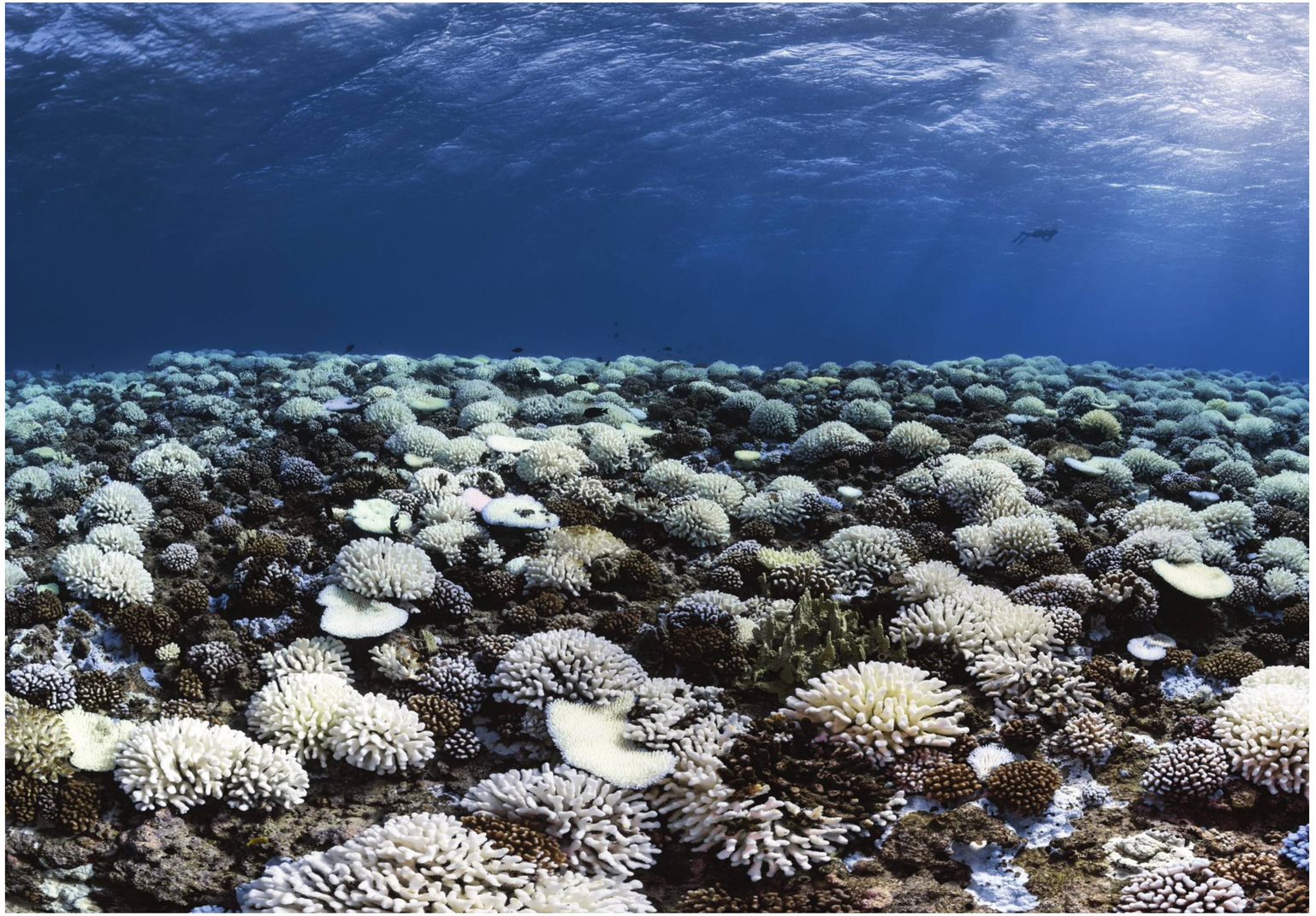
Risks arise from several factors. First, critical infrastructure is built for long-term operation, but most facilities were designed with the assumption that future climate conditions would mirror those of the past—a premise that no longer holds. Climate models quickly become outdated. Second, many of these systems rely on fragile components and offer limited redundancy, making them more vulnerable to disruption.

A FOCUS ON MARITIME AND UNDERWATER IMPACTS

The maritime and underwater domains are especially vulnerable, hosting rich biodiversity and playing a key role in regulating the global climate by cycling heat, water, and elements such as carbon. Rising ocean and seafloor temperatures are driving more severe weather patterns—altering ocean currents, intensifying storm surges, and strengthening hurricanes. These shifts pose risks to both coastal infrastructure, such as landing stations and terminals, and underwater assets like pipelines and cables. At the same time, climate change is reshaping infrastructure development, particularly in the Arctic, where melting ice is opening new navigation routes and project opportunities. Meeting these challenges will require innovative regulation and significant financial investment to adapt infrastructure systems.

The rising frequency and intensity of extreme weather events are a direct result of climate change and are increasingly impacting maritime infrastructure. In particular, warming ocean temperatures—both at the surface and on the seafloor—are amplifying storm-related risks. Stronger winds and sharper drops in barometric pressure are fueling more destructive storm surges and hurricane activity across oceanic, sea, and coastal regions. Research shows that extreme weather events on the high seas tripled over the course of the twentieth century. Projections suggest that ocean warming will continue throughout the 21st century, with both surface and deep sea temperatures increasing. The greatest warming is expected in the tropics, North Pacific, and Arctic Ocean, where temperatures could rise by more than 4°C under worst-case emissions scenarios.

Rising sea temperatures are significantly altering ocean circulation patterns. One of the most concerning developments is the documented weakening of the Gulf Stream system, which scientists are watching with increasing alarm. If this critical current continues to decline—or collapses entirely—it could have far-reaching, severe consequences for global climate patterns, marine ecosystems, and coastal regions. Ocean currents also influence the accumulation of debris on the seafloor, and changes in their direction or strength may pose additional risks to submarine infrastructure.



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Climate change is introducing new risks by shifting natural phenomena into regions historically unaffected, exposing submarine infrastructure to threats in areas unprepared for such events. One example is the "tropicalization" of weather patterns, which could bring hurricane-strength cyclones to previously sheltered regions such as European coastal zones and northern Atlantic waters. While the full effects will unfold over time, many existing underwater systems are already vulnerable to these climate-driven hazards. Closing this adaptation gap will require substantial investment in prevention and resilience—particularly in regions like Europe and the Mediterranean, where extreme weather events are becoming increasingly unprecedented.

OCEAN ACIDIFICATION

Beyond warming oceans, greenhouse gas emissions are altering the chemical composition of seawater through acidification and oxygen depletion. While falling oxygen levels primarily threaten marine life, increasing ocean acidity poses serious risks to both natural ecosystems and human-made maritime infrastructure. IPCC projections indicate that ocean acidity could rise by up to 150 percent if carbon emissions continue unabated. Acidification increases the corrosiveness of sea water — a concern considering the use of steel reinforcements in concrete structures. In the coming decade, this could accelerate the deterioration of protective coatings on submarine pipelines and cables, leading to faster structural degradation and higher maintenance costs over time.

Climate change will also have serious effects on coastal areas, particularly at the interface between underwater infrastructure and land-based networks, such as landing stations. Meltwater from glaciers and ice sheets, along with the thermal expansion of seawater, has already caused a global average sea-level rise of 3.2 mm per year. This rise increases the risk of coastal erosion, more frequent storm surges, and a higher incidence of flooding—all of which threaten the integrity and operation of critical coastal infrastructure.

Climate change is also reshaping where infrastructure can be developed, with particularly significant effects in the Arctic. As ice cover continues to retreat, larger areas of the Arctic Ocean are becoming navigable for longer periods each year. If current trends persist, the region could see ice-free summers as early as 2035. These changes are prompting new plans for telecommunication infrastructure, including subsea cable projects. One example is the Russian Optical Trans-Arctic Submarine Cable System, which aims to connect Japan with the Russian Arctic, with branches extending to South Korea and China. A similar effort, the Arctic Connect subsea cable—a Finnish-led initiative launched in 2015 to link Europe and Asia via the Northern Sea Route—was suspended in 2021 due to escalating tensions between Europe and Russia.

ADDRESSING THE RISK – WHAT EUROPE IS DOING TO ADAPT

The expected rise in climate-related damage to infrastructure—both maritime and terrestrial—across Europe in the coming decades has strengthened the European Union's push to make climate change a central focus of its budget and policy agenda. While current projections carry uncertainty, they still offer valuable insights. In particular, the geographic and sectoral distribution of anticipated economic impacts can help identify regions and industries most in need of investment to improve the climate resilience of both existing and future infrastructure. These findings highlight the importance of embedding climate adaptation across a broad range of EU policy initiatives and financial instruments.

Europe is expected to face a steady and intensifying rise in multi-hazard, multi-sector damage in the coming decades. Given the deep interdependencies within modern infrastructure networks, it is essential to adopt collaborative, cross-sector approaches to climate adaptation and resilience. Integrated planning acknowledges that vulnerabilities in one sector can trigger cascading effects across others, making coordinated strategies far more effective than isolated, sector-specific measures.

From a regulatory standpoint, Europe has already begun addressing the challenge, notably through its 2021 EU Strategy on Adaptation to Climate Change. This strategy emphasizes climate-resilient infrastructure and builds on the 2018 stocktake titled *Climate Change Adaptation of Major Infrastructure Projects*, which aimed to identify ways to strengthen the climate resilience of the EU's infrastructure network.

The stocktake found that many infrastructures originally designed for long operational lifespans are struggling to adapt to changing climate conditions, leading to rising maintenance and repair costs. Harmonizing regulatory frameworks across Member States will be increasingly important to avoid cascading failures. In response, the first von der Leyen Commission expanded the mandate of European Standardisation Organisations to incorporate climate considerations into infrastructure standards and encouraged Member States to improve coordination on transnational infrastructure development.

Previous EU efforts to establish a broad framework for critical infrastructure have largely overlooked the climate crisis. The 2006 European Programme for Critical Infrastructure Protection (EPCIP), for example, does not mention climate change or climate-induced disasters as risks.

By contrast, the 2023 directive on the resilience of critical entities marks a step toward a more comprehensive regulatory approach. It explicitly cites climate change as a driver of more frequent and severe extreme weather events that can reduce infrastructure capacity, efficiency, and lifespan. However, the directive stops short of defining a common EU-wide framework for what constitutes critical infrastructure, leaving it largely to Member States to make that determination within their own national contexts.

The directive provides only broad criteria aimed at achieving a "minimum level of harmonisation" and offers a general categorization of sectors: energy, transport, banking, financial markets, digital infrastructure, health, public administration, space, food, and water. In trying to be all-encompassing, it overlooks a key distinction—between land-based infrastructure and infrastructure in maritime and underwater domains. And while climate is acknowledged as a threat, the directive does not propose specific adaptation strategies or resilience measures to address it.

Europe still lacks an adequate adaptation framework to address the climate-related risks facing critical infrastructure, particularly in the maritime domain. Sector-specific regulations are notably absent. This gap is especially urgent in congested chokepoints like the Baltic Sea and in areas where underwater infrastructure links the EU with third countries, such as the English Channel and the North Sea.

In some Member States, responsibilities for protecting critical infrastructure and responding to damage—including from natural disasters—fall to military or naval forces. This further complicates efforts to establish a unified regulatory framework, particularly when military and non-EU actors are involved.

To address these challenges, the EU should supplement its Adaptation Strategy with permanent coordination groups that include climate experts, infrastructure regulators and operators, and military representatives. These groups should be tasked with regularly assessing risks and threats to critical infrastructure arising from climate change and helping to shape a more coherent and effective response.



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Rising ocean and seafloor temperatures are leading to an increase in extreme weather phenomena, which threaten both coastal structures (landings and terminals) and deep-laid facilities (pipelines and cables).



Climate change has a direct impact on energy production and the resilience of physical infrastructure. The freezing rain in 2020 that covered the power lines in the Russian Far East left hundreds of thousands of homes without electricity for several days.

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Drill, baby, build

by **Ben Cahill**

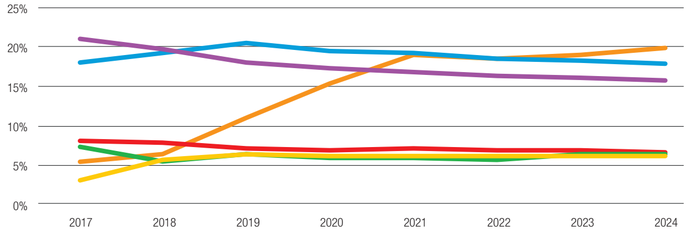
THE MAIN ENERGY CHALLENGE CURRENTLY FACING THE UNITED STATES IS THE CONSTRUCTION OF SUFFICIENT INFRASTRUCTURE TO MEET DOMESTIC DEMAND AND SUPPORT EXPORTS—A NEED VOICED BY BOTH FOSSIL FUEL PRODUCERS AND RENEWABLE ENERGY DEVELOPERS

PRESIDENT TRUMP often repeats the slogan "drill, baby, drill," first popularized in 2008 when the shale boom was starting and U.S. oil imports were near record highs. The landscape has shifted: the United States is now the world's largest oil and gas producer, and companies worry less about resource access than about the infrastructure needed to meet rising domestic demand and sustain exports. Both fossil-fuel and renewable-energy industries now urge Washington to "build, baby, build." Can the country deliver?

THE REMARKABLE DEVELOPMENT OF RECENT YEARS

Over the past 15 years, much energy infrastructure has been built despite persistent obstacles. The shale boom began in the

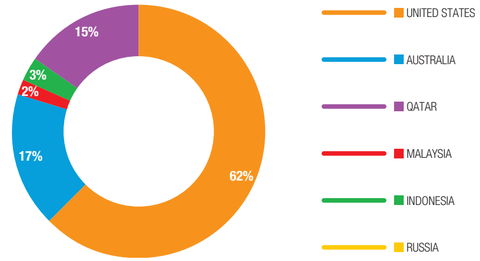
LNG: SHARE OF GLOBAL LIQUEFACTION CAPACITY (%)



Source: International Gas Union, 2025 World LNG Report

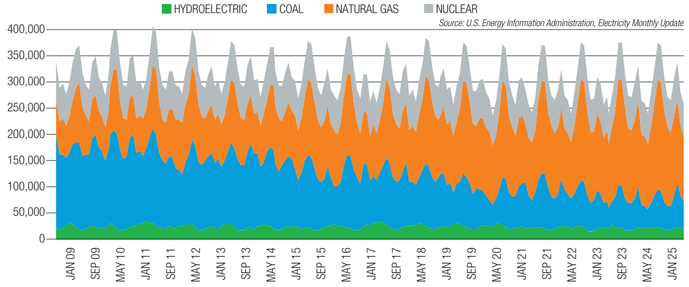
SHARE OF GLOBAL LIQUEFACTION CAPACITY ADDITIONS

(2017-2024, %)



The United States led the growth of global LNG liquefaction capacity between 2017 and 2024, accounting for 62% of the total increase, ahead of Australia (17%) and Russia (15%). During the same period, the U.S. share of global capacity rose sharply, surpassing both Qatar and Australia, and marking a new balance in the international liquefied gas market.

U.S.: NET GENERATION BY FUEL TYPE (THOUSAND MEGAWATT HOURS)



Source: U.S. Energy Information Administration, Electricity Monthly Update

Over the past fifteen years, electricity generation in the United States has been dominated by natural gas, while coal has experienced a steady decline, though it still plays a significant role. Nuclear power has remained stable, and hydropower shows seasonal fluctuations.

late 2000s, and production surged. In late 2015, the United States ended a 40-year ban on crude-oil exports and quickly became one of the world's top exporters. In 2024, it shipped 4.2 million barrels per day (b/d) of crude oil and 10.8 million b/d of combined crude, petroleum products, and natural-gas liquids—more than either Russia or Saudi Arabia. Gas followed a similar trajectory. The United States exported no liquefied natural gas (LNG) at the start of 2016 but became the world's largest LNG exporter by 2023. In 2024 it sent out 11.9 billion cubic feet per day (Bcf/d), well ahead of Qatar and Australia. By 2030, the United States could supply about 30 percent of global LNG.

An extraordinary infrastructure build-out enabled this export boom. The U.S. oilfield services industry marshalled the materials, expertise, and capital to build pipeline infrastructure, crude oil loading terminals, liquefaction facilities, and many other parts of the value chain.

Naturally, there have been plenty of challenges. Much of the infrastructure was built in so-called red states that welcome fossil fuel and industrial developments. Pipeline takeaway capacity is still tight in the Northeast and elsewhere. Concerns over market, climate, and local impacts of LNG exports prompted President Joe Biden to "pause" federal permits for new export terminals. Even so, the United States has built enough infrastructure to sustain a transformative shift in its energy production and exports.

More recently, tax incentives in the Inflation Reduction Act (IRA) and other recent laws have triggered a surge of investment in renewables, lower-carbon fuels, and related sectors. In 2024 alone, more than $270 billion went into clean energy, electric vehicles, building electrification, and carbon management.

Yet renewable energy and fossil fuels alike face infrastructure constraints. Advocates of "resource abundance" agree that the United States needs to remove these obstacles to remain economically competitive. Without faster permitting, construction, and deployment, the United States will fall behind China, which is now realizing the fruits of a 20-year effort to build capacity in clean energy, electrification, battery manufacturing, and automotive exports.

NEXT STAGE OF GROWTH

Over the past year, the U.S. debate on energy infrastructure has shifted. Surging demand from data centers, AI workloads, semiconductor fabs, and other manufacturers is raising supply concerns. After decades of flat electricity use, utilities now expect significant load growth. The North American Electric Reliability Corporation projects peak winter demand will rise 18 percent in the next decade. S&P Global estimates that 2024–30 U.S. data centers could add demand equal to New York City's entire consumption. The International Energy Agency



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projects global data-center use could double by 2030 to about 945 terawatt-hours. If AI hardware becomes more efficient, these figures may prove high, but the industry's rapid expansion has sharpened attention.

Policymakers are aware that other countries are competing to attract these strategically important industries, and they see abundant, reliable energy as an advantage for the United States. But it will be challenging to develop the resources it will take to satisfy this anticipated demand and to ensure grid stability. Several trends are apparent, encompassing oil and gas as well as renewable energy.

First, many types of energy will be required. Tech companies, even those with ambitious emissions reduction goals, are pursuing an "all of the above" strategy to secure supplies from renewable energy, natural gas, nuclear energy, and advanced geothermal. Policymakers should take note of this holistic approach to energy sources. Natural gas is an essential dispatchable source, but "speed to power" is important as well. In this respect, renewable energy has important advantages, especially solar energy and battery storage. Solar energy advocates contrast the rapid pace and low cost of solar deployment with the long lead times for the gas turbines needed for gas-fired power generation. The U.S. Energy Information Administration (EIA) estimates that solar and batteries will account for 81 per-



After decades of relatively stagnant electricity demand, US utilities anticipate a sharply rising load due to high consumption related to the development of artificial intelligence. An electrical substation near a small town in Oregon.



Tax incentives under the Inflation Reduction Act (IRA) and other federal regulations have led to a boom in US investment in renewable energy, low-carbon fuels and related sectors. Pictured: wind turbines on the mountainside at the edge of the Mojave Desert in California.

cent of utility-scale capacity additions in the United States this year.

Second, tensions could emerge between meeting domestic demand and supporting export growth—particularly for natural gas. Gas is now the largest fuel source for power generation, even as the United States has expanded LNG exports and pipeline deliveries to Mexico. This year, natural gas flows to U.S. LNG export facilities topped 15 Bcf/d, and new terminals expected in 2025 and 2026 will add another 6 Bcf/d. With additional projects under construction, LNG export capacity could nearly double over six years—and more proposals are still in the queue.

Many companies believe rising demand for natural gas will draw out sufficient supply. But in today's context of macroeconomic uncertainty and lower oil prices, associated gas—produced alongside oil in places like the Permian Basin—may be more vulnerable. The United States could follow a pattern seen in countries like Egypt and Australia, which built LNG export capacity only to face tighter-than-expected domestic markets. The U.S. resource base is vast, but can it devote a quarter of its gas production to LNG exports without pushing up domestic prices? A key factor is whether developers can build enough pipeline capacity to link producing basins with emerging demand centers and export terminals.

A third challenge is permitting and approvals. Building large-scale energy infrastructure in the United States is difficult. Federal, state, and local approvals are often needed, and projects can be blocked or delayed at any level. Environmental reviews are especially complex for interstate projects and those on federal land. Legal challenges can arise at multiple stages, creating uncertainty even for fully permitted projects. Public support also varies widely, particularly for fossil fuel infrastructure.

Energy companies and policymakers across the board recognize the need to speed up project development. The growing interconnection queue for grid access has raised alarms. Permitting reform was a major topic in Washington last year, and a Senate bill aimed at easing approvals for both fossil fuel and renewable projects made some headway before stalling ahead of the 2024 elections. President Trump addressed the issue through his "Unleashing American Energy" executive order, which aimed to streamline permitting and federal reviews, though concrete outcomes remain limited. Washington's current focus on AI competitiveness may help drive progress—either through an upcoming reconciliation bill on energy and climate, or a future standalone measure.

NEW MINDSET ON ENERGY DEVELOPMENT

Few countries enjoy the resource abundance of the United States—from oil and gas reserves to wind and solar resources, to established nuclear and hydropower. The country also has unique strengths in technology and R&D, entrepreneurship, and deep capital markets that support resource development.

Still, in recent years, energy policy has become increasingly politicized. President Biden issued a moratorium on oil and gas leasing on public lands during his first days in office, while President Trump halted leasing and permitting for offshore wind. At the time of writing, House Republicans are pushing for major changes to tax credits for wind, solar, and low-carbon manufacturing—moves that would undercut the post-IRA investment boom. Energy, like many other issues in a divided United States, has become tribalized.

Perhaps the twin specter of growing energy demand and growing competition from China will lead to a more dispassionate view of various energy sources, including their strengths, weaknesses, and complementarities. The United States has all the tools to be a diversified energy superpower, rather than simply doubling down on fossil fuels. But to deploy enough energy to keep its economic edge, policymakers will have to take advantage of all energy resources.



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BEN CAHILL

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THE BELT AND ROAD INITIATIVE and Eurasian connectivity

by **Li Lifan**



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THROUGH MASSIVE INVESTMENTS IN ENERGY INFRASTRUCTURE, CHINA IS RESHAPING THE EURASIAN GEOECONOMY AND FOSTERING A NEW ENERGY COMMUNITY UNDER ITS INFLUENCE

SINCE CHINA launched the Belt and Road Initiative in 2013, energy cooperation has been one of its core components. Through investments in natural gas pipelines, power grid upgrades, and renewable energy projects, China has not only reshaped the energy interconnection patterns across the Eurasian continent but also significantly influenced the region's geopolitical dynamics.

Since President Trump took office, the U.S.–China trade war has escalated, weakening the momentum of global economic recovery. The crisis in Ukraine remains unresolved, and the conflict between Israel and Palestine has reignited. Geopolitical risks continue to inject instability and uncertainty into global economic development.

Chinese enterprises, as pioneers of the Belt and Road Initiative, have primarily focused their Eurasian investments on natural gas pipelines, power system upgrades, and renewable energy infrastructure.

NATURAL GAS PIPELINE: RECONSTRUCTING THE EURASIAN ENERGY ARTERY

In the oil and gas sector, energy cooperation—particularly upstream exploration and development projects, along with the construction and operation of cross-border infrastructure—has become a central feature of China's energy diplomacy. In 2022, the overseas oil and gas production of China's central petroleum and petrochemical enterprises reached 185 million tons of oil equivalent, with equity production accounting for 102 million tons. The layout of international cooperation continues to improve, with overseas oil and gas equity steadily increasing.

China's construction of natural gas pipelines in Central Asia is a key strategic move to overcome the "Malacca dilemma" and enhance energy security. By developing joint projects such as the China–Kazakhstan natural gas pipeline and the China–Central Asia pipeline, China has established a direct channel between Central Asian energy resources and its domestic market—reducing its reliance on maritime routes and weakening Russia's position as an intermediary.

Taking Kazakhstan as an example, the China–Kazakhstan oil

pipeline transports 20 million tons of crude oil annually, accounting for 7 percent of China's crude oil imports. Upon completion, the China–Central Asia natural gas pipeline's D line will raise total gas transmission capacity to 85 billion cubic meters per year—roughly one-quarter of China's natural gas imports. These pipelines not only bypass Russia but also extend toward the Caspian Sea through key transit countries like Uzbekistan, forming the basis of a potential land corridor linking the Middle East and Europe. For instance, the planned China–Kyrgyzstan–Uzbekistan railway, once completed, will bypass Russia and establish a direct overland energy and trade route to Europe, thereby reducing the effectiveness of U.S. maritime containment strategies.

China's plan to expand the China–Russia Arctic LNG-3 project and associated crude oil pipeline to 30 million tons per year illustrates its strategy to consolidate strategic autonomy through diversified energy imports while carefully managing its relationship with Moscow.

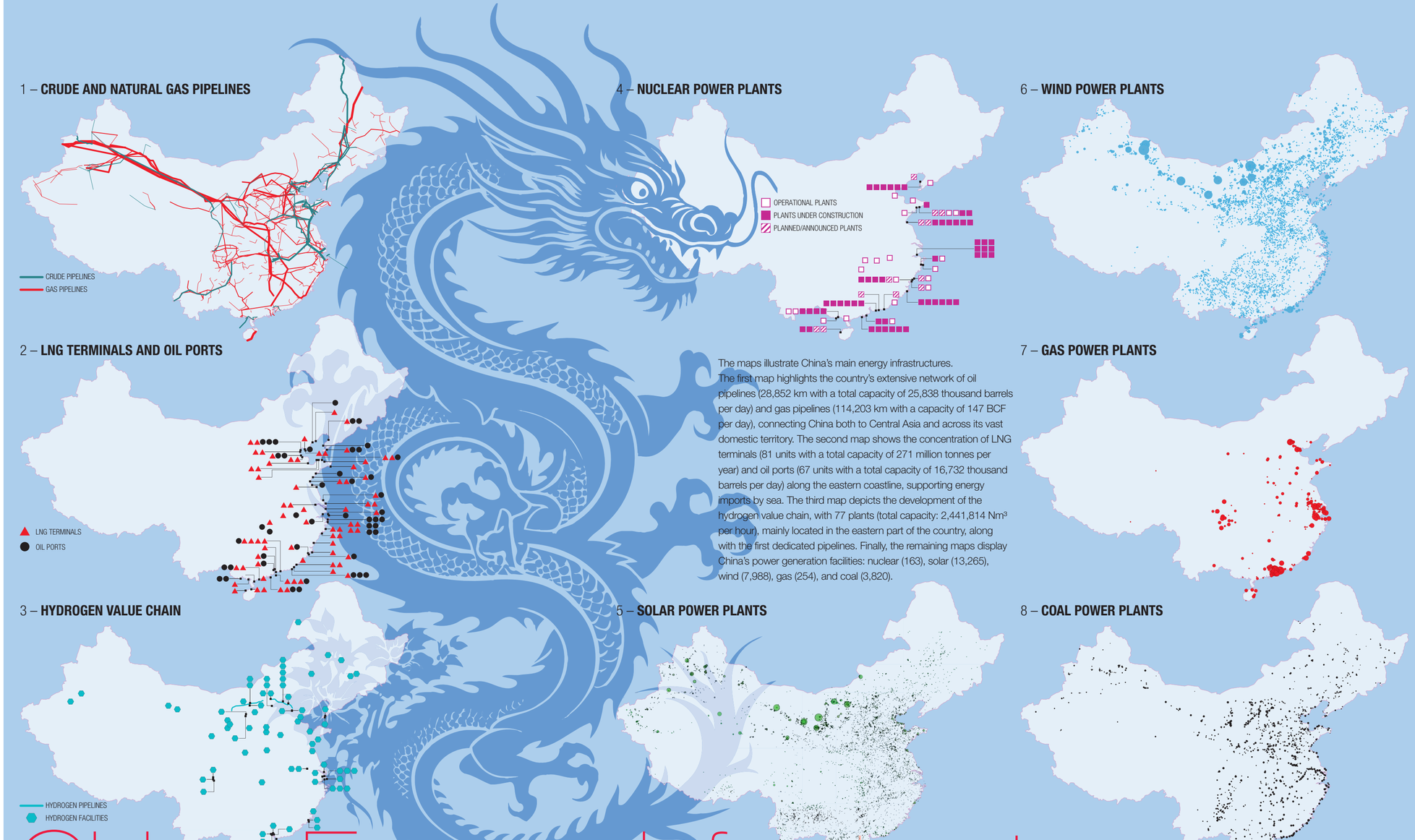
GRID INTERCONNECTION AND ENERGY STORAGE TECHNOLOGY

Central Asia's power infrastructure is outdated and urgently requires new construction and upgrades. This presents new challenges for system stability, especially with the large-scale integration of renewable energy. Forecasts estimate that from 2023 to 2040, electricity demand in the region will grow at an average annual rate of 1.7 percent to 2.9 percent. By 2040, total electricity demand is projected to reach 276–331 billion kilowatt-hours, with installed power capacity reaching 89–108 million kilowatts.

China's investment in Central Asia's power grid aims to address regional power shortages and enable the integration of renewable energy. Aging infrastructure from the Soviet era remains a major challenge, with Kazakhstan experiencing transmission losses of up to 15 percent, and Kyrgyzstan and Tajikistan struggling to ensure stable hydropower supply due to seasonal fluctuations. China is promoting modernization by constructing ultra-high-voltage transmission lines and energy storage facilities.

Sungrow (China), in partnership with China Energy Engineering Corporation (CEEC), announced the successful commissioning of the 150MW/300MWh Lochin energy storage project in Uzbekistan's Andijan Region. Equipped with Sungrow's liquid-cooled ESS PowerTitan 2.0 and AI-based pre-diagnostic technology for rapid fault response, this is Uzbekistan's first energy storage project and the largest of its kind in Central Asia. CEEC's 1.8GWh distributed energy storage project cluster aggregates wind and solar resources using a "virtual power plant" model, offering replicable, market-oriented transition solutions for countries like Kazakhstan. These projects not only enhance grid stability but also promote the export of Chinese technical

China: Energy infrastructure



The maps illustrate China's main energy infrastructures. The first map highlights the country's extensive network of oil pipelines (28,852 km with a total capacity of 25,838 thousand barrels per day) and gas pipelines (114,203 km with a capacity of 147 BCF per day), connecting China both to Central Asia and across its vast domestic territory. The second map shows the concentration of LNG terminals (81 units with a total capacity of 271 million tonnes per year) and oil ports (67 units with a total capacity of 16,732 thousand barrels per day) along the eastern coastline, supporting energy imports by sea. The third map depicts the development of the hydrogen value chain, with 77 plants (total capacity: 2,441,814 Nm^3 per hour), mainly located in the eastern part of the country, along with the first dedicated pipelines. Finally, the remaining maps display China's power generation facilities: nuclear (163), solar (13,265), wind (7,988), gas (254), and coal (3,820).

Source: Baker Institute

standards—Kazakhstan's adoption of the Chinese GB/T energy storage grid connection standard marks a shift from equipment exports to rule-setting.

RENEWABLE ENERGY: BUILDING A GREEN SILK ROAD

The global energy transition has driven Chinese companies to actively engage in overseas renewable energy projects. These enterprises offer comprehensive services, including geological surveys, planning and site selection, wind and solar resource measurement, assessments, system design, grid access analysis, and operations and maintenance. Through a combination of technical assistance and engineering services, they implement joint innovation demonstration projects and promote a new model of cooperation based on technology sharing and mutual benefit.

Take the Zanatas wind farm in Kazakhstan, for example: the project generates 350 million kilowatt hours of electricity annually, covering 20 percent of the electricity shortfall in southern Kazakhstan and reducing consumption of 110,000 tons of standard coal. China is advancing the renewable energy industry chain in Central Asia through technology transfer and localized production—such as achieving 75 percent localization of components at the Almaty wind turbine factory. At the same time, the China-led "Wind-Solar-Hydrogen-Storage" superhub converts Central Asia's solar resources into green electricity transmitted directly to China, demonstrating the viability of the "Energy Storage + Renewable Energy" model.

These projects not only alleviate local energy shortages but also attract international green finance through carbon accounting systems—such as support for the Tajikistan Rogun hydropower station energy storage project—thereby promoting a shift in global energy governance rules toward a low-carbon trajectory.

GEOPOLITICAL IMPACT: POWER RESTRUCTURING AND GAMING

The energy network in Central Asia during the Soviet era was centered on Russia. China has reduced Central Asian countries' dependence on Russia by building independent pipelines and power grids. For example, Turkmenistan was once forced to export natural gas at low prices due to Russian price cutting. The China–Turkmenistan natural gas pipeline enabled it to bypass Russia and supply gas directly to China, reshaping regional energy trade dynamics.



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China has also built overland routes that bypass both the Strait of Malacca and Russia—such as the China–Europe Land-Sea Express and the China–Kyrgyzstan–Uzbekistan Railway—reducing its reliance on sea lanes controlled by the United States. The Second Eurasian Continental Bridge (Lianyungang to Rotterdam) and other planned corridors are intended to give China a more proactive geopolitical position in Eurasian trade.

Finally, the EU is supporting the Baltic states' efforts to disconnect their power grids from Russia through the Connecting Europe Facility, intensifying competition with China in third-party markets. However, there is potential for cooperation between China and Europe in green energy and infrastructure, particularly through complementarity between the EU's "infrastructure software" (standards and management) and China's "infrastructure hardware" (technology and financing).

CHALLENGES AND FUTURE PROSPECTS

In the future, China may further integrate hydrogen energy and digital twin technologies, promote the construction of a Eurasian energy internet, and deepen cooperation with the EU and ASEAN through a "technology plus carbon finance" model, aiming to build a more inclusive system of energy governance.

Through its Belt and Road energy investments, China is redrawing the geoeconomic map of Eurasia. From gas pipelines to power grids, from fossil fuels to renewables, these projects not only enhance China's energy security but also create a new energy community centered on Chinese technical standards and regulatory frameworks. This process challenges the traditional hegemonic order while offering alternative pathways for the global energy transition. The key question is whether China can manage the geopolitical risks and competing interests involved to realize the vision of a "Green Silk Road."

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A GLOBAL LEADER IN BOTH COAL AND RENEWABLES, CHINA IS ALSO GAINING A DOMINANT POSITION IN POWER GRIDS. WITH WORLD-UNIQUE UHV NETWORKS AND MASSIVE MANUFACTURING CAPACITY, BEIJING AIMS TO RESHAPE TRADITIONAL ENERGY INTERCONNECTIONS



AN ELECTRIC SUPERPOWER

by **Michal Meidan**



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CHINA RANKS first globally in many energy markets: it is the world's largest crude oil importer, the top coal producer and buyer, and the largest deployer of renewables. Less well known is China's global leadership in ultra-high voltage grids and associated equipment. As it strengthens its position as an "electro-power," it is poised to play a dominant role in modern grid systems.

As the world's largest crude importer and a growing buyer of liquefied natural gas (LNG), China is highly exposed to geopolitical shocks, supply security concerns, and price volatility. Decision-makers have long worried about instability in producer countries, threats to sea lanes and chokepoints, and the effects

of sanctions on trade flows and pricing. In response, the government has pursued supply diversification, expanded the role of national oil and gas champions across the value chain—from upstream to shipping and trading—and increased stockpiling. It has also promoted transport electrification to reduce reliance on imported oil.

A decade-long push to develop and promote electric vehicles has made China the global leader in EV sales. While it remains the world's largest oil importer, crude purchases in 2024 fell below 2023 levels. Electrification and fuel switching in transport have already led to peak gasoline and diesel demand, suggesting crude imports are unlikely to grow much further. Concerns over import security persist, but their nature is shifting: reducing fossil fuel imports and expanding renewables are now seen as both climate and security priorities.

China's leadership in renewable deployment is becoming a central pillar of its evolving energy security strategy. In 2024, it added 80 GW of new wind capacity—equivalent to Germany's total—and 275 GW of solar, surpassing all of North America's installed solar capacity. Similar additions are expected in 2025. As of early 2025, China's installed wind and solar capacity exceeded its thermal generation capacity. While coal still provides about two-thirds of total power generation, new electricity demand is now primarily being met by renewables.

One key reason behind China's rapid deployment of wind and solar is its dominant position in manufacturing. China produces an estimated 75–80 percent of the world's solar wafers, cells, and modules, and holds similar market shares in lithium-ion battery cell production. Notably, China's clean-tech manufacturing capacity may already be sufficient to meet the IEA's projected global needs under its Net Zero Emissions Scenario for 2030. At the same time, rapid supply growth has driven costs down by 80–90 percent compared to 2010 levels.

THE CHALLENGES OF ELECTRIFICATION

The availability and low cost of these technologies, combined with supportive policies, have enabled rapid electrification in China. According to the IEA, electricity accounted for 28 percent of China's final energy consumption in 2024, compared to 22 percent in the United States and 21 percent in the European Union. China's National Energy Administration expects this share to exceed 30 percent in 2025.

China's electrification drive is motivated by multiple factors, including its "dual carbon" targets—to peak emissions before 2030 and achieve carbon neutrality by 2060—as well as the goal of enhancing energy security. While coal's continued dominance in the power mix complicates the emissions target, electrification is already curbing oil consumption.

Renewable deployment and rising electrification are creating new challenges. While most of China's power demand is concentrated in the eastern provinces, renewable generation is largely located in the inland west. To address this imbalance, China has invested in expanding and upgrading its grid infrastructure, particularly through ultra-high-voltage (UHV) transmission lines, which allow electricity to travel long distances with minimal losses. Planning began as early as 2006, and China has since completed nearly 40 UHV projects—more than any other country. The national grid now spans over 1.6 million km of transmission lines (across all voltage levels), with a growing share of UHV. By contrast, the EU has no UHV network, and the U.S. grid, with approximately 965,000 km of high-voltage lines, operates at lower voltages and is less integrated for long-distance, high-capacity transmission.

In theory, China's UHV grid allows it to integrate renewables more easily and rapidly, helping to displace coal and improve reliability and resilience against local disruptions. In practice, however, UHV construction alone has not been enough to drive rapid coal displacement. Institutional and political barriers—particularly coal's entrenched role in local economies and grid operations—continue to slow the phaseout. Renewable integration also faces technical and regulatory hurdles, though China is testing both market-based mechanisms and engineering solutions to reduce curtailment.

Alongside grid expansion, distributed solar PV has become a major component of China's renewable rollout, especially in coastal and eastern provinces. National programmes have promoted rooftop solar in rural counties, while major cities support installations on residential, commercial, and public buildings through incentives and utility partnerships. By the end of 2022, China had 157 GW of distributed PV—more than double the U.S. total—and this segment accounted for over half of new solar additions. Leading Chinese manufacturers are also developing microgrids for domestic use and export, with applications in rural electrification, island systems, hybrid utility-scale projects, and cross-border renewable corridors, particularly in Africa, Southeast Asia, and the Middle East.

GLOBAL ENERGY INTERCONNECTION

The emergence of private firms capable of exporting low-cost solar-plus-storage solutions may complicate efforts to build large-scale cross-border grid infrastructure. Internationally, China's UHV technology and expertise are central to its Global Energy Interconnection (GEI) initiative, endorsed by President Xi Jinping in 2015, which aims to extend China's clean energy and technology influence abroad. GEI envisions linking remote renewable resources to major consumption centers via continent-spanning UHV lines and smart grid technologies. For example, evening peak demand in eastern China could be met by midday solar output from Central Asia. The initiative is led by GEIDCO, a non-profit backed by State Grid, China's largest grid company. Its goals include constructing a global "super grid" and developing the governance structures necessary to



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The ten years dedicated to developing and promoting the deployment of electric vehicles have made China the world leader in zero-emission mobility. Pictured: workers at the Zeekr plant in Ningbo, China.



In 2024, China installed 80 gigawatt (GW) of new wind power capacity, roughly equal to the entire capacity of Germany, and 275 GW of solar power, which is more than the installed capacity of North America, and additions of a similar level are expected by 2025. Pictured: a solar power plant in Yancheng, Jiangsu province, China.

enable global energy interconnection by 2070.

On paper, the proposal offers clear benefits. In practice, grid construction and cross-border integration are expensive and operationally complex. However, given China's leadership in UHV transmission and related innovation and standard-setting, integrating the GEI with the Belt and Road Initiative could allow Chinese firms to expand global market share and export domestic UHV technologies. This may create long-term path dependencies, positioning China as the default provider for GEI and other large-scale grid projects.

Even if the GEI falters or sees only limited uptake, Chinese firms are increasingly positioned to deliver full-package energy solutions—combining generation technologies (coal, hydro, renewables) with UHV systems and a growing share of grid integration equipment, such as transformers and inverters. China now accounts for roughly half of global inverter shipments and leads in transformer production. For recipient countries, this creates a compelling but dependency-inducing offer, increasing their exposure to Beijing's political preferences. Additional concerns mirror longstanding criticisms of the Belt and Road Initiative: that GEI projects could drive up debt, enable corruption, harm ecosystems, and extend China's law enforcement reach and strategic footprint along transmission corridors. There are additional concerns that China could use the GEI for espionage, sabotage or coercion.

The extent to which the Chinese government would use a project like GEI for espionage, sabotage, or economic coercion remains uncertain. The barriers to implementing the GEI vision are substantial. Yet even without full realization, Chinese firms are well positioned to shape the infrastructure of emerging energy systems and set the standards and norms governing both centralized and distributed grids. The upside: Chinese technology and expertise can help accelerate the energy transition in many countries. The downside: China will increasingly define the terms of those new connections.

we

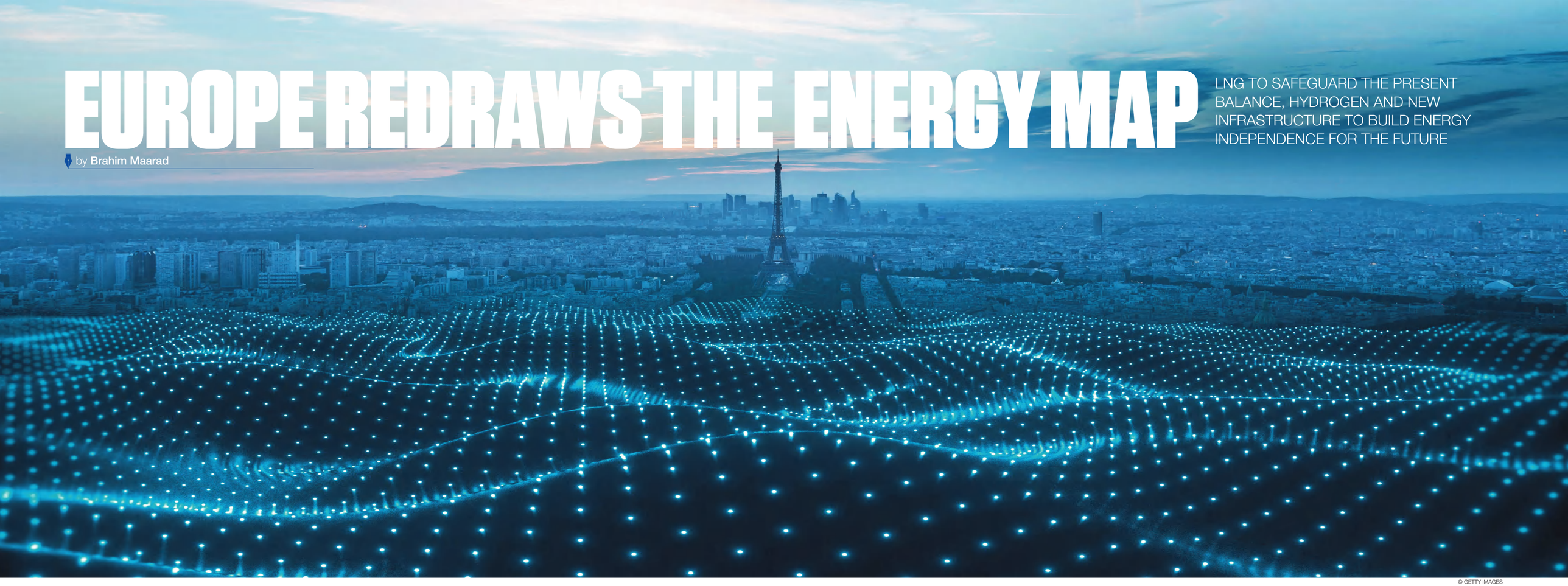
MICHAL MEIDAN

Michal Meidan is Head of China Energy Research at the Oxford Institute for Energy Studies. Before joining OIES in July 2019, she headed cross-commodity China research at Energy Aspects. Prior to that, she headed China Matters, an independent research consultancy providing analysis on the politics of energy in China.

EUROPE REDRAWS THE ENERGY MAP

LNG TO SAFEGUARD THE PRESENT BALANCE, HYDROGEN AND NEW INFRASTRUCTURE TO BUILD ENERGY INDEPENDENCE FOR THE FUTURE

by **Brahim Maarad**



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IT TOOK EIGHTEEN YEARS of planning, over 40 infrastructure projects and more than EUR 1.2 billion in European investments. But they did it: on February 8, 2025, Estonia, Latvia and Lithuania disconnected from Russia and Belarus's electric grid and, the following day, synchronized with the European grid via Poland. This marked their full integration into the EU's internal energy market and, more importantly, guaranteed Europe's independence from a grid controlled by Russian President Vladimir Putin.

"All of it was worth it. Because today, we are not just talking about energy [...]. Synchronization is about sovereignty. We remember 1990, when the Soviet Union imposed an economic and energy blockade on reborn Lithuania. A desperate act to stop independence. Yet here we are today, standing together, 35 years later, cutting the last dependence on Russian energy," European Commission President Ursula von der Leyen declared during the ceremony. "These chains of power lines, linking the Baltic states to hostile neighbors will be a thing of the past. This is freedom. Freedom from threats and blackmail," she added.

The initiative—historic in scope—is part of the EU's broader strategy to place energy infrastructure at the center of its geopolitical agenda. In November 2023, the European Commission launched its Action Plan for Grids, aimed at addressing infrastructure bottlenecks and ensuring that renewable electricity is delivered efficiently to citizens, businesses, and industrial ecosystems.

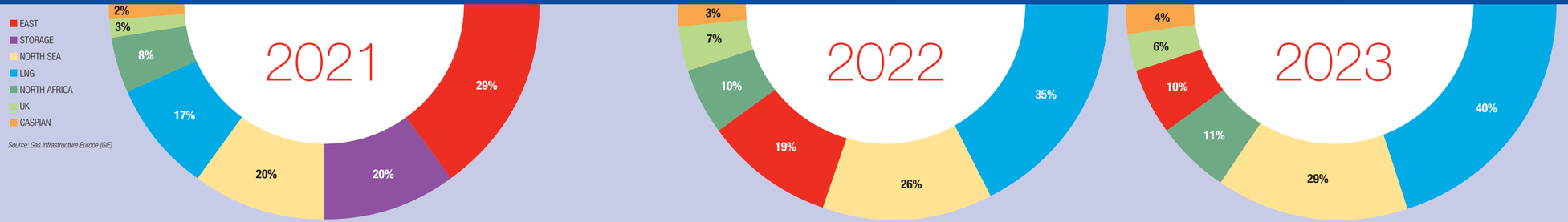
Europe currently boasts one of the most advanced and resilient electric grids in the world. Yet the demands of the next decade will call for a pace of expansion with no precedent. Electricity consumption is projected to increase by 60 percent by 2030, driven by the growing adoption of heat pumps, electric vehicles, energy communities, and hydrogen production. To meet this demand, cross-border transmission capacity must double—from the current 93 gigawatts (GW) to more than 180 GW.

NEEDED INVESTMENTS AND PROJECTS

The EU's plan calls for an estimated EUR 584 billion in investment over this decade, including EUR 375–425 billion dedicated to renewing and digitizing aging distribution networks.

THE GROWTH OF LNG

Thanks to increased capacities, the LNG large-scale terminals assured 41% of EU gas supply in 2023, compared to 17% in 2021. Capacity reserves have proven critical in reducing gas prices and volatility. Significant additional capacity for LNG regasification and storage is under construction. More than ever, the LNG industry is critical to maintaining the security of supply for the next years while preparing to accommodate new gases.



Source: Gas Infrastructure Europe (GIE)

With 40 percent of Europe's transmission infrastructure over 40 years old, upgrades are essential to integrate decentralized renewable energy sources. The plan centers on seven key areas: accelerating Important Projects of Common European Interest (IPCEI), long-term grid planning, ex-ante regulatory incentives, improved grid utilization, access to EU funding, streamlined permitting processes, and strengthening supply chains.

Projects of Common European Interest are the core operational tool of this strategy. Among the projects already launched is the Celtic Interconnector, which links Ireland with Brittany in France and will enable the exchange of 700 megawatts (MW) of electricity—enough to power approximately 450,000 homes. It will be Ireland's only direct energy link to continental Europe, improving energy security, lowering consumer costs, and supporting the country's shift to a low-carbon energy system. The project will also establish a direct fiber-optic connection between Ireland and France. In 2019, it received EUR 530.7 million in funding from the Connecting Europe Facility (CEF) to support design and delivery, with operations expected to begin in 2027.

CobraCable is a 350-kilometre offshore interconnection with a capacity of 700 MW linking Denmark and the Netherlands. It facilitates greater integration of renewable energy and is designed to accommodate the future connection of an offshore wind farm. The cable also strengthens energy security by increasing cross-border electricity exchange and providing redundant capacity in case of failures elsewhere in the network. Completed in 2019, CobraCable is part of the Northern Seas Offshore Grid (NSOG) priority corridor.

The Bay of Biscay Interconnection is a 370 km submarine electricity link between Spain and France. It aims to strengthen grid reliability, improve supply security, and enhance system efficiency by reducing the need for peak-generation plants. Once operational, it will double the electricity exchange capacity between the two countries to 5,000 MW—enough to supply around 2 million households annually with zero-emission electricity. The project is expected to be completed by 2028 and will help avoid an estimated 600 million tons of CO_2 emissions per year.

By mid-2027, Germany is expected to complete the North-South Interconnection, a roughly 400 km underground cable with a capacity of 2,000 MW. Part of the national grid expansion plan, the project aims to enhance north-south transmission, integrate more renewable energy, and stabilize supply. It also addresses cross-border grid stability, helping to reduce negative spillover effects on neighboring countries such as Hungary, Poland, the Czech Republic, and Slovakia.

Then there is ELMED, the first electricity interconnection between Europe and a non-EU country to receive financing under the Connecting Europe Facility (CEF) for Energy. This high-voltage submarine cable links Italy and Tunisia, spans 200 km, and involves a total investment of EUR 850 million—of which over EUR 307 million comes from the EU. Now under construction, the project is expected to become operational in 2028.

Still in its early stages, the Bornholm Energy Island is an innovative hybrid interconnector in the Baltic Sea. It will link Denmark and Germany while integrating 3 GW of offshore wind capacity. The project aims to be operational by 2034.

The European Union is also making major investments in smart grids. The Sincro.Grid project, for example, establishes a virtual control center between Slovenia and Croatia to manage the variability of renewable energy more effectively. The Smart Border Initiative (SBI) promotes shared energy solutions between border regions such as Saarland and Lorraine. Danube InGrid, a cross-border smart grid project between Hungary and Slovakia, aims to integrate renewables and improve system balancing. These efforts all support a more flexible, secure, and sustainable energy system.

IMMEDIATE RESPONSE VIA LNG

While the electric grid is essential for the green transition, gas pipelines and LNG terminals remain the EU's most immediate response to the energy crisis triggered by Russia's invasion of Ukraine and the resulting surge in gas prices. For the European Commission, projects like the Baltic Pipe—linking Norway, Denmark, and Poland—and the Gas Interconnector Greece-Bulgaria (IGB) are considered strategic for reducing dependence on single suppliers and strengthening overall system resilience.

The gas interconnector between Denmark and Poland, which began operating in 2022, is a key diversification project transporting up to 10 billion cubic meters (bcm) of gas annually from the North Sea to Poland and onward to Central and Eastern Europe—a region historically reliant on Russian supplies. Designated as a Project of Common Interest (PCI) in 2013, the Baltic Pipe received approximately EUR 267 million in EU funding.

The IGB pipeline, launched on October 1, 2022, provides a direct link between the national gas systems of Greece and Bulgaria. It enhances energy security in southeastern Europe by diversifying supply routes and sources, including from the Caspian Sea and the Middle East, through its connection to the Interconnection Turkey-Greece-Italy (ITGI) corridor. The pipeline has an initial capacity of 3 billion cubic meters (bcm) per year in the south-to-north direction.

The Balticconnector pipeline, along with the Gas Interconnection Poland-Lithuania (GIPL), connects Finland's gas network to the continental European system, effectively ending its previous isolation. Together, these projects enable Finland and the Baltic states to diversify their gas sources, routes, and trading partners, thereby strengthening regional interdependence and increasing the region's energy security and solidarity.

However, it is not just about pipelines. Liquefied Natural Gas (LNG) has also played a critical role in offsetting the collapse of Russian gas supplies. The 137 bcm of natural gas the EU imported from Russia in 2021 fell by 77 percent to just 31.6 bcm in 2024. Russia's share of pipeline gas dropped from 41 percent of EU imports in 2021 to around 18 percent in 2024. This shortfall has been largely filled by LNG from the United States, which accounted for 45 percent of EU LNG imports in 2024, as well as increased pipeline deliveries from Norway (50 percent, up from 30 percent in 2021), North Africa (18 percent), and Azerbaijan (7 percent).

Since Russia's invasion of Ukraine, Europe has added 78.6 bcm of new LNG regasification capacity, with 70.9 bcm of that total built within the EU, according to the Institute for Energy Economics and Financial Analysis (IEEFA).

Among the countries that have added LNG regasification capacity since February 2022 are Germany (24.7 bcm), the Netherlands (13 bcm), Turkey (7.7 bcm), Italy (7.5 bcm), France (6.5 bcm), and Belgium (6.3 bcm).

THE POTENTIAL OF HYDROGEN

Looking to the future, the European Commission is placing major emphasis on hydrogen. Over the next two years, hydrogen infrastructure will receive more than EUR 250 million in grants across 21 development studies. These projects span Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Italy, Lithuania, Latvia, Poland, Portugal, Spain, and Sweden. Notable initiatives include the BarMarH2med project—a 455 km submarine hydrogen interconnector between Barcelona and Marseille—as well as backbone networks in Italy, Portugal, and Spain, and new hydrogen corridors and routes in the Baltic region.

we

BRAHIM MAARAD
AGI reporter. Brussels correspondent.

IMPORT CAPACITY IN THE EU27

33
operational large-scale terminals, including onshore and offshore

7
terminals under construction and

16
terminals under construction and

Current importing capacity of

~2500
TWh per year

Another

~1100
Wh/year capacity to be built by 2030

The ENERGY UNion

EUROPE HAS BEEN BUILDING AN INTEGRATED INFRASTRUCTURE NETWORK FOR YEARS, WITH PROJECTS SHARED BETWEEN MEMBER STATES AND NEIGHBORING COUNTRIES. FROM ELECTRICITY TO GAS, VIA SMART GRIDS: CROSS-BORDER CONNECTIONS ARE EVERYWHERE

by **Roberto Di Giovan Paolo**



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THERE IS OFTEN much talk about Europe's missed opportunities, and far less about its concrete achievements. Yet the European Union did not wait for the Ukraine–Russia war to begin addressing the challenge of energy coordination and exchange. As early as 2013, the first joint projects led to valuable collaborations among member states and neighboring countries through the creation of Projects of Common Interest (PCIs) and Projects of Mutual Interest (PMIs), under the revised Trans-European Networks for Energy (TEN-E) framework.

These projects align with the EU's commitments under the Paris Agreement and follow a multilevel approach. Each must involve at least one energy source that meets TEN-E program criteria and connect a minimum of two countries. They represent a joint effort by governments, companies, and local authorities, contributing meaningfully to the EU's decarbonization goals—even when non-member countries are involved. Cost-effectiveness is also a key consideration, with expenditures required to show clear economic or energy benefits.

Projects involving small and medium-sized enterprises receive additional support from the EU, including faster planning permits and streamlined oversight through a single national authority. The EU also encourages transparency and public engagement by offering reduced administrative burdens and access to funding from the Connecting Europe Facility (CEF), a key pillar of the European Green Deal.

ELECTRICITY INTERCONNECTIONS AND GAS INFRASTRUCTURE

An interactive, continuously updated map tracks the EU's progress in the energy sector, showing connections and their impacts across member states. In electricity, for example, the "Celtic Interconnector" links Ireland and France, enabling the exchange of 700 megawatts and also carrying fiber-optic lines for communications. The "Baltic Synchronisation Project" connects Estonia and Finland (via Estlink I and II), Lithuania and Sweden (Nord Balt), and Lithuania and Poland (LitPol Link). The "German North-South Connection" not only links northern and southern Germany but also serves as a backbone for electricity flows between Hungary, Poland, the Czech Republic, and Slovakia, with completion expected in 2025.

In the gas sector, the "IGB Pipeline" has connected Greece and

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Driven by the need to strengthen energy autonomy and reduce emissions, Europe is accelerating on solar energy. Pictured: a photovoltaic plant overlooking the Baltic Sea in the Brandenburg region.

Bulgaria since October 1, 2022, with an initial capacity of 3 billion cubic meters per year and EUR 84 million in financing. Also launched on the same day, the "Baltic Pipe" links Denmark and Poland, transporting over 10 billion cubic meters of gas annually from the North Sea to Poland. It received about EUR 267 million in EU funding through the Connecting Europe Facility (CEF). The "Balticconnector" links Finland to the continental European gaseous grid, enhancing regional energy security and diversifying supply sources.

DIGITAL INTEGRATION AND INNOVATION

Connection projects between Slovenia and Croatia—such as the “Sincro.grid” digital control center—are helping to integrate power grids and improve the security and efficiency of energy flows both eastward (to Bulgaria, Romania, and Ukraine) and westward (to Italy, Switzerland, France, and Germany). The “Smart Border Initiative” between Germany’s Saarland and France’s Lorraine region focuses on joint solutions for energy savings and renewable energy deployment through digitization and artificial intelligence. Now beyond the experimental phase, this project could serve as a model for other regions in Europe and beyond.

The interactive map highlights many additional projects, reflecting Europe’s emphasis on energy, renewable deployment, and integration into broader energy corridors. These initiatives offer a concrete picture—in kilowatt-hours, cost breakdowns, and financing—of a Europe that, beyond rhetoric, is taking real steps to address recent crises with a long-term vision rooted in early 2000s planning and targets set for 2030 and 2050. For once, Europe is letting actions speak louder than words, and its plans are becoming reality.

we

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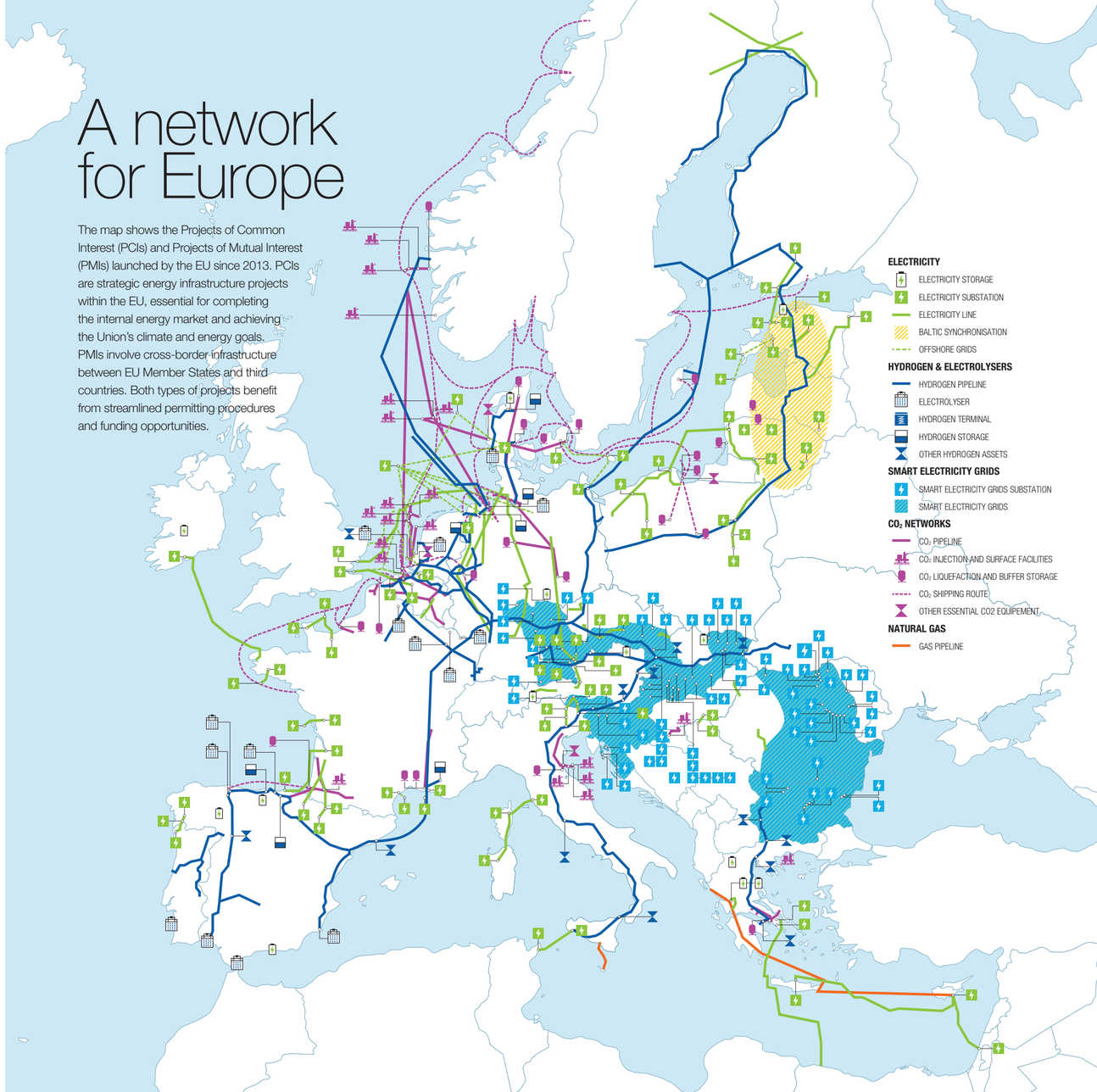
A journalist, he has written for, among others, *ANSA*, *Avvenire* and *Famiglia Cristiana*. He was Secretary General of the Italian Association for the Council of European Municipalities and Regions, and he is a lecturer at the University of International Studies of Rome.

A network for Europe

The map shows the Projects of Common Interest (PCIs) and Projects of Mutual Interest (PMIs) launched by the EU since 2013. PCIs are strategic energy infrastructure projects within the EU, essential for completing the internal energy market and achieving the Union’s climate and energy goals. PMIs involve cross-border infrastructure between EU Member States and third countries. Both types of projects benefit from streamlined permitting procedures and funding opportunities.





THE ROLE OF MARITIME TRANSPORTATION

by **Alessandro Panaro** and **Consuelo Carreras**

CURRENT GEOPOLITICAL TENSIONS AND THE TRADE WAR BETWEEN THE UNITED STATES (U.S.) AND CHINA ARE IMPACTING GLOBAL ENERGY LOGISTICS. SHIPPING TIMES AND COSTS HAVE INCREASED, REDUCING TRAFFIC THROUGH THE MAIN GLOBAL CHOKEPOINTS

TODAY'S ENERGY logistics mirror shifting geopolitical power balances—now under intensified strain from disruptive global events. The inauguration of a new U.S. administration has ignited a fresh trade war, compounding the instability already generated by two ongoing military conflicts.

The "Make America Great Again" (MAGA) platform, with its emphasis on energy independence, is redrawing the global energy map. This push is rooted in a paradox: while the U.S. is largely self-sufficient in fossil fuels, it remains deeply reliant on imports of critical raw materials essential for clean energy technologies. Solar panels, batteries, and wind turbines depend on components sourced almost entirely from Southeast Asia or

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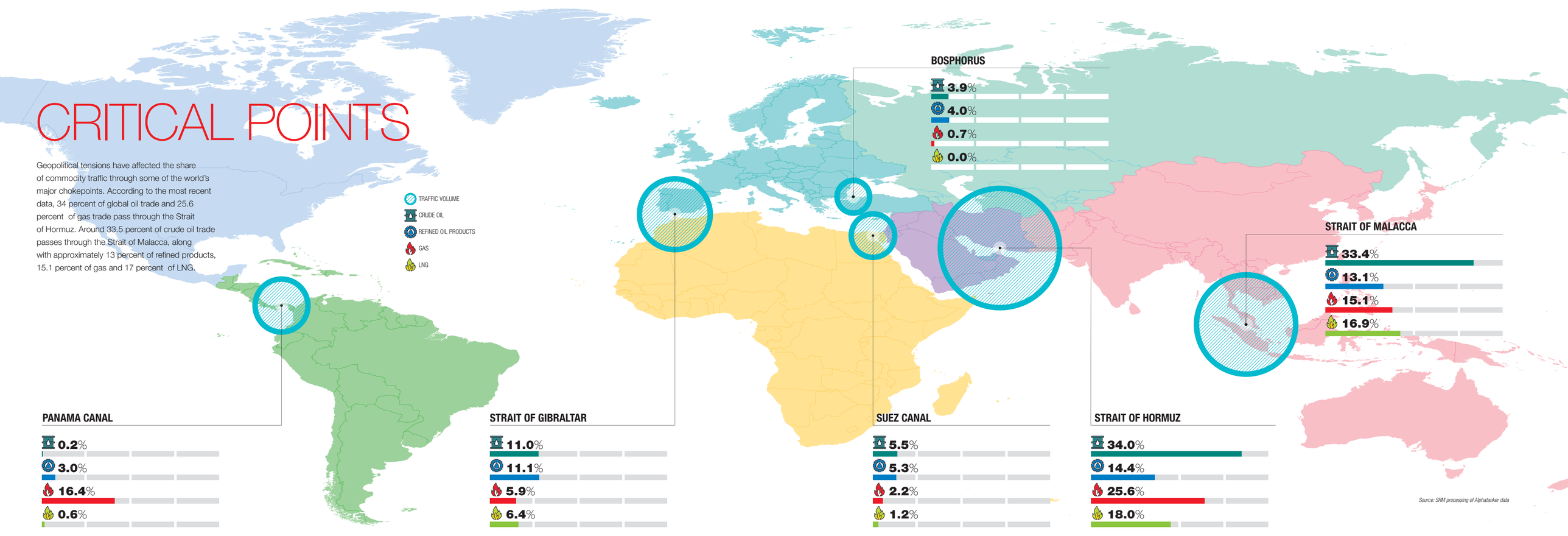
CRITICAL POINTS

Geopolitical tensions have affected the share of commodity traffic through some of the world's major chokepoints. According to the most recent data, 34 percent of global oil trade and 25.6 percent of gas trade pass through the Strait of Hormuz. Around 33.5 percent of crude oil trade passes through the Strait of Malacca, along with approximately 13 percent of refined products, 15.1 percent of gas and 17 percent of LNG.



Source: SRM processing of Alphatanker data

China. For wind turbines alone, steel and aluminum make up roughly 85 percent of total weight—materials that are increasingly entangled in geopolitical tension.

These dependencies are now flashpoints in a broader trade conflict. The resulting uncertainty threatens to stall investment, inflate costs, and undermine long-term energy security.

Although their final form remains uncertain, the new tariffs are already reshaping global energy flows—not just for fossil fuels, but for renewables as well. The initial shock came on Liberation Day, when sweeping restrictions were imposed on a long list of countries. Most of those measures were later suspended, opening the door to negotiations. Early trade deals with the White House have since helped ease tensions—but only partially.

ROUTES AND CHOKEPOINTS

Today's landscape is shaped by ongoing trade negotiations and their expected impact on economic growth—and by extension, commodity demand. Commodities are once again a central concern, with implications for port operations and global shipping routes. These routes have already been upended by Houthi attacks in the Red Sea, forcing detours around the Cape of Good Hope. Shipping companies have had to reschedule and reroute voyages, resulting in substantial delays and a sharp rise in costs—freight, insurance, and crew among them. For the energy sector, this disruption has raised serious concerns about the reliability of supply chains.

Armed conflict has also reshaped the flow of global commodities through key maritime chokepoints. The Strait of Hormuz now handles 27 percent of global oil and gas trade. The Strait of Malacca carries about 33.5 percent of crude oil, 13 percent of refined products, 15.1 percent of gas, and 17 percent of LNG. The Suez Canal—once a vital corridor for crude oil, refined products, and gas—has seen a steep drop in traffic. Before the current crisis, it handled 10 percent of global oil products and 8 percent of LNG shipments. Those figures have since fallen to 5 percent and 1.2 percent, respectively. LNG tanker transits have dropped 90 percent compared to 2023 averages, and oil tanker traffic is down by 40–50 percent.

Geopolitical tensions are also disrupting ports and the wider logistics system—critical links in the global supply chain for fossil fuels.

Ports have long served as energy gateways—hosting fossil fuel terminals, pipeline endpoints, and hubs for the import and export of oil, refined products, and LNG. They are typically located near energy-intensive industries. Now, ports face a dual mandate: maintain their critical role in energy logistics while adapting to the green transition. This shift is transforming

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ITALY: TOP 10 ENERGY PORTS

(THROUGHPUT IN MILLION TONS)

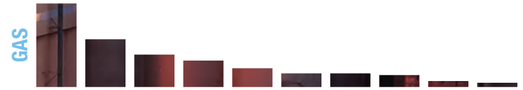
Source: Alphatanker

The table lists the main Italian energy ports by crude oil, refined products, gas and LNG throughput (in million tons). Trieste leads in crude oil, Augusta dominates in refined products, while Naples leads in gas and Porto Levante in LNG. The data highlight the strategic role of some key infrastructures in the Italy's energy logistics.









many into smart, low-emissions hubs. In Italy, where energy accounts for 35 percent of total port activity, the implications are particularly significant.

THE CHALLENGE OF SUSTAINABILITY

Several Italian ports already rank among the top energy hubs in the Mediterranean, particularly in oil and derivatives. But their future role is shifting. As the energy transition accelerates, these ports are becoming central to decarbonization strategies. By adopting cleaner fuels, building out renewable energy projects—solar, wind (including offshore), hydrogen—and investing in cold ironing, ports can reduce emissions and serve as a testbed for sustainable logistics. Energy Communities based in ports can extend benefits to nearby industrial zones. New infrastructure, such as LNG terminals and bunkering for alternative fuels, will reinforce both energy security and the transition away from fossil fuels.

Research from the SRM study center underscores the shift: sustainable development is no longer optional but strategic. In a fast-changing landscape, ports must move beyond passive adaptation. They will need to lead—driving innovation, pursuing sustainability, and accelerating digitalization. Those that succeed will cement their position as core engines in the emerging energy geography.

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Energy ties across the Indian Ocean

by **Phillip Cornell**



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IN THE FACE OF AN UNSTABLE GLOBAL ORDER, ENERGY INTERCONNECTION BETWEEN THE GULF, INDIA, AND ASEAN IS GROWING, MARKED BY NEW INVESTMENTS AND STRATEGIC ALLIANCES. THE REGION IS EMERGING AS A KEY HUB FOR ENERGY SECURITY, FLEXIBILITY, AND TRANSITION

IN A FRAGMENTING global order, energy interdependence is being reshaped. While advanced energy technologies and value chains have long created new commercial ties, the shift is increasingly strategic. As the reliability of traditional energy and trade corridors—anchored in major markets—is thrown into doubt by American transactionalism, stalled Chinese development, Russian aggression, and European weakness, countries are diversifying their partnerships to enhance security, flexibility, and long-term resilience. This includes turning to closer neighbors and elevating formerly secondary relationships. One of the most notable developments in this landscape is the growing energy and infrastructure connectivity among the Gulf Cooperation Council (GCC), South Asia, and ASEAN countries.

NEW ENERGY CONNECTIONS

Rather than forming around a single dominant project or pipeline, these connections are emerging through a broad web of strategic investments, cross-border infrastructure, and growing policy alignment. The result is a more horizontal axis of interdependence and energy trade spanning the Arabian Sea and Indian Ocean—what our recent work at the Atlantic Council terms the "ASIO" region.

The forces behind this realignment are structural. The ASIO region's deepening economic ties, growing populations, and sustained energy demand—alongside the pressures of the energy

transition—are driving increased trade and investment in the energy sector. At the same time, today's geopolitical and trade dynamics are pushing many countries to reduce reliance on legacy Western or Chinese value chains, avoid binary alignments, and instead prioritize intra-regional cooperation. Economic complementarity and shared interests are reviving longstanding trade relationships with new strategic purpose.

Countries with sovereign wealth and energy to export are investing heavily in infrastructure to support both fossil fuel trade and the clean energy transition. The UAE is emerging as a major cross-regional investor and project sponsor. Masdar has taken stakes in leading Indian clean energy firms and committed to major projects in Malaysia, while ADNOC is building out logistics infrastructure in India, Indonesia, and other Southeast Asian markets.

Oman is positioning itself as a hub for energy transition investment and logistics, leveraging its strategic location, port assets, and hydrogen ambitions to strengthen ties with India and Southeast Asia. Aramco has invested tens of billions in Indian and Malaysian refining capacity, while Saudi Arabia is expanding its bilateral relationships and commercial footprint through capital partnerships via the Public Investment Fund (PIF).

Sovereign wealth funds such as the Qatar Investment Authority and Abu Dhabi Investment Authority are also channeling capital into Indian infrastructure, ASEAN renewables, and regional digital platforms. These moves reflect a broader Gulf strategy to leverage their own economic transformations and "vision" programs to chart an independent course and take a leadership role in emerging energy technologies and markets.

INDIA AND SOUTH-EAST ASIA

In parallel, India has become an increasingly active player in developing infrastructure for both upstream energy procurement and downstream export of energy technologies. Indian public and private firms have expanded their footprint in the Gulf—not only through LNG import deals but also via joint ventures in refining, hydrogen, and renewables. New Delhi has also worked to strengthen institutional ties with ASEAN countries, participating in multilateral forums such as the India-ASEAN Energy Dialogue and engaging in regional power interconnection initiatives. Geographically, India is well positioned to serve as a bridge between GCC and ASEAN energy grids, enabling load balancing across time zones and advancing deeper interregional integration.

In Southeast Asia, governments are making concrete progress toward regional grid integration. The region's leadership in utility-scale solar and battery storage is increasingly supported by clean energy investments from Gulf firms like Masdar and ACWA Power. These efforts complement significant downstream oil investments and LNG supply deals with Gulf producers.

With electricity demand rising rapidly—driven by economic growth and favorable demographics—countries such as Indonesia, Malaysia, and Vietnam are leading global orders for both gas turbines and renewable technologies. Expansion in generation capacity, grid investment, interconnections, and growing demand from data centers are creating the foundation for broader energy connectivity. The International Energy Agency projects a five-fold increase in electricity trade between Southeast and South Asia by 2030.

Singapore has played a leading role in driving regional momentum, backing ASEAN grid integration through policy leadership and strategic investment. By leveraging its capital reserves, it is pursuing a hedging strategy to manage growing geopolitical uncertainty while anchoring itself as a regional energy hub.



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A BASIS FOR STRATEGIC ALIGNMENT

One of the defining features of energy dynamics in the broader ASIO region is the alignment of new commercial relationships with deeper diplomatic coordination. Infrastructure partnerships are increasingly supported by sovereign wealth funds and national development strategies that view energy interconnection as a geopolitical priority. This trend is visible in the Gulf states' eastward investment strategies, ASEAN's focus on regional energy security, and India's efforts to assert regional strategic leadership through energy diplomacy and integration.

This evolving regional integration also raises key questions about how these blocs will align technical standards, manage geopolitical risks, and ensure that energy transition pathways remain both inclusive and secure. Between 2020 and 2025, countries across the ASIO region signed a wave of bilateral Comprehensive Economic Partnership Agreements, while regional multilateral efforts gained momentum—even as global multilateralism has struggled. India and ASEAN formalized a strategic partnership in October 2024, and in May 2025, the second GCC–ASEAN Summit convened in Kuala Lumpur, presenting what the Asia Times described as "a civilized vision in a fractured world."

If these countries can succeed in scaling infrastructure, aligning regulation, and building trust, the ASIO region may serve as a blueprint for regional cooperation. Energy infrastructure is not only a channel for economic exchange but also a foundation for strategic alignment in the 21st century.

PHILLIP CORNELL
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SMART INFRASTRUCTURE



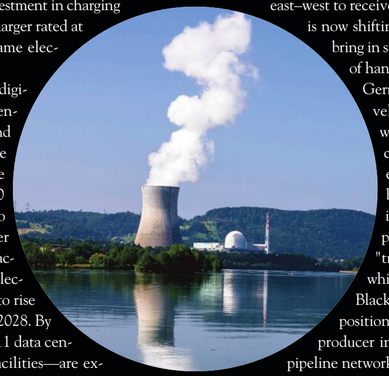
by **Kaush Arha**

THE TRANSFORMATION OF GLOBAL ENERGY INFRASTRUCTURE REFLECTS A NEW BALANCE BETWEEN SECURITY, SUSTAINABILITY, AND COMPETITIVENESS. THE TRANSITION REQUIRES GEOPOLITICAL VISION, COOPERATION, AND TECHNOLOGICAL REALISM

ENERGY IS A FUNDAMENTAL DRIVER of economic growth and national resilience, and energy security is central to sovereignty. It is too serious a topic to be guided by virtuous rhetoric alone—it requires realism. As GDP grows, so does energy consumption; per capita energy use and GDP are closely correlated. The International Monetary Fund projects that developing and emerging economies will grow at an average annual rate of 3.7 percent, with leading countries in Africa, the Americas, and Asia growing at or above 5 percent. Their energy use will rise accordingly, helping to narrow the stark gap in per capita energy consumption between developed and emerging economies.

Replacing 1 MW of fossil fuel power typically requires 4 to 6 MW of renewable capacity, due to the intermittent nature of solar and wind. These sources require significantly more installed capacity to match the stable output of fossil fuels. A global shift to electric vehicles will also require major investment in charging infrastructure. A single DC fast charger rated at 350 kW consumes roughly the same electricity as 300 homes.

At the same time, the expanding digital economy—driven by data centers—is pushing energy demand even higher. Small data centers use between 1 and 5 MW, while large hyperscale centers can consume 20 to 100 MW. AI processors use 4 to 6 times more energy than earlier generations. In 2023, data centers accounted for 4.4 percent of U.S. electricity use; this share is projected to rise to between 6.7 and 12 percent by 2028. By the end of 2025, an estimated 6,111 data centers—including 567 hyperscale facilities—are expected to be operational, with the highest concentration in the Indo-Pacific region. By 2030, that number is projected to reach 8,378.



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THE PREVALENCE OF FOSSIL FUELS

For the foreseeable future, a significant increase in global energy demand is expected. Fossil fuels, supplemented by additional nuclear capacity, will continue to provide the dominant share of baseload power, even as more renewable sources come online. Fossil fuel infrastructure is extensive and deeply embedded, while renewable infrastructure is still in its early stages.Smart energy infrastructure—especially electric transmission networks, pipelines, and terminals—will be essential to support both energy security and the broader energy transition.

In addition to rising demand, geopolitics is expected to play an increasingly significant role in shaping global energy infrastructure. Russian energy remains heavily sanctioned by the U.S. and Europe, with further restrictions likely. China, lacking sufficient oil and natural gas reserves, has committed substantial state resources to dominate global markets for renewable energy components and electric vehicles. Meanwhile, North American fossil fuel production has grown over the past decade, and under the Trump administration, the U.S. is actively promoting energy exports. With careful planning and credible agreements, the U.S. has the opportunity to position itself as a reliable energy supplier to allies in Europe and the Indo-Pacific.

Projected energy demand—combined with the likely continuation of Western tensions with Russia and China—suggests four broad drivers that will shape future energy infrastructure.

First, U.S. oil and natural gas exports to Europe and the Indo-Pacific are expected to play a major role in shaping infrastructure in both supplier and recipient regions. Before the Ukraine conflict, Europe's oil and gas pipeline networks were largely oriented east–west to receive Russian energy. That orientation is now shifting, requiring new infrastructure to bring in supplies from port terminals capable of handling American exports.

Germany and Poland are actively developing terminals and pipeline networks along their Baltic Sea coastlines to accommodate U.S. energy imports. Italy is projected to build the largest terminal capacity in Europe, using its Mediterranean ports to receive American and other "trusted" energy supplies. Meanwhile, Romania is expected to bring its Black Sea gas reserves online by 2027, positioning itself as the largest natural gas producer in Europe, supported by a regional pipeline network.

U.S. energy export capacity is currently concentrated on the East coast, well positioned to serve European markets. To fully capitalize on growing demand in the Indo-Pacific, the U.S. will need to develop corresponding export capacity on the Pacific coast. Given the projected energy needs of rapidly growing Asian economies and the geographic scale of the Pacific region, a strategic approach would involve closer coordination among the U.S., Australia, Canada, and Mexico. Together, these countries could offer “trusted” energy security to Indo-Pacific allies and partners—including India, Japan, South Korea, ASEAN members, and the Pacific Islands.

THE RENAISSANCE OF NUCLEAR ENERGY

Second, nuclear energy is likely to see a durable resurgence as a reliable, low-emission source capable of meeting rising energy demand. Germany has recently reconsidered its position on nuclear power. Poland is planning to construct three new nuclear

plants in collaboration with American, European, and Asian partners. Romania is actively working to integrate Small Modular Reactors (SMRs) into its national energy system.

A recent U.S.–Ukraine agreement includes modernizing Ukraine's nuclear power plants as part of a broader effort to jointly develop the country's mineral resources. India is also pursuing nuclear expansion to meet its rapidly growing energy needs. Japan remains open to international partnerships for nuclear development, while France continues to support its long-standing nuclear sector. In the Middle East, several countries are showing strong interest in building civil nuclear capabilities.

It would be a strategic folly for the US and allies to relegate new nuclear energy developments to the sole purview of its strategic adversaries – Russia and China. Of the world's 439 operational nuclear reactors, more than 80 are either located in Russia or built with Russian technology, with an additional 15 under construction. Until recently, Russia controlled 40 percent of global uranium conversion capacity and 46 percent of global enrichment capacity.

High capital costs and long construction timelines present major obstacles to new nuclear energy projects. Overcoming these challenges will require active public sector involvement, including regulatory support and financing mechanisms, to help catalyze a nuclear energy revival.

AFRICAN ENERGY POTENTIAL

Third, unlocking Africa's energy potential will not only transform the continent's infrastructure but also strengthen its integration with Europe. The lack of affordable, accessible energy remains one of the biggest barriers to Africa's economic development, particularly its industrialization. Yet the continent holds abundant reserves of fossil fuels, uranium, and renewable energy resources.

With a rapidly growing young population and expanding middle class, Africa's energy needs are rising sharply. Global demand for Africa's rare and critical minerals is also increasing. To realize its industrial ambitions, Africa would benefit more from processing these resources domestically rather than exporting raw materials to countries like China. Accelerating large-scale energy production to support mineral processing and related manufacturing will likely reshape Africa's economic and energy landscape over the coming decades.

From Nigeria to Morocco to Europe, new oil and gas pipelines are planned to help meet European energy needs. Similar infrastructure projects are underway across North Africa. Developing Africa's energy resources remains a high priority within the European Union's Africa strategy, as well as the national strategies of Italy, France, and Spain. This evolving energy landscape presents a compelling opportunity for the United States to align its strategic interests in critical and rare minerals with the EU's Global Gateway initiative, Italy's Mattei Plan, and efforts by Japan and India. Coordinated investment in African energy infrastructure could deliver outcomes far greater than the sum of their parts.



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The need to meet the world's growing demand for energy will most likely lead to a renaissance of nuclear energy as a reliable and clean fuel.

INVESTMENT IN ELECTRIC GRID

Fourth, public investment in resilient national and regional electric grids is essential to ensuring energy security and supporting the energy transition. A robust grid enables the optimal integration of renewable and conventional energy sources, allowing systems to balance base and peak loads efficiently. It is also critical for scaling up electric vehicle adoption.



Unlocking Africa's energy potential, rich in fossil, uranium and renewable resources, is key to the continent's industrialization and economic integration. In the photo, the Vaal Dam, in South Africa.

In much of Africa, the absence of strong national grid systems remains the biggest obstacle to harnessing the continent's vast solar and renewable energy potential. Addressing this infrastructure gap is key to unlocking long-term, sustainable energy development across the region.

A nation's energy resilience is closely tied to the strength of its electric grid. In most countries, transmission networks are built around traditional coal, gas, or nuclear generation, typically located near major demand centers such as industrial hubs and urban areas. In contrast, large-scale renewable energy projects—particularly wind and solar—are often sited in remote regions beyond the reach of existing grid infrastructure. Fully harnessing their potential will require substantial investment in expanding and reinforcing the grid.

An integrated and resilient electric grid is essential not only for optimizing a nation's energy mix but also for supporting neighboring allies and partners during times of crisis. Parts of Ukraine are currently receiving electricity through grid connections with Poland and Romania. Deeper grid integration among these countries is likely to play a central role in Ukraine's future reconstruction and long-term energy stability.

Energy politics, demand, and usage are rapidly reshaping global energy infrastructure. Natural gas and nuclear are expected to remain central components of national energy portfolios, even as more renewables come online. Energy security will consistently take precedence over energy transition—because, as the saying goes, you don't talk about balanced nutrition on an empty stomach. A transition grounded in energy security prioritizes pragmatic, non-ideological strategies—focusing on matching energy sources to demand in a responsible and sustainable way.

Most pragmatic nations will adopt an "all-of-the-above" strategy—drawing on fossil fuels, nuclear, natural gas, and renewables—while prioritizing energy accessibility, affordability, and security over ideology or virtue-signaling. These realities will shape the future of global energy infrastructure. Europe will continue to reorient its infrastructure to receive energy from North America and other trusted partners, reducing dependence on Russia. Africa is poised to attract unprecedented investment in energy infrastructure, with growing integration between African and European systems across the Mediterranean. National and regional grid resilience will become a top priority to ensure both energy security and a successful transition.

Despite high capital costs and long lead times, nuclear energy will play an expanding role in energy portfolios. Across the board, smart infrastructure—capable of managing diverse sources and dynamic demand—will define the next phase of global energy development.

we

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THE STAR-SPANGLED MARITIME GIANT IS BACK

by **Leslie Palti-Guzman**



A STRATEGIC PUSH IS NEEDED TO COUNTER CHINA AND SAFEGUARD ENERGY FLOWS

THE UNITED STATES is finally waking up to the geoeconomic vulnerability of ceding maritime dominance to China. For decades, the West has neglected the strategic importance of the global merchant fleet, including commodity tankers, allowing China to dominate maritime infrastructure, logistics, and routes. Today, China is the world's largest shipbuilder and shipowner. It commands port access at key chokepoints, shapes maritime standards, and controls critical shipping logistics. This carefully built advantage gives Beijing significant leverage—not only over global supply chains but also over energy flows and wartime logistics. Now that the U.S. is the world's largest exporter of seaborne commodities, Washington must act quickly to regain



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The Panama Canal (pictured) has become a symbol of the United States reaffirming its national security by ensuring unimpeded access to strategic ports and maritime routes.

leverage, even if the process will be costly and long.

In times of war, trade disputes, demand/supply shocks, or supply chain disruptions, control over the commercial shipping fleet can become a weapon. The owner of the ship ultimately controls the trade. The West's overreliance on Chinese-built and -owned ships could quickly become a liability. The weaponization of shipping—particularly for energy commodities like LNG—would reverberate across markets and pricing, with immediate consequences for national security and economic stability.

Recognizing this risk, the Trump administration has elevated shipping as a strategic priority. At least three executive orders reference maritime security and shipbuilding as core national interests. The vision is ambitious and cannot be executed overnight, but the strategic direction is clear. In partnership with capable foreign allies, U.S. policymakers are laying the groundwork for the long-term rebuilding of American sovereign capacity in shipbuilding and maritime logistics, while ensuring worldwide freedom of navigation.

STRATEGIC PILLAR 1: REBUILDING US SHIPBUILDING WITH CAPABLE PARTNERS

The U.S. and China are now also competing over the physical infrastructure that underpins global commerce: ships. About 80% of global trade by volume is seaborne, yet the U.S. has just 80 internationally trading vessels under its flag, while China has over 5,500. The imbalance is even more pronounced in segments like LNG, where only one U.S.-flagged, U.S.-crewed, and U.S.-owned LNG carrier exists today: the American Energy, reflagged in 2024 to carry U.S. LNG to Puerto Rico.

Beijing has methodically captured market share in shipbuilding, recently surpassing South Korea and Japan. Chinese shipyards are now building the bulk of global vessels. South Korea still dominates the shipbuilding of LNG tankers (~70% share for new orders) though China would like to catch-up.

LNG exports—now a central pillar of US energy and trade policy—depend on ships that are mostly foreign-owned, foreign-flagged, and foreign-crewed. In a geopolitical crisis, these ships may be recalled, rerouted, or denied access altogether.

It has not gone unnoticed by allies like South Korea that the U.S. is now investing political capital into maritime reindustrialization. In his 2025 State of the Union address, President Trump was unequivocal: "To boost our defense industrial base, we are also going to resurrect the American shipbuilding industry, including commercial shipbuilding and military shipbuilding."

The legislative embodiment of that vision is the bipartisan SHIPS for America Act, which proposes a Shipbuilding Financial Incentives Program to revitalize the U.S. shipbuilding sector. It would offer grants, tax credits, and other tools to support the construction, repowering, or reconstruction of eligible oceangoing vessels in domestic shipyards.

The Office of the United States Trade Representative (USTR) is also exploring a policy requiring at least 1 percent of U.S. LNG exports to be transported on U.S.-flagged and U.S.-operated vessels. Although USTR removed the original 2029 deadline—deemed unrealistic by stakeholders—the move sends a commercial signal for investment in U.S. LNG shipping capacity.

The road ahead won't be easy. Greenfield LNG shipyards will require substantial capital expenditure, multi-year timelines, and significant government support. Realistically, progress will depend on a mix of legislative backing—grants, subsidies, procurement guarantees—and close collaboration with allies that already possess the necessary technical expertise, such as Korea and Japan.

Industry stakeholders are clear-eyed. As one executive put it, "We won't be able to build a US LNG tanker with 100 percent American components—that's not realistic." A more realistic approach is a hybrid solution: partnering with trusted and capable allies to co-produce ships, while educating US policymakers on the technological and financial runway required. If the government provides that runway, the private sector is likely to respond.

While the U.S. lacks the full supply chain to build an LNG carrier entirely from domestic components, a hybrid approach—importing key parts while constructing hulls and integrating systems in U.S. yards—could lay the foundation for a revitalized LNG fleet.

STRATEGIC PILLAR 2: SECURING MARITIME ACCESS AND SEA LANES

Controlling ships is one side of maritime power; securing routes is just as strategic. China's global port footprint—mainly via state-linked firms like COSCO and CMPort—extends to over 80 terminals, including in key chokepoints like the Panama and Suez Canals. This commercial reach gives Beijing

potential leverage to disrupt trade flows without resorting to military force.

The Panama Canal has become a symbol of U.S. efforts to reassert control over strategic maritime access. China, meanwhile, holds key positions in Panama's port infrastructure: CMPort has stakes in the Colón Container Terminal, and Hutchison Ports—a Hong Kong-based firm with close ties to Beijing—controls the Balboa and Cristóbal ports. These holdings give China influence near both entrances to the canal.

This has not gone unnoticed in Washington. The U.S. has made clear its intent to ensure secure, sovereign transit through the Panama Canal for both commercial and military purposes. Under sustained diplomatic pressure since late 2024, Panama officially withdrew from the Belt and Road Initiative in early February 2025—a turning point in its relationship with China, following years of deepening economic and infrastructure ties. Panama's long-delayed approval of the \$1.6 billion Rio Indio reservoir project, now slated for completion by 2032, was another win for the White House. The reservoir is expected to ease the water shortages that have constrained canal traffic and to restore strategic continuity for key commodity flows—particularly U.S. LNG. In 2024, 94 percent of U.S. LNG bound for Asia had to reroute via the Cape of Good Hope due to Panama Canal bottlenecks.

Another major disruption to global shipping in 2024–2025 has been the Red Sea, forcing the U.S. to resume its traditional role as guarantor of maritime security. Over the past 18 months, much of the Western global vessel fleet—especially LNG tankers carrying U.S. exports to Asia—has opted to avoid the Bab el-Mandeb Strait, rerouting around the Cape of Good Hope. Meanwhile, oil shipments involving Russia, China, and Iran have continued to use the Red Sea route, reflecting tacit alliances, intelligence sharing, and opaque trade arrangements. Initially reactive, the U.S. adopted a more assertive military stance by late 2024 to deter Iran-backed Houthi attacks on commercial vessels and reestablish freedom of navigation. U.S. B-2 stealth bombers were deployed against Houthi targets in Yemen in early 2025, sending a clear signal to Tehran. Though the LNG market has adapted, the longer route adds cost and inflationary pressure.

While the Houthis may be one of the last remaining Iranian proxies still operational, the May 6 cease-fire with the U.S., combined with Israel's intelligence capabilities and demonstration of air superiority during the recent 12-day Iran-Israel war, appears to have deterred the group from intervening. It may be too early to draw firm conclusions, but the prospect of reopening the Red Sea route before the end of 2025 is beginning to look increasingly plausible.

When the U.S. reasserts deterrence, both allies and adversaries take note. Beijing is closely observing U.S. actions in other regions to assess its commitment to keeping the South China Sea open. Maritime security operations are not only about safeguarding cargo—they are about reinforcing the credibility of American power and ensuring the competitiveness of U.S. exports to Asia



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To counter China's growing maritime power, the Trump administration is focusing on investing in the domestic shipbuilding industry. In the photo, the U.S. president visits the Fincantieri shipyard in Marinette, Wisconsin.

GREEN SHIPPING: THE BATTLE OVER STANDARDS

China's rise in maritime capacity also positions it to influence global standards-setting. Beijing is not only exporting ships but also shaping benchmarks for decarbonized shipping—whether through LNG, methanol, ammonia-fueled engines, hydrogen fuel cells, battery-electric propulsion, or digital logistics systems. This confers soft power: countries reliant on Chinese shipbuilders may find themselves increasingly aligned with Chinese regulatory norms and technologies.

The US cannot afford to let China set global shipping standards unilaterally. Revitalizing American shipbuilding offers an opportunity to leapfrog in green maritime technology. By partnering with Korea and Japan—leaders in advanced propulsion and maritime R\&D—the US can help shape an alternative set of standards that prioritize both decarbonization and strategic security.

HOW TO REVOLUTIONIZE THE PLAYING FIELD

China's maritime dominance, built over two decades through state-led industrial policy, won't be undone quickly. But with strategic patience and urgent action, the balance can shift.

That calls for investing in U.S. shipyards as a matter of national security, not nostalgia. It means securing chokepoints like the Panama Canal, asserting presence in contested sea lanes like the South China Sea, and helping set the rules for maritime decarbonization—so that American energy doesn't sail on foreign terms. Reasserting U.S. maritime sovereignty depends on sustained political will.

we

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LNG

THE STRATEGIC ROLE OF INFRASTRUCTURE

by Anne Sophie Corbeau



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THE GLOBAL MARKET IS GROWING LIKE NEVER BEFORE, BUT IT FACES GEOPOLITICAL CHALLENGES AND UNCERTAINTY OVER FUTURE DEMAND. INFRASTRUCTURE—BOTH FOR EXPORT AND IMPORT—REMAINS CENTRAL. ITS FUTURE WILL DEPEND ON POLITICAL DECISIONS, INVESTMENTS, AND CORPORATE STRATEGIES

THE GLOBAL LIQUEFIED natural gas (LNG) market is entering its strongest growth phase to date, but this is unfolding amid unprecedented geopolitical tensions and major uncertainties about future regional demand for gas and LNG, as well as the role of lower-carbon alternatives. In this context, LNG infrastructure—both export plants and import terminals—plays a critical role in the market's operations and flexibility. Infrastructure investments, policy decisions, and corporate strategies will shape how LNG infrastructure evolves in the decades ahead.

CURRENT LNG EXPORT PLANTS AND LNG IMPORT TERMINALS SITUATION

In 2024, 406 million tons (Mt) of LNG were traded globally—about one in every eight molecules of natural gas consumed worldwide. Global LNG trade surpassed interregional pipeline trade in 2020. Since the decline of Russian pipeline gas to Europe in 2022, interregional pipeline volumes have fallen sharply and now sit well below the steadily rising levels of LNG trade. Global liquefaction capacity reached 492 million tons per annum (mtpa) in 2024, with average utilization around 85 percent once idle plants are excluded. Twenty-two countries now export LNG, with the United States, Qatar, and Australia leading the pack. Three new export projects came online in 2024: two small floating LNG (FLNG) projects in Congo and Mexico, and the first train of Arctic LNG 2 in Russia. Although Arctic LNG 2 began operations in August, it shut down a few months later after failing to secure buyers for its sanctioned cargoes, which were operating via a dark fleet.

As of 2024, 49 countries import LNG across all regions, with total import capacity reaching 1,188 mtpa—more than twice global export capacity. This gap exists because LNG terminals are rarely used at full capacity year-round. Many countries build excess import infrastructure to ensure energy security, accommodate seasonal fluctuations, and provide supply flexibility. For instance, Middle Eastern countries typically import more LNG in the summer to meet air conditioning demand, and little to none in winter. Longtime importers like Japan and South Korea

have maintained large import capacity to manage seasonal needs, given limited domestic storage and, in Japan's case, its island geography.

The development of regasification capacity in Europe has been shaped by earlier optimistic demand forecasts, gas market liberalization, declining domestic production, and efforts to diversify supply. The rapid build-out since 2022—largely through floating storage and regasification units (FSRUs)—was driven by the need to replace Russian pipeline gas and secure the continent's energy supply. LNG import terminals serve a different function from pipelines in this context. While pipelines typically operate near capacity, regasification terminals offer flexibility, allowing countries to respond to supply disruptions or demand surges. Unlike pipelines, which tie buyers to specific suppliers, LNG terminals enable access to a range of sources, market arbitrage, and more dynamic responses to shocks.

LOOKING FORWARD

Looking ahead, a wave of liquefaction projects—led by the United States and Qatar—is set to add well over 200 mtpa of LNG export capacity, reinforcing LNG's central role in the global gas market. The United States, already the world's largest LNG exporter, aims to more than double its export capacity by the end of the decade. This expansion is underway, with projects such as Venture Global's Plaquemines and Cheniere's Corpus Christi Stage 3. By 2030, the U.S. is expected to account for more than quarter of global LNG export capacity, effectively dominating the market.

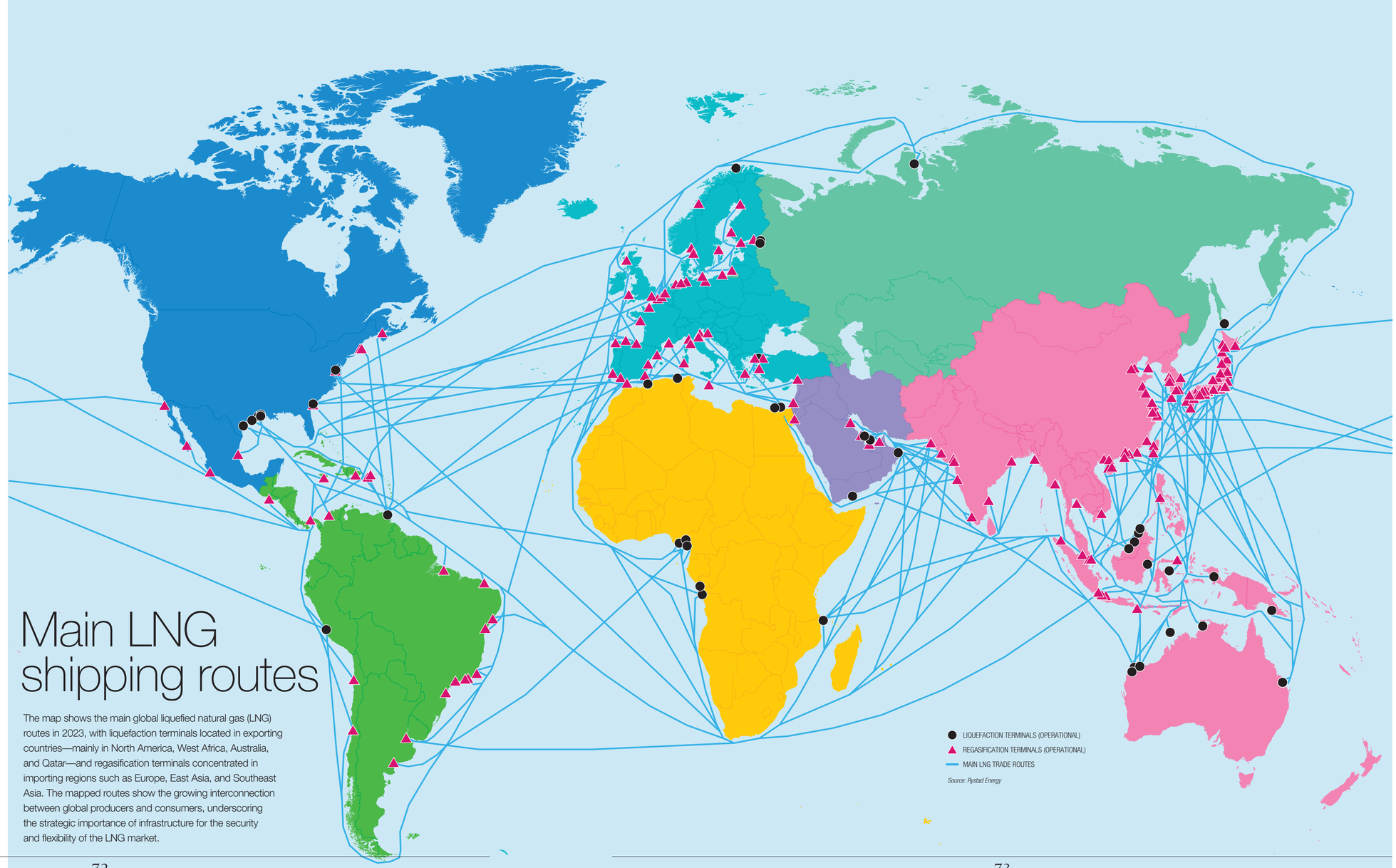
This dominance faces challenges. Qatar is also expanding its LNG export capacity, supported by low-cost gas and a strategic location that allows it to arbitrage between Asian and European markets. Still, based on officially sanctioned projects, U.S. LNG export capacity will be about 40 percent greater than Qatar's. Australia remains a major exporter but is expected to begin importing LNG soon due to regional supply shortfalls.

Finally, Russian pipeline gas and LNG remain key competitors to U.S. LNG. Since 2022, reduced Russian pipeline flows to Europe have been partly offset by U.S. LNG, supporting new liquefaction projects. Whether the European Commission's goal to phase out Russian gas by 2027 will succeed remains uncertain, especially amid ongoing peace discussions related to Ukraine. Oil and gas will be part of any eventual settlement. A further decline in Russian pipeline deliveries to Eastern Europe—currently around 15 billion cubic meters—would create more room for U.S. LNG. But a return of Russian gas to Europe, which has been widely discussed, would undermine U.S. LNG prospects and reduce utilization of Europe's regasification capacity.

On the demand side, countries such as Australia, Cyprus, and South Africa may begin importing LNG in the coming year. Still, despite the recent rise in European LNG imports, Asia

Main LNG shipping routes

The map shows the main global liquefied natural gas (LNG) routes in 2023, with liquefaction terminals located in exporting countries—mainly in North America, West Africa, Australia, and Qatar—and regasification terminals concentrated in importing regions such as Europe, East Asia, and Southeast Asia. The mapped routes show the growing interconnection between global producers and consumers, underscoring the strategic importance of infrastructure for the security and flexibility of the LNG market.





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The global liquefied natural gas (LNG) market is experiencing unprecedented growth. In 2024, 406 million tons of LNG were traded worldwide. This means that one out of every eight molecules of natural gas consumed globally was traded as LNG.

remains the center of gravity for global LNG consumption. Two-thirds of the regasification capacity added in 2024 (35 mtpa) was located in Asia. Future demand growth is expected to come from China, India, and Southeast Asian countries, though the drivers differ—rising electricity demand, LNG replacing declining domestic production, or substituting for pipeline imports. India and Southeast Asia face three main challenges: making LNG cost-competitive with coal, expanding regasification capacity, and building downstream pipeline networks. The latter two face financing hurdles, while affordability is critical to avoid a leap directly from coal to renewables.

Some countries both export and import LNG. Egypt, for example, began importing LNG in 2015 due to domestic gas shortfalls. Although it returned to net exporter status from 2019 to 2023, declining gas production has led it to resume imports in 2024. FSRUs have been key in enabling these shifts. Similarly, countries like Indonesia and Malaysia—longtime LNG exporters—are increasingly turning to imports to meet growing domestic demand.

In Europe, LNG infrastructure owners are beginning to move beyond traditional regasification, exploring investments in multi-molecule terminals—facilities designed to handle not only LNG but also greener alternatives such as hydrogen, ammonia, bio-LNG, and synthetic methane. This shift aligns with the EU's broader decarbonization goals and reflects a push toward future-proof infrastructure. However, concerns remain about the long-term viability of some terminals, especially if industrial activity shifts to regions with cheaper energy amid the ongoing trade war. Uncertainty also persists over which greener molecules will ultimately dominate.

Over the past two years, two chokepoints have emerged that significantly disrupted LNG shipping routes. Houthi attacks in the Red Sea and low water levels in the Panama Canal have forced LNG cargoes—particularly from the U.S. and Qatar—to take longer alternative routes. At the same time, geopolitical and commercial developments are making LNG trade less flexible, more polarized, and potentially less efficient. The U.S.–China trade war disrupted U.S. LNG exports to China, with Chinese-contracted cargoes diverted to Europe. Even if flows resume, this second major disruption between the world's largest LNG exporter and importer will have lasting effects. Europe, meanwhile, plans to end imports of spot Russian LNG by end-2025 and all Russian LNG by end-2027. Its upcoming methane regulation could further segment the market by distinguishing between "clean" and "dirty" LNG supplies.

AN EVOLVING ROLE

The LNG sector stands at a critical juncture. Existing infrastructure reflects both past priorities and future ambitions—import capacity is often intentionally oversized to ensure security and flexibility yet may face declining regional use in the coming decades. Looking ahead, the market will be shaped by a few dominant exporters and complex geopolitical dynamics, with demand increasingly centered in developing Asia. As the world navigates climate goals, growing power needs, and shifting trade patterns, LNG will continue to play a pivotal—though evolving—role.

we

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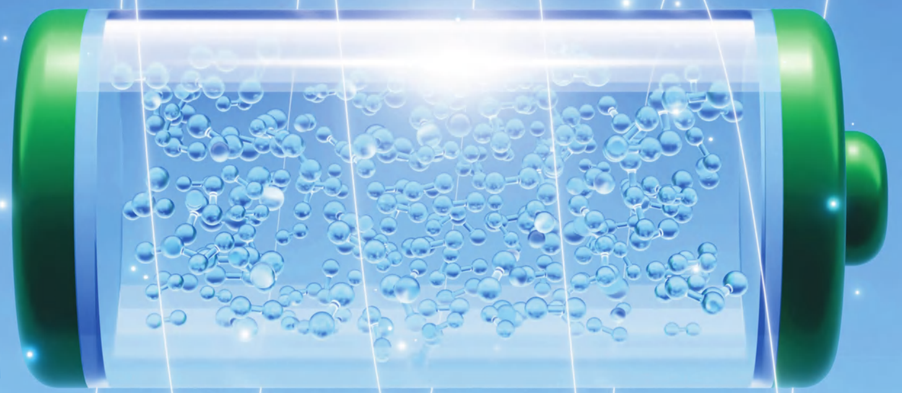
THE HYDROGEN RACE BETWEEN THE US & CHINA



by **Jacopo Maria Pepe**

WHILE NOT CURRENTLY AMONG THE LEADING EXPORTERS, BOTH COUNTRIES ARE VYING FOR LEADERSHIP IN THE HYDROGEN ECONOMY, RECOGNIZING ITS POTENTIAL BOTH FOR THEIR DOMESTIC ENERGY TRANSITIONS AND FOR SHAPING FUTURE GLOBAL POWER DYNAMICS

AS THE GLOBAL ENERGY system shifts away from carbon-intensive fuels, hydrogen has emerged as a central pillar in strategies aimed at decarbonizing hard-to-abate sectors such as heavy industry, shipping, aviation, and maritime trade. Moreover, hydrogen can also serve as a storage medium to stabilize power grids as the share of electricity generated by volatile solar and wind energy steadily grows worldwide.

Aganist this backdrop, policymakers and experts have long hoped that once the hydrogen market ramps up, it might also fundamentally change the geopolitics of energy trade and flows—promoting energy independence, reducing risky fossil energy relations, and strengthening value-based trade. However, hydrogen is a technological- and industrial-intensive energy source, with significant ramifications in critical mineral value and supply chains, as well as complex logistics. As a consequence, hydrogen has its own geopolitics and the interplay of mineral concentration, technological-industrial competition, transport constraints, and current geopolitical power dynamics will influence hydrogen policy and decision-making along the entire value chain. Actors often still prioritize socioeconomic, geopolitical, and technopolitical considerations over climate priorities when entering the hydrogen race, and their interest and positioning in the future hydrogen economy might differ greatly, depending on these factors.

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THE HYDROGEN VALUE AND SUPPLY CHAIN

The hydrogen value chain is fundamentally different from that of fossil fuels or even renewable electricity, as it presents itself as a complex and interwoven ecosystem—either for the production of gaseous hydrogen or hydrogen derivatives like ammonia (Figure 1). It can be divided into three primary segments (upstream production, midstream logistics, and downstream applications) and one often-overlooked but essential pre-chains segment (industrial components and raw material processing).

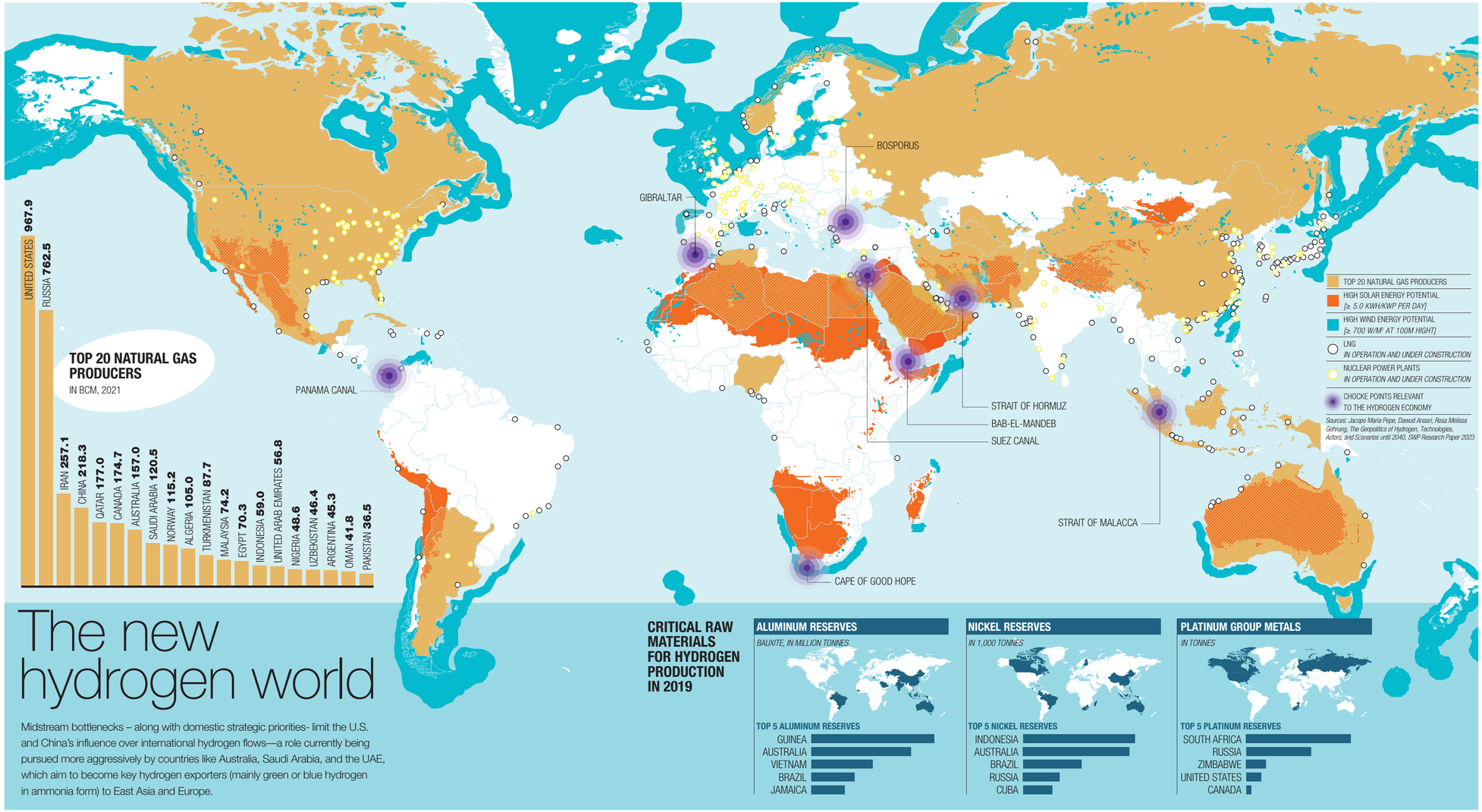
Pre-chains, while not directly related to hydrogen or hydrogen products as final good, are particularly relevant for hydrogen production, especially green, as they include vaue and supply chains for raw materials and critical/strategic minerals needed for hydrogen such as nickel, PGM metals, but also silicon and lithium, as well as the very manufacturing process of solar panels, wind turbines, and electrolysers.

The upstream segment includes hydrogen production itself, either from renewable electricity (green hydrogen via electrolysis, yellow hydrogen from nuclear energy), natural gas with steam methane reforming or pyrolysis and carbon capture (blue hydrogen), or traditional steam methane reforming with no carbon capture (so called grey hydrogen).

The midstream encompasses storage, distribution, and transportation infrastructure such as pipelines (up to roughly 4,000 km), ships, liquefaction and shipping terminals, and conversion technologies like ammonia synthesis for long-distance transport (above 5,000 km) while the Downstream segment refers to end-use applications in mobility (fuel cell vehicles, heavy transport), industrial processes (steel, ammonia, refining), and power generation.

Especially the midstream and upstream segment are intervowen: depending on the end-use, hydrogen and hydrogen derivatives have each their own value chain and transport logistics. For hydrogen to be produced either as gas or as derivative and used on site or transported over longer distances, differently complex chemical processes are needed. Industrial clusters either close to ports and their hinterlands or close to final consumption define logistics(power lines, pipelines, ships, liquefaction and shipping terminals, and conversion technologies) and hence reconfigure the economic geography of both industry and energy.

Currently, transport and industrial infrastructure, are often considered the missing link in the market ramp-up for clean hydrogen. Without the capacity to store and transport hydrogen economically and safely at scale—as well as the capacity mass-produce electrolysers, or develop enabling technologies—investments in upstream production and downstream demand remain fragmented, isolated, and uncertain, and the cost of hydrogen—especially from renewables—remains high. To this adds the challenge to extract, process and secure supply of critical raw materials especially needed for the production of green hydrogen (Figure 2).

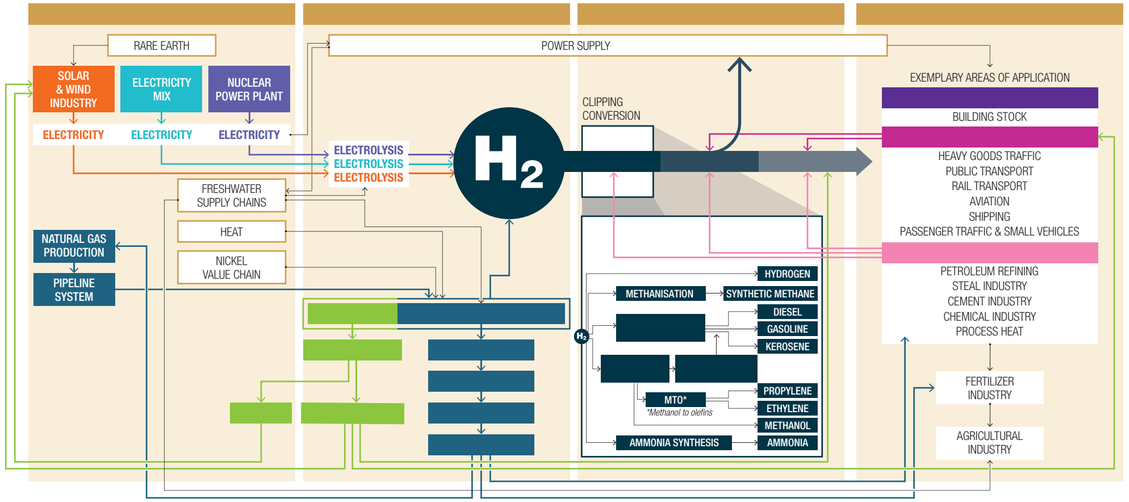


The new hydrogen world

Midstream bottlenecks – along with domestic strategic priorities- limit the U.S. and China's influence over international hydrogen flows—a role currently being pursued more aggressively by countries like Australia, Saudi Arabia, and the UAE, which aim to become key hydrogen exporters (mainly green or blue hydrogen in ammonia form) to East Asia and Europe.

SUPPLY AND VALUE CHAINS OF HYDROGEN

Source: Julian Grinschgl, Jacopo Pape, Kirsten Wetsphal, A new hydrogen world: geotechnological, economic, and political implications for Europe, SWP Comment, 2021



The hydrogen value chain is a complex and interwoven ecosystem—both for the production of gaseous hydrogen and for hydrogen derivatives like ammonia. It can be divided into three primary segments (upstream production, midstream logistics, and downstream applications) and one pre-chain segment.

CHINA AND THE UNITED STATES' STRATEGIC POSITIONING

China and the United States, given their paramount roles in energy markets and in shaping the global order, see hydrogen as an additional battlefield in the global energy race and in their geopolitical rivalry. In fact, both are vying for leadership in the hydrogen economy, recognizing its potential not only to drive domestic energy transitions but also to shape the contours of future global power. Yet, the race to hydrogen dominance is neither linear nor uniform; as shown, it unfolds across complex and interwoven value and supply chains, where both countries take different but crucial roles .

Neither China nor the United States is currently positioned—or willing—to emerge as a major hydrogen exporter, though both could become pivotal in shaping regional hydrogen economies and eventually a gloabl hydrogen market. Particularly, midstream bottlenecks – along with domestic strategic priorities- limit their influence over international hydrogen flows—a role currently being pursued more aggressively by countries like Australia, Saudi Arabia, and the UAE, which aim to become key hydrogen exporters (mainly green or blue hydrogen in ammonia form) to East Asia and Europe (Figure 2).

Yet, the U.S. and China's geopolitical priorities, together with peculiar technological-industrial capabilities and energy resource bases, give them key levers to influence the hydrogen market ramp-up and its geopolitics in the coming decades.

CHINA'S STRATEGY: PRE-CHAIN AND UPSTREAM MASTERY

China's hydrogen ambitions are grounded in considerations of energy security and energy independence, as well as in its sustainability aspirations and industrial policy. However, its strategic competition with the U.S. fuels the race for technological and market leadership in the hydrogen sector as well. By 2025, the country aims to produce between 0.1 and 0.2 million tonnes of hydrogen annually from renewable energy, positioning it as both a self-sufficient producer and a potential trade hub.

China's approach to hydrogen is characterized by rapid scaling and strategic integration into broader industrial and environmental policies. The country leads globally in electrolyser manufacturing, with companies like Longi and SinoHytec dramatically expanding production capacities. Particularly, China has established itself as a key player in the global electrolyser market by leveraging its mature manufacturing capabilities in alkaline (ALK) water electrolysis technology, while rapidly catching up in proton exchange membrane (PEM) technology. As a refiner of many raw materials—such as nickel (needed for ALK) and critical PGM metals (needed for PEM)—and as a leading manufacturer of solar panels and wind turbines, China holds the key to future hydrogen production.

Large-scale green hydrogen projects are also underway in renewable-rich regions such as Inner Mongolia and Xinjiang, aiming to decarbonize heavy industries. Moreover, China has been aggressively building domestic hydrogen infrastructure in the heavy transport sector, with over 300 hydrogen refueling stations in operation as of early 2025—more than any other country. This is complemented by massive public and private investment, guided by the central government's 2021–2035 Hydrogen Development Plan, which targets 50,000 fuel cell vehicles on the road by 2025. Yet, China's hydrogen economy remains largely domestically focused. Its vast internal market and logistical geography make domestic consumption more attractive than export, while it holds competitive advantages in industrial manufacturing, raw materials processing, and technological know-how. Consequently, in the midstream, the country faces constraints it has no incentives to overcome. Hydrogen is challenging to transport due to its low energy density, and China lacks so far the liquid hydrogen shipping capabilities or export-oriented pipeline infrastructure that would position it as a major global hydrogen supplier.

This domestic orientation aligns with China's strategic goals of energy security and technological self-reliance as hydrogen is just one of many tools to reduce greenhouse gas emissions while guaranteeing self-sufficiency.

THE UNITED STATES: A TECHNOLOGICAL POWERHOUSE WITH EVOLVING PRIORITIES

The U.S. could play a special role as a potentially influential "prosumer" (both a producer and consumer) in the future hydrogen world. Compared to China, the United States has adopted a more fragmented but equally technologically agnostic and highly innovative approach to hydrogen, particularly under the previous Biden administration's climate agenda.

Over the past years, the Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) catalyzed a hydrogen boom, offering generous production tax credits (up to $3/kg for green hydrogen) and funding for "hydrogen hubs" across the country. The U.S. excels in upstream innovation for green hydrogen, as it is home to leading PEM electrolyser technology firms. It has also targeted blue hydrogen production, leveraging abundant natural gas resources and expertise in carbon capture technologies.

Here, projects in the Gulf Coast region have explored opportunities for hydrogen exports, particularly to Europe and Asia. During the Biden Administration, projects in Texas, Louisiana, and Appalachia began laying the groundwork for large-scale blue hydrogen production. The U.S. hydrogen strategy, released in 2023, envisions domestic production of 10 million tonnes of clean hydrogen annually by 2030, increasing to 50 million tonnes by 2050—potentially exceeding long-term domestic demand and leaving room for exports to allies.

The downstream sector has also gathered momentum, with hy-



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drogen being integrated into ammonia and methanol production, and new hydrogen-based steelmaking pilot projects. American automakers lag behind their Asian counterparts in fuel cell vehicles, but partnerships with logistics and heavy-duty transport firms (like Nikola and Cummins) are advancing niche applications.

However, similar to China, the U.S. lags in midstream infrastructure and shows limited interest in investing in H_2-ready transport systems. Only a few dedicated hydrogen pipelines exist—mostly in the Gulf Coast region. Liquefaction and export terminals for hydrogen or its derivatives (like ammonia) remain limited, and the domestic hydrogen refueling network is sparse compared to Europe or China.

Moreover, currently, the new Trump Administration has redefined energy and climate policy priorities, focusing on LNG rather than hydrogen production and exports, and de-prioritizing climate-mitigating technologies like green hydrogen. President Trump's IRA funding pause—while not impacting the tax credits—has jeopardized billions in hydrogen grant funding and loans to major producers such as Plug Power. Meanwhile, higher tariffs on solar and wind components and Chinese steel will further raise costs for upcoming renewable projects, essential for green hydrogen production.

This may limit the U.S. role as a major hydrogen exporter in the near term, constraining investment in production and transport infrastructure. However, because the clean hydrogen push is also tied to systemic rivalry with China, industrial competition with China and Europe, and efforts to secure critical supply chains, the Trump Administration may still support select hydrogen technologies. In particular, it may favor blue hydrogen production and exports as part of a mercantilist strategy focused on leveraging domestic fossil resources and industrial capacity.

In this scenario, easing environmental concerns and political resistance to fossil-fuel-derived hydrogen—even with carbon capture—would facilitate blue hydrogen exports and related infrastructure investment. This becomes more likely if the global hydrogen race accelerates or if LNG prices fall to a point where blue hydrogen becomes more competitive than LNG and remains significantly cheaper than green hydrogen.

GEOPOLITICAL IMPLICATIONS FOR AN HYDROGEN ECONOMY

The divergent strategies and positioning of China and the U.S. in the hydrogen sector carry significant geopolitical implications for the emerging hydrogen economy. In particular, the development of hydrogen infrastructure—spanning midstream logistics, industrial pre-chains, and upstream production—is not just a technical or economic undertaking, but a strategic priority with long-term consequences for global energy leadership.

Ultimately, the hydrogen race between China and the U.S. is less about dominating the global hydrogen trade and more about securing technological and industrial leadership in the green economy. Both countries are focused on anchoring upstream and downstream segments of the hydrogen value chain—via domestic production, R\&D, component manufacturing, and vertical integration—while bolstering their geoeconomic resilience and expanding their geopolitical room to maneuver. This is not a replication of the 20th-century oil-export model, but a bid to shape the foundations of future industrial power.

However, this contest is not purely economic. Hydrogen technologies depend on critical raw materials—such as iridium, platinum, and rare earths—and on advanced manufacturing capabilities, including membranes and catalysts. Control over these inputs and technologies offers strategic leverage, arguably more than controlling hydrogen flows or transport infrastructure. In this domain, China holds a clear advantage in raw material processing and electrolyser manufacturing, while the U.S. maintains a lead in innovation and startup activity, supported by its academic institutions and federal R&D programs.

In this emerging geopolitical landscape, hydrogen infrastructure—broadly defined to include not just transport and logistics, but also industrial and manufacturing capacities—serves as both a lever of domestic modernization and a means of projecting international influence and industrial-geopolitical resilience. While midstream bottlenecks may still constrain their export capacity, China and the U.S. remain central to shaping global norms, standards, and supply chains. The evolution of their national strategies and geopolitical postures will not only define their own hydrogen trajectories but also influence the structure and geopolitics of the global hydrogen economy.



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In recent years, the Bipartisan Infrastructure Law and the Inflation Reduction Act (IRA) have supported the hydrogen boom in the US through generous tax credits for production and funding for building hydrogen hubs across the country. Pictured: TrueZero hydrogen car refueling stations in Fountain Valley, California.



China aims to produce 0.1-0.2 million tons of hydrogen per year from renewable energy by 2025, to position itself as a self-sufficient producer and potential commercial hub. Pictured: workers assembling fuel cell engines at the plant owned by Hynamo New Energy Technology Co. in Luoyang city.

CHALLENGES FOR EUROPE IN THE EMERGING HYDROGEN RACE

Unlike the oil market—centralized and dominated by a handful of major producers and chokepoints—the hydrogen economy is more likely to evolve into a decentralized, regionalized system. Technological hurdles, regulatory fragmentation, and high transport costs will favor the rise of regional hubs and bilateral trade corridors over a unified global market.

However, this new energy order is not inherently more stable or cooperative. The U.S.-China competition over hydrogen illustrates how concentrated technology and mineral supply, fragmented value chains, industrial rivalry, and infrastructure bottlenecks heighten the risk of disruption and conflict. Green hydrogen and its associated supply chains are becoming arenas for geopolitical competition over industrial and technological leadership—beyond climate considerations.

Europe's biggest challenge as a future net importer will be to build a competitive domestic industrial base, secure sustainable access to critical raw materials, promote common standards with strategic partners, and invest in infrastructure cooperation. Without these, it risks remaining dependent and exposed in a fragmented hydrogen economy.

we

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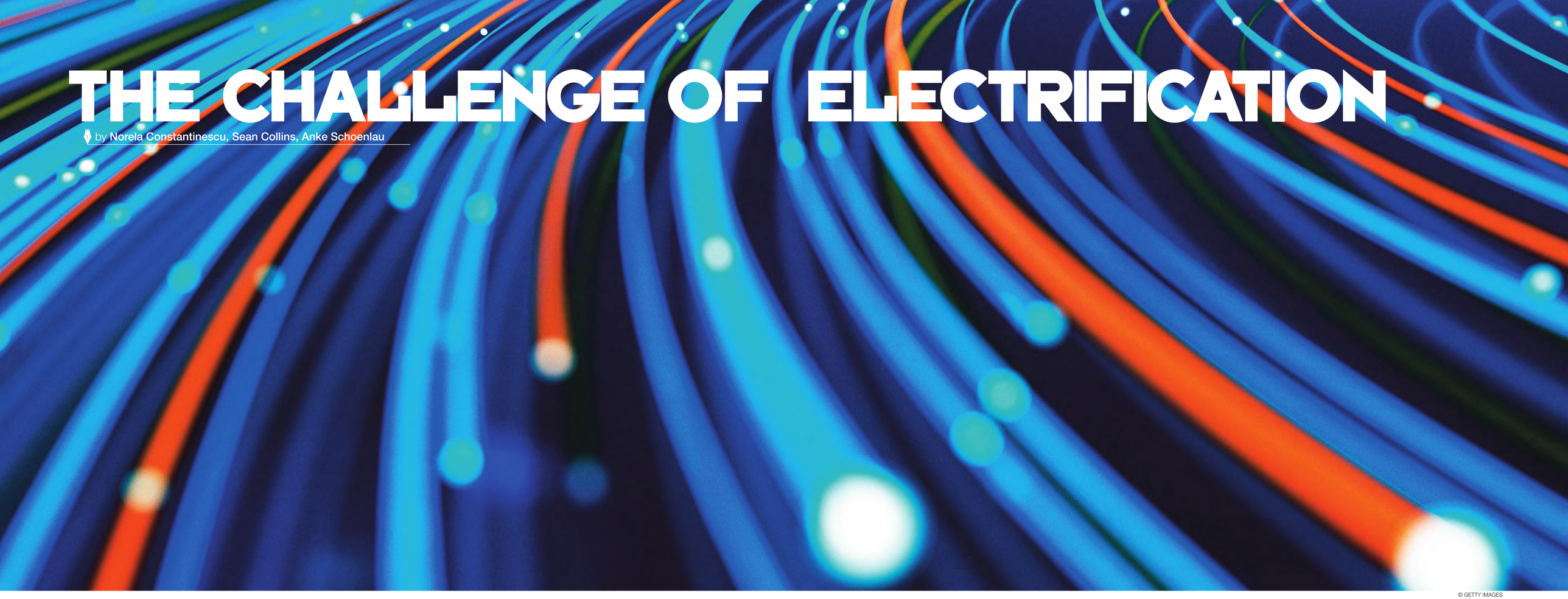
THE CHALLENGE OF ELECTRIFICATION

by Norela Constantinescu, Sean Collins, Anke Schoenlau



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FROM INDUSTRIAL PRODUCTION TO TRANSPORT, THE SHIFT TO ELECTRIC ENERGY IS AT THE HEART OF EUROPE'S STRATEGY FOR CLIMATE NEUTRALITY BY 2050. BUT ACHIEVING THIS GOAL WILL REQUIRE RECORD INVESTMENTS IN RENEWABLES, GRIDS, AND DIGITALIZATION

EUROPE IS AIMING to build a net-zero energy system by 2050, while also boosting short-term competitiveness through lower energy costs for industry and households and ensuring supply security. To achieve this, the EU must accelerate the integration of renewables by upgrading and expanding infrastructure to support widespread electrification and deploy complementary infrastructure for other energy carriers such as clean hydrogen.

This transformation will reshape trade flows, energy alliances, and economic competitiveness. IRENA's new Regional Energy Transitions Outlook for the European Union outlines potential pathways.

RENEWABLE CAPACITY AND TRANSFORMATION OF END USE SECTORS

According to IRENA's *World Energy Transitions Outlook*, electricity is set to become the dominant global energy carrier by 2050, accounting for over 50 percent of final energy consumption in a 1.5°C-aligned scenario—up sharply from around 21 percent today (Figure 1).

Buildings, transport, and industry can decarbonize through heat pumps, efficient appliances, and electric vehicles—supported by flexible electrification strategies and decentralized energy systems. Delivering on ambitious renewable deployment targets is essential to achieving these goals. In harder-to-abate sectors—such as shipping, aviation, petrochemicals, and parts of the power system—green hydrogen and its derivatives will play

a key role. However, current levels of investment and implementation fall short of stated ambitions (Figure 2).

EUROPE IS A GLOBAL LEADER IN RENEWABLE ELECTRICITY DEPLOYMENT

Europe is already a global leader in renewable electricity deployment. In 2024, it accounted for 14 percent of global renewable capacity additions—ranking ahead of the United States (7%) but well behind China (64 percent) (Figure 3). However, meeting the EU's 2030 and 2050 targets will require an unprecedented scale of infrastructure investment. Grid expansion, digitalization, cross-border interconnections, and the electrification of end-use sectors—either directly through electricity or indirectly via carriers like hydrogen—will be essential to manage variable renewable energy and ensure system reliability.

IRENA's EU Regional Energy Transitions Outlook, particularly its Decarbonising Energy Scenario (DES), outlines alternative pathways and additional measures to reach the 1.5°C target—while reinforcing energy security and competitiveness. Under this scenario, EU renewable electricity generation would rise from 967 TWh in 2021 to 2,250 TWh by 2030 and 4,250 TWh by 2050, reaching 91 percent of total power capacity by mid-century. Achieving this requires doubling the share of renewable electricity to 71 percent by 2030 compared to 2021. Installed renewable capacity would grow from 491 GW to 1,250 GW by 2030 and reach 2,450 GW by 2050.

ELECTRIFICATION OF END USE SECTORS SHOULD ACCOMPANY THE RENEWABLES DEPLOYMENT

The share of direct electrification is expected to reach within the EU 33 percent by 2030 and 64 percent by 2050 of total final energy consumption, up from 22 percent in 2021 (Figure 5).

NEW DEMANDS BY HYDROGEN AND DERIVATIVES

Though direct electrification is expanding in Europe, some sectors will continue to rely on indirect electrification as the most viable option. IRENA projects that clean hydrogen could represent up to 14 percent of global final energy use by 2050. In Europe, hydrogen is expected to play a key role in decarbonising industry, heavy transport, and providing seasonal energy storage. The EU Hydrogen Strategy sets a target of 40 GW of electrolyser capacity within the EU by 2030, plus an additional 40 GW in neighbouring regions for import.

IRENA's DES shows that hydrogen production (blue and green) would scale from under 1 Mt to 10 Mt by 2040, and 20 Mt by 2050.

Hydrogen's share of final energy consumption in Europe is projected to remain limited through 2030—reaching 10.6 Mt by 2030 and 36.8 Mt by 2050 (equivalent to 2 percent and 4 percent of final consumption, respectively). This underscores hydrogen's role as a targeted solution for sectors such as industry

The EU towards net zero

FIGURE 1 – **HIGHER SHARES OF DIRECT ELECTRICITY IN FINAL CONSUMPTION**

The increase in electricity within final energy consumption (which by 2030 will account for 30% compared to 23% in 2022) and the growing role of hydrogen and its derivatives are changing the dynamics of the global energy system.

**Renewable share*
(1) TFEC: Total Final Energy Consumption

Source: IRENA World Energy Transitions Outlook 2024

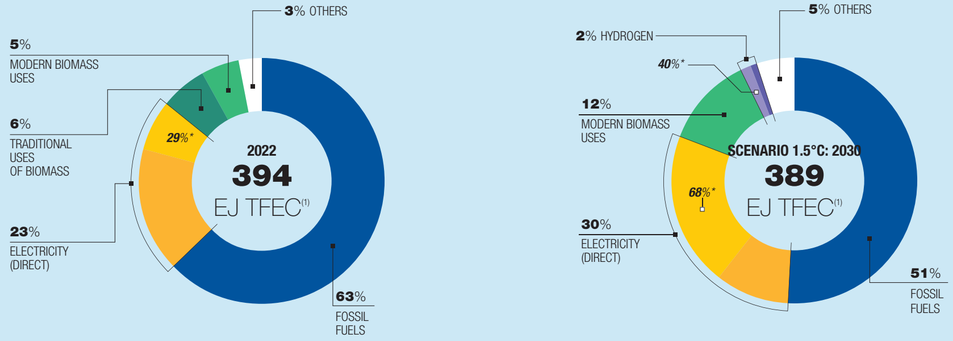
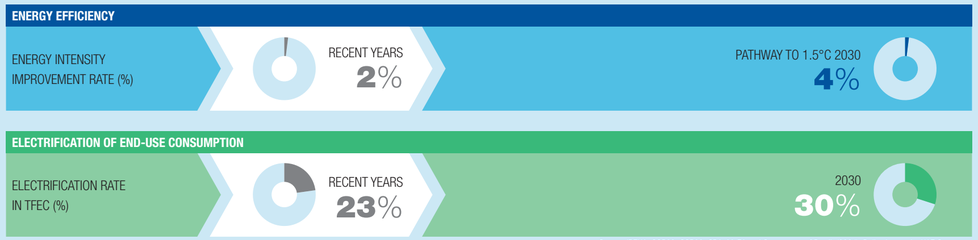


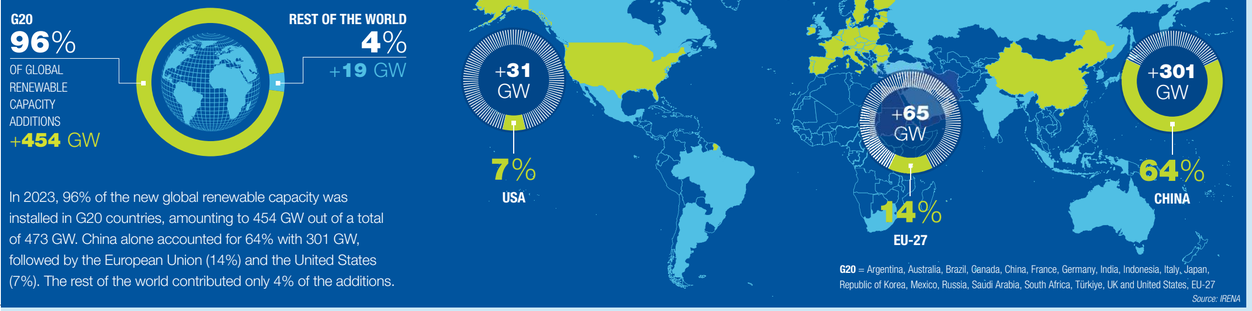
FIGURE 2 – **ACCELERATE ENERGY EFFICIENCY AND ELECTRIFICATION**

Meeting the ambitious targets for the deployment of renewable energy sources is essential to achieving the 1.5°C goal. Green hydrogen and its derivatives will play an important role in certain sectors and parts of the energy system.



Source: IRENA, COP28, COP29, GRA, MoEA and Government of Brazil (2024), Delivering on the UAE Consensus

FIGURE 3 – **THE G20 IS DRIVING RENEWABLE ENERGY GROWTH**

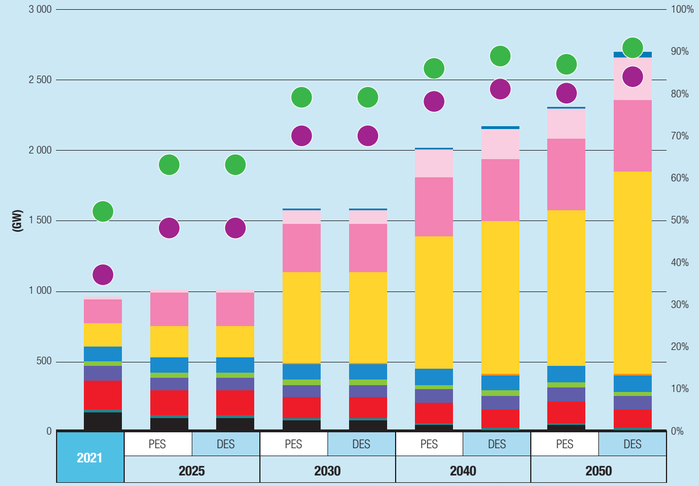


In 2023, 96% of the new global renewable capacity was installed in G20 countries, amounting to 454 GW out of a total of 473 GW. China alone accounted for 64% with 301 GW, followed by the European Union (14%) and the United States (7%). The rest of the world contributed only 4% of the additions.

G20 = Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Republic of Korea, Mexico, Russia, Saudi Arabia, South Africa, Türkiye, UK and United States, EU-27

Source: IRENA

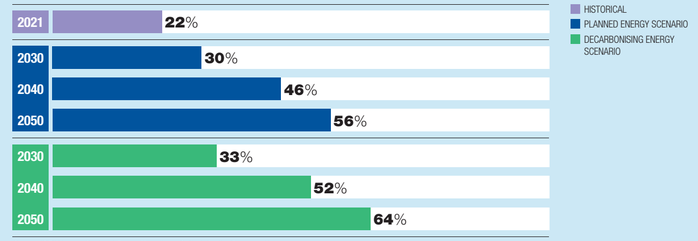
FIGURE 4 – **UE, INSTALLED POWER GENERATION CAPACITY BY TECHNOLOGY AND SCENARIO**



Notes: GW = Gigawatt; CSP = concentrated solar power; PV = energia solare fotovoltaica; VRE = variable renewables (right Y-axis); RE = renewables (right Y-axis)
Source: IRENA's new Regional Energy Transitions Outlook for the European Union.

The chart shows the evolution of global installed power generation capacity by 2050 according to two IRENA scenarios: the Planned Energy Scenario (PES) and the 1.5°C-aligned Decarbonisation Scenario (DES). In both cases, renewable sources—especially solar photovoltaics and wind—become dominant, exceeding 70% (PES) and reaching over 90% (DES) of total capacity.

FIGURE 5 – **EU ELECTRIFICATION RATE**



Source: IRENA's new Regional Energy Transitions Outlook for the European Union

The electrification rate in end-use sectors (transport, buildings, industry) is expected to grow from 22% in 2021 to 56% by 2050 under currently planned energy scenarios. However, to meet climate goals, a faster pace will be needed: in the decarbonisation scenario, the share should reach 64%.

and heavy transport, rather than a broad-based energy carrier. Its development will depend on global trade routes and coordinated EU planning.

While domestic production is central, strategic infrastructure for imports and storage will be essential to meet seasonal demand and ensure supply security. Key infrastructure requirements include regional hydrogen hubs, dedicated pipeline networks, and large-scale electrolysers, which are projected to reach 120 GW of capacity under IRENA's Decarbonising Energy Scenario (DES) by 2050.

GRID EXPANSION AND DIGITALISATION ARE BOTH IMPORTANT

The European Network of Transmission System Operators for Electricity (ENTSO-E) presented in 2024 an assessment of the infrastructure needed to support Europe's evolving electricity system. The plan identifies the need for significant grid development, the importance of interconnectors, storage needs. IRENA estimates in its DES scenario that total power sector infrastructure investment needs are EUR 5.5 trillion (2025–2050). Grid investments alone represent EUR 2.5 trillion, with the bulk required after 2030 to accommodate electrification and renewables. Battery storage investment reaches EUR 224 billion, with capacity exceeding 240 GW by 2050 to stabilize the grid. Key bottlenecks in the EU include slow permitting processes, insufficient interconnection capacity, and limited system flexibility for integrating variable renewables. To meet rising demand from electric vehicles, heat pumps, and industrial electrification, infrastructure investments must be accelerated and strategically aligned with these evolving needs.

IRENA also underscores the importance of digitalisation in managing the complexity and enhancing the flexibility of future power systems. Investments in digital infrastructure—including sensors, data platforms, and cybersecurity—are as essential as those in physical assets. IRENA's ongoing work for Canada's 2025 G7 Presidency on digitalisation and AI for power grids reflects this growing priority.

GEOPOLITICAL SHIFTS WILL IMPACT THE TRANSITION

The energy transition is reshaping global geopolitics. While renewables and hydrogen reduce reliance on a few fossil-fuel exporters by enabling broader geographic production, new dependencies are forming—particularly in clean technology supply chains. To address this, countries are focusing on diversifying sources of critical minerals for batteries and electrolysers, developing domestic or regional manufacturing capacity, and forging strategic hydrogen partnerships, notably with North Africa and the Middle East.

IRENA's analysis indicates that hydrogen trade will be more regionalized than oil and gas, constrained by high transport costs. This gives Europe a strategic advantage through its proximity to renewable-rich neighbors and highlights the growing role of infrastructure diplomacy.

The EU's industrial electrification rate is projected to rise from 31 percent to 61 percent by 2050, significantly cutting fossil fuel use in manufacturing. Heat pump deployment would reach 87 million units in buildings, largely replacing fossil-based heating systems.

This transition is reshaping the energy system into a decentralized, digitalized, and low-carbon network. Companies and governments must adapt accordingly. Fossil fuel-era companies may find strategic advantages by leveraging existing capabilities. Integrated infrastructure planning—connecting electricity, hydrogen, transport, and industry—and coordinated energy-industrial policies will be critical to reduce costs and enhance system efficiency.



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THE THIRST FOR ENERGY IN THE AGE OF AI

by **Thomas Spencer** and **Siddharth Singh**



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ARTIFICIAL INTELLIGENCE IS ACCELERATING THE INTEGRATION OF DIGITAL AND ENERGY INFRASTRUCTURES, DRIVING RAPID GROWTH IN DATA CENTERS AND GLOBAL ELECTRICITY CONSUMPTION. THIS DEVELOPMENT PRESENTS CRITICAL CHALLENGES

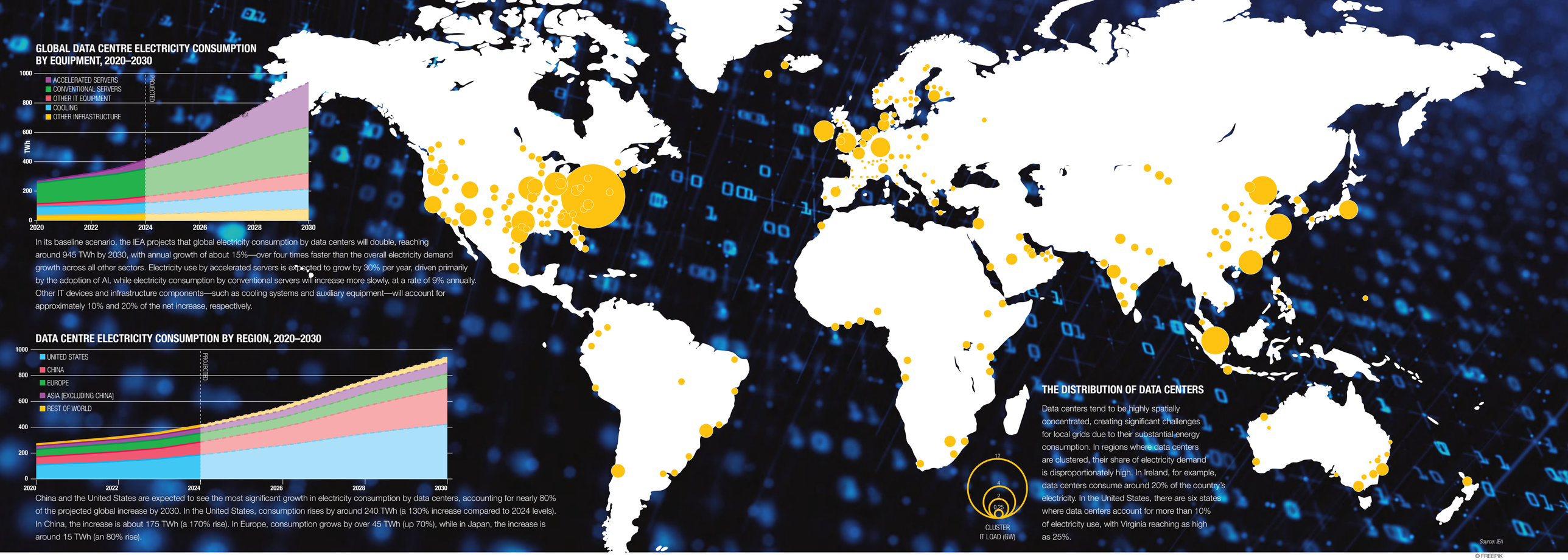
MODERN ECONOMIES rely on vast networks of digital and energy infrastructure. These systems are becoming increasingly interconnected as artificial intelligence grows in importance for both the global economy and the energy sector. AI models are trained and operated in large, power-intensive data centers, which in turn rely on steady energy supplies from electricity grids and continuous data flow through fiber optic networks. Ensuring sufficient domestic computing capacity is now a key policy goal for many governments—an objective made more urgent by current geopolitical and trade tensions.

Cutting edge artificial intelligence models, such as ChatGPT, are too large and complex to run on laptops and phones. Instead, they are trained and run in large, specialized data centers. As artificial intelligence emerges as a potentially transformative general-purpose technology, investment in these facilities has surged. According to the International Energy Agency (IEA), more than USD 500 billion is expected to be invested in data centers globally in 2025—equivalent to nearly 0.5 percent of global GDP or about 2 percent of total global investment.

Data centers are growing significantly in scale. Prior to the AI boom, a typical data center had a capacity of 10–20 megawatts (MW). Today, hyperscale facilities commonly reach 100 MW. The largest currently under construction is expected to reach 2,000 MW, with some proposed centers aiming for as much as 5,000 MW. These are enormous figures—by comparison, a typical aluminum smelter, one of the most energy-intensive industries, consumes around 700 MW.

THE SURGE IN ELECTRICITY CONSUMPTION

The rise of larger, more power-intensive data centers has driven a sharp increase in electricity consumption across the sector. The IEA estimates that data centers now consume around 415 terawatt-hours (TWh) of electricity globally—more than the total electricity use of Italy. While this accounts for only about 1.5 percent of global electricity consumption, it has been growing rapidly—at an average annual rate of 12 percent over the past five years, more than four times the growth rate of overall electricity demand.



Meeting the rapid growth in data center electricity demand is already straining power systems. This challenge is compounded by several characteristics that make data centers a distinct type of energy infrastructure.

First, data centers tend to cluster—often around fiber optic hubs, near concentrations of digital service demand such as financial centers, and in areas with a skilled workforce to build and operate them. Second, these clusters are typically located near cities, which have large, digitized, service-oriented economies. Proximity also helps meet the needs of customers who prioritize low latency, requiring data centers to be physically close.

Finally, data centers can be built quickly—sometimes in as little as 18 months—much faster than major energy infrastructure like power plants or transmission lines. In contrast, building a transmission line capable of serving a hyperscale data center can take 4 to 8 years in advanced economies.

For these reasons, even though data centers account for a small share of global electricity use, their local impact can be far greater. In six U.S. states, data centers already consume more than 10 percent of total electricity. In Ireland and Virginia, that share exceeds 20 percent. In some jurisdictions, grid constraints have led authorities to impose restrictions on new data center development.

Looking forward, the IEA projects that data center electricity consumption will more than double by 2030, reaching around 945 TWh—exceeding Japan's current total electricity use. While data centers will still represent a relatively small share of global electricity consumption, they are expected to be major drivers of demand growth in certain regions. In the United States, for example, data centers are projected to account for nearly half of total electricity consumption growth through 2030.

Electricity grids in advanced economies are aging, with more than half of transmission and distribution lines in Europe and the United States now over 20 years old. These older grids also tend to lag in adopting smart technologies, reducing their efficiency and resilience. At the same time, supply chains for grid equipment are under pressure. Average lead times for cables and large power transformers have nearly doubled since 2021, with transformer prices rising sharply over the same period. Similar constraints are affecting generation equipment—wait times for gas turbines now stretch to 5–7 years, and prices have surged.

THE COMPLEXITY OF SUPPLY CHAINS FOR THE IT COMPONENTS

Trade adds another layer of complexity. The supply chains for



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Power grids in advanced economies are becoming obsolete: more than half of the transmission and distribution lines in Europe and the United States are more than 20 years old. Older grids are less capable of adopting smart grid technologies, which can make them more efficient and resilient. Pictured: a model of a smart grid.

IT components used in data centers are highly globalized and intricate. The same is true for the power electronics, cables, backup batteries, and transformers that keep data centers running—these rely on international supply chains for both critical raw materials and finished products.

For instance, the IEA estimates that data center demand for gallium—a key metal used in advanced power electronics and semiconductors—could reach the equivalent of 10 percent of current global production. Yet the supply chain for gallium is extremely concentrated, with a single country responsible for 99 percent of refined output.

Policymakers, investors, the energy sector, and the tech industry now face a highly complex and uncertain landscape. Much of this uncertainty stems from the rapid evolution of a new technology. The uptake of AI could either fall short of or exceed current expectations. While AI hardware and models have already made significant gains in computational and energy efficiency—and further breakthroughs are possible—many tech firms are also deploying increasingly complex models that require greater computational power and so more energy. Broader macroeconomic and trade conditions will also play a role in shaping future investment in data centers.

The IEA's projections for data center electricity consumption in 2030 vary widely, with the highest scenario reaching 1,265 TWh and the lowest at 670 TWh—a difference of nearly twofold. Cumulative investment in data centers through 2030 ranges from USD 2.5 trillion in the low scenario to USD 6.5 trillion in the high scenario.

If the energy sector fails to expand quickly enough, it could slow AI development or force trade-offs with other electricity-intensive industries such as manufacturing reshoring or decarbonization targets. Conversely, if investment lags behind actual demand, substantial amounts of capital could be misallocated.

A ROADMAP FOR POLICYMAKERS

As policymakers pursue goals like building domestic digital infrastructure and advancing decarbonization, they must navigate an increasingly complex landscape shaped by the growing interdependence of digital and energy systems.

First, stronger dialogue is needed between the energy sector and the tech industry to support better planning and coordination of infrastructure development. Major tech firms should be more transparent about their current and projected electricity use. Second, "no-regrets" investments in modernizing electricity systems—making them more digitalized, flexible, and resilient—are more urgent than ever. These improvements will help accommodate not just data center growth, but rising demand from other sectors as well. Third, both policymakers and tech companies should explore strategies and incentives to maximize the efficiency and grid flexibility of data centers, reducing their strain on power systems. Fourth, recent steps to shorten permitting timelines for energy infrastructure will need to be expanded and reinforced. Fifth, securing local community support for data center development will require clear frameworks for benefit sharing and fair allocation of costs, along with sustained engagement.

The energy sector is central to one of today's most significant technological shifts. There is no AI without energy. But no one actor can meet this challenge alone, and focusing solely on one aspect—such as ramping up power generation—will not be enough. What's needed are smart, flexible, and collaborative strategies to navigate this new map.

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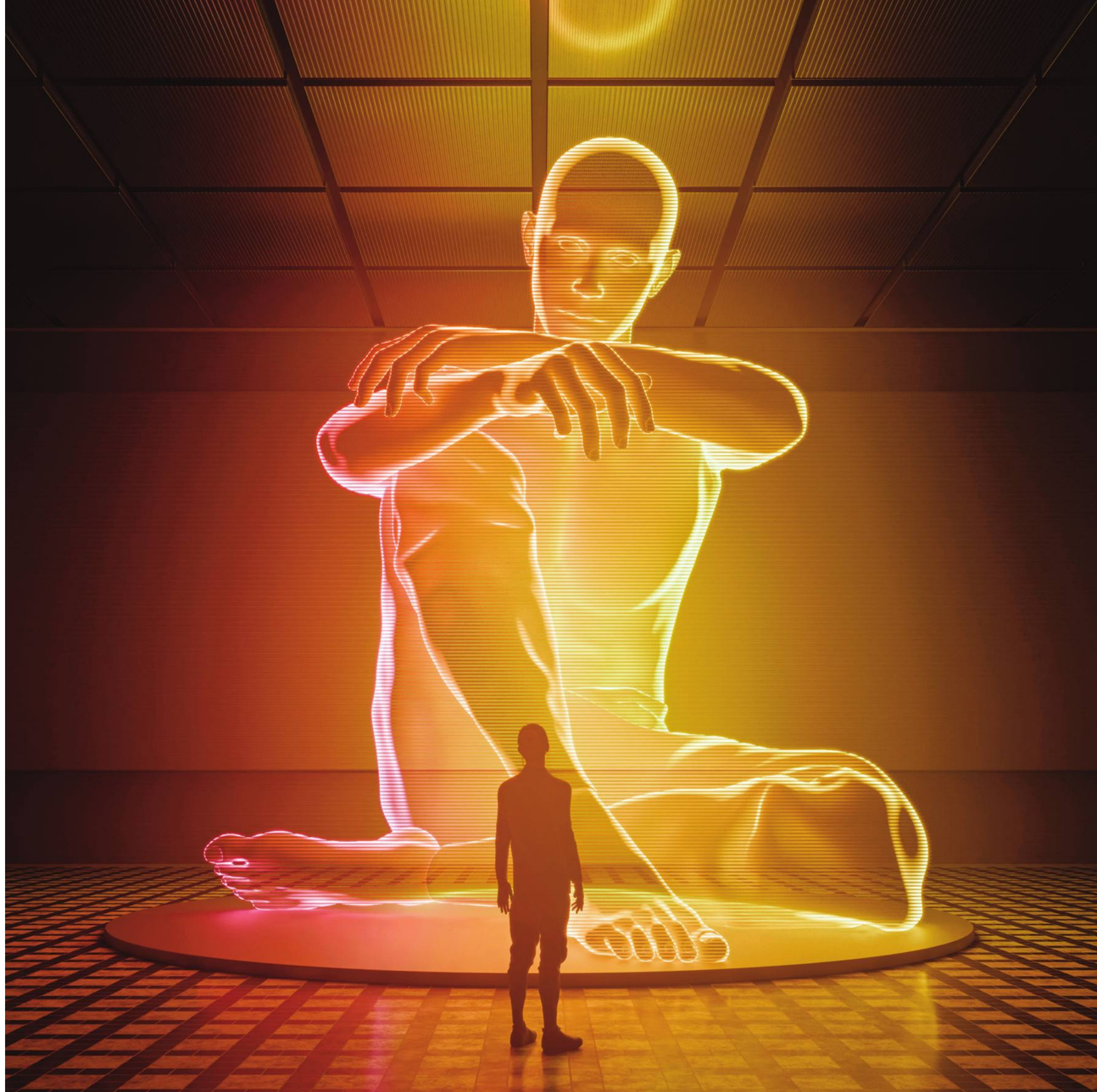

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THE LONG JOURNEY OF ENERGY

by **Davide Tabarelli**

FROM HAND-GATHERED TIMBER IN AFRICAN VILLAGES TO LIQUEFIED NATURAL GAS TRAVELING BETWEEN CONTINENTS, VIA STRATEGIC PIPELINES: LOGISTICS IS THE HIDDEN INFRASTRUCTURE OF THE ENERGY TRANSITION

IN SUB-SAHARAN African villages, women still spend hours each day walking up to seven kilometers to gather fuel for cooking, heating, and lighting. Meanwhile, in affluent Europe, green hydrogen remains stalled despite ambitious policy goals. High storage and transport costs, along with unresolved safety concerns, continue to delay its adoption. Energy is complex at both ends of the spectrum: from the archaic forms human communities have relied on for millennia, to the futuristic vision of solar power stored in hydrogen split from water.

Yet the core issue remains the same: logistics. Energy must be collected, stored, transported, and delivered in the right form, place, and time to be useful. This is true for any commodity, but for energy—especially in modern economies—logistics becomes strategic. Pipelines, tankers, power lines, terminals, storage systems: these are the backbone of the energy system. And the more advanced the energy source, the more complex the infrastructure required to manage it. The blackout in Spain on April 28, 2025 offers a stark reminder: as energy systems grow more sophisticated, so too do its vulnerabilities. Network management becomes not just a technical task, but a critical national priority.

COAL, OIL AND GAS: THE ENERGY OF MODERNITY

Economic development over the past three centuries has been built on energy consumption—and, often unnoticed, on the transportation and distribution systems that make it possible. Modernization began with the coal-fired industrial revolution. Watt's steam engine was first developed to pump water from mines, then became essential for hauling coal by rail. Even today, coal consumption continues to grow globally. It remains logistically convenient: abundant, easy to store, cheap to transport, and often close to consumption centers. That's why it remains the dominant fuel for power generation in many developing countries.

Reducing coal use, given its high CO_2 emissions, requires stable and scalable alternatives—natural gas foremost among them. But gas use depends on complex infrastructure: pipelines, LNG terminals, and shipping capacity. Gas is cleaner than coal or oil, but far harder to move. Once again, the history of energy is also the history of logistics. In the 1700s it was coal. Then came



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Coal, logistically convenient, abundant, close to consumption centers, with low transportation and storage costs, still remains the preferred source for electricity generation in developing countries. Pictured: a train carrying coal.

oil: first kerosene, then gasoline. Gas rose after World War II, supplied through major pipelines from Russia, the Netherlands, and Algeria. In the 1990s, it became central to power generation through combined-cycle gas turbines.

More recently, major energy corridors have been developed from the Caspian to Europe (TAP), from Russia to Germany (Nord Stream), and from Russia to China (Power of Siberia). In all these cases, logistics infrastructure doubled as geopolitical leverage—especially after the war in Ukraine, which disrupted and, in some cases, sabotaged Russian export facilities.

A MORE INTEGRATED SYSTEM FOR MORE JUST ENERGY

The war accelerated an existing trend: the global boom in liquefied natural gas (LNG), which is more flexible and faster to deploy than pipeline gas. By 2024, global regasification capacity reached 1.1 billion tons, up from 400 million in 2000. LNG accounted for more than 60 percent of global gas trade in 2024, compared to just 24 percent at the start of the century.

The link between gas and electricity is set to grow stronger. Gas remains the best available fuel to displace coal, which is more polluting and less efficient. The future of energy will be increasingly electric, driven by technological shifts—heat pumps, electric vehicles, air conditioning, and electrified industrial processes—and by the pressure to decarbonize.

But renewables alone won't suffice. Even as solar and wind power become cheaper, they are intermittent. Backup is needed when the sun doesn't shine or the wind doesn't blow, or when battery storage is maxed out. That's where gas-fired power plants, especially turbogas facilities, remain essential. This is the next phase for energy logistics: more complex and integrated systems, where multiple carriers interact to ensure that energy remains reliable, safe, and clean.

The hope is that this evolution won't be confined to rich countries. In sub-Saharan Africa, millions of women still spend hours each day collecting wood, brush, or agricultural waste for cooking and heating. Extending modern energy access to them is not just a technical challenge—it is a moral imperative.

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