

Center for Geopolitics
Derek Chollet
Head of the JPMorganChase Center
for Geopolitics

Corporate Advisory, Commercial & Investment Bank
Dr Sarah Kapnick
Global Head of Climate Advisory

September 2025

Power Rewired: The New Map of Energy and Geopolitics



JPMorganChase

Key Takeaways

→ **A new energy security age is here**

Nations' economic futures hinge on how they play the natural resources hand they have been dealt—via policy, investment, and alliances—amid AI-driven demand spikes, conflict shocks, and access to capital. In this era, seeking energy resiliency, if not dominance, is a strategic imperative.

→ **Oil & Gas are not the only geopolitical levers**

Critical minerals and technological know-how are increasingly important tools of geopolitical leverage that are shaping trade deals, peace talks, and strategic alliances.

→ **Business plans need to reflect changing reality**

Companies—whether they are energy producers or energy consumers, whether they are regional or global—need to incorporate the realities of this new age into their business plans.

→ **Fragmenting order, rising blocs**

The global energy order is splintering into alliances defined as much by cables, pipes, and patents as by ideology. Rising “grid diplomacy” and cross-border energy links are binding neighbors closer together—creating both resilience and shared vulnerabilities.

→ **Divergent energy paths shaping geopolitics**

India, China, Brazil, and others are shaping new energy alliances and setting their own standards based on competitive advantages in natural resources, energy self-sufficiency shifts away from fossil fuels, and technological exports. Strategic energy independence actions are strengthening to reduce geopolitical exposure to former trade partners.

Table of Contents

Executive Summary, page 3

Section One: Mapped—The Uneven Energy Chessboard, page 6

Section Two: Three Structural Shifts, page 15

Appendix: Global Hydropower Potential and Development, page 34

Data Explanation, page 36

About the Center, Authors, Disclaimers, page 41

Executive Summary: Power Rewired

Energy has always been intrinsic to geopolitics. Throughout history, competition over resources and innovations have fueled global rivalries, created alliances, and sparked wars. Yet today, the traditional energy security paradigm—rooted in supply diversification and market liberalization, and centered on hydrocarbons—has given way to new forms of infrastructure nationalism, resource weaponization, and partnerships shaped by technological and mineral interdependence.

Today's contest is no longer just about barrels and pipelines. It's about who controls minerals, grids, financing, and technologies that will power the 21st century. In this **New Energy Security Age**:

- Energy security is industrial strategy.
- Infrastructure is a tool of diplomacy.
- The global energy order has the potential to fracture into rival blocs with divergent interests and supply networks.

Artificial intelligence (AI) has only supercharged this shift. The data centers driving the AI race require gigawatts of stable electricity, forcing governments to treat power as a strategic asset on par with oil in the 20th century. Otherwise, they risk missing out on a new wave of innovation and economic growth as the technology transforms societies.

This is not a single contest, but many overlapping ones—rooted in geography, natural resources, innovation, and industrial capacity. Competitive advantages in natural resources domestically and with allies are leading to divergent behavior globally as countries seek to increase power supply and invest in domestic infrastructure, including for AI. Policy and technology innovation determine how these cards are played.

While the U.S. is focused on nuclear, geothermal, and liquified natural gas (LNG) exports, nations from India to China to Brazil are forging new alliances around energy self-sufficiency through solar, storage, nuclear, coal, and standards-setting. Three structural shifts are now redrawing the global energy landscape:

- **Resources**
- **Infrastructure**
- **Technology**

Risking oversimplification, Figure 1 summarizes the state of resource availability and technological innovation focus across the globe that we further analyze in this report. While maps of this nature are not traditionally utilized to support investment theses or make asset allocation decisions, they are foundational to understanding how governments view and assess strategic choices related to developing their domestic economies, assessing their competitors, and forging diplomatic relations and trading partners. This has direct and clear impacts for businesses operating in these geographies.

Using this security-focused lens, we conclude that clear competitive advantage for fossil fuel dominance is in North America, the Middle East, and Asia. However, other sources of energy production see additional strategic advantages in North America and Asia, but also Africa, Australia, South America, and Europe. Water availability, sunshine, wind, geothermal access, critical minerals, and technology innovation provide additional strategic national resource advantages. **Technology innovation—especially for those with self-sufficiency to move away from fossil fuels—has had historic advantages in the U.S., EU, Russia (nuclear) and Australia, but is gaining in Asia.**

Figure 1. Comparing comparative advantage: energy distribution across continents



Note: Nuclear is based on uranium fuel access and geothermal is based on 2,000m depth.

The natural resource hand that individual countries have been dealt is not necessarily deterministic. Both price and geopolitics will play a role in how regions choose to further develop their natural resources to build out energy infrastructure for independence or cross-border partnerships. Geopolitics and national security interests will increasingly influence market-driven principles, changing how resources are used and which technologies scale. This may alter the total addressable market size for certain technologies, companies, or resources, limiting growth in some areas and accelerating it in others.

If you assume energy supply growth will be prioritized above other considerations, then an “all of the above” approach will be taken, optimizing for strategic advantages within one’s borders and trading partner allies. Access to pools of specialized capital to support specific energy technologies, either from the private sector or governments, will speed or slow deployment; however, energy security considerations will drive growth overall.

Business leaders need to familiarize themselves with these changing dynamics in order to best capitalize on emerging global dynamics. Financial success will hinge on understanding how geopolitical shifts impact future investments and are included in strategic planning. Those who can anticipate and adapt to these changes will be best positioned to capitalize on the opportunities and manage the risks that arise in this New Energy Security Age.

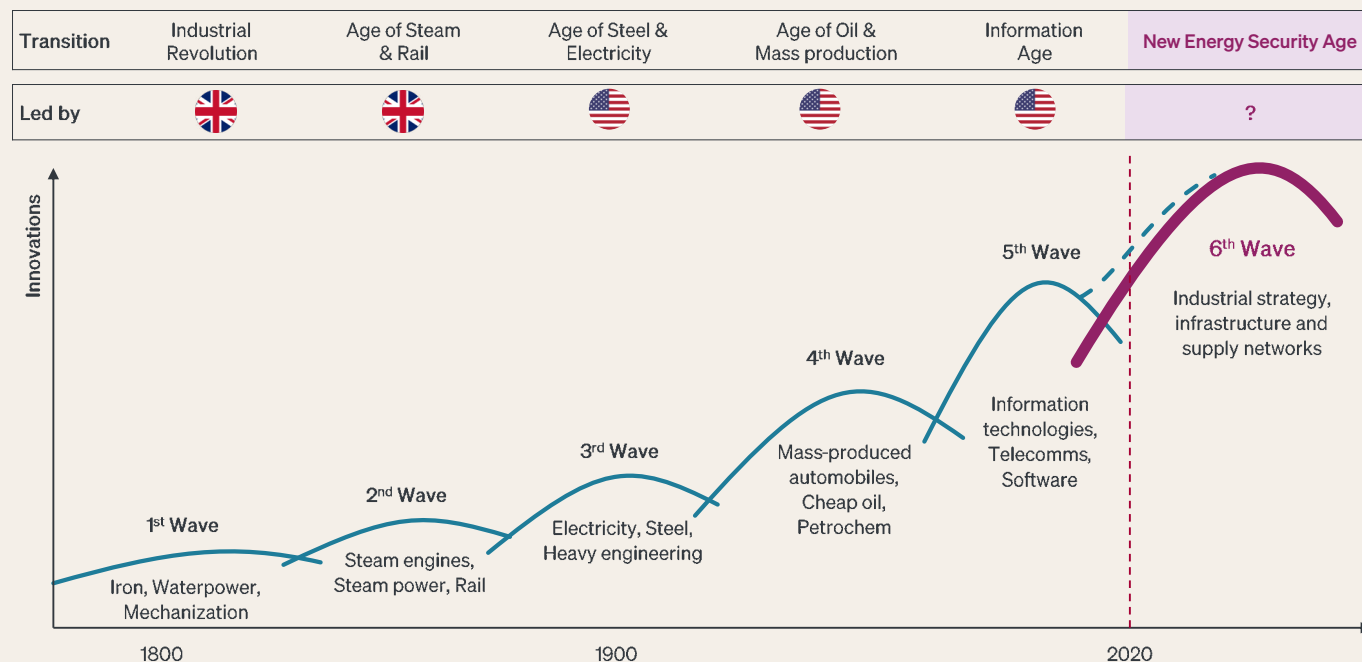
What is the New Energy Security Age?

The **New Energy Security Age** is the emerging geopolitical era in which access to, control over, and resilience of energy systems have become primary determinants of national power and economic competitiveness. Unlike earlier periods when energy security was framed mainly in terms of oil shocks, diversification, and market liberalization, today's picture is defined by:

- **Self-Sufficiency & Stability:** The use of nuclear, geothermal, solar, wind, and storage to reduce reliance on fossil fuel imports and produce stable electricity prices to attract industry, as well as the export of electricity or domestic fossil fuels to allies.¹
- **Minerals:** Competition for critical materials (e.g. lithium, cobalt, nickel, rare earths) that underpin advanced technologies.
- **Infrastructure & Interconnection:** Cross-border grids, pipelines, and digital-energy systems that both enable resilience and expose shared vulnerabilities.
- **Technology & Industrial Policy:** The race to dominate strategic technologies (AI, batteries, advanced nuclear) where energy is both an input and an output.
- **Finance & Statecraft:** The deployment of capital, subsidies, sanctions, and investment controls as levers of energy power.

In this age, **energy continues to be a front-line instrument of statecraft**, shaping alliances, trade flows, and even conflict, but in new, more complicated ways as the landscape **shifts from the dominance of hydrocarbons and demand skyrockets to meet new technologies**.

Figure 2. Who Will Define The New Energy Security Age?



Source: J.P. Morgan adapted from RMI: *The Renewable Revolution It's exponential, global, and this decade*; Carlota Perez (first five); RMI (Renewable Age); For more see X-Change: *The Race to the Top*

Section One

Mapped—The Uneven Energy Chessboard

No energy source is universal. **Geography still dictates strategic advantage—and disadvantage.** Countries and regions have different competitive edges in natural resources. Optimization for energy production, especially with pressures from AI and its potential to transform technology and economies, will lead to countries seeking different energy paths depending on resource access and technological trajectories.

The following **five energy resource maps** provide essential context for understanding how regions formulate energy security plans focused on emerging energy technologies for self-sufficiency:

- Solar Irradiation
- Wind Strength
- Geothermal Potential
- Australian Critical Mineral Deposits
- North America's Broad Competitive Advantage

These maps quantify accessible resources for energy self-sufficiency, highlighting potential vulnerabilities and needs for cooperation, innovation, and investment.

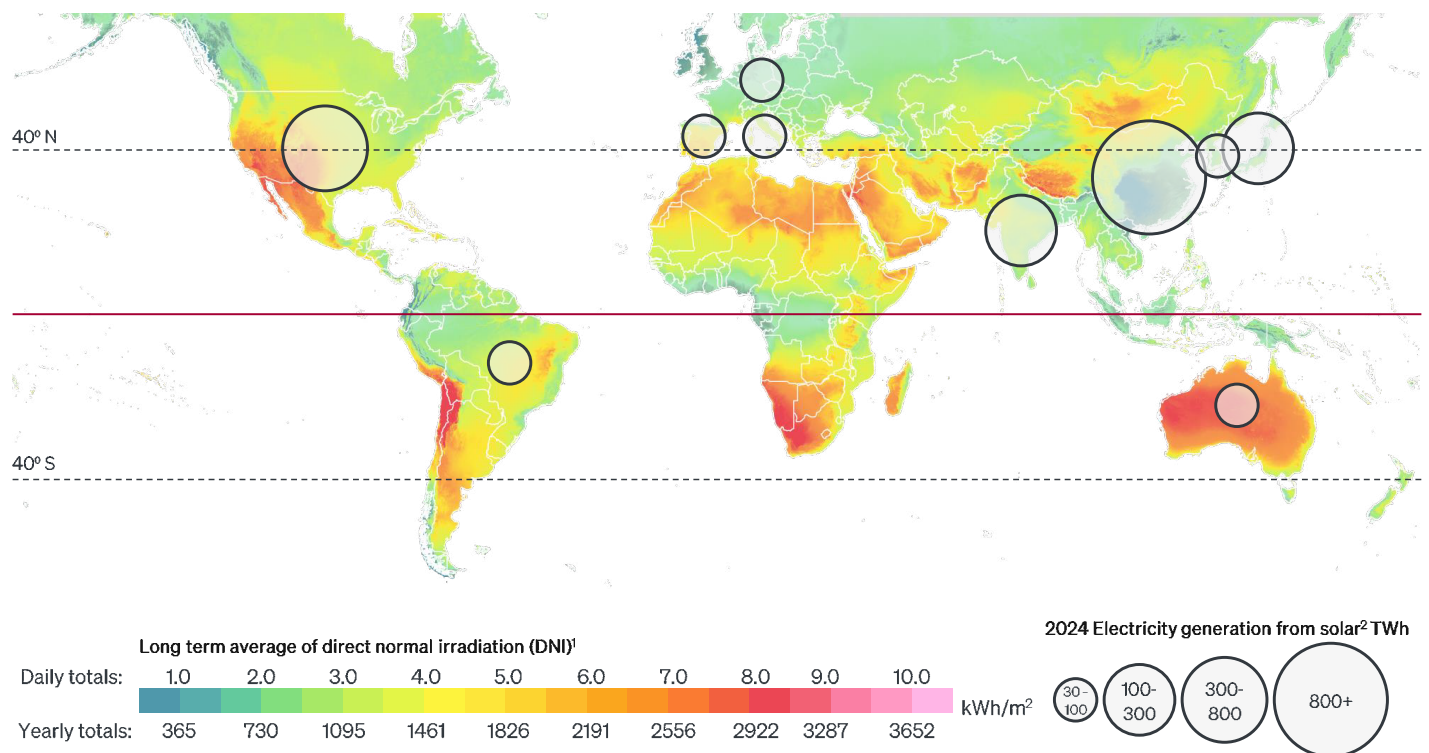
An important caveat: these maps highlight *potential* energy, without regard for the cost of extracting available resources, should innovation and investment fully unlock capacity. This is very specific to considering present and future national security, natural resource potential with technological innovation and investment leading to realized benefits. We've identified where innovation or differences in technology choice can operationally translate *potential* energy into *realized* energy produced.

1. It's not always sunny in...

Solar irradiation—or where the sun shines strongest to allow for solar panels to capture energy—is not distributed evenly across the globe. This is due to cloud coverage at the equator and less sunlight on an annual basis as you approach Earth's poles. This means maximum solar potential for capture is only concentrated across two narrow bands of latitude that experience minimal cloud cover, as Figure 3 shows.

Note: This is an atmospheric scientist measurement of solar energy at the surface of Earth, but energy production locally (solar capacity factor) will be a function of solar panel technology. **This phenomenon means well-optimized solar projects bode particularly well for the American southwest, central Mexico, Chile, and Bolivia, as well as the northern and southern regions of Africa and Australia. However, investments have been the highest recently in China and India.** Even traditionally rich petro-states like Saudi Arabia are taking advantage of their geography's unique disposition for solar irradiation, as well as wind: in 2025, Saudi Arabia inked \$8.3 billion worth of deals for five massive solar farms and two wind farms across the country, together totaling about 15 gigawatts of new renewable capacity.

Figure 3. Where the sun shines: mapping irradiation hot spots around the world



Source: ¹SolarGIS; ²Ember (2025); Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data

Note: ²Only shows countries with >30TWh

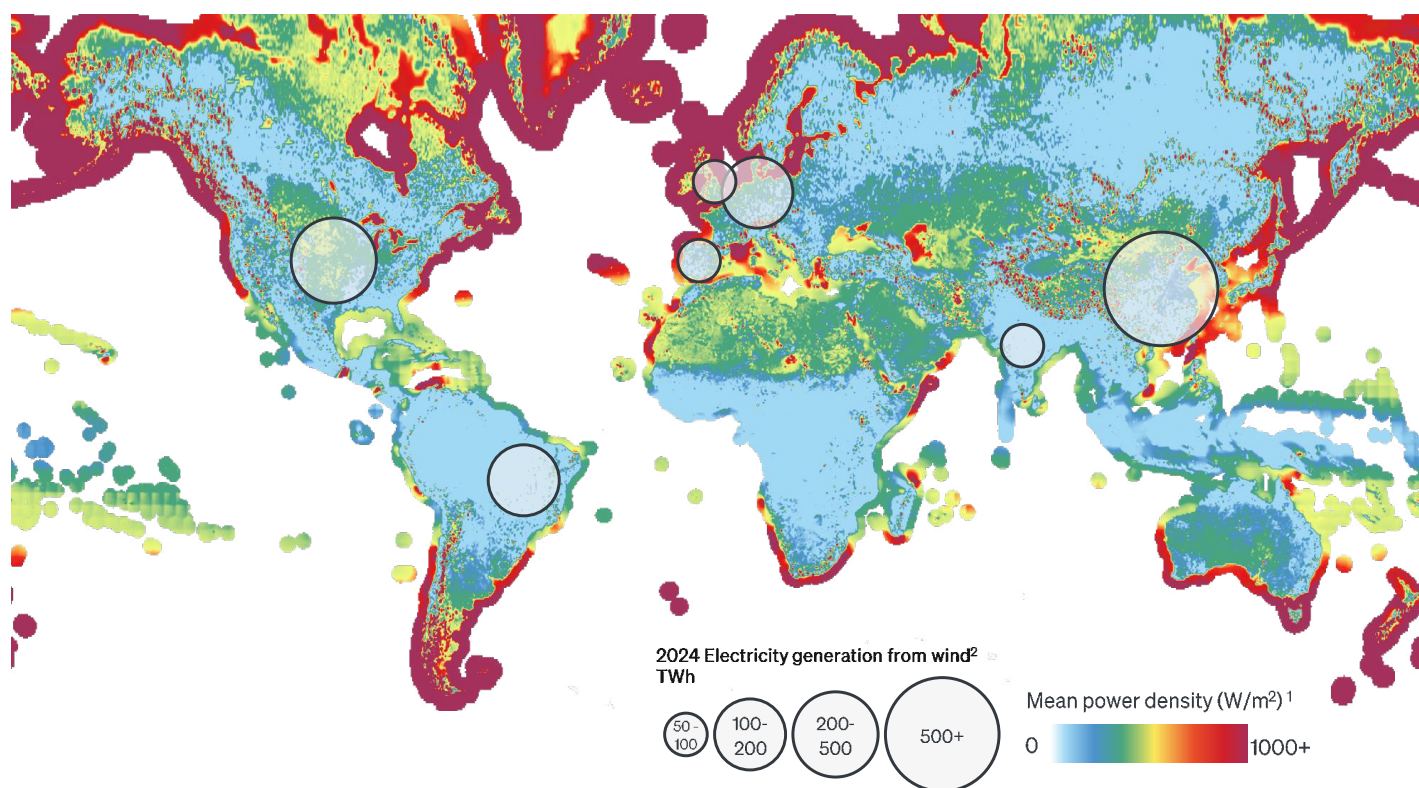
[View text version](#)

2. Wind power favors the poles and coastal waters

As Figure 4 shows, **wind strength** is concentrated at both the northern and southern poles of the Earth. This contrasts with the solar irradiation bands seen in Figure 3, illustrating that **while some nations may not enjoy reliable high-level exposure to one kind of renewable, that very same geography may pre-dispose them to another renewable source**, such as wind. Case in point: In cloudy northern Europe, a consortium of “North Sea” nations are exploring the creation of artificial islands and “wind parks” in the Dogger Bank portion of the North Sea as a way to harvest the region’s high wind speeds. Given these power-per-area estimates are made with current technologies, further wind technology advancement could increase power potential. Ocean depths also play a role in site selection and viability with current anchored technology.

We expect to see Northern Europe, Southern Australia, and North America have the advantage when it comes to harnessing wind potential in relatively shallow coastal shelf ocean waters where historic oil and gas infrastructure has also de-risked construction and operation. China also enjoys a strategic advantage in wind, which it is vigorously exploiting. In 2024, China added about 80 GW of new wind capacity, bringing its total to roughly 520GW, the most installed wind capacity globally, and pushing wind to account for 10% of China’s electricity generation. By the end of 2024, the United States ranked second with about 150 GW of installed wind capacity, while Germany stood third at approximately 73 GW, cementing Beijing’s status as the world’s largest wind power producer.

Figure 4. Windy waters: mapping offshore destinations for turbine projects



Source: ¹Global Wind Atlas; ²Ember (2025); Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data
Note: ²Only shows countries with >60TWh

[View text version](#)

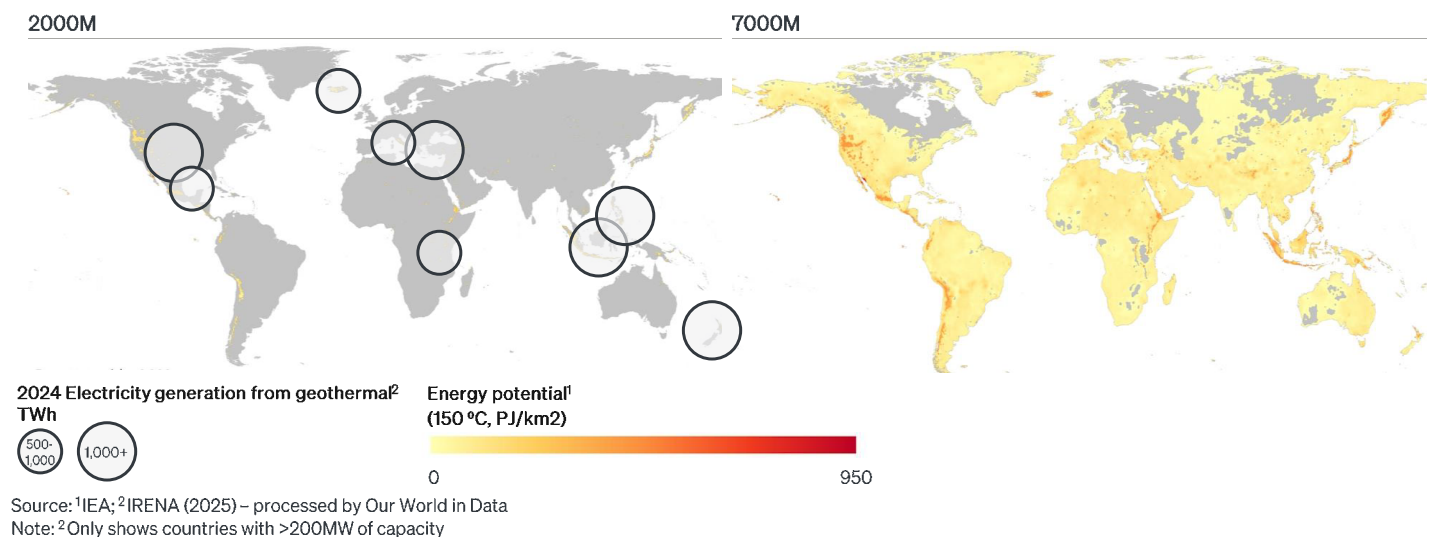
3. Hot stuff: Geothermal energy's emerging potential in power production

Until recently, the majority of **geothermal power production** has been concentrated in a few locations—the western U.S., Indonesia, Philippines, Turkey, Kenya, New Zealand, and Iceland—where geothermal energy resources are close to the Earth's surface, i.e. within 2,000 meters. These are tectonically-active regions where the Earth's plates meet and move. As a result, current geothermal production has been concentrated in countries with easily identifiable resources (e.g. near fault lines with earthquakes and volcanoes).

However, with advanced drilling depth capabilities (down to 7,000m), geothermal productivity potential stretches around the world. Additionally, new horizontal drilling techniques can unlock additional energy from a single vertical well, maximizing more shallow resources. This technology is changing rapidly in the U.S. right now. Recently in Utah, Fervo Energy drilled a well to 15,765ft (4,805m) in a little over 2 weeks accessing temperatures of 520°F. The company is advancing horizontal drilling techniques to increase power production in a single deep well to maximize these temperatures found at great depth.ⁱⁱ

These map estimates have the potential to be revised upwards globally with efficiency gains from new technologies and prospecting activities; i.e. while general productive areas are known globally, local potential requires measurements at the surface and subsurface. Unlike solar and windpower potential, which is observable from space, geothermal potential estimates require penetrating the Earth's surface with drilling technology similar to that used in oil and gas exploration and operations. **Given this required expertise, we expect the U.S. and Mexico to have the advantage in capitalizing on geothermal technology domestically and for exporting both electricity and technology.**

Figure 5. Digging deeper: geothermal opportunities expand at 7000 meters below Earth's surface

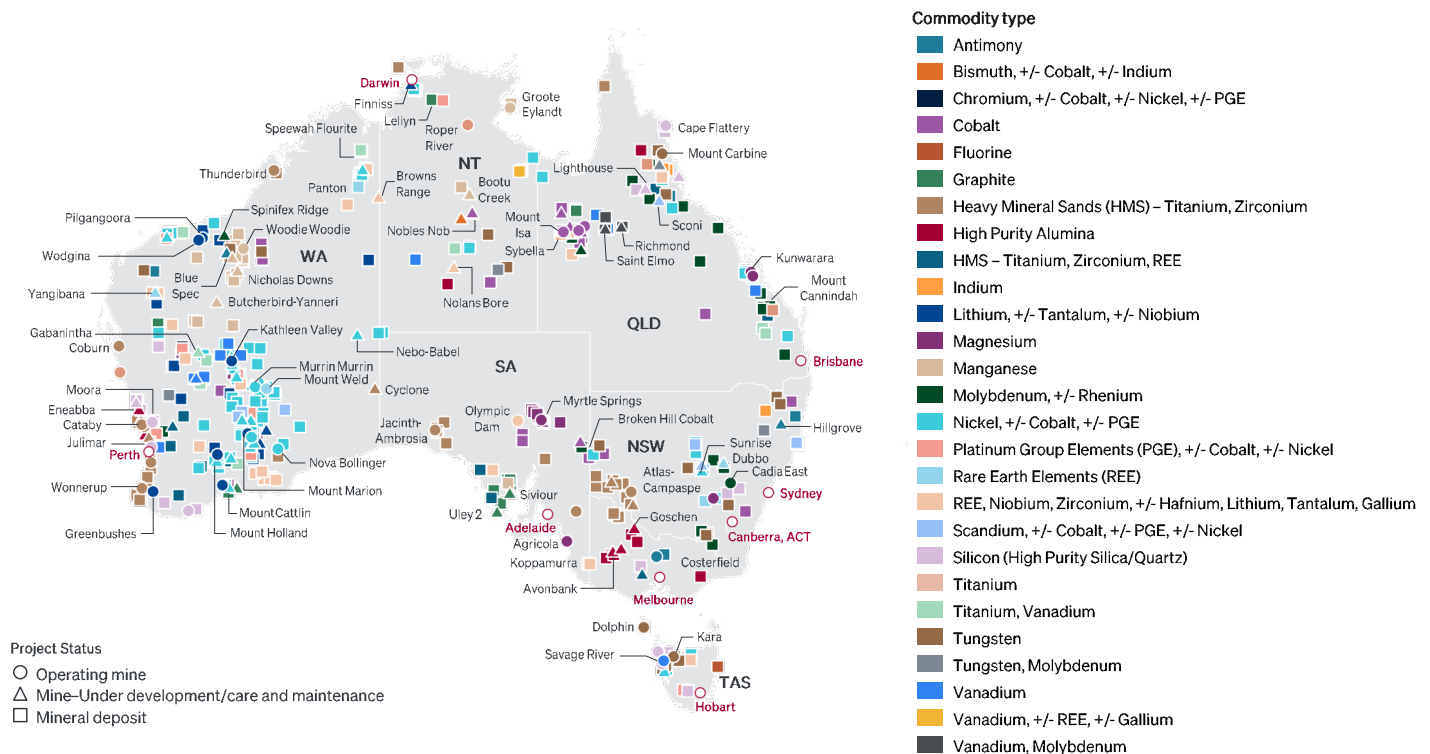


[View text version](#)

4. Australia hit the energy and minerals jackpot

Few countries are as blessed with an abundance of renewable, fossil, and nuclear fuel deposits as is **Australia**. Few countries match Australia's energy diversity: it is a top exporter of coal and LNG while also fielding excellent prospects for solar and wind power. As Figure 6 shows, it is also home to some of the world's largest and most diverse reserves of critical minerals. At 49% of global production, Australia is the world's largest producer of lithium (a key battery component), and a top supplier of cobalt, nickel, and other rare earth metals that power everything from semiconductors to medical devices to defense industry products. Australia is a major exporter of its mined raw materials, leaving it vulnerable to post-processed supply chains. It has recently laid out plans to build processing capabilities.ⁱⁱⁱ **With such abundance, we expect Australia to be a major player in the New Energy Security Age.**

Figure 6. I Come From the Land Down Under: Australia's Rare Earths Abundance



[View text version](#)

5. North America: Broad competitive advantage across energy sectors

Energy Abundance, Global Leverage

Since the 1800s, **fossil fuels** have powered industrial revolutions, built global trade systems, and today account for, roughly **40% of global seaborne trade by volume**. This dominance stems from a combination of technological innovation, natural resource abundance, and decades of infrastructure development. **Now, North America is uniquely positioned to leverage these advantages to pursue an “all of the above” energy strategy—mirroring China’s aggressive push to pair hydrocarbons with nuclear, solar, and wind.**

The Geography and Geology Edge

North America’s energy advantage is rooted in its diverse natural resource base and favorable geography:

- **Solar:** The sun-rich U.S. Southwest and Mexico’s northern states (Sonora, Chihuahua, Baja California) average 5.5 kWh/m²/day, placing them among the highest solar irradiation zones globally. Canada’s Alberta and Saskatchewan provinces also offer vast solar potential.
- **Wind:** Mexico’s Isthmus of Tehuantepec is among the planet’s premier wind corridors, boasting consistent 10 m/s wind speeds, while the U.S. Northeast and Pacific Northwest are building world-class offshore wind projects. In Canada, Ontario and Quebec also deliver extensive wind resources.
- **Fossil Fuels:** The U.S. and Canada rank among the top producers of oil and natural gas globally, with abundant shale reserves, extensive refining capacity, and world-leading LNG export infrastructure (see *Figures 8 and 9*). Mexico’s offshore oil fields and onshore shale reserves complement the region’s hydrocarbon dominance.

AI, Energy, and the Clock

While the Trump Administration has unleashed a slew of new hydrocarbon projects to drive down prices and boost U.S. production, these projects, including LNG export terminals and oil refineries, still face time constraints. Even when expedited, LNG terminals and refineries often require five years of permitting, financing, and construction. Solar and wind farms, by contrast, can be deployed faster to bridge the gap, typically in 2–3 years at scale, making them a strategic solution to meet immediate-term electricity demand driven by AI data centers, electrification, and industrial reshoring. **This speed matters given the crucial window of the next 5–6 years,** which will shape large language model training and accelerate AI adoption.

Regional Momentum

North America is accelerating toward diversified energy mixes:

- **Mexico:** President Sheinbaum's 2025 Energy Reform aims to add 23 GW of capacity by 2030, heavily weighted toward solar and wind.
 - **Canada:** Renewables are projected to grow from 115 GW today to 149 GW by 2030, supported by federal and provincial investments.
 - **United States:** The U.S. added 12 GW of solar in the first half of 2025, with another 21 GW expected before year-end. Together, solar and wind now generate 17% of U.S. electricity, surpassing coal and expanding rapidly.
- **Mexico:** In arid northern regions, agrivoltaics are reducing irrigation needs for crops such as chili peppers and tomatoes, aligning energy transition goals with food security.
 - **Canada:** Alberta and Saskatchewan are testing dual-use systems to stabilize farm income and optimize land use.
 - **United States:** Pilot programs in Arizona and Massachusetts show yield improvements for certain crops while providing farmers secondary revenue streams for hosting panels.

Agrivoltaics: Energy Security Meets Food Security

Strategically deploying solar and wind delivers a second dividend through **agrivoltaics**—integrating solar panels with active agricultural land. Rather than competing with farmland, agrivoltaic systems generate electricity while allowing crops to grow beneath or between arrays. This approach reduces land-use conflicts, improves soil moisture retention to improve

water efficiency, and shields crops from extreme heat. These are common and growing issues across the U.S., Canada, and Mexico.

Strategic Imperative

An “**all of the above**” approach—hydrocarbons, renewables, geothermal, and nuclear—positions **North America to be one of the most flexible and resilient energy ecosystems** in the world. In the race to meet surging power demand, the region's ability to balance **speed, diversity, and scale** offers a distinct geopolitical advantage.

Figure 7.

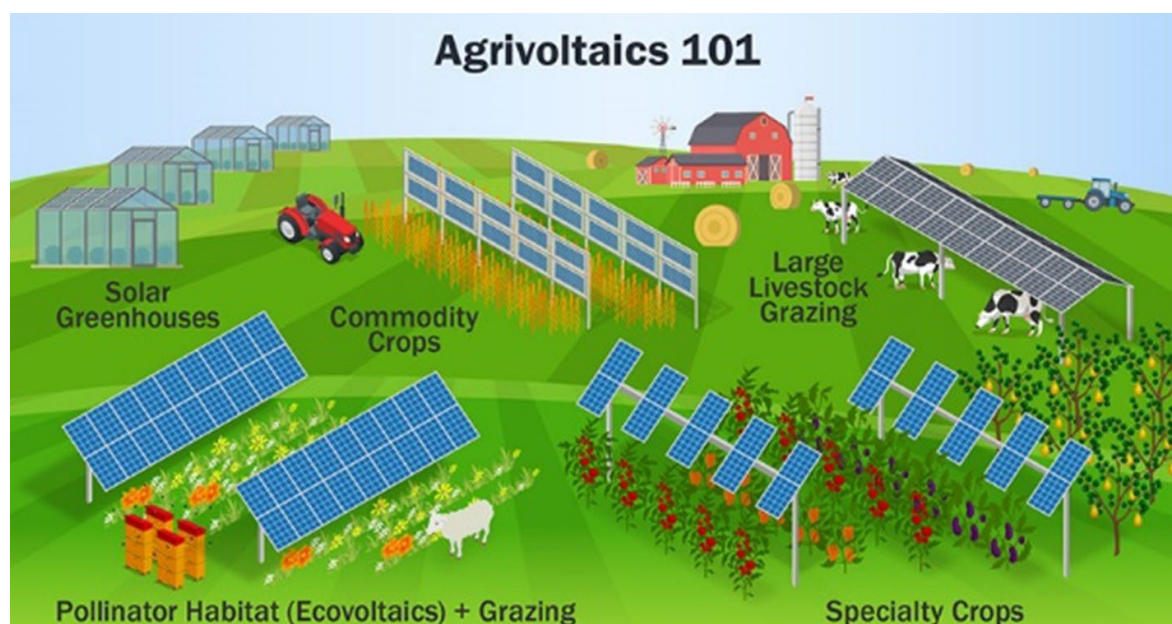
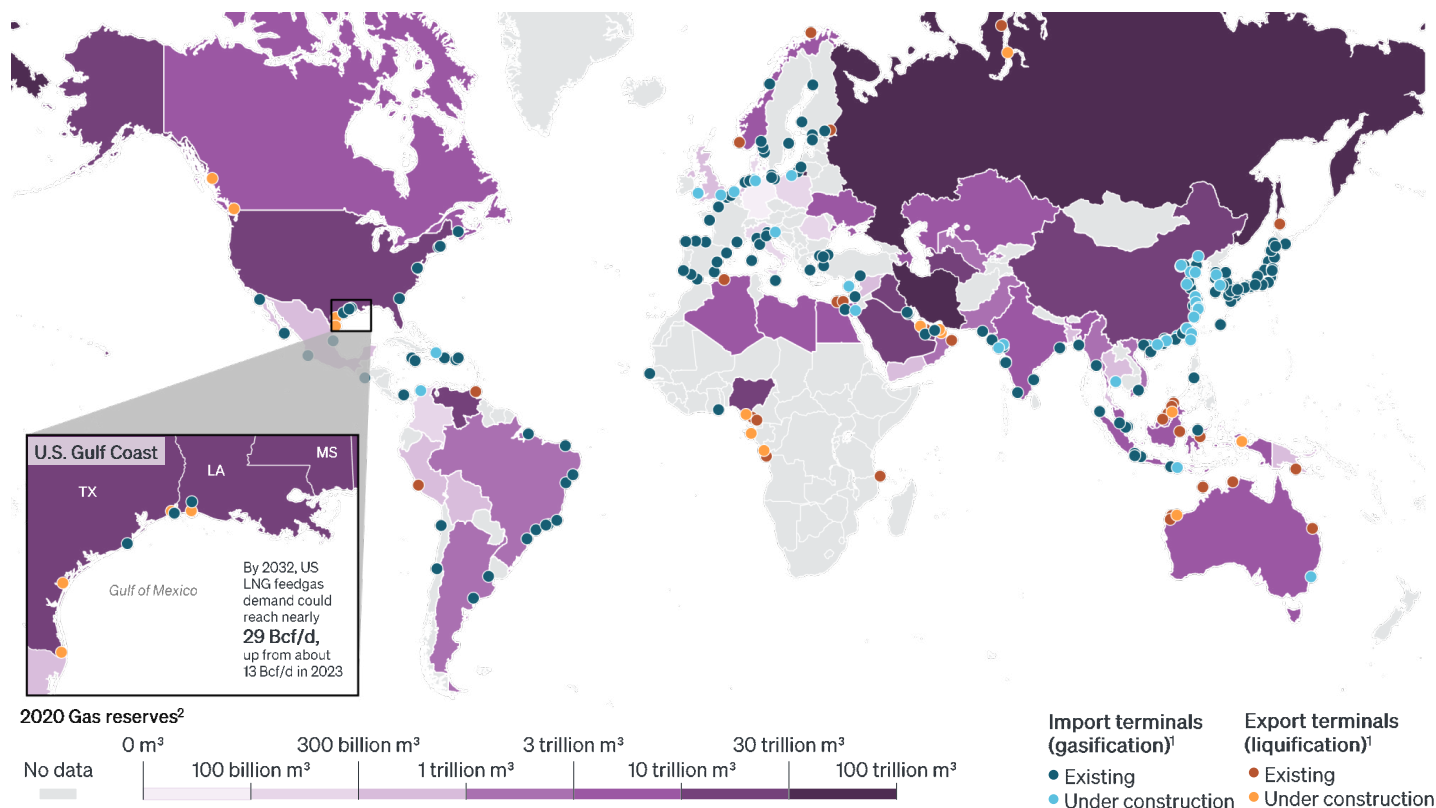


Illustration by Tom Hickey and Al Hicks, NREL

Figure 8. LNG let loose: global LNG import and export infrastructure explodes

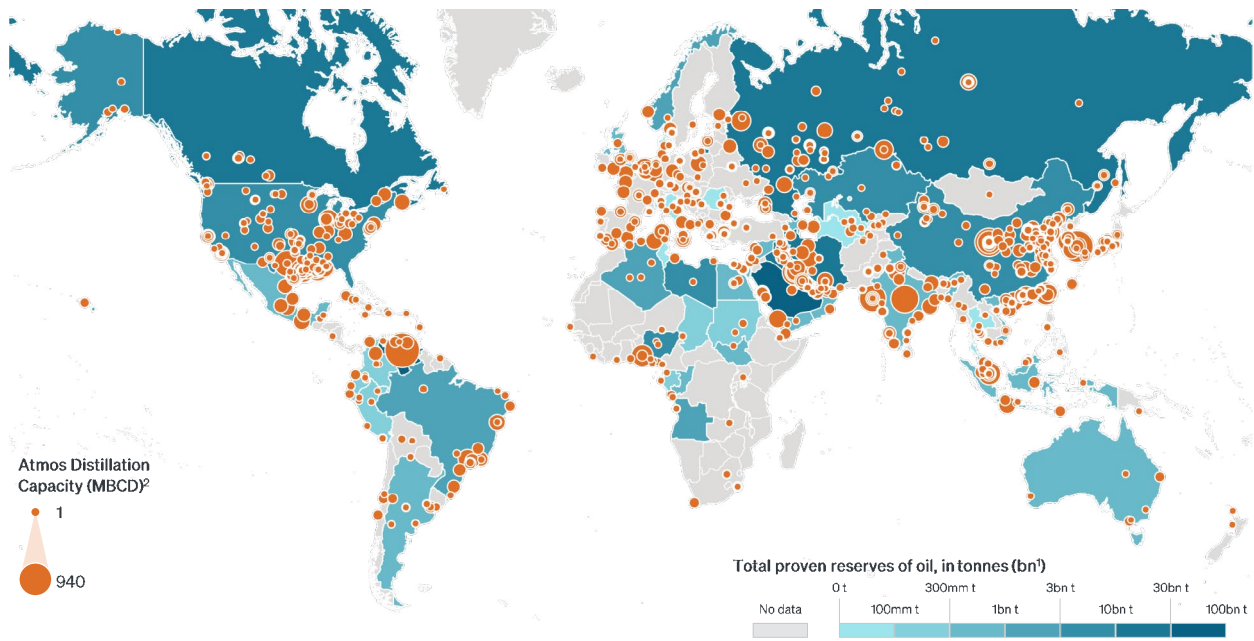


Sources: ¹S&P Global Commodity Insights; ²Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data

Note: ²Proved reserves, measured in cubic meters, are generally those quantities that can be recovered in the future from known reservoirs under existing economic and operating conditions, according to geological and engineering information.

[View text version](#)

Figure 9. Up From the Ground Comes a Bubblin' Crude: Proven oil reserves across the world

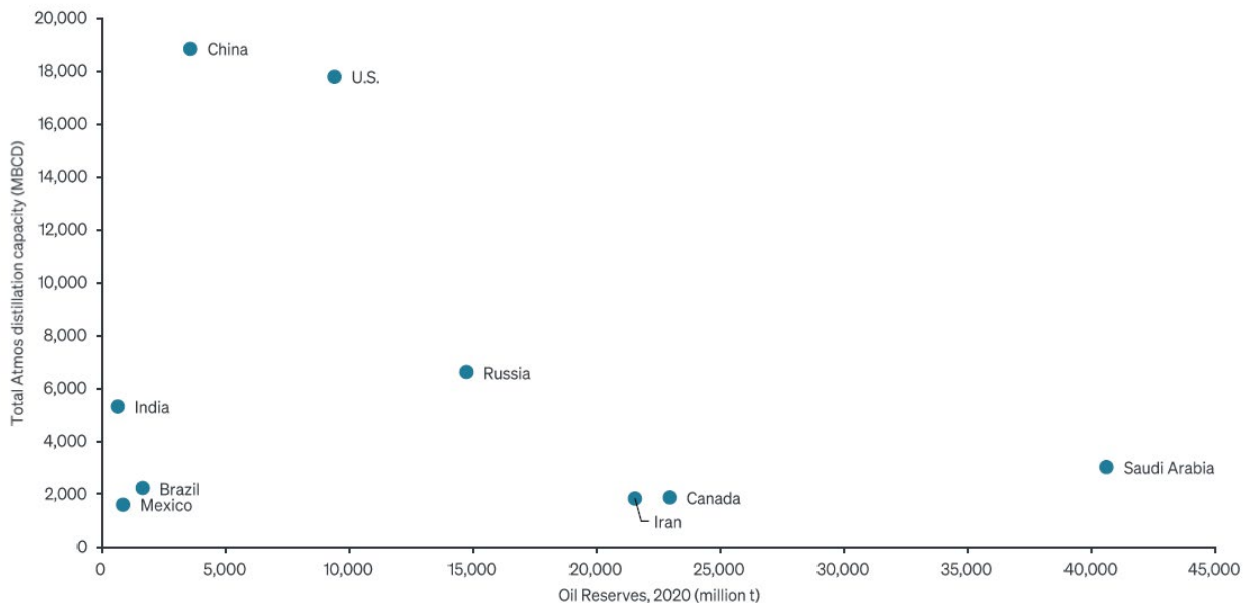


Sources:¹Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data; ²S&P Global Commodity Insights, ©2025 by S&P Global Inc
 Note: ¹Shown are the total proven reserves of oil, in tonnes. This is oil that we know with reasonable certainty can be recovered in the future under existing economic and operating conditions. Proven reserves decrease when we extract oil, and increase as new resources are discovered or become economically viable to extract; ²As of 2024

[View text version](#)

Figure 10. Supply and Refine: Where oil reserves and processing infrastructure meet

The U.S. and China each have ~3x the refining capacity as the next largest players, pointing to oil's role in their respective economies historically. Saudi Arabia, Canada and Iran have the largest oil reserves globally.



Sources:Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data; S&P Global Commodity Insights, ©2025 by S&P Global Inc
 Note: Shown are the total proven reserves of oil, in tonnes. This is oil that we know with reasonable certainty can be recovered in the future under existing economic and operating conditions. Proven reserves decrease when we extract oil, and increase as new resources are discovered or become economically viable to extract; Capacity as of 2024; only shows countries with capacity greater than 1,500 MBCD and reported oil reserves

Section Two

Three structural shifts—in *resources*, *infrastructure*, and *technology*—are shaping the New Energy Security Age.

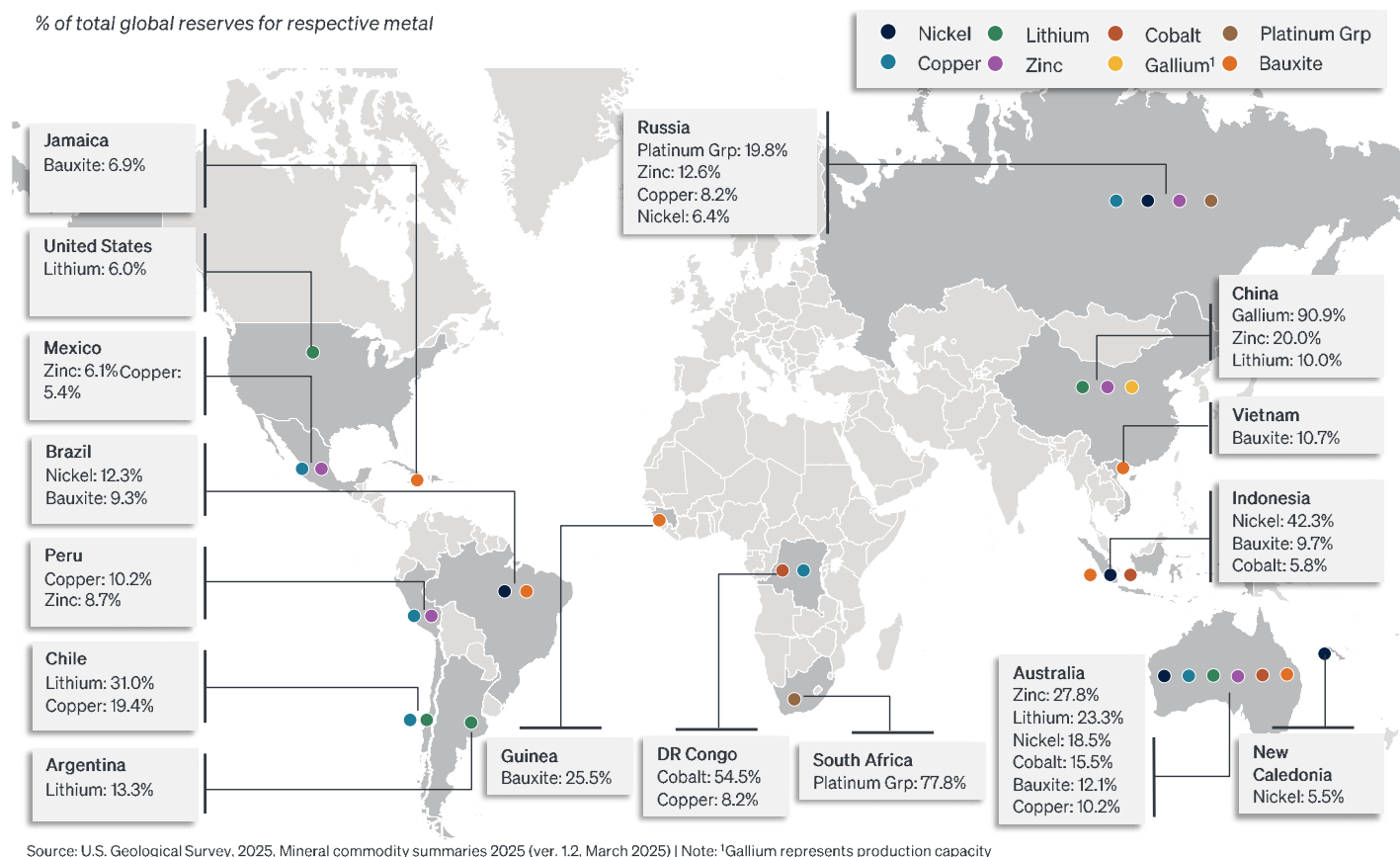
Three transformative shifts are redefining how nations harness and manage their natural resources, influencing new geopolitical and economic strategies globally.

Structural Shift 1: Critical Resources, Critical Leverage

In the New Energy Security Age, control over both minerals and money translates into geopolitical leverage. The emergence of new technologies for energy, AI, and defense has introduced a new set of supply chains forming strategic advantages and vulnerabilities. **Various competitive technologies—including chips, semiconductors, quantum, defense, space, battery storage, wind power, and nuclear—depend on the mining and refining of critical minerals**, many of which are concentrated in fragile or geopolitically-contested regions.

The scramble for minerals—like lithium in Chile (31% global reserves), cobalt in the Democratic Republic of Congo (55% global reserves), and nickel in Indonesia (42% global reserves)^{iv}—is reshaping trade and diplomacy. We provide a subset of critical minerals for these technologies in Figure 11, mapping out those with 5% or more of global reserves. Note: Depending on rarity and demand, fully processed small values of reserves may be just as important to a supply chain as less processed large values of reserves. This map shows critical mineral potential vs. realized available minerals.

Figure 11. All That Glitters Is Not Just Gold: Mapping Critical Mineral Deposits Globally

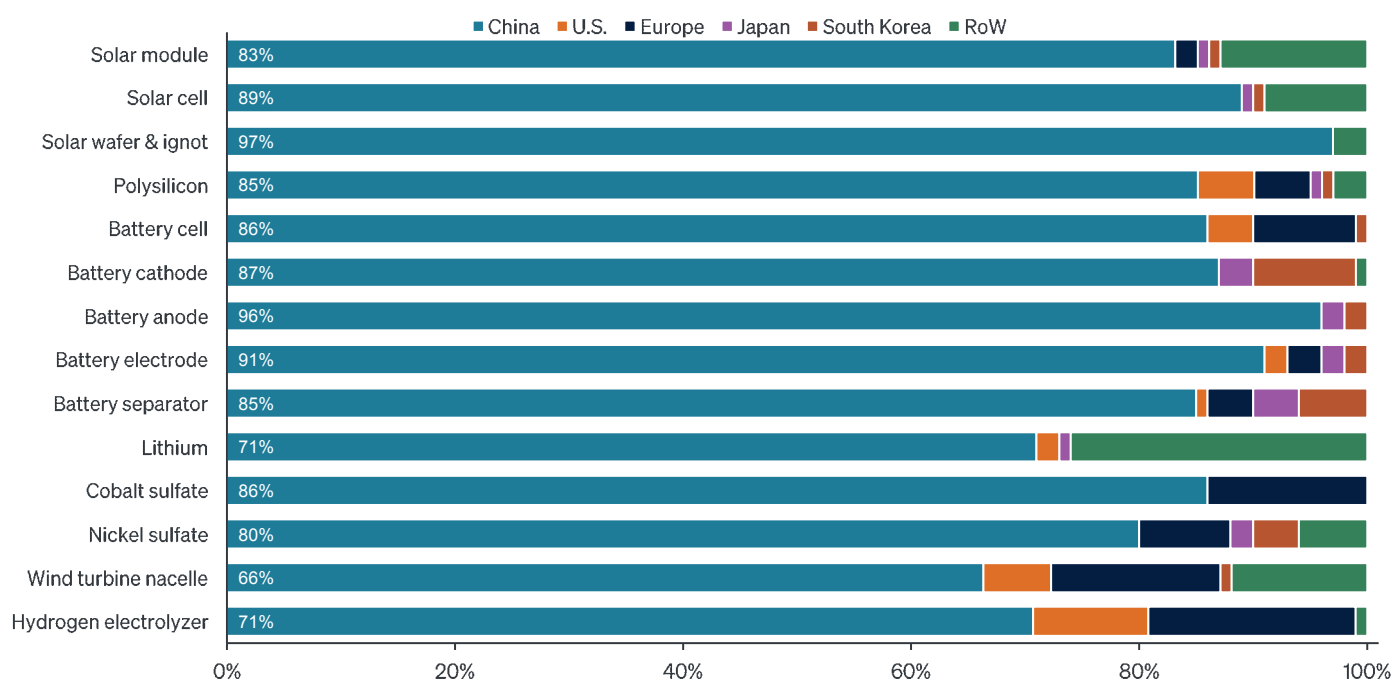


Some governments are imposing export restrictions to retain their advantage and shape global supply chains. For others, dominance rests not only on resources in the ground and on refining capacity, but on control of capital flows—who finances the mines, who underwrites the factories, and who sets the standards for investment. These can present business risks if standards and underwriting practices are set to support specific countries or entities.

Outbound investment and export controls, sanctions, and restrictions on foreign participation in energy infrastructure and supply chains are becoming standard tools of economic statecraft. Countries that dominate development banks, sovereign wealth flows, or global bond markets are able to steer the direction of energy investment—tilting the playing field in their favor. ***This weaponization of critical mineral supply chains and finance marks a structural shift: critical minerals and renewable resources are not just traded commodities, they are strategic levers in a broader geopolitical contest that defines the New Energy Security Age.***

- China has a tight grip on global critical mineral supply chain and refining capacity.**
 Beijing's export restrictions on graphite and gallium—critical to batteries and semiconductors—demonstrate how midstream processing capabilities can be repurposed as tools of coercion. Its outbound investment screening and competing subsidy regimes are also turning energy technology into a central front in the U.S.-China rivalry. Beijing's Belt and Road Initiative and state banks provide loans for energy (especially solar, battery storage, nuclear) and transmission projects in Africa, Southeast Asia, and Latin America. These packages have two outcomes: (1) partner countries become less reliant on fossil fuels to develop energy independence; and (2) they are often tied to Chinese equipment and labor, cementing China's market share, influence, and technological partnership. Crucially, **this is not just a money-making exercise**. Beijing views the expansions of its energy and financing leadership as part of a deliberate strategy to reduce dependence on imported crude and natural gas, moving China toward greater self-sufficiency, and giving it leverage—over trade partners and over standard-setting in forums like the United Nations.

Figure 12. Beijing's Green Thumb: China dominates global clean tech supply chains



Source: BloombergNEF

Note: Capacity is for physical facility location, not manufacturer headquarters. Lithium refers to lithium hydroxide and carbonate; Data normalized to 100%

- The **United States and its allies** are moving rapidly to onshore or “friend-shore” production, reflected in U.S. policy support for new energy technologies (especially nuclear and geothermal), the EU Green Deal, and Japan’s GX Strategy. With a shift in administration, Washington has refocused on deploying tens of billions in Department of Energy loan guarantees that advance and scale the mining, processing, and manufacturing of critical minerals and underwrite grid modernization, nuclear, and battery storage projects. These tools are designed not only to lock in private investment and shorten deployment timelines, but also to ensure allied supply chains remain resilient and insulated from adversarial control. LNG offtake agreements have been a part of tariff negotiations. To close trade negotiations, the EU pledged to purchase \$750 billion in U.S. energy exports (including nuclear technology and fuel, LNG, and crude oil) through 2028.^y
- **Indonesia** has used its dominant position in nickel and bauxite production and reserves to impose a raw export ban and catalyze domestic refining investment, which may serve as a model for other resource-rich states seeking to retain more of the economic and strategic value of their resources at home. For example, **Guinea** has followed Indonesia’s example by taking actions like transferring assets to state-backed firms against bauxite companies for failing to meet domestic processing commitments, with the goal of boosting its own downstream industries.

Expect to see critical minerals play a central role in future international negotiations, from trade agreements to peace settlements. Whether it is Washington wrestling Beijing to re-permit its export of certain critical minerals during tariff negotiations, or the recently-brokered Democratic Republic of Congo (DRC)-Rwanda peace deal centered on critical minerals access, governments are increasingly including critical minerals and their technologic derivatives as a core tenet of international negotiations, with countries leveraging their supplies for security and foreign direct investment.

Structural Shift 2: Growing Grid Entanglement—Resilience Meets Risk

Increased cross-border electricity integration is being driven by strategic necessity as well as diplomacy. It allows countries to balance natural resource supply and demand across borders, stabilize volatile renewable flows, and scale electrification faster than national grids can manage alone. Energy cooperation also serves as a trust-building mechanism, as a lever for regional influence, and builds regional energy resilience through source diversification.

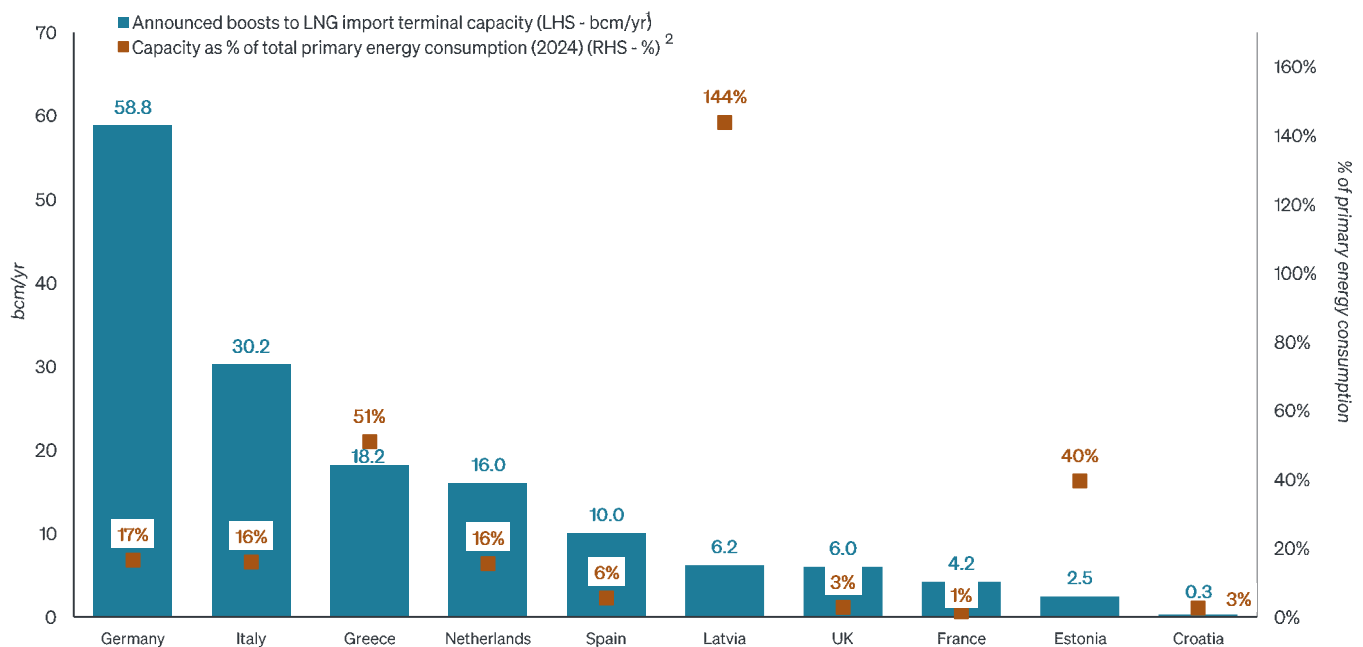
But **“grid diplomacy”** also creates shared vulnerabilities—from cyberattacks, natural disasters, and physical sabotage to regulatory shifts and energy nationalism—that raise the stakes of alignment. A breakdown in one part of a shared grid can cascade across borders, and tensions between neighbors can quickly become energy crises.

In an era of rising geopolitical friction, the interdependence of energy infrastructure is both a source of resilience and a point of risk—much like Russia’s historic leverage over European gas pipelines during the age of oil and mass production.

- **Europe:** Energy infrastructure, both renewable and non-renewable, is rapidly being built to meet European nations’ strategy to diversify away from Russian-sourced pipeline oil (See Figure 13).

Figure 13. No More Bear Oil: Europe’s large-scale LNG pivot

BREAKDOWN OF ANNOUNCED BOOSTS TO LNG IMPORT TERMINAL CAPACITY, INCLUDING EXPANSIONS OF OPERATING TERMINALS



Source: ¹Global Energy Monitor; ²Energy Institute (2025), Statistical Review of World Energy 2025

Note: ¹ Projects announced prior to May 16, 2022, not all newly announced projects have confirmed their planned capacity volumes, including a proposed FSRU terminal in Estonia with expected capacity of ~2.5 bcm/yr; ² bcm of LNG is converted to EJ assuming a 90% utilization rate, and a conversion factor of 1 bcm NG = 34.121 trillion Btu (Iowa State University)

According to the Global Energy Monitor, the EU has proposed, revived, or fast-tracked 30 LNG terminal projects since early 2022. The EU has also deployed new floating storage and regasification units (FSRUs)-notably in Germany, Finland, and Greece-to diversify supply routes and build new infrastructure in record time. **This infrastructure build-out has made Europe the largest global importer of LNG, relying heavily on supplies from the United States and Qatar.** On the electrification side, new “grid alliances” are also emerging, such as the Baltic nations of Estonia, Lithuania, and Latvia’s recent decision to retrofit their electrical grids away from the joint Russian-Belarusian grid and instead connect to the more geopolitically secure “Continental European Network” (CEN) regulated by the EU. Ukraine, too, is already taking steps to ensure its post-war reconstruction energy infrastructure is rebuilt under EU standards.

- Middle East:** The Gulf Cooperation Council Interconnection Authority (GCCIA) has spearheaded a regional energy grid initiative since 2009 to connect the power grids of Kuwait, Oman, Bahrain, Qatar, Saudi Arabia, and the United Arab Emirates. As Figure 14 shows, this grid alliance provides a safety net against blackouts and facilitates a more reliable supply of electricity, especially during periods of peak demand or emergencies. According to the GCCIA, the GCC grid has already generated \$3 billion in economic savings for member states since 2009 and may create opportunities for electricity trading with neighboring regions. Potential next steps for the GCC’s grid include developing “electricity highways” to Europe, allowing for the exchange of surplus energy during seasonal peak demands or, in the long-term, developing a broader “pan-Arab” electricity market.

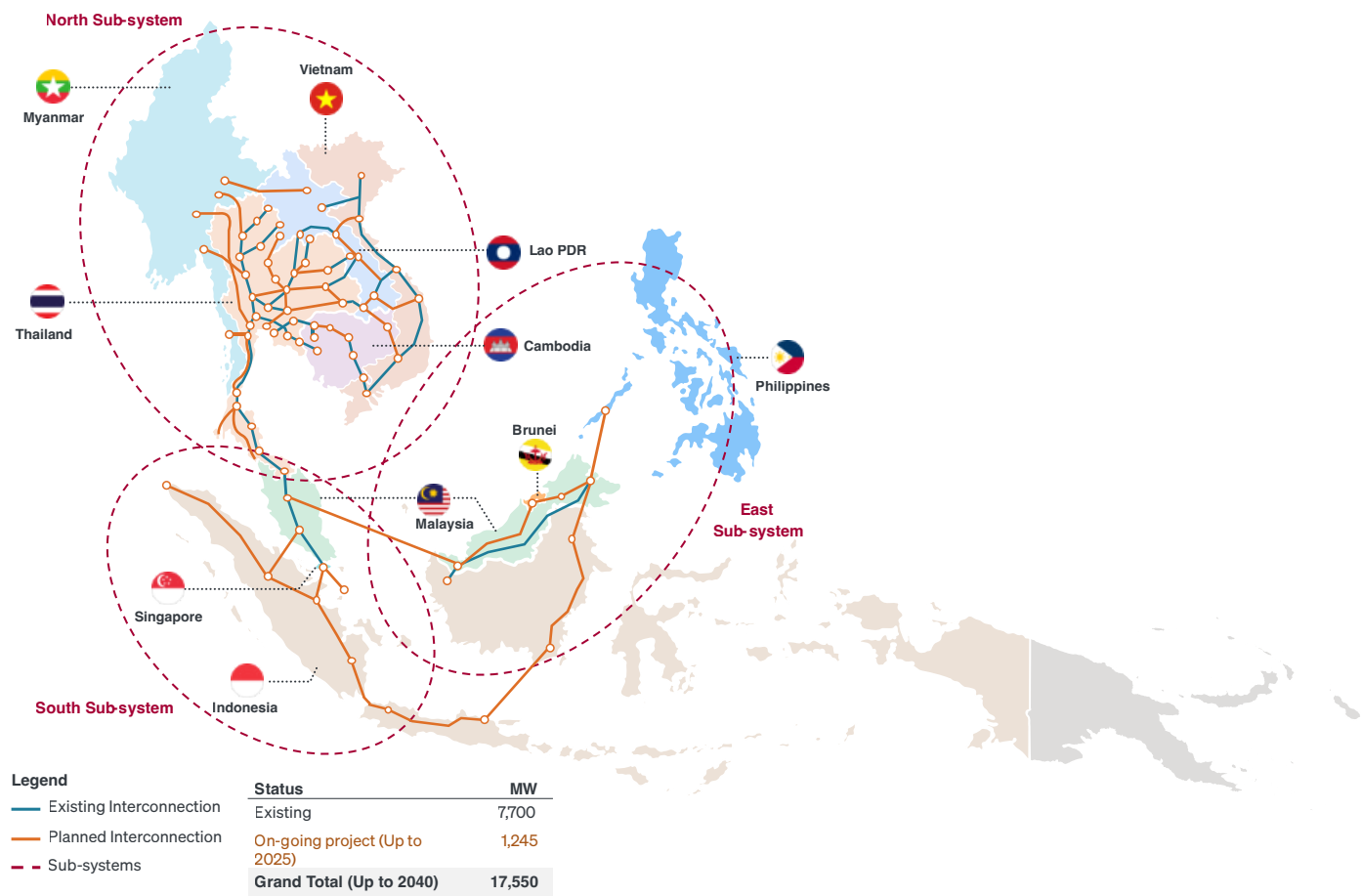
Figure 14. Protons for peace: the Gulf’s “grid diplomacy”



Source: IEEE Access: “GCC Countries’ Renewable Energy Penetration and the Progress of Their Energy Sector Projects”

- Asia-Pacific:** Several technologies are being built out. LNG import terminals have been built across Japan and China. Japan and Australia are investing in hydrogen hubs and regional supply corridors. ASEAN’s Power Grid initiative—which aims to create a multilateral electricity market across Southeast Asia—is gradually linking national grids (see Figure 15). Laos, branding itself as the “Battery of Southeast Asia,” is already transmitting hydropower to Thailand, Malaysia, and Singapore.

Figure 15. ASEAN’s energy alliance: doubling down on electrical exchanges

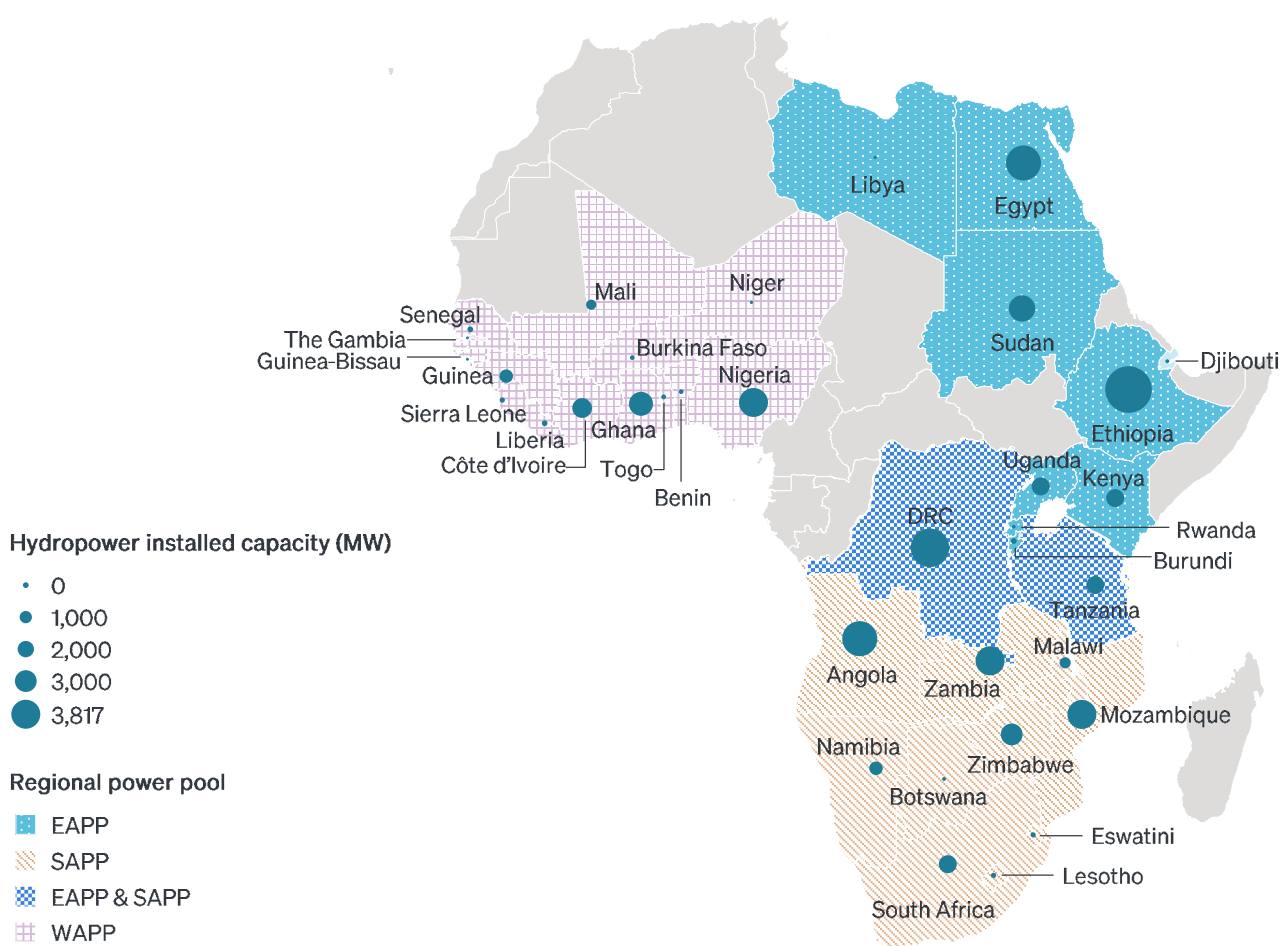


Source: CASE for Southeast Asia; Updated Power Development Plan (PDP) scenario under AIMS III, 2022

- Latin America:** Regional power integration is advancing through efforts like the Andean Electrical Interconnection System and the Central American Electrical Interconnection System (SIEPAC), which connects six countries and is expanding to include Mexico and Colombia. Brazil and Argentina also share significant cross-border electricity flows with Brazil exporting surplus hydropower during peak periods. Brazil is the second largest global hydropower producer with 56% of total electricity use in 2024 (see Appendix, Figure 23).

- Africa:** The African Union's Continental Power System Master Plan is guiding interconnection goals. Key regional projects—such as the Eastern Africa Power Pool (EAPP), the West African Power Pool (WAPP), and the Southern African Power Pool (SAPP)—are enabling power exchanges between countries in each region, with further future interconnection across the continent. These efforts aim to increase energy access, lower costs, and harness the continent's abundant renewable potential, from Ethiopian hydropower to Kenyan geothermal. Cross-continent, long-range subsea cables have also been under development. One project was to connect solar-rich Morocco to the UK, though it recently lost government support with the UK Energy Minister stating a preference to build homegrown power before relying on substantial imports from Africa.^{vi} The connection may ultimately end up in the EU.^{vii}

Figure 16. **I Bless The Rains: Africa's Hydropower Pools**



Source: Energy Research & Social Science: "African power pools and regional electricity market design: Taking stock of regional integration in energy sectors"

Hot Zones: Where Energy Meets Conflict

Russia–Ukraine

Russia's war against Ukraine transformed Europe's reliance on cheap Russian gas. The Nord Stream 2 pipeline was abandoned. Nuclear is being reconsidered as a source provider. LNG terminals were fast-tracked across the continent. EU countries have cut Russian gas imports by more than half since 2021 and imposed sweeping bans on Russian oil. European utilities now pay a price for energy security in the form of higher volatility and infrastructure costs. According to the Household Energy Price Index (HEPI), households in EU capitals paid 36% more for electricity in January 2025 compared to January 2021, before the war in Ukraine began. The war also highlighted a disturbing battlefield tactic: the targeting of civilian energy infrastructure as a weapon of war. Russia, in turn, has deepened its energy ties with China and India.

Middle East

The Red Sea and Strait of Hormuz remain among the world's most vital oil corridors. Approximately 20% of global oil and 20% of global LNG trade passes through the Strait of Hormuz. Iran's threats to block Hormuz—and attacks by proxies in Yemen on shipping in the Red Sea—have again revealed the vulnerability of these shipping chokepoints, as well as the flexibility of the global trading system.^{viii} In 2024, oil flow through the Bab el-Mandeb Strait dropped by 50% – averaging 4 million barrels per day, down from 8.7 million barrels per day in 2023, per the U.S. Energy Information Agency. As part of a longer-running trend, Middle Eastern countries are investing in new strategies focused on diversification and de-risking their energy supply chains:

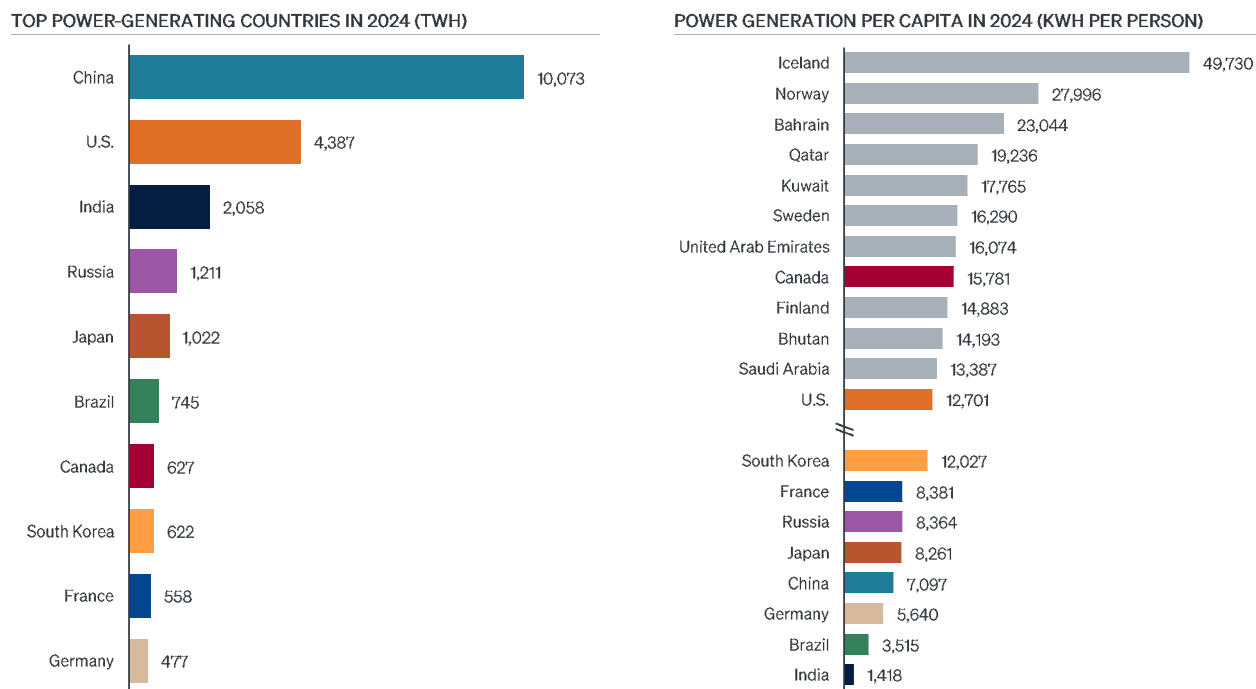
- **Israel** has deployed Sa'ar corvettes—warships armed with advanced surface-to-air missiles—for the explicit mission of protecting its Leviathan and Karish offshore natural gas platforms from missile and drone threats.
- The **UAE, Saudi Arabia, and Oman** have launched megaprojects in solar, wind, battery storage, and low-carbon hydrogen.
- **Saudi Arabia** aims for 50% renewable power by 2030, supported by multi-gigawatt solar tenders awarded to TotalEnergies and EDF Renewables.
- **Egypt** recently fast-tracked North Africa's largest wind farm—Egypt's 650 MW Red Sea project—projected to cut gas imports and stabilize power markets.

Structural Shift 3: Innovation & Powering the Next Technological Wave

From AI to EVs, energy is at the center of the next wave of technological innovation and rivalry. Training large models on high performance computing systems requires immense volumes of stable power—measured in gigawatts—to function reliably, triggering new investment in high-capacity grids and data center power sourcing. From Pennsylvania’s new nuclear-backed AI data clusters to Abu Dhabi’s 5GW AI megapark, energy is now the limiting factor in digital power. **Some estimate that AI will require a doubling of global data center power requirements to 68 gigawatts (GW) by 2027**, almost equivalent to California’s total capacity in 2022. The International Energy Agency predicts global data center demand could reach 945,000 GWh (**~108 GW per year**) by 2030, exceeding the entire nation of Japan’s current electricity consumption. **Governments are responding with muscular industrial policies – recognizing that AI dominance means securing energy dominance. They are increasingly investing not just in projects but in ecosystems—regional clusters of production, innovation, and finance to build next-generation energy industries.**

China leads the world in terms of both overall energy production and specifically electrical output—a crucial ingredient for the powering of data centers used to develop and train large-language AI models (see *Figures 17 and 18*).

Figure 17. Global Powerhouses: Top-Power Generating Countries



Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025); Population based on various sources (2024) – with major processing by Our World in Data

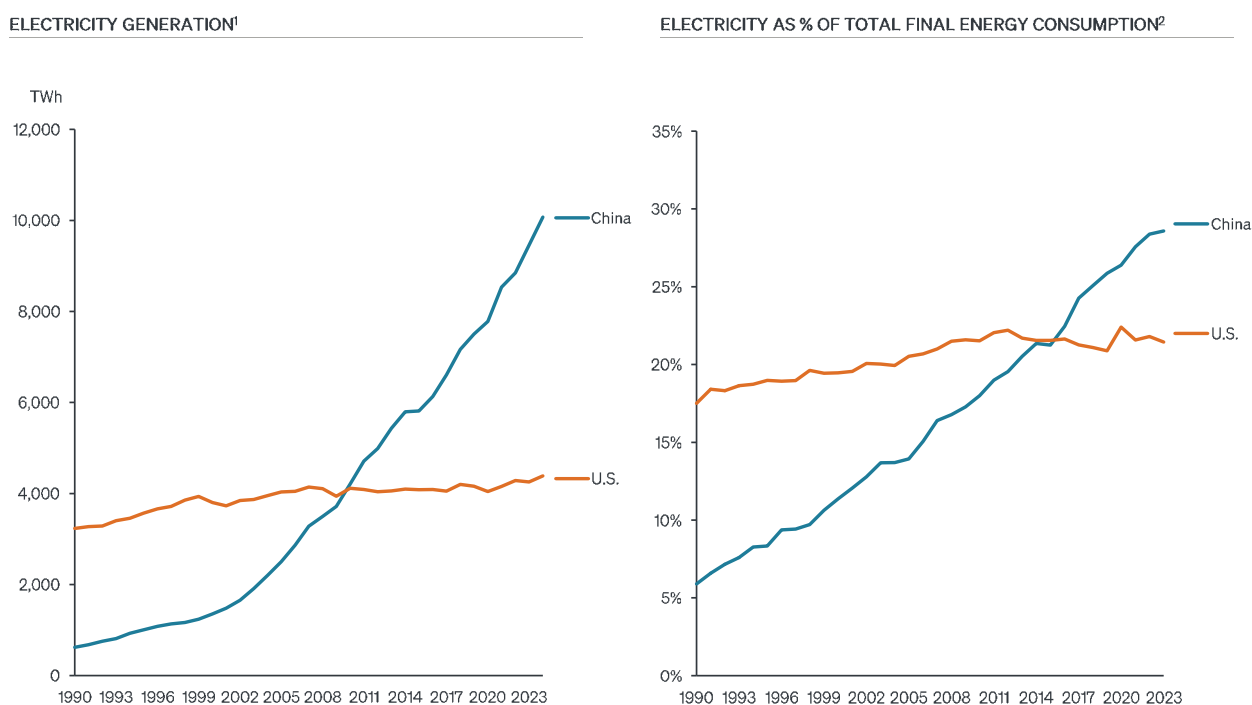
Chinese central planners have explicitly tied AI data center development to energy production planning, with the stated goal that 80% of their data center energy be produced by renewable energy sources. By some accounts, Chinese data centers are expected to triple their electricity demands in the next five years. To support its objective, China has rapidly increased R&D spending over the last decade, resulting in scientific breakthroughs and new energy infrastructure. **China now dominates EVs, solar, and battery markets, and is aggressively building influence through energy technology exports.**

At the same time, however, China's domestic consumption strategy diverges from its clean energy narrative. The country still relies heavily on coal-based power plants—more than any other nation—to power its cities and factories. In 2024 alone, construction began on approximately 95 GW of new coal-fired plant builds – the most in nearly a decade – while work resumed on an additional 3 GW of suspended coal

plant projects. This coal buildout reflects not only inertia in the system, but also a structural need for fast-responding, reliable backup power beyond the capability of current battery storage systems to balance the intermittency of rapidly expanding solar and wind generation.

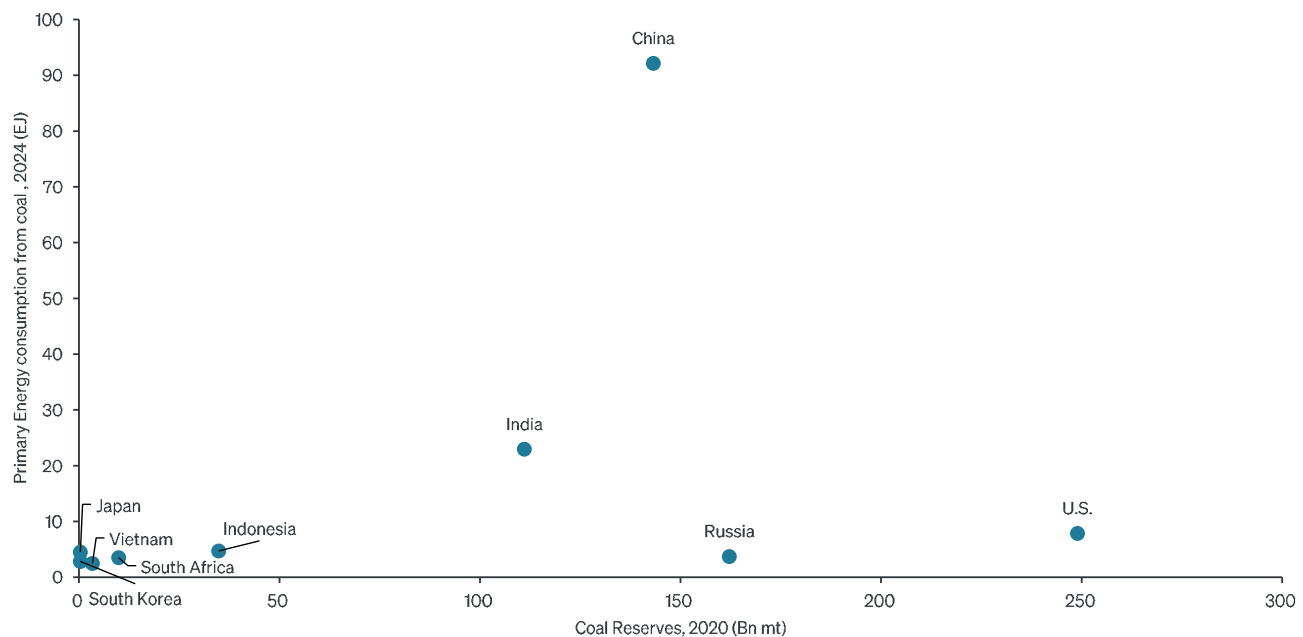
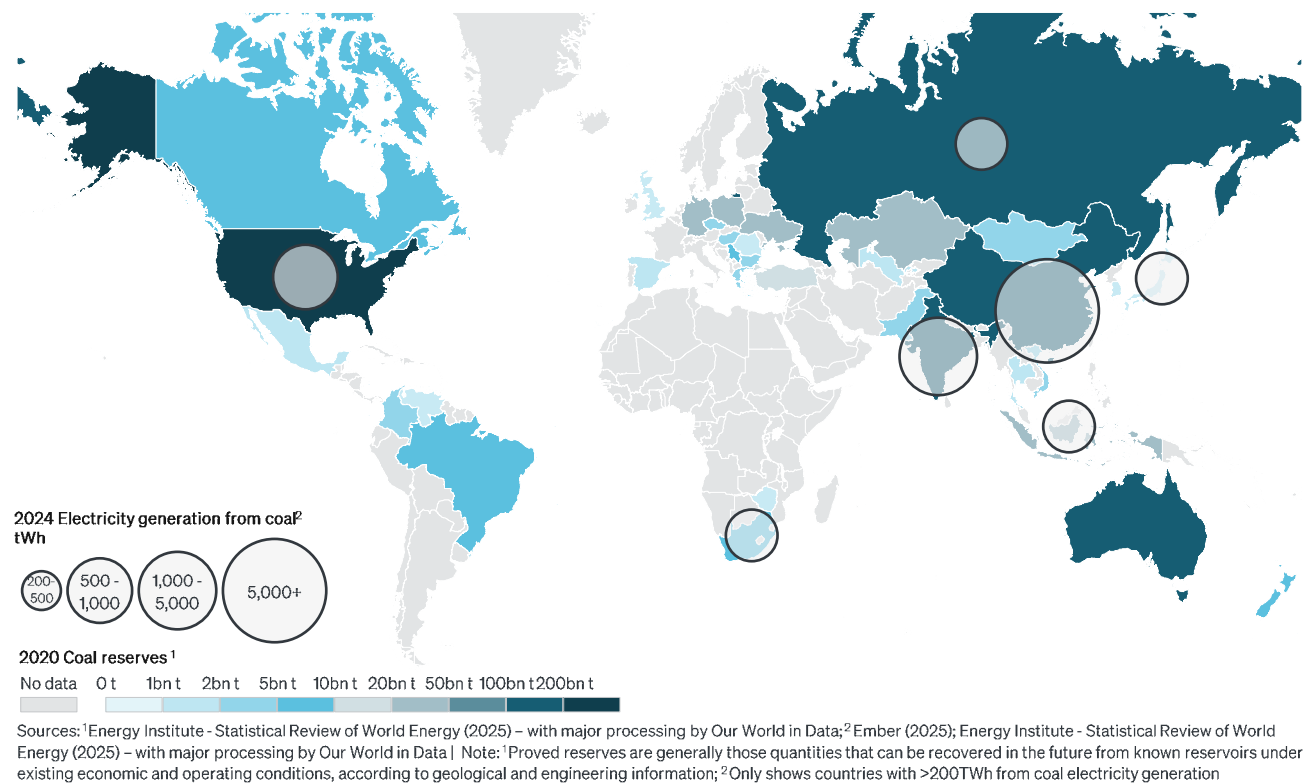
With natural gas resources limited and expensive domestically, coal remains China's primary dispatchable option to stabilize the grid. Even with a recent surge in wind and solar supply coming online in early 2025, contributing to a modest 1% year-over-year drop in CO₂ emissions in the first half of the year^{ix}, **coal remains China's largest overall electricity generation resource.** For the foreseeable future, **Beijing will continue to deploy an energy strategy that seeks to dominate global strategy:** seeking to dominate global renewable energy innovation, exports, and markets while still relying on sources like coal at home to power China's industrial and technological rise.

Figure 18. Current events: China takes the lead in electrical generation



Source: ¹Ember (2025); Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data; ²IEA

Figure 19. Coal country: the US, India, China still lead the world in coal usage



Sources: Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data; Energy Institute - Statistical Review of World Energy (2025)
Note: Proved reserves are generally those quantities that can be recovered in the future from known reservoirs under existing economic and operating conditions, according to geological and engineering information; Only shows countries with >2EJ of primary energy consumption from coal

[View text version](#)

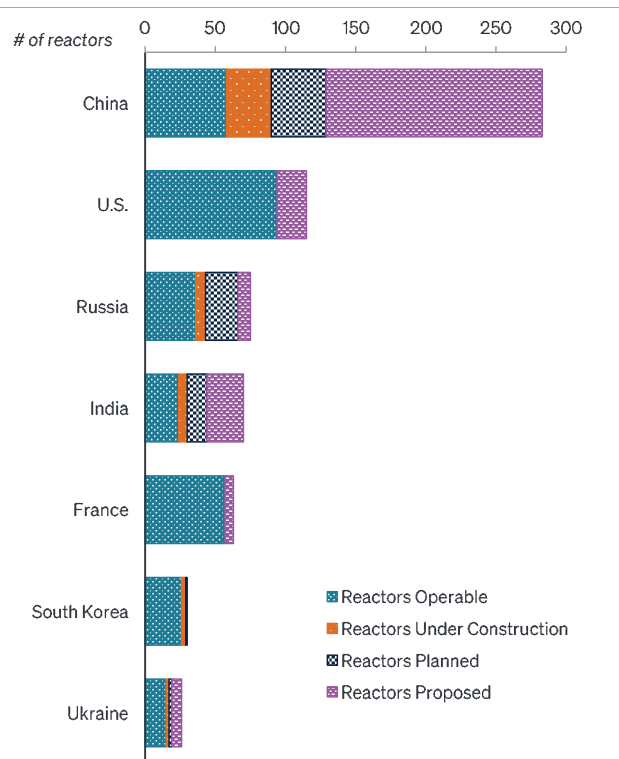
Nuclear: From Thorium to SMRs

New research developments are reshaping and reinvigorating interest in nuclear—from novel reactor designs to the possibility of shifting fissile materials away from uranium to a more widely-available element like thorium. Public support for nuclear energy has varied globally over the years, and its historical headwinds will likely continue to color debate on the energy source. Significant nuclear disasters in Three Mile Island (1979) and Chernobyl (1986) reduced support for nuclear plants in some geographies, increased regulation for safety, and slowed the overall growth of deployment outside Russia and China. The 2011 meltdown of the Fukushima nuclear power plant in Japan led to a second wave of anti-nuclear political backlash around the world—with several governments committing to phase out their nuclear programs in response.

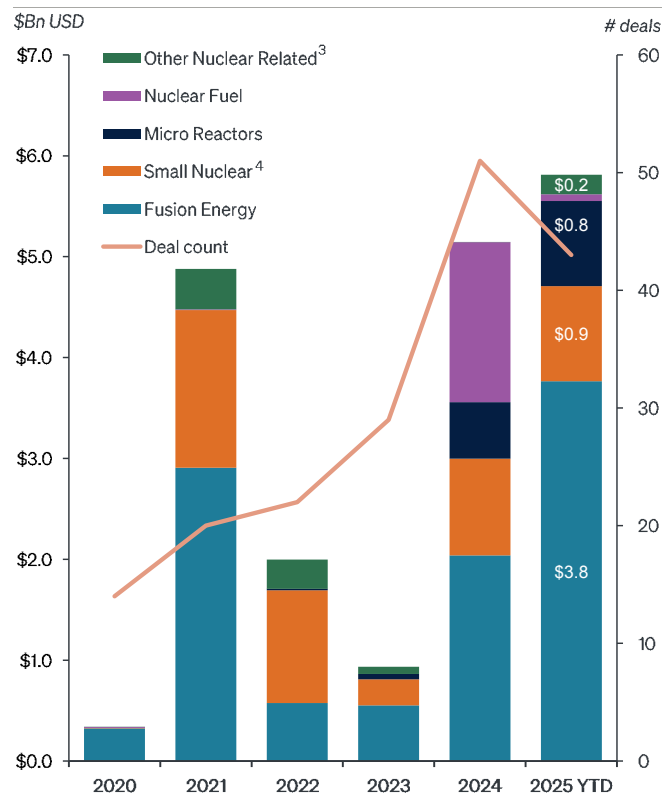
In the past half decade, however, nuclear power has experienced a resurgence in interest and investment – driven by both research breakthroughs and geopolitics (see Figure 20). The global energy price shock caused by Russia's 2022 invasion of Ukraine made some governments and the public rethink their post-Fukushima aversion to nuclear, particularly in Europe. Facing a dramatic energy price hike due to the war in Ukraine, Belgium, for example, extended the operating licenses of their soon-to-be-decommissioned reactors by 10 years. Later, in 2025, the Belgian parliament voted to repeal its 2003 nuclear-phase-out law entirely, opening the door to new nuclear development. The Swiss government has also stated it will seek to lift the country's ban on the construction of new nuclear power plants following energy pricing uncertainty caused by the war in Ukraine.

Figure 20. Going Nuclear: A Red Hot Sector in Construction and Investments

NUCLEAR REACTOR PIPELINE THROUGH 2030¹



CAPITAL FLOWS INTO NUCLEAR OVER TIME²



Sources: ¹World Nuclear Association as of 8/6/2025, ²Sightline Climate as of 8/28/2025 | Note: Includes deals in the "Fusion Energy" and "Nuclear" Primary Sectors, excluding deals categorized as large nuclear, for the following types of financing: Seed, Series A, Series B, Series C, Series D, Growth, PE Expansion, PE Buyout, Corporate Strategic, Other, Debt, PF Debt, SPAC, IPO, Post-IPO Equity, Post-IPO Debt; ³Includes Nuclear Supply Chain, Waste Management & Decommissioning, Development, Construction, & Licensing Services, and Other related; ⁴Includes Small Modular Reactors (SMRs), Small High Temperature Gas-cooled Reactors (HTGR), Small Molten Salt Reactors (MSR), Small Liquid Metal-Cooled Fast Reactors (LMR), Small Light Water Reactors (LWR)

In Asia, countries are moving full-speed ahead in the pursuit of nuclear-forward energy mixtures and have the most recent experience in successful new builds. China currently leads the world in terms of number of new nuclear reactors in the construction pipeline through 2030. **India's** government has set an ambitious target to grow nuclear capacity to at least 100 GW by 2047. **Russia** currently has 6 reactors under construction domestically and approximately 20 internationally. After Russia and China, **South Korea** has been building the newest plants worldwide in the last decade. **The Philippines**, whose government abandoned its nuclear energy program in the 1980s, now aims to have its first nuclear power plant operational by 2032 as electricity demand in the country is expected to triple by 2040.

Materials matter. New research has led to interest in thorium as a different fuel source to power nuclear

reactors. Thorium is three times more abundant in nature than uranium, with significant deposits in India (see Figure 21). Due to the use of molten salt for temperature control in thorium reactors inhibiting catastrophic meltdown, they are also considered less dangerous.

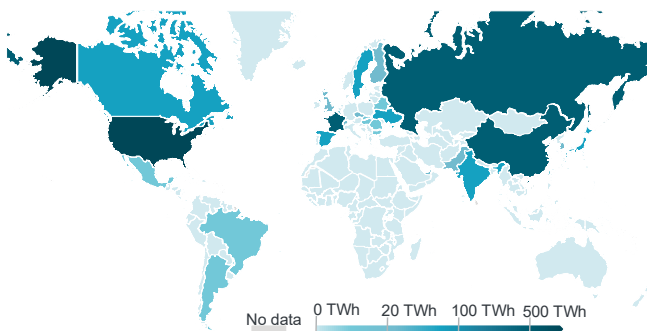
As a result, India, China, and the European Union have been investing heavily in thorium reactor technology research and building demonstration projects. China's Shanghai Institute of Applied Physics is developing a 10 megawatt (.01 GW) electric molten salt thorium reactor prototype in the Gobi desert, while Danish firm Copenhagen Atomics recently received millions in EU funding to further develop a prototype for its "containerized" thorium molten salt reactor that is specifically designed to be mass-produced in a factory and for ease of transport. In the U.S., public-private partnerships are leading thorium technological development.^x

Figure 21. Mapping Nuclear Power: Ingredients and Generation

WORLD DISTRIBUTION OF URANIUM DEPOSITS¹



NUCLEAR POWER GENERATION, 2024 (TWh)²



WORLD DISTRIBUTION OF THORIUM DEPOSITS¹



Sources: ¹ IAEA INFCIS; ² Our world in data: Ember (2025); Energy Institute - Statistical Review of World Energy (2025)

[View text version](#)

Nuclear Microgrids: Decentralized Energy with Strategic Upside. Small modular reactors (SMRs) have been operating on military nuclear submarines to strategically avoid refueling and reduce detectability. The ability to power remote defense assets and decades of success has driven new interest in broader, civilian deployment. If the technology successfully adapts and commercializes, their modularity makes them suitable for microgrids—self-contained energy systems that operate independently or in conjunction with the larger grid—offering enhanced resilience where grid access is limited.

Enthusiasm for this energy solution is reflected in capital flows since 2021 (Figure 20). Investment theses for SMRs have been related to lowering carbon emissions of energy production (to access climate mitigation focused capital) and energy security.

The U.S., Canada, and UK are targeting deployment before 2030, hoping to position SMRs as a geopolitical tool for energy access outside of North America. These could be strategically positioned in locations with limited wind or solar productivity, particularly in remote equatorial regions (Pacific Islands and Africa) where China or Russia have used energy access as leverage. Sub-Saharan Africa, too, is also exploring SMRs to power mining operations, remote communities (i.e. fossil fuel transport is difficult), and grid-limited regions.

Floating Offshore Wind: Unlocking the Deep-Water Frontier

Unlike traditional offshore wind turbines that are fixed to the seabed in shallow coastal waters, floating offshore wind platforms are anchored in place and can operate in much deeper waters—often 60 meters or more (see *Figure 22*). This expands the potential for wind energy generation to “blue-water” zones that were previously inaccessible, such as off the coasts of Japan, California, Norway, and parts of the UK. Because wind speeds are generally higher and more consistent farther offshore, these platforms could generate more reliable renewable power—without the coastal land-use conflicts or visual disruptions that often stall onshore and nearshore projects. The technology is still early-stage and cost-intensive, but several pilot projects are underway, mainly led by European companies to both address regional energy needs (due to natural resource competitive advantage of steady strong wind flow) and position themselves for first-mover advantage in this emerging offshore segment.

Figure 22: A mock-up of Dutch grid operator TenneT's proposal for the construction of artificial islands in the North Sea to use as a multi-national hub for wind energy. Source: TenneT BV.



Spotlight on the R&D Race

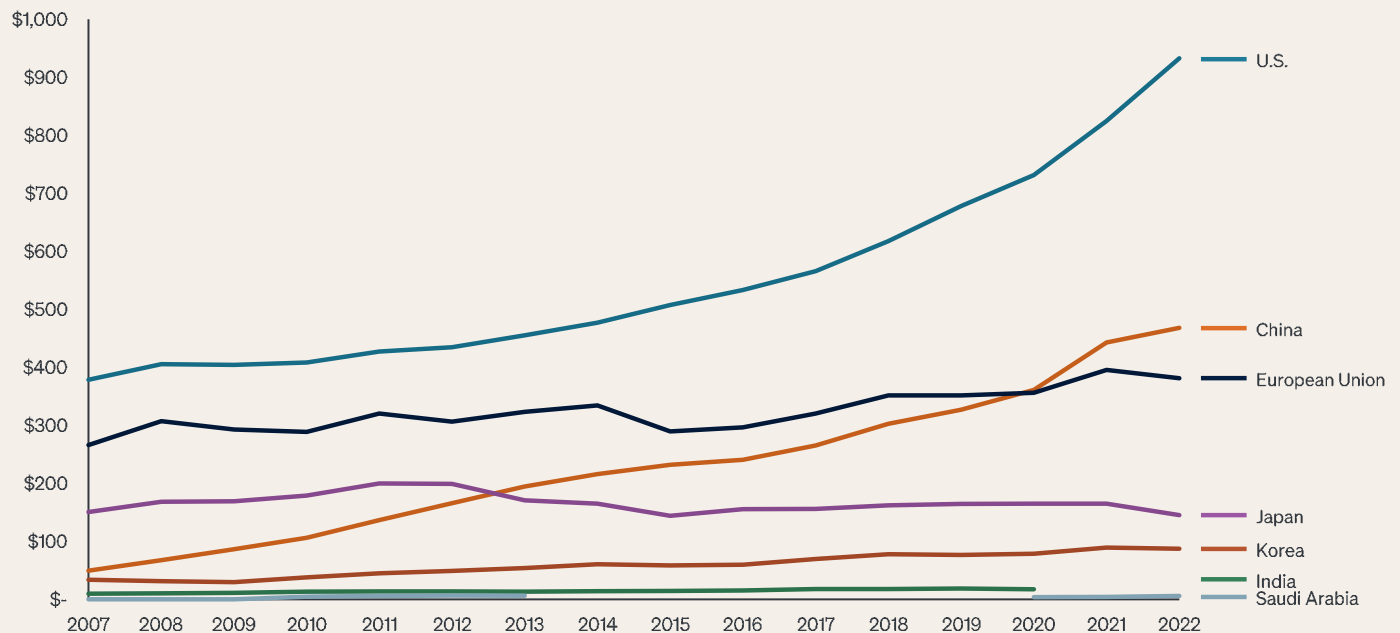
Scientific publications serve as a barometer of innovation output after years of investment. While China now vastly out publishes by volume, (see *Figure 24*) the U.S., UK, and Australia are more efficient, with each country individually producing more than 13% of the World's most highly cited papers.^{xi} As *Figure 23* shows, China has been steadily ramping up investments in R&D; scientific output should continue to rise for years after these investments. Further commercialization of these discoveries will determine where new sectors emerge and drive economic growth.

Patents serve to formalize and protect innovations on the path to commercialization. They reflect historic investment to achieve new and protectable discoveries, which can lead to emerging industries with further investment and scaling from the public and private sectors. As *Figure 25* shows, cumulative patents over 2000-2024 reveal that in all measured countries except Saudi Arabia and Norway, energy patents for renewables outstrip those for fossil fuels. Note: differences in legal conditions contributes to higher numbers of patents in some countries to protect innovation. The most critical information in this figure is the weighting towards emerging energy technologies.

Figure 23. Present Output & Future Innovation

GROSS DOMESTIC EXPENDITURE ON R&D (GERD)

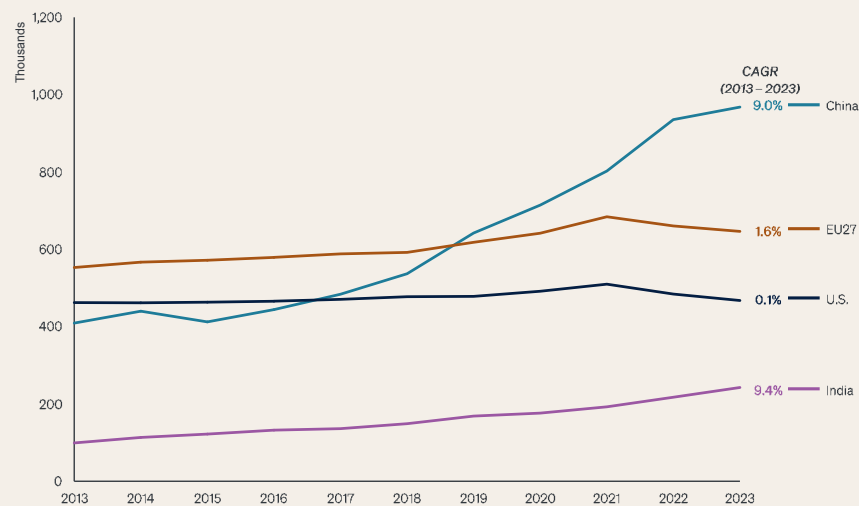
(Bn current \$USD)



Source: World Bank

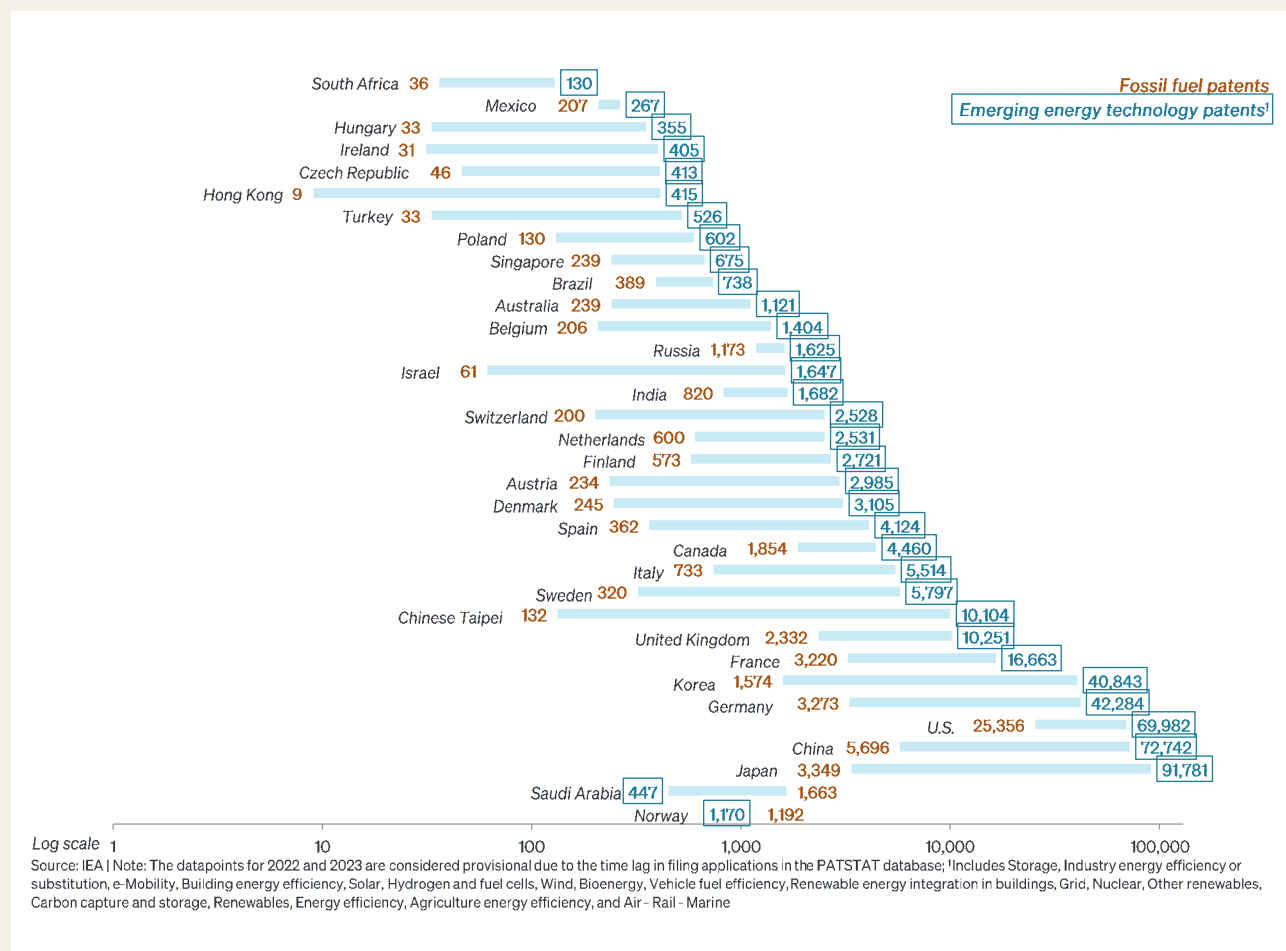
Figure 24. Growth in scientific peer-reviewed published papers by major region

TRENDS IN VOLUME OF SCOPUS-INDEXED SCIENTIFIC PUBLICATION OUTPUT
Four largest publishing territories (fractional counts)



Source: OECD

Figure 25. Emerging energy technology patents dominate innovation for commercialization worldwide.



What we're watching:

→ **Will the U.S. fully embrace its potential for energy dominance?**

North America has a significant strategic advantage in energy because of the sheer number of energy resources it has a competitive advantage in—fossil fuels, solar, geothermal, and wind. If the U.S. fully takes advantage of all those energy resources, it will be unrivaled in the New Energy Security Age. But recent policy shifts from Washington are creating uncertainty for America's offshore wind ambitions—which can be a key strategic advantage for the United States alongside fossil fuels, geothermal, and nuclear. The Northeast, for example, is increasingly energy constrained and needs drastically more electrons on the grid. Wind offers one of the fastest, scalable ways to deliver those electrons. If wind projects are sidelined, the U.S. risks being able to deliver those electrons and remain competitive. Will the U.S. embrace its potential for energy dominance using all resources at its disposal, including wind? Or will we see a pullback from key strategic resources like wind at the federal level—delaying projects and the pace at which North America can compete and lead? There is a developing industry working to exploit this strategic energy resource, but policy shifts could halt that development and risk investor capital already deployed.

→ **Saudi's Civilian Nuclear Program**

The Kingdom has long desired a “full-cycle” nuclear program, where Riyadh would have the ability to domestically enrich uranium for its reactors rather than import low-grade uranium from abroad. Geopolitical dynamics and non-proliferation considerations have stalled Riyadh's ambitions for years, as existing nuclear powers tend to advocate against non-nuclear countries from developing in-house enrichment capabilities. But the Trump Administration, in its campaign to furnish closer ties with the Kingdom, may change all that—including “de-linking” the issue from Saudi recognition of Israel as the Biden Administration had done. The U.S. Energy Secretary recently told reporters he sees a “pathway” to a deal on U.S.-Saudi civil nuclear cooperation and to expect “meaningful developments” on the topic in 2025-26. Notably, thorium reactor technology removes the need for enriched uranium. If the technology advances in the EU or Asia, it could ultimately displace uranium reactor ambitions.^{xii}

→ **FDI in India's Exploding Energy Economy to Enable Self-Sufficiency**

Construction and installation of renewable energy projects is exploding in India – with renewables representing 89% of India's new installed power capacity in FY2025, the majority of which is solar. The Indian government aims to generate 500 GW of non-fossil fuel capacity by 2030. To achieve this, New Delhi is attempting to make foreign direct investment (FDI) as easy as possible in the sector, a goal which appears to be working: FDI in India's renewable energy sector has surged from \$1.6 billion in 2022 to \$3.4 billion so far this year, cementing the country as a hot destination for foreign investors seeking to test and build the next generation of renewable energy technology for the country's 1.45-billion-person customer base. As thorium reactor technology develops, India will be a prime location with ample thorium deposits for the first operational reactors.

→ **Energy Innovation & Diplomacy**

China and India have been increasing R&D spending and have the opportunity to expand their energy technology diplomacy as discoveries are commercialized—forging strategic partnerships with low- and middle-income countries seeking investment, infrastructure, and know-how. The European Union and China recently pledged an expanded partnership as part of this year’s EU-China Summit in Beijing, even as Brussels drives forward on a campaign to diversify its supply chains away from China. One of the agreements: to accelerate global renewable energy deployment.^{xiii}

→ **Will Outbound Controls Expand?**

The U.S. has already restricted semiconductor exports to protect its AI edge. Energy infrastructure may be next. With AI demanding immense power inputs, the next frontier of outbound investment screening could target U.S. capital flowing into foreign-owned AI-adjacent energy assets—especially in countries outside the American alliance system. This could bifurcate markets for certain technologies into American alliance vs. rest-of-the-world, reducing total addressable market size for each.

→ **Australia’s Critical Minerals Moment**

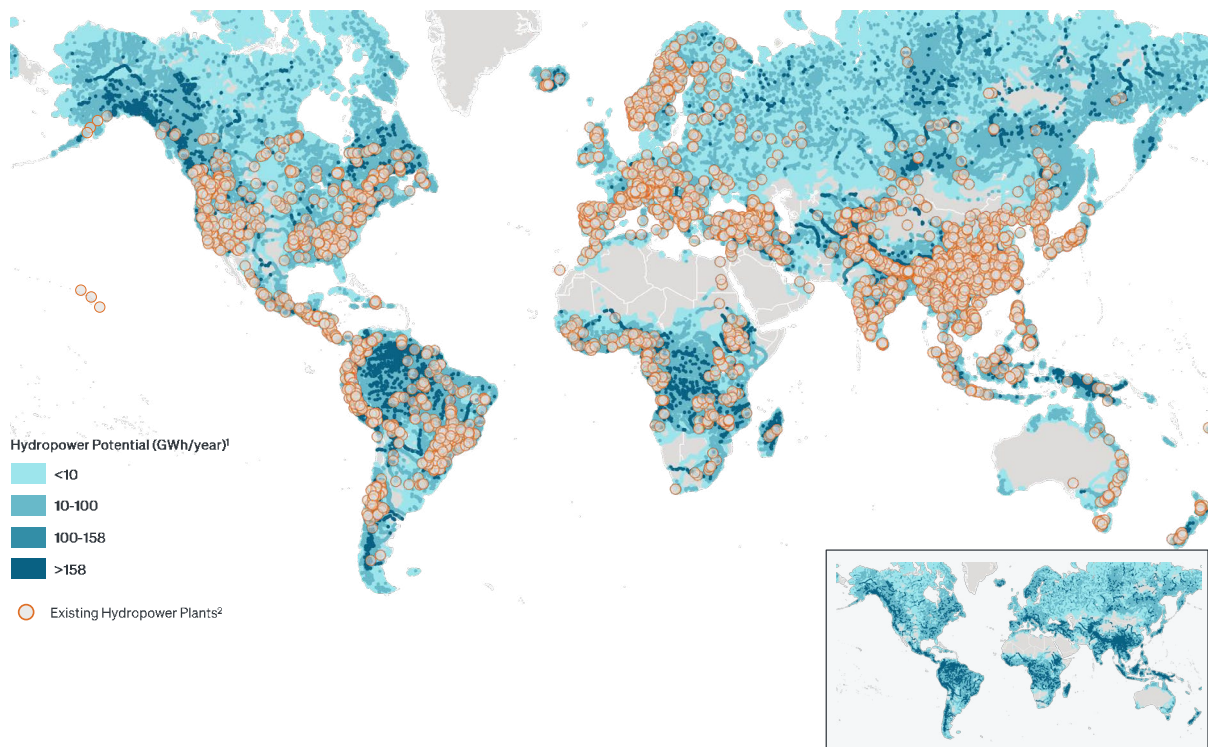
Rich in numerous critical minerals, Australia is emerging as a linchpin in NATO-aligned mineral strategy. Its deep trade and defense ties with the U.S., UK, and EU position it to become a key partner in resilient, trusted supply chains for both energy and defense technologies.

Appendix

Global Hydropower Potential and Development

While the main text focuses on the importance of hydropower in Africa, this appendix provides a global view for those seeking comparable analysis for energy potential everywhere. Hydropower follows global river networks, heavily concentrating in mountain-fed watersheds globally. While an estimated 1/4 of all hydropower resources have been developed, food security (freshwater fish availability) and wider ecosystem impacts inhibit development at full capacity.^{xiv} The World Bank has historically funded hydropower in developing countries to provide not only energy, but also reduce water supply volatility to improve food security and reduce flood risk.^{xv}

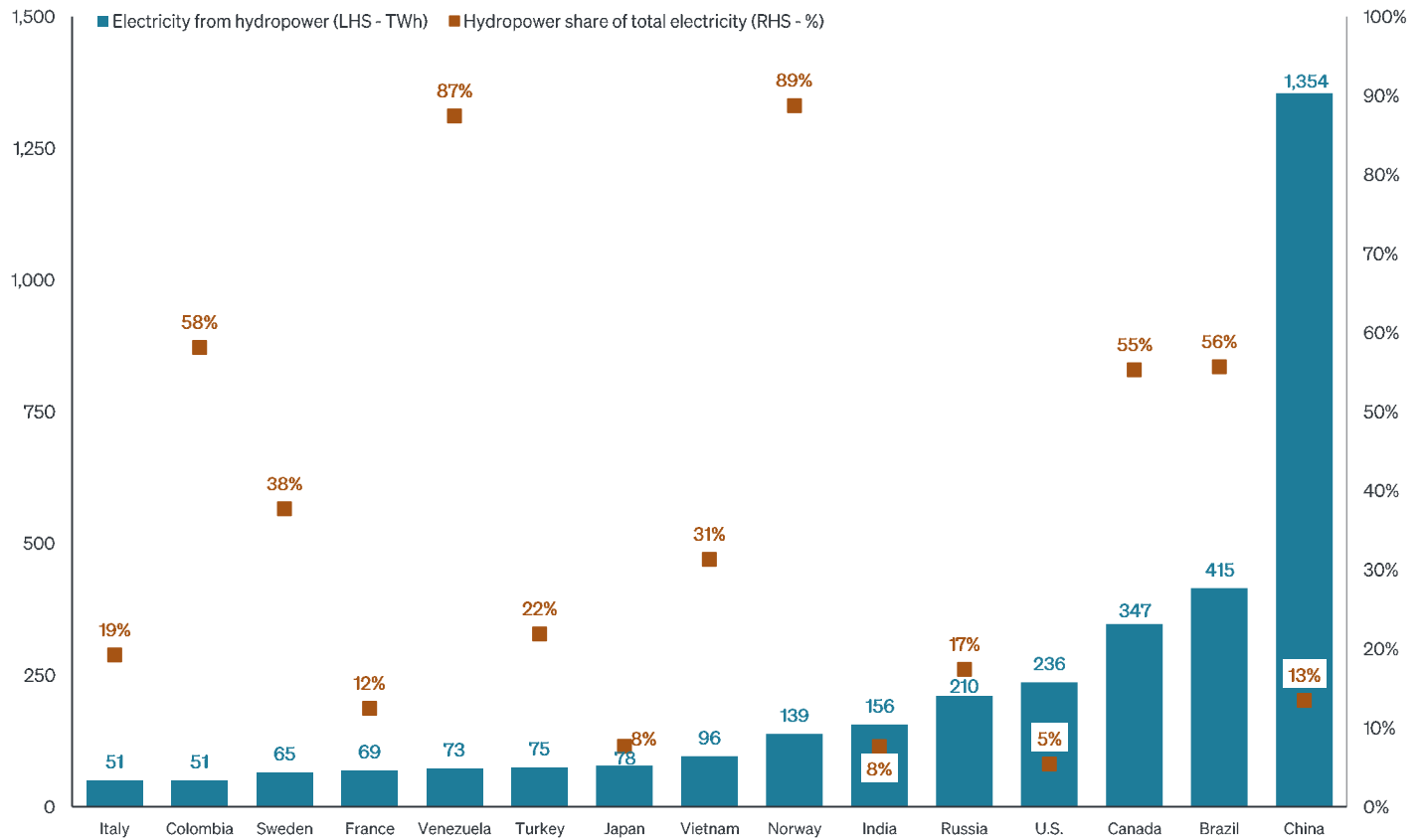
Figure 26: Hydropower Potential Distribution and Current Plants in 2020



Source: ¹"Systematic high-resolution assessment of global hydropower potential"; ²"Climate change and the hydropower sector: A global review"

[View text version](#)

Figure 27. Hydropower Production and Share of Total Electricity Generation in 2024 by Country



Source: Ember (2025); Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data

Data Explanation

Figure 3. Where the sun shines: mapping irradiation hot spots around the world

Electricity generation from solar, 2024

- 800+ TWh: China
- 300-800 TWh: United States
- 100-300 TWh: India, Japan
- 30-100TWh: Brazil, Germany, Spain, Australia

Long term average of DNI, 2020

- North America: higher values concentrated in the west and southwest
- South America: higher values concentrated in the middle of the region on the west coast
- Africa: higher values concentrated at the northern and southern regions
- Europe: lower power concentration
- Middle east: entire region has strong potential, with highest values near the coastlines
- Asia: generally lower values with some higher values in the northwest region
- Indonesia: concentration of very higher values all across Australia

[View chart version](#)

Figure 4. Windy waters: mapping offshore destinations for turbine projects

This is a world map showing global wind power potential and actual electricity generation from wind in 2024. The map uses color shading to represent mean wind power density, measured in watts per square meter (W/m^2). The color scale ranges from blue (lowest power density, 0 W/m^2) through green and yellow, to red (highest power density, $1000+ \text{ W/m}^2$).

Coastal regions and some offshore areas are highlighted in red and yellow, indicating high wind power density, while most inland areas are shaded blue and green, indicating lower wind power density.

Large circles are placed over several countries to indicate their total electricity generation from wind in 2024, measured in terawatt-hours (TWh). The size of each circle corresponds to the amount of wind electricity generated:

- Smallest circles: 50–100 TWh
- Medium circles: 100–200 TWh
- Large circles: 200–500 TWh
- Largest circles: over 500 TWh

Notable large circles appear over the United States, Brazil, several European countries, and China, indicating these are major wind power producers.

The map is sourced from the Global Wind Atlas and Ember (2025), with data processing by Our World in Data.

[View chart version](#)

Figure 5. Digging deeper: geothermal opportunities expand at 7000 meters below Earth's surface

These world maps show global geothermal energy potential and actual electricity generation from geothermal sources in 2024, specifically using Enhanced Geothermal Systems (EGS) technologies.

Left Map: 2024 Electricity generation from geothermal (TWh)

Displays countries with significant geothermal electricity generation in 2024. Circles are placed over countries with the size of each circle corresponding to the amount of electricity generated from geothermal sources, measured in terawatt-hours (TWh):

- **Large circles: 1,000+ TWh:** United States, Indonesia, Turkey, Philippines, New Zealand
- **Small circles: 500–1,000 TWh:** Iceland, Mexico, Italy, Tanzania, Kenya

Right Map: Geothermal Energy Potential (150°C, PJ/km²)

- **Highest potential (up to 950 PJ/km²):** Western United States, Andes region in South America, East African Rift (Kenya, Ethiopia), Southeast Asia (Indonesia, Philippines), New Zealand
- **Moderate potential:** Southern Europe, Turkey, Japan, parts of Australia
- **Lower potential:** Most of Canada, Northern Europe, Northern Asia, and much of Africa outside the Rift Valley

The map is sourced from the International Energy Agency (IEA) and IRENA (2025), with data processing by Our World in Data. Only countries with more than 200 MW of geothermal capacity are shown.

[View chart version](#)

Figure 6. I Come From the Land Down Under: Australia's Rare Earths Abundance

This map displays the distribution and status of critical mineral deposits and mines across Australia in 2024. It highlights the locations of operating mines, mines under development or care and maintenance, and identified mineral deposits. Each site is marked with a distinct symbol:

- Circles for operating mines
- Triangles for mines under development or care/maintenance
- Squares for mineral deposits

Key Observations:

- **Western Australia (WA):** Highest concentration of critical minerals, especially in the southwest and central regions; key producer of lithium, nickel, cobalt, and rare earth elements.
- **Northern Territory (NT) & Queensland (QLD):** Several operating mines and deposits, mainly in northern and central areas; important for manganese and rare earths.
- **South Australia (SA):** Notable sites including Olympic Dam, a major source of copper, uranium, and rare earths.
- **New South Wales (NSW) & Victoria (VIC):** Fewer sites, but some operating mines and deposits in eastern and southern regions.
- **Tasmania (TAS):** A handful of mineral sites, contributing to national output.
- Major projects like Greenbushes, Mount Holland, Olympic Dam, and Mount Isa are highlighted as key contributors.

Geographical Trends and Summary:

- The majority of critical mineral activity is concentrated in the western and northern regions of Australia, with sparser distribution in South Australia (SA) and Queensland (QLD).
- Many mines and deposits are located in remote or rural areas, reflecting the geological distribution of Australia's mineral resources rather than proximity to major cities.
- Overall, Australia's critical mineral resources are widely distributed, but Western Australia is the dominant region for both operating mines and mineral deposits.

The map provides a comprehensive overview of the country's strategic mineral assets, underlining the importance of ongoing development and exploration to support global supply chains for technologies such as batteries, electronics, and renewable energy.

[View chart version](#)

Figure 8. LNG let loose: global LNG import and export infrastructure explodes

This map displays global natural gas reserves in 2020 and the locations of LNG import and export terminals. Countries are shaded in purple by reserve size—darker shades mean larger reserves, lighter shades mean smaller. Grey indicates no data.

Key Features:

Gas Reserves:

- **30–100 trillion cubic meters (tn m³):** Russia, Iran
- **10–30 tn m³:** United States, Turkmenistan, Saudi Arabia, United Arab Emirates, Nigeria, Venezuela, China, Iraq
- **3–10 tn m³:** Algeria, Australia, Libya, Egypt, Indonesia, Malaysia, Norway, Kazakhstan, Azerbaijan, Canada, India
- **1–3 tn m³:** Pakistan, Vietnam, Myanmar, Oman, Uzbekistan, Argentina, Brazil
- **300 billion (bn) – 1tn m³:** Bolivia, Peru, Mexico, Yemen, Thailand, New Guinea, Bangladesh, Syria, United Kingdom, Netherlands
- **100 bn – 300 bn m³:** Romania, Italy, Poland, Algeria
- **0 bn – 100 bn m³:** Germany

LNG Terminals:

Import terminals (gasification):

- Major clusters in Europe, East Asia (Japan, South Korea, China), South Asia (India) and North America.
- Both existing and under construction terminals shown.

Export terminals (liquefaction):

- Major clusters in the United States (especially Gulf Coast), Australia, Qatar, Russia, Nigeria, Algeria, Malaysia, Indonesia, and Trinidad and Tobago.
- Both existing and under construction terminals shown.

Inset Map:

- A zoomed-in view of the U.S. Gulf Coast highlights the concentration of LNG terminals in Texas and Louisiana
- The inset notes that by 2032, U.S. LNG feed gas demand could reach nearly 29 billion cubic feet per day, up from about 13 billion cubic feet per day in 2023

Summary:

The map illustrates that the largest natural gas reserves are found in Russia, the Middle East, and North America. LNG terminals are widely distributed, with major clusters in the U.S. Gulf Coast, Europe, East Asia, and Australia. The map provides a comprehensive overview of the global landscape for natural gas resources and infrastructure as of 2020.

[View chart version](#)

Figure 9. Up From the Ground Comes a Bubblin' Crude: Proven oil reserves across the world

This map shows the distribution of global oil reserves in 2020 and the locations and capacities of oil refineries as of 2024. Countries are shaded in varying intensities of blue to indicate the size of their proven oil reserves, measured in tonnes. Darker shades represent larger reserves, while lighter shades indicate smaller reserves. Countries with no data are shown in grey.

Key Features:

Oil Reserves:

- **30–100 billion tonnes (bn t):** Venezuela, Saudi Arabia,
- **10–30 bn t:** Iran, Iraq, Russia, Kuwait, United Arab Emirates, Canada
- **3–10 bn t:** United States, Libya, Nigeria, Kazakhstan, China,, Qatar
- **1–3 bn t:** Brazil, Norway, Algeria, Angola
- **300 million (mm) t–1 bn t:** Australia, Indonesia, Brunei, India, Vietnam, Egypt, South Sudan, Congo, Argentina, Mexico, Yemen, Oman, United Kingdom
- **100 mm t – 300 mm t:** Peru, Ecuador, Columbia, Sudan, Chad, Gabon,
- **0 t – 100 mm t:** Turkmenistan, Uzbekistan, Tunisia, Romania, Italy, Thailand

Refinery Capacity:

- **Largest capacities:** United States, China, Russia, India, Japan, South Korea, Saudi Arabia
- **Significant clusters:** North America, Europe, Middle East, East Asia, South America

Summary and Trends:

The map illustrates that the largest oil reserves are found in Russia, the Middle East, and North and South America. Oil refineries are distributed globally, with significant concentrations in regions with large reserves and high demand, such as North America, Europe, and Asia.

[View chart version](#)

Figure 19. Coal country: the US, India, China still lead the world in coal usage

Electricity generation from coal, 2024

- **5000+ Terawatt hours (TWh):** China
- **1000-5000 TWh:** India
- **500-1000 TWh:** United States
- **200-500TWh:** Japan, Indonesia, Russia, South Africa

Coal Reserves, 2020

- **200 billion tonnes (bn t) +:** United States
- **100-200bn t:** Russia, Australia, China, India
- **50-100bn t:** n/a
- **20-50bn t:** Germany, Indonesia, Ukraine, Poland, Kazakhstan
- **10-20bn t:** Turkey
- **5-10bn t:** South Africa, New Zealand, Serbia, Brazil, Canada,
- **<5bn t:** Colombia, Czechia, Vietnam, Pakistan, Hungary, Greece, Mongolia, Bulgaria, Uzbekistan, Mexico, Spain, Thailand, Venezuela, Zimbabwe, Japan, South Korea, Romania, United Kingdom

[View chart version](#)

Figure 21. Mapping Nuclear Power: Ingredients and Generation

Nuclear power generation, 2024

- **500+ Terawatt hours (TWh):** United States
- **100-500 TWh:** Russia, China, France, South Korea
- **20-100 TWh:** Canada, Japan, Spain, India, Ukraine, Sweden, United Kingdom, UAE, Finland, Belgium, Czechia, Pakistan, Switzerland, South America
- **0-20 TWh:** Slovakia, Belarus, Hungary, Brazil, Bulgaria, Mexico, Taiwan, Romania, Argentina, South Africa, Iran, Slovenia, Netherlands, Armenia

[View chart version](#)

Figure 26: Hydropower Potential Distribution and Current Plants in 2020

Hydropower Potential, gigawatt hours per year (GWh/year)

- **>158 GWh/year:** Concentrated in regions with major river systems, including parts of South America (Brazil, Colombia, Peru), Central Africa (Democratic Republic of Congo, Ethiopia), South Asia (India, Nepal, Bhutan), and East Asia (China).
- **100–158 GWh/year:** Found in additional areas of South America, Africa, Europe (Norway, Sweden, Switzerland), and Asia (Vietnam, Laos).
- **10–100 GWh/year:** Widespread across North America, Europe, Asia, and Oceania.
- **<10 GWh/year:** Present in arid regions, flatlands, and areas with limited river flow

Existing Hydropower Plants

- **High density:** China, Brazil, United States, Canada, India, Southeast Asia and much of Europe.
- **Moderate density:** Central and South America, parts of Africa.
- **Low density:** Australia, Russia, Canada, Northern Africa, Middle East, and some island nations.

[View chart version](#)

Endnotes

- i Energy security relating to extreme weather events and a changing climate are an important consideration in multi-decade infrastructure, but are a focus of other previous and future papers in the climate intuition series.
- ii <https://fervoenergy.com/fervo-energy-pushes-envelope/>
- iii https://www.aph.gov.au/About_Parliament/Parliamentary_departments/Parliamentary_Library/Research/Policy_Briefs/2025-26/Criticalminerals
- iv U.S. Geological Survey, 2025, Mineral commodity summaries 2025 (ver. 1.2, March 2025): U.S. Geological Survey, 212 p., <https://doi.org/10.3133/mcs2025>.
- v <https://www.whitehouse.gov/fact-sheets/2025/07/fact-sheet-the-united-states-and-european-union-reach-massive-trade-deal/>
- vi <https://www.bbc.com/news/articles/cn8659z0p0do>
- vii <https://www.africaintelligence.com/north-africa/2025/08/01/snubbed-by-london-xlinks-continues-its-lobbying-efforts-with-the-eu,110507845-art#:~:text=A%20big%20surprise,4.0%20Ventures%20and%20Con%20Energy.>
- viii See <https://www.jpmorgan.com/insights/sustainability/climate/future-proofing-ports>
- ix <https://www.carbonbrief.org/china-briefing-21-august-2025-chinas-co2-decline-two-mountains-chinas-cement-challenge/>
- x <https://inl.gov/feature-story/idaho-researchers-collaborate-with-u-s-company-to-develop-novel-nuclear-fuel-to-preserve-improve-todays-reactors/>
- xi Measured by % of papers among the World's 10% top cited publications in 2023. Exact numbers from OECD: UK (14%), Australia (14%), U.S. (13%), and China (12%).
- xii A note on proliferation concerns: Thorium reactors require different fuels and produce different types of waste products than currently operational uranium nuclear reactors. But do not reduce nuclear proliferation risks to zero. See: <https://www.tandfonline.com/doi/abs/10.13182/NT10-203>
- xiii <https://www.consilium.europa.eu/en/press/press-releases/2025/07/24/joint-eu-china-press-statement-on-climate/>
- xiv <https://www.nature.com/articles/s41893-023-01260-z>
- xv Bucknall, Julia; Foster, Vivien; Liden, Mats Johan Rikard; Lyon, Kimberly Nicole; Rex, William. Supporting hydropower : an overview of the World Bank Group's engagement (English). Live wire knowledge note series|no. 2014/36 Washington, DC : World Bank Group. <http://documents.worldbank.org/curated/en/628221468337849536>

About the JPMorganChase Center for Geopolitics and JP Morgan Climate Advisory

The JPMorganChase Center for Geopolitics harnesses the firm's vast global network of expertise and know-how to help clients successfully seize opportunities and weather the trends transforming our global landscape. Access to the Center's offerings can be facilitated through bankers or other client advisors. For more information or to contact the JPMorganChase Center for Geopolitics, please visit: www.jpmorganchase.com/geopolitics

The JPMorgan Climate Advisory guides the bank's clients on climate, energy, biodiversity and sustainability topics. Responsible for overseeing the Firm's climate thought leadership strategy, Climate Advisory leverages extensive technical and scientific expertise to drive content strategy and advise clients at the intersection of finance, climate science, commerce, and national security.

About the Authors

Dr. Sarah Kapnick

Global Head of Climate Advisory, JP Morgan Commercial and Investment Bank

Derek Chollet

Managing Director and Head of the JPMorganChase Center for Geopolitics

Lisa Sawyer

Executive Director of the JPMorganChase Center for Geopolitics

Acknowledgements

Matthew Keating for research support. Isabel Ernst and Jesse McCormick for research support and development of data and graphics. Jonathan Cox, Rama Variankaval, James Janoskey, Marilyn Ceci, Natasha Kaneva, Kenan Arkan and Robert Scher for helpful review and comments.

Disclaimers

This material (including any commentary, data, trends, observations or the like) has been prepared by certain personnel of JPMorgan Chase & Co. and the JPMorgan Chase Center for Geopolitics (the “Geopolitics Center”). It has not been reviewed, endorsed or otherwise approved by, and is not a work product of, any research department of JPMorgan Chase & Co. and/or its affiliates (collectively, “JPMorgan Chase”, “The firm”, “we”, “our”, or “us”). Any views or opinions expressed herein are solely those of the individual authors and may differ from the views and opinions expressed by other departments or divisions of JPMorgan Chase.

The information provided in this document reflects its authors’ understanding and approach to climate change as at the date of this document and is subject to change without notice. We do not undertake to update any of such information in this document. Any and all transactions (including potential transactions) presented herein are for illustration purposes only. Neither JPMorgan Chase nor any of its directors, officers, employees, or agents shall incur any responsibility or liability whatsoever to any person or entity with respect to the contents of any matters referred herein, or discussed as a result of, this material. This material is for general information only and is not intended to be comprehensive and does not constitute investment, legal, or tax advice and it is not intended as an offer or solicitation for the purchase or sale of any financial instrument or as an official confirmation of any transaction or a recommendation for any investment product or strategy. The opinions and estimates herein constitute the author’s judgment and should be regarded as indicative, preliminary and for illustrative purposes only.

No reports, documents or websites that are cited or referred to in this document shall be deemed to form part of this document. Information contained in this document has been obtained from sources, including those publicly available, believed to be reliable, but no representation or warranty is made by the document’s authors or JPMorgan Chase as to the quality, completeness, accuracy, fitness for a particular purpose or non-infringement of such information. Sources of third-party information referred to herein retain all rights with respect to such data and use of such data by JPMorgan Chase herein shall not be deemed to grant a license to any third party. In no event shall JPMorgan Chase be liable (whether in contract, tort, equity or otherwise) for any use by any party of, for any decision made or action taken by any party in reliance upon, or for any inaccuracies or errors in, or omissions from, the information contained herein and such information may not be relied upon by you in evaluating the merits of participating in any transaction. Numbers in various tables may not sum due to rounding. This material does not and should not be deemed to constitute an advertisement or marketing of the Firm’s products and/or services or an advertisement to the public. The use of any third-party trademarks or brand names is for informational purposes only and does not imply an endorsement by JPMorgan Chase or that such trademark owner has authorized JPMorgan Chase to promote its products or services.

RESTRICTED DISTRIBUTION: This material is distributed by the relevant JPMorgan Chase entities that possess the necessary licenses to distribute the material in the respective countries. This material and statements made herein are proprietary and confidential to JPMorgan Chase and are for your personal use only and are not intended to be legally binding. Any distribution, copy, reprints and/or forward to others is strictly prohibited.

<https://www.jpmorgan.com/disclosures>

©2025 JPMorgan Chase & Co. All rights reserved.