

Energy Atlas

Thematic Report

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The “New” Energy Trilemma

The geopolitical tensions that are accelerating the transformation of the Energy Sector. Among the energy vectors, Electricity is the fastest-growing one, low-carbon technologies are capturing an increasing share of incremental demand, while grids, flexibility and critical supply chains are emerging as the key physical constraints of the transition. We provide our reading of the current industry outlook, identifying: a) structural trends and expected developments; b) strongest business models.

The key trends recently outlined

Latest available industry statistics suggest a few clear trends:

- 1) Investment in power generation has outpaced network capex for years, and grids are becoming the bottleneck for connecting generation, storage and new electricity loads;
- 2) The “Age of Electricity” is a reality: global electricity demand was up 3% in 2025, more than twice the 1.3% growth in total energy demand;
- 3) Solar deployment keeps growing, but the focus is shifting to system integration with mature markets facing curtailment and negative prices;
- 4) Firm and flexible power is necessary to manage the rising shares of intermittent renewables and large concentrated loads of data centres;
- 5) Critical-mineral and battery supply chains concentration is now an economic-security risk, subject to increasing export restrictions.

Expected developments

The most visible developments ahead, in our view, are:

- 1) Electricity (+3.6% p.a. over 2026-2030) should keep outgrowing the broader energy system, also driven by data centres and AI though the transition remains additive rather than substitutive of oil, gas and coal;
- 2) Grid development / upgrade should enter a global supercycle, with investments up ca. 50% by 2030 according to IEA;
- 3) Storage and flexibility should become core infrastructure, while digitalisation / grid-enhancing technologies increasingly complement physical storage by unlocking underutilised system capacity;
- 4) Supply-chain concentration should support expansion of recycling and circular-economy solutions, with affordability and industrial competitiveness impacting the speed and design of the transition.

Winning models: the electrification enablers

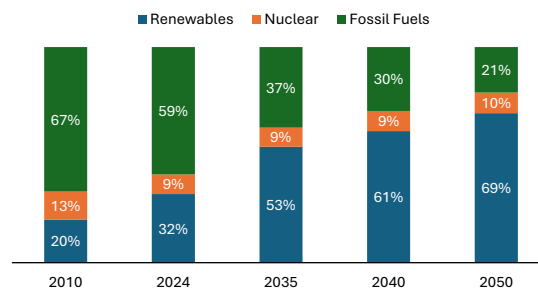
We see electricity TSOs and DSOs, and integrated power solution providers / grid-equipment manufacturers and engineering as the clearest structural beneficiaries of the transition.

Grid/BESS monitoring / orchestration / optimization software solution providers should also be among the main beneficiaries.

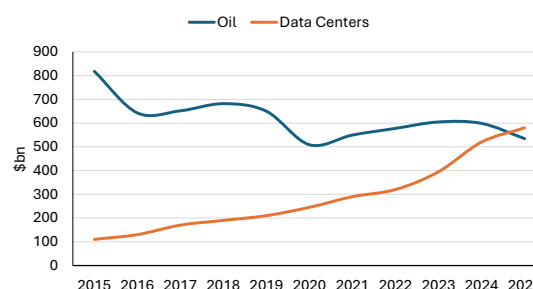
Players in circular economy should face increasing need to create a strategic domestic supply of critical energy-related minerals.

Last but not least, renewable developers, EPC and IPPs remain attractive selectively with RTB assets, hybrid RES+BESS projects and contracted portfolios more valuable than generic MW pipelines.

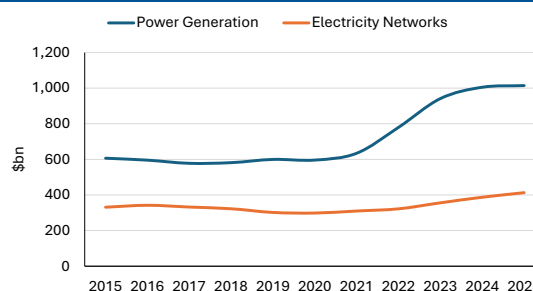
POWER GENERATION MIX



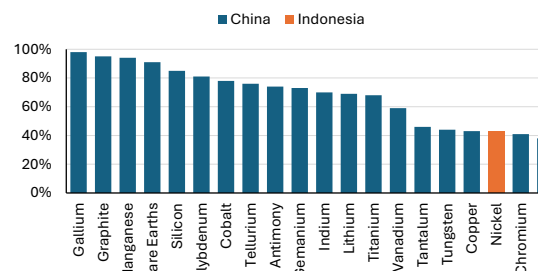
ANNUAL SPENDING IN DATA CENTERS VS OIL SUPPLY



INVESTMENTS IN POWER GENERATION VS ELECTRICAL GRIDS



LEADING PRODUCERS OF KEY ENERGY-RELATED MATERIALS



Source: IEA, Value Track Analysis

Executive Summary

Driven by many different factors, the global energy system is entering / has entered the "**Age of Electricity**" with several implications in terms of the so-called Energy Trilemma" – i.e. **Energy Security, Sustainability and Affordability**.

With this report we try to spot some of the most important trends and developments of the sector, the business models and industry segments (products and services) that are likely to benefit, and the opportunities currently arising for investors.

The analyses are based on specific scenarios, as indicated by the International Energy Agency (IEA) in its World Energy Outlook 2025 and World Energy Review 2026: CPS (Current Policies Scenario), STEPS (Stated Policy Scenario), NZE (Net Zero Emission by 2050) and ACCESS (Accelerating Clean Cooking and Electricity Services);

Energy Security: drivers, outlook, issues of today "top priority"

Energy security has evolved into a fundamental matter of economic and national security, demanding a three-pronged approach centred on **meeting highly increasing demand, ensuring grid stability, and diversifying mineral-heavy supply chains**. The key messages of our analysis are the following:

- **Record power demand ahead: the Age of Electricity is already visible in actual data.** Global electricity demand grew by almost 3% in 2025 versus +1.3% for total energy demand, and IEA forecasts electricity demand to grow by 3.6% p.a. in 2026-30, at least 2.5x faster than overall energy demand.

Looking further out, power demand could still rise by ~40-50% to 2035 depending on scenario, driven by global cooling demand, electrification (of mobility and heating) and digitalization (Data Center);

- **Low-carbon sources are capturing an increasing share of incremental demand, but the transition remains additive before becoming fully substitutive:** oil, gas and coal all increased in 2025, while low-emission sources accounted for almost 60% of global energy-demand growth.

Over the longer term, by 2050 electricity demand should still be 80% higher than 2024 and become the primary energy source for 50% of global GDP, with oil demand a few p.p. lower, coal demand almost halved, and fossil fuels in power generation declining from 60% in 2024 to 20% in 2050, replaced by renewables;

- **Asia remains the centre of gravity of electricity demand growth:** emerging economies are expected to account for nearly 80% of additional electricity consumption through 2030, with China alone remaining the largest contributor and India and Southeast Asia progressively increasing their share.

China also remains the "green giant" of this new era, effectively leveraging its massive manufacturing surplus to control over 80% and 85% of the world's solar PV and battery storage manufacturing at every stage of the supply chains, respectively, at prices that no competitor can match;

- **There is a Chinese "bottleneck" in critical minerals' refining and technologies:** the challenge of energy security today lies in the strategic securing of supply chains for strategic minerals, where market concentration creates extreme systemic vulnerabilities.

Critical-mineral refining remains highly concentrated and is becoming more, not less, strategic: excluding rare earths, the average share of the leading refining country (China) reached 72% in 2025, while export controls have turned concentration risk into an immediate economic-security issue;

- **Global supply is stuck in bureaucracy and infrastructure (grid) bottlenecks:** more than 2,500 GW of generation, storage and large-load projects remain stalled in grid connection queues worldwide, highlighting that network capacity is becoming the key bottleneck linking new supply and demand.

In EU/Italy the "permitting wall" remains a primary barrier, and solar deployment remained at record levels in 2025 — the more relevant structural issue is the shift from generation-cost constraints to integration constraints, with curtailment, negative prices, grid congestion and storage needs increasingly shaping deployment economics — while Global electricity grids require an expansion of over 25 million kilometers by 2035 to connect decentralized generation and modernize a backbone that has faced decades of under-investment;

- **A rising premium on firmness and flexibility** supports a multi-tool reliability mix including selected gas-fired generation, hydro, nuclear, storage and demand response, as the value proposition increasingly shifts from bulk energy volumes toward availability and responsiveness;
- **Storage and flexibility, the new core system resources:** battery additions reached around 110 GW in 2025 (+40%), while demand response, aggregators, smart meters, AI-enabled forecasting and grid-enhancing technologies are increasingly used to manage congestion, curtailment and volatile prices. This combines also with PSH (pumped storage hydropower) and low-emission hydrogen as further pillars of system flexibility.

Energy Sustainability: don't get distracted...still a priority (especially for EU)

Among the three pillars of the Trilemma (i.e. the priorities in the energy sector) probably today **Energy Sustainability** (i.e. decarbonization) is perceived as no longer really top-priority, due to geopolitical shocks and affordability concerns. However, the 2025 data show that low-emission technologies continue to scale rapidly, underscoring that sustainability remains a structural policy objective and should not distract from the primary long-term objectives, i.e. **achieving Net Zero Emissions scenario (“NZE”) by mid-century**.

We would assess that **renewables are the primary engine** of this shift, and especially **for the EU**, renewables are also **a key driver for security**, as fossils are not an option to improve its energy independence. Yet, achieving absolute **sustainability requires also**:

- A complex portfolio of **innovative technological solutions** to address the temperature overshoot. While several technologies have exceeded expectations, including batteries, electric vehicles (EVs), liquefied natural gas, shale oil, and solar photovoltaics, other technologies are taking longer to mature despite initial enthusiasm, such as **carbon capture and storage and clean hydrogen**.

Among the most promising we flag Carbon Capture, Utilization, and Storage (“CCUS”), Direct Air Capture (“DAC”) and Bioenergy with CCS (“BECCS”) and, with a longer time horizon, Small Modular Reactors (“SMRs”) and Next-Generation Geothermal, Bioenergy and Hydrogen-based fuels and all the Storage Spectrum;

- Sustainability transitioning from a purely environmental goal to a structural economic requirement, where **material efficiency and circularity** are as critical as the energy source itself, serving as a structural imperative to ensure technology sovereignty in a resource-constrained world.

Global economy is currently only 7.2% circular, total material consumption (now around 100bn tons of materials per year) is projected to double by 2050 and circularity is no longer just an environmental goal but a geopolitical necessity to enhance energy independence.

In the energy sector specifically, under current policy settings, secondary supply for key energy minerals could rise from around 10% today to close to 20% by 2040, making recycling an increasingly important supply-security tool;

- Maximizing the existing infrastructure “value” (i.e. power), **via repowering and revamping** policies. Without further land usage, modern technologies serve as a significant lever of the circular economy. Repowering offers a few advantages: a) it allows developers to bypass the bureaucratic wall; b) it can help to reach 2030 targets without controversial new transmission corridors; c) In the solar sector, shortening replacement schedules could expand the global PV market by up to 60% by 2035, even without adding new operational capacity.

Energy Affordability: now it is an issue for the whole value chain

Energy Affordability is a pre-requisite for widespread adoption of new low-carbon technologies. For many nations, high energy prices can crash an economy and cause social tension, making the predictability of costs as vital as the clean nature of the energy itself. Ultimately, achieving equity means ensuring that the benefits of the transition (such as lower marginal costs) are shared across all social strata while providing investors with the regulatory certainty needed to fund a €3tn infrastructure super-cycle.

The transition is increasingly shifting affordability risk from fuel procurement toward financing, networks and system integration. In a more capital-intensive electricity system, WACC, grid charges and the recovery of infrastructure costs become as important as commodity prices. This creates a causal chain where the

high upfront costs of clean technologies dictate the affordability of energy for those who supply it, those who consume it, and those who finance its expansion:

- **For Suppliers** – The affordability for energy producers is defined by their ability to recover massive upfront investments through stable, long-term revenue streams. In fact, the traditional risk of fuel price volatility is replaced by the logistical and financial challenges of an infrastructure-heavy grid.

In other terms, in the legacy fossil-fuel model, fuel and carbon costs accounted for roughly 75% of a project's lifetime expenses, while in the renewables-led system, upfront capital represents over 67% of total costs, with "marginal cost" of energy frequently dropping to zero.

Hence, the average cost of energy comprises four critical components: a) **Capital Recovery**; b) **Fuel and O&M Costs**; c) **Emissions-Related Costs** (as European emissions trading system, or "ETS") and d) **Grid Tariffs**.

In addition, to manage the risks of high upfront investments and volatile spot prices, suppliers are transitioning from simple "kWh retailers" to **integrated service providers**, i.e. no longer "naked" energy (kWh) but provider of integrated energy services such as grid stability, flexibility, and ancillary solutions.

- **For Consumers** - The structural shift toward electric mobility and heating is increasing consumer sensitivity to electricity price fluctuations. Yet, household energy bills typically do not reflect only commodity prices and energy delivery costs, but also policy and market design.

Residential electricity prices vary significantly across countries and regions, and Europe has some of the world's highest prices.

European affordability is increasingly shaped by a two-sided volatility problem: scarcity hours can still transmit gas and capacity costs into high prices, while periods of renewable surplus generate zero or negative prices and weaken capture rates. Market design must therefore reconcile affordable consumer bills with adequate remuneration of capacity, grids and flexibility.

While household energy bills in all advanced economies are projected to fall by 2035 due to the superior efficiency of electric technologies, a new "**financing barrier**" has emerged. Also consumers (or prosumers) are moving to a more capital intense model and affordability for the modern consumer depends not only on the price per kilowatt-hour (the operating cost) but on the ability to finance the high upfront capital costs to buy efficient equipment (e.g. heat pumps and EVs) required to access lower long-term operating costs.

A mechanism introduced in Italy to directly enhance consumer affordability is **Renewable Energy Communities ("CERs")**: a sophisticated legal and operative ecosystem (association or cooperative) that shares energy locally, which may allow households to join as "consumers" with zero upfront investment, participating in local generation and energy sharing. CERs illustrate the shift from passive consumers toward active participants: their economics depend on the specific configuration, consumption profile, incentive-sharing rules and degree of simultaneous local consumption, so benefits should be presented as case-specific rather than as a standard discount range.

- **For investors** – As energy transition is a structural shift from an "Opex-driven" system to a "Capex-driven" one, **WACC** remains one of the most important determinants of project economics in capital-intensive energy infrastructure, particularly for renewables and grids, while revenue structure, capture-price exposure, permitting and connection risk are increasingly important co-determinants.

With \$3.2tn of global energy investments in 2024, affordability for investors means securing **predictable, long-term returns in a capital-intensive environment**. This implies that

a) even minor variations in interest rates or **risk premiums** can affect high-quality renewable resources viability - note that the cost of capital for power generation projects in emerging and developing economies is over twice as high as in advanced markets;

b) developers need **standardized market instruments** to bridge the structural mismatch between their long-term needs and the short-term preferences of energy buyers, the Power Purchase Agreements (PPAs) and Contracts for Difference (CfDs), which "bancabilize" projects by providing fixed revenue streams and reducing the overall LCOE (Levelized Cost of Energy) to support transition;

c) the large **regulated asset bases** of large-scale grid operators provide the high earnings visibility required to navigate a generational investment cycle, granting investors superior visibility.

Winning Business Models: the enablers of electrification

In such a challenging scenario, the players / business models / verticals that in our view are structural beneficiaries of the transition, are the following ones:

1. **Transmission System Operators (TSOs) & Regulated Utilities:** electricity TSOs and DSOs remain among the clearest winners of the electrification cycle, as grid expansion and modernization support sustain RAB growth and regulated earnings visibility, while the same certainty should not be extended automatically to all gas utilities;
2. **Equipment and Infrastructure Manufacturers:** grid-equipment manufacturers – including high-voltage cables, transformers, switchgear, power electronics– remain strongly positioned as supply-chain bottlenecks and long lead times support robust demand, although pricing power should be assessed in every specific vertical;
3. **Smart Grid and AI Software Providers:** smart-grid software, aggregators and digital platforms benefit from the need to forecast variable supply, optimize networks, coordinate distributed assets and activate demand response. AI is an enabling technology within this broader digital-flexibility stack rather than the sole driver;
4. **Flexible generation and Storage Operators:** in a system led by intermittent renewables, these players win by providing "split-second responsiveness". They profit from "value stacking": combining wholesale price arbitrage (i.e. buying low, selling high) with high-margin grid stability contracts;
5. **Renewables Operators (not always):** EPCs are due to build the massive additional wind and solar capacity (mostly expected by 2030-2035) and IPPs to operate it, provided the former operate in attractive margin segments and the latter adopt flexible models, supported by storage and/or PPAs or fixed-price contracts (CfDs/PPAs), and/or in a stable regulatory framework;
6. **Circular Economy Specialists:** with a projected 30-40% supply shortfall in minerals like copper and lithium by 2035, firms that recover minerals from electronic waste win by creating a strategic domestic supply, reducing dependency on concentrated imports;
7. **Nuclear Technology Vendors and SMR Developers:** Existing nuclear fleets, life extensions and selected nuclear supply-chain vendors benefit from renewed policy support for firm low-carbon power. Small Modular Reactors remain a potentially attractive but higher-risk, longer-dated optionality, with commercial execution still less proven than conventional nuclear or grid solutions.

Weaker models: fossil and rigid IPPs, capital-constrained

Among the business models that in our view might be negatively impacted by the sector changes, there are:

1. **Unabated Coal & Inflexible Baseload Generators:** the biggest losers face structural decline due to carbon pricing ("ETS"). They lose because they cannot ramp output fast enough to handle the "Duck Curve" or negative price events caused by zero-marginal-cost renewables;
2. **Unhedged Pure Commodity Retailers:** facing "extinction-level" risks. Relying on selling "naked" kWh without sophisticated hedging or energy services leaves them exposed to spot market price.
3. **Single-Source Dependent Manufacturers:** industries (e.g. automotive and hardware) that rely on a single country for >70% of refined minerals face risks from export controls / geopolitical trade barriers;
4. **Standalone/Uncontracted Renewable Power Producers:** IPPs of pure-play solar or wind without storage or fixed-price contracts (CfDs/PPAs) suffer from "price cannibalization". Their high production crashes market prices during the very hours they are most active, eroding their revenue;
5. **Energy-Intensive Industries with Slow Electrification Pathways:** Failure to adopt industrial heat pumps or other electric processes face an inevitable "competitiveness gap".
6. **Traditional Residential Gas Utilities and gas-equipment (boiler) Manufacturers:** Possible demand decline as electric heat pumps and residential technologies displace natural gas in buildings.

The “New” Energy Trilemma in the “Age of Electricity”

Since the World Energy Council presented at the beginning of the century the “*Energy Trilemma*” (i.e. the challenge of balancing Energy Security, Energy Affordability, and Energy Environmental Sustainability), such a concept has become much more challenging due to **geopolitical tensions** and the **rapid technological change**.

Hence, the traditional definitions of these pillars are evolving, and the trilemma now requires the simultaneous focus on multi-fuel **security**, capital-heavy **affordability**, and accelerated **sustainability**, requiring a shift in how governments and industries prioritize investments and policies.

As the global energy system enters the “**Age of Electricity**”, core priorities are shifting. Unfortunately, the recent years’ geopolitical events make it much more difficult to predict how they will evolve in the coming future and what implications they will have for the global economy and for the energy industry.

Our report includes two levels of analysis:

1. The analysis of the current **outlook of the energy industry**, moving from the three pillars of the “Energy Trilemma” - i.e. Energy Security, Sustainability and Affordability - on the back of latest sector information, regulatory news and data;
2. The drawing of a few conclusions about the **most/least favorite business models** and industry segments (products and services), with the elements of strength (“*why they are strongly positioned to benefit from the expected industry trends*”) and potentially strategic challenges (“*why we see some risk for business models*”).

Projections provided in the following pages are often related to specific scenarios, as indicated by the International Energy Agency (IEA) in its World Energy Outlook 2025 and World Energy Review 2026: it defines two exploratory scenarios that project forward from current conditions (CPS, i.e. Current Policies Scenario and STEPS, Stated Policy Scenario) and two normative scenarios that work backward from defined goals (Net Zero Emission by 2050 Scenario, NZE, and Accelerating Clean Cooking and Electricity Services Scenario, ACCESS).

In short, these scenarios which you will find mentioned in the next chapters, can be briefly described as follows:

- **CPS** - Current Policies Scenario: This scenario is the most cautious and considers only policies and regulations already enacted into law as of 2025. It assumes no further policy changes even if governments have signaled an intention to act. Hence it generally implies a slower pace of technological deployment and integration compared to other scenarios, leading to higher levels of energy demand and emissions;
- **STEPS** - Stated Policies Scenario: It includes not only enacted legislation but also policies that have been formally proposed or “tabled”. It offers a more dynamic view of technology and market trends than the CPS but does not necessarily assume that aspirational targets are met;
- **NZE** - Net Zero Emissions by 2050 Scenario: This scenario maps a pathway to achieve net-zero global energy-related CO₂ emissions by 2050, aligned with limiting global warming to 1.5 °C, albeit the 2025 update acknowledges that exceeding 1.5 °C is now inevitable, with temperatures projected to peak at approximately 1.65 °C around 2050, and returning below 1.5 °C by 2100 through the use of carbon removal technologies;
- **ACCESS** - Accelerating Clean Cooking and Electricity Services Scenario: This scenario has been introduced in 2025, as a roadmap for achieving universal energy access by 2035 and clean cooking by 2040, prioritizing cost-effective and proven solutions.

#1 Energy Security

Energy Security is now a matter of economic and national security, demanding a three-pronged approach centred on **meeting record demand, ensuring grid stability, diversifying mineral-heavy supply chains**.

The key messages of our analysis are the following:

- **Record demand for power:** power demand is projected to grow 4x faster than overall energy use, rising by ~40-50% to 2035 depending on scenario, driven by global cooling demand, electrification (of mobility and heating) and digitalization (Data Center);
- **Mix should change dramatically with oil/coal incidence down:** by 2050 electricity demand should be 80% higher than 2024 and it should be the primary energy source for 50% of global-GDP, while oil demand should be few p.p. lower with coal demand almost halved.

Fossil fuels incidence in power generation should decline from 60% of 2024 to 20% of 2050, replaced by renewables. EU's total cumulative solar capacity reached an estimated 406 GW in 2025, above the 400 GW target set by the EU Solar Strategy in 2022;

- **The surge of Asia on both demand and supply:** in terms of geographies we witness a shift in the center of gravity toward India and Southeast Asia, which are projected to drive nearly all global demand growth through 2035 (>+30%) and with China as the "green giant" of this new era, effectively leveraging its massive manufacturing surplus to control over 80% and 85% of the world's solar PV and battery storage manufacturing at every stage of the supply chains, respectively, at prices no competitor can match;
- **There is a Chinese "bottleneck" in critical minerals' refining and technologies:** the challenge of energy security today lies in the strategic securing of supply chains for strategic minerals, where market concentration creates extreme systemic vulnerabilities.

IEA notes a critical "bottleneck" in the refining sector, where China maintains a market share of 70% in 19 out of 20 strategic energy-related minerals;

- **Global supply is stuck in bureaucratic and infrastructural (grid) bottlenecks:** massive 2,800 GW queue of solar and wind projects is waiting for grid connections, with the gridlock primarily due to a widening investment mismatch between booming power generation and lagging investment on grids.

In EU/Italy the "permitting wall" remains a primary barrier, and in the next future new solar PV installations are estimated to remain flattish, after a decade of acceleration, while we reckon Global electricity grids require an expansion of over 25 million kilometers by 2035 to connect decentralized generation and modernize a backbone that has faced decades of under-investment;

- **A second life for Natural Gas and nuclear power:** if renewables are seen to deliver over half of global generation, the supply system will require a massive scale-up of balancing technologies and a "multi-tool" approach: natural gas, hydropower, and nuclear energy are evolving from bulk generation providers into critical sources of seasonal reliability and secure backup capacity.
- **Storage (BESS & others) and flexibility (AI) is the new mantra:** Battery Storage Energy Systems (BESS) is emerging as the fastest-growing power technology, with global additions surging to over 75 GW in 2024, providing the split-second responsiveness required for frequency regulation and grid services that traditional mechanical turbines cannot match. This combines also with PSH (pumped storage hydropower), low-emission-hydrogen.

In addition, digitalization / AI act as the system's "neural network," with digitalization and demand-side response (DSR) becoming essential to mitigate rising curtailment and negative prices caused by simultaneous high output of intermittent wind and solar PV.

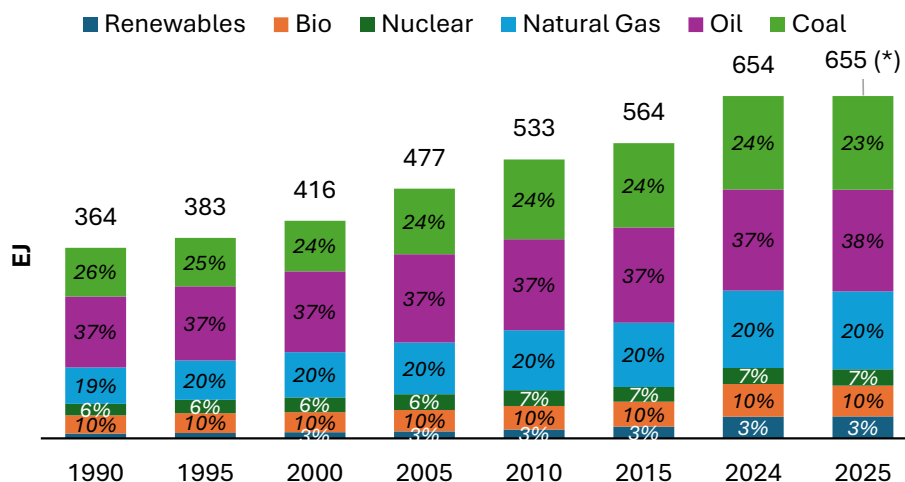
Let's now dive into the three key main themes of Energy Security, i.e. Abundance, Stability, and Supply Diversification.

Abundance

Global energy demand reached an all-time high of over 655 EJ in 2025.

This growth is driven by a **larger and richer global population**, particularly as populous low- and middle-income countries (e.g., India, Indonesia) undergo rapid urbanization and industrialization.

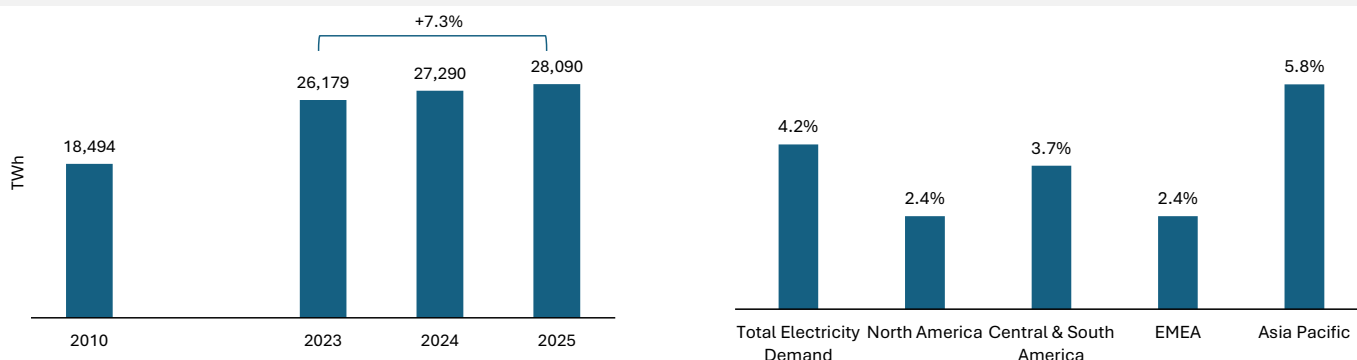
Global Energy Demand Reached an All-Time High of 654 EJ in 2024 (+2.1% y/y)



Source: IEA "World Energy Outlook 2025", Value Track Analysis, IEA "Global Energy Review 2026"
 (*) 2025 preliminary data

The current energy landscape is characterized by a structural shift toward a world that is increasingly **"thirsty for electricity,"** evidenced by a **record jump of 1,100 TWh in global demand** during 2024, (nearly twice the long-term average) and by **further 800 TWh increase in 2025**. Beyond traditional economic expansion, this surge was significantly amplified by record heatwaves that triggered an unprecedented spike in **cooling demand**, which is projected to add up to **500 GW to global peak loads** by 2035, and the early effect of **hyper-digitalization**.

Global Electricity Demand Evidenced a Record Jump of 1,900 TWh in 2025 vs. 2023 (+7.3% y/y cumulated)



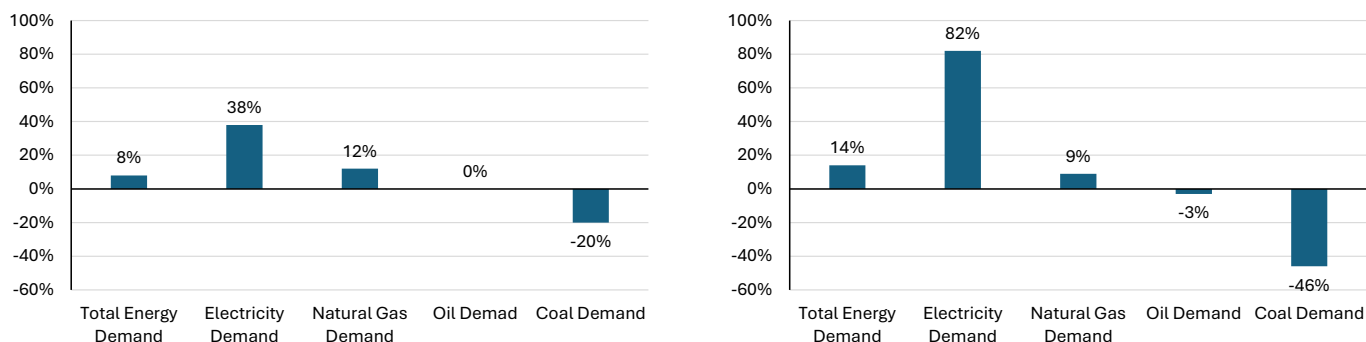
Source: IEA "World Energy Outlook 2025", Value Track Analysis

As a result, the world has entered a phase of **secular energy demand growth**, where **electricity** is no longer a background commodity but the **core engine of the global economy**, already **powering sectors representing 40% of global GDP**.

The Arrival of the “Age of Electricity” - Focus on Demand

The world has officially entered the “**Age of Electricity**,” a period where **power demand is projected to grow four times faster than overall energy use**, rising by **~40% to 2035** in both the CPS and the STEPS, and by more than 50% in the NZE Scenario.

Electricity Demand is Projected to Grow by ~40% to 2035 (4x Faster than Overall Energy Demand) and +80% to 2050

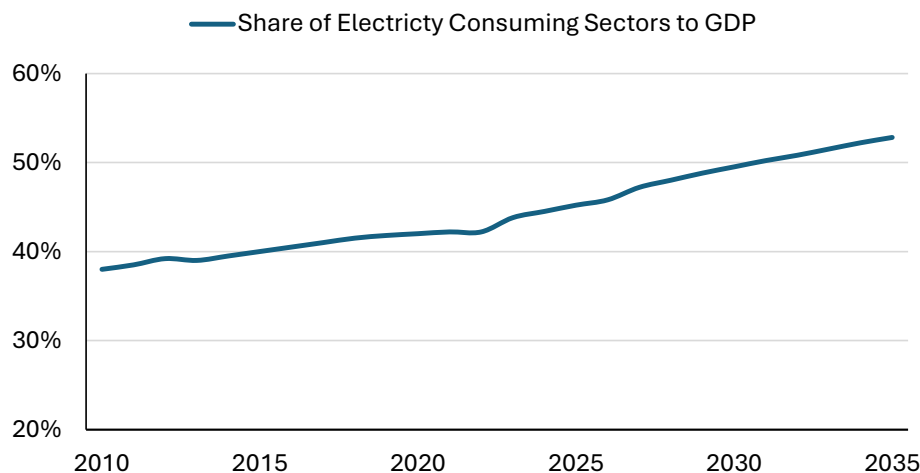


Source: IEA “World Energy Outlook”, Value Track Analysis

This structural shift is driven by the simultaneous electrification of **mobility**, **heating**, and **cooling**, alongside the explosive expansion of the **digital economy**.

Electricity already serves as the primary energy source for sectors accounting for **40%** of global GDP, a figure expected to reach **50% by 2035** as the global energy system transitions from a fuel-intensive model to a **capital-intensive** one.

Electricity Serves as the Key Energy Source for Sectors Accounting for 40% of Global GDP

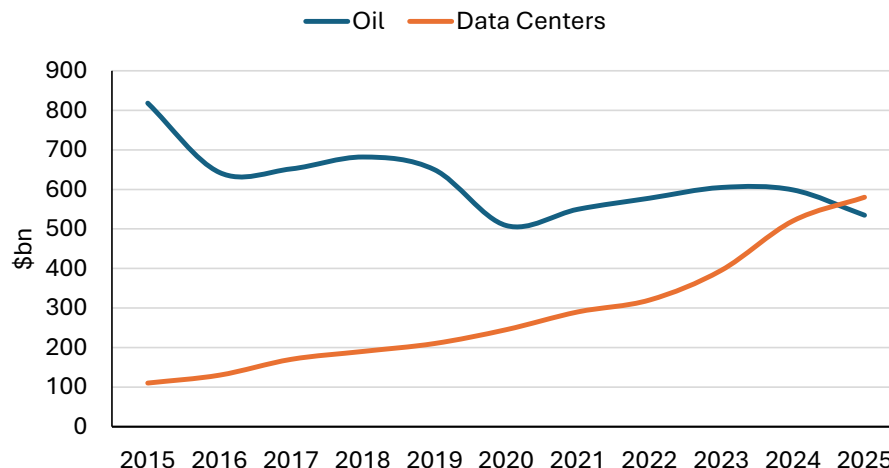


Source: IEA “World Energy Outlook 2025”, Value Track Analysis

A defining marker of this new era is the historic shift in capital allocation: annual investment in **data centers** and AI infrastructure is estimated to reach \$580 billion in 2025, **surpassing global spending on oil supply** for the first time.

While data centers represent roughly 10% of total global electricity demand growth, their impact is highly concentrated geographically, accounting for nearly **half of all demand growth in the United States through 2030**.

Annual Investment in Data Centers Surpassing Global Spending on Oil Supply for the First Time



Source: IEA, Value Track Analysis

Parallel to the digital boom, the rapid adoption of **electric vehicles** (EVs), which are set to exceed 50% of global car sales by 2035, and the doubling of **heat pump** penetration are structurally displacing millions of barrels of oil and cubic meters of gas in transport and buildings.

Finally, as global temperatures rise and incomes increase in emerging economies, **space cooling** has become a critical necessity, projected to add up to 500 GW to global peak loads by 2035.

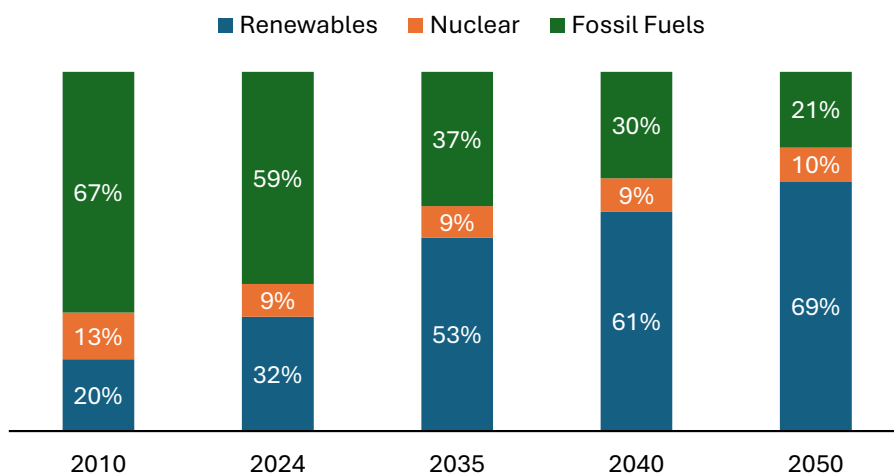
This convergence of factors confirms that electricity has evolved from a background commodity into the core engine and primary constraint of future economic growth.

A Structural Transformation of the Supply Mix is on the Way- Focus on Supply

Underpinned by state policies and regulations targeting the expansion of clean sources, the global supply mix is structurally transforming to ensure renewables capture the largest share of growth to meet a booming electricity demand.

Globally, the share of fossil fuels in power generation is projected to decline sharply from **60% in 2024 to just 20% by 2050** under IEA's STEPS. This shift is led by **renewables**, which are expected to deliver over half of global power by 2035 and two-thirds by 2050.

Fossil Fuels Share in Power Generation Should Decline from ~60% in 2024 to ~20% by 2050



Source: IEA "World Energy Outlook 2025", Value Track Analysis

This transformation is bolstered by aggressive targets in the **European Union**, such as Italy's updated PNIEC 2024, which aims to cover 63.4% of electricity consumption with renewables by 2030, up from 37% in 2022. Similarly, **China** continues to dominate global deployment, with wind and solar set to reach nearly 50% of its total generation by 2035. In contrast, the **United States** has pivoted its strategy through the One Big Beautiful Bill Act ("OBBBA") of 2025, which emphasizes domestic oil, gas, and coal alongside a nuclear renaissance and geothermal expansion while accelerating the phase-out of tax credits for wind and solar.

Despite these regional policy divergences, legacy fuels are nearing a structural peak; **global coal and oil demand are projected to peak by 2030** as **renewables and nuclear become the primary engines for growth**.

However, this clean energy surge creates a new security challenge: the demand for critical raw materials needed for these technologies is estimated to be **six times larger by 2040 than in 2022**, creating a new landscape of technological and supply chain dependencies.

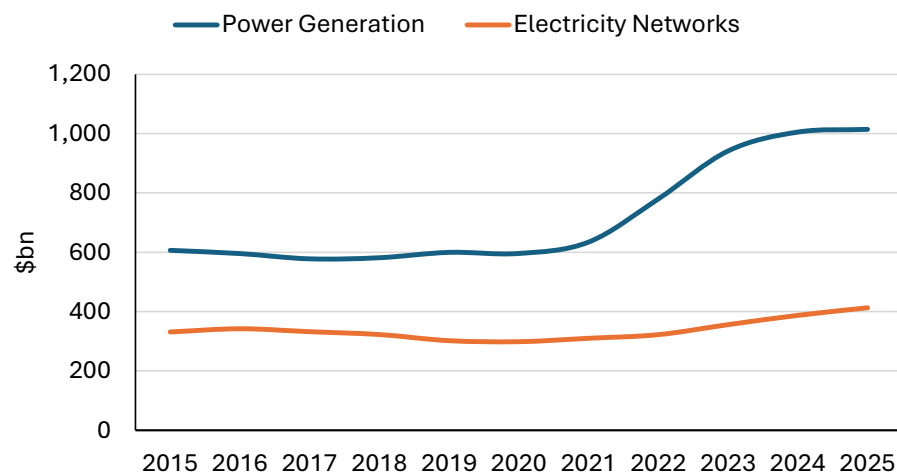
The Supply Paradox: Targets vs Bureaucracy – Focus on Bureaucracy and Grid

A significant "**supply paradox**" is emerging where ambitious energy targets are increasingly hindered by bureaucratic and infrastructural bottlenecks.

While political mandates like the **EU Green Deal** and **Italy's PNIEC 2024** set record-breaking goals, they are clashing with the physical reality of the grid. Globally, a massive **2,800 GW queue of solar and wind projects** is currently waiting for grid connections, with **1,700 GW** of these already at advanced stages of development.

This gridlock is primarily driven by a **widening investment mismatch**: for every dollar currently spent on global power generation, only 40 cents are allocated to the grids needed to carry that power, a sharp decline from the 60 cents spent in 2016.

For Every Dollar Spent on Power Generation, Only 40 Cents Are Allocated to the Grids



Source: IEA "World Energy Outlook 2025", Value Track Analysis

In the **European Union**, these system constraints are beginning to impact the pace of deployment. In **the next future, new solar PV installations** are estimated to remain flattish in the 60 GW p.a. due to system and permitting constraints.

Despite this localized slowdown, the EU's total cumulative solar capacity reached an estimated **~407 GW** in 2025, in line with the 400 GW target set by the EU Solar Strategy in 2022.

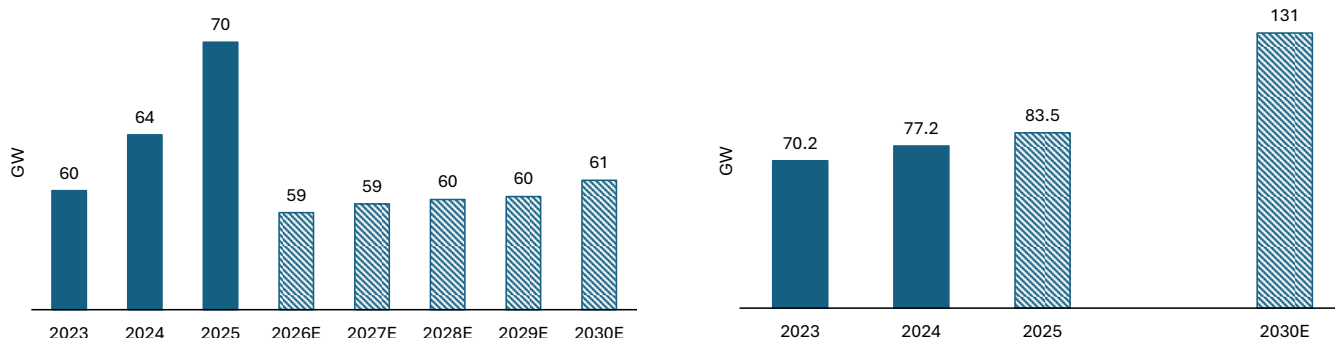
Locally, **Italy** faces an even steeper challenge as it aims for over **131 GW** of total renewable capacity by **2030** to meet its policy targets. However, the "permitting wall" remains a primary barrier; for instance, the average time to authorize a wind project in Italy is **7 years**. This delay creates significant financial risks, as projects

may "age" technologically or economically before they are even built, leading to potential **"stranded assets"**.

From an **equity perspective**, this paradox has created a massive valuation gap. There is scarce value for **"projects on paper"** that are stuck in the connection queue, while a significant premium is placed on assets that are already authorized or ready-to-build ("RTB").

As grid expansion and modernization become political priorities to prevent a power crisis, the focus is shifting from simple generation targets to solving the **permitting and connection bottlenecks** that prevent cheaper, cleaner energy from reaching consumers.

EU Annual PV Net Additions Expected to remain flattish y/y and Italy's Renewable Capacity Target at 131 GW in 2030



Source: IEA, PNIEC, Value Track Analysis

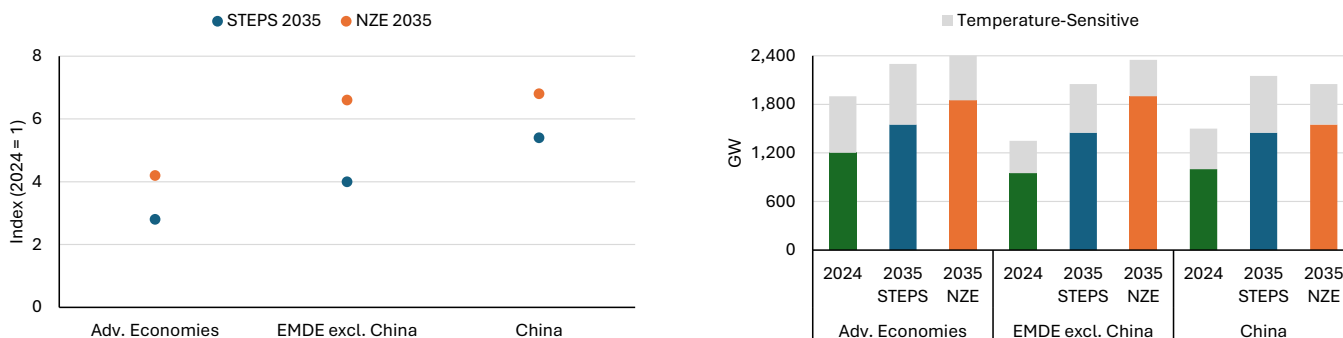
Stability

Maintaining a stable power supply amid the inherent variability of a renewable-led grid (set to deliver over half of global generation by 2035) requires a rapid and coordinated scale-up of **system-balancing technologies**.

This structural transformation triggers an unprecedented surge in global **flexibility requirements**, which are projected to grow **two- to ten-times** by 2035 to manage weather-dependent supply.

To bridge these stability gaps, the global system is shifting toward a **"multi-tool" approach**: **natural gas**, **hydropower**, and **nuclear energy** are evolving from bulk generation providers into **critical sources of seasonal reliability** and **secure backup capacity**. Simultaneously, Battery Storage Energy Systems (**BESS**) has emerged as the fastest-growing power technology, with global additions surging to over 108 GW in 2025, providing the **split-second responsiveness** required for frequency regulation and grid services that traditional mechanical turbines cannot match.

Short-Term Flexibility Needs and Peak Demand Rise Through 2035 by Scenario



Source: IEA "World Energy Outlook", Value Track Analysis

Digitalization and AI act as the system's **"neural network,"** transforming passive grids into intelligent platforms capable of predicting weather-driven fluctuations and orchestrating the "supply-demand mismatching" created by millions of decentralized prosumers. The urgency of these stability investments is underscored by the rising economic stakes of an electrified world; the 2025 blackouts in both Chile and the Iberian Peninsula served as powerful global reminders that even brief interruptions in modern, digitalized economies now carry **unacceptable social and massive economic costs.**

The New Baseload: Not Just Capacity, But Power Availability When Needed

To manage the inherent variability of a renewables-led grid, **the traditional concept of "baseload" as constant bulk production is being replaced by a diverse portfolio of dispatchable sources.** In this new energy paradigm, security of supply depends on a coordinated mix of nuclear energy, natural gas, and massive energy storage that provides the essential reliability and secure capacity required to balance the system during periods of low wind and solar output.

While the total volume of energy is becoming abundant through renewables, the nature of energy security is fundamentally changing; the focus is shifting from simply generating kilowatt-hours to providing "firmness" and flexibility, that is the ability to deliver power exactly when it is needed.

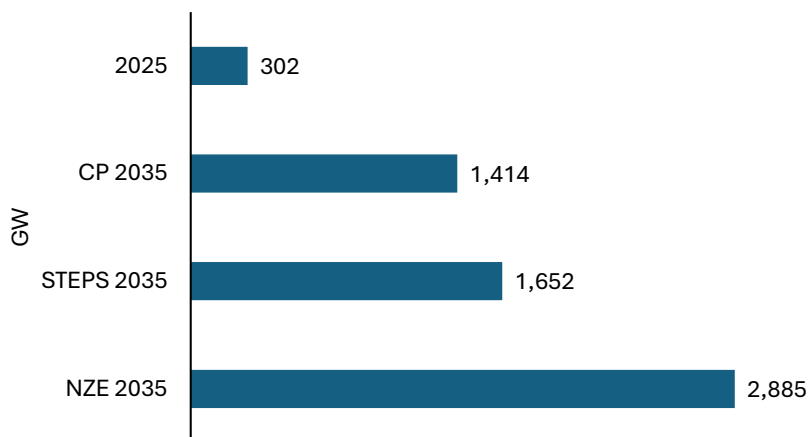
The central challenge is no longer just a technological one but a matter of managing systemic "friction points". These include grid congestion, rising curtailment (forced production cuts), and the **"cannibalization effect"** where simultaneous high renewable production crashes market prices toward zero or negative levels. These friction points are driving a significant shift in value: pure-play "merchant" solar projects are seeing their returns compressed by capture-price risks, while a significant **valuation premium is being assigned to "hybrid" assets** (wind/solar plus storage) and projects backed by well-structured, long-term power purchase agreements (**"PPAs"**) or contracts for difference (**"CfDs"**) that provide revenue certainty.

In this context, **flexibility and storage have become the "new baseload"** Value is moving from the production of the energy commodity to the provision of a dispatching service.

Storage and digitalization are no longer optional "add-ons" but have become the **pillars of project bankability.**

To ensure global grid reliability and absorb the surplus of renewable output, the **installed capacity of stationary batteries must increase 5-fold by 2035** (STEPS, while ca. 10-fold according to the NZE scenario). Without this massive growth in storage capacity, electrified economies risk facing either technical blackouts or economic ones driven by extreme price volatility.

BESS Installed Capacity to Increase by 5-10 Times by 2035 Depending on Scenarios



Source: IEA "World Energy Outlook 2025", IEA "Global Energy Review 2026", Value Track Analysis

From an **equity and investment perspective**, the transition creates clear winners: entities that invest in battery storage, owners of flexible generation (“FlexGen”) legacy assets like combined cycle gas turbines (“CCGTs”), and providers of the “digital neural network” (the aggregators and software firms that coordinate decentralized flexibility).

Conversely, non-flexible renewable portfolios that remain exposed to spot market volatility face structural IRR erosion, marking the end of the era for standalone, uncontracted intermittent assets.

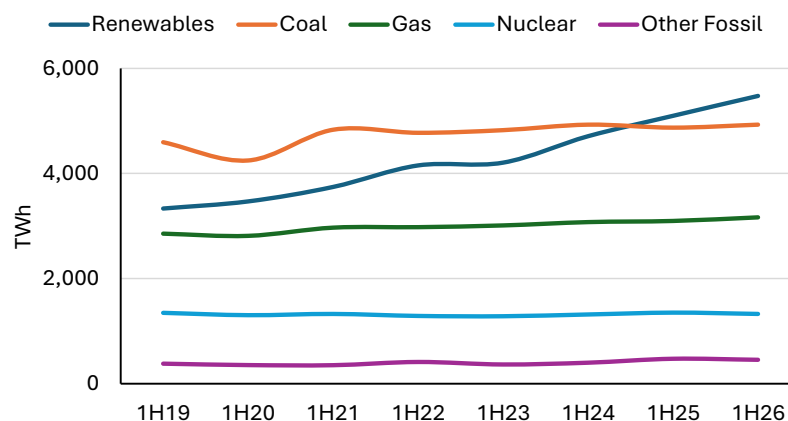
The Shifting Role of Natural Gas and Other Fossil Fuels

Natural gas is structurally evolving from a **bulk energy provider** into a critical pillar of **grid stability and seasonal flexibility** during the global energy transition. As intermittent renewables grow to dominate the generation mix (set to deliver over half of global power by 2035) natural gas use in electricity generation is projected to **increase by over 15% through 2035** (STEPS) to provide the essential firm capacity required to balance weather-dependent supply.

This transition establishes natural gas as the “value chain underdog”, where legacy assets like CCGTs are being repurposed as FlexGen resources that capture high margin returns during scarcity events rather than just selling bulk volume. In the United States, natural gas is emerging as a primary enabler of the digital economy, providing the stable 24/7 power required by **AI data centers**, which are increasingly incompatible with the intermittent nature of standalone wind and solar.

At the same time, also **coal** is facing a **stability**, with its role shifting toward providing “stress capacity” for the system. A historic milestone was reached in the first half of 2025 when global **renewable generation overtook coal’s share of the electricity mix for the first time**.

Renewables Generated More Electricity Than Coal for the First Time in 1H25



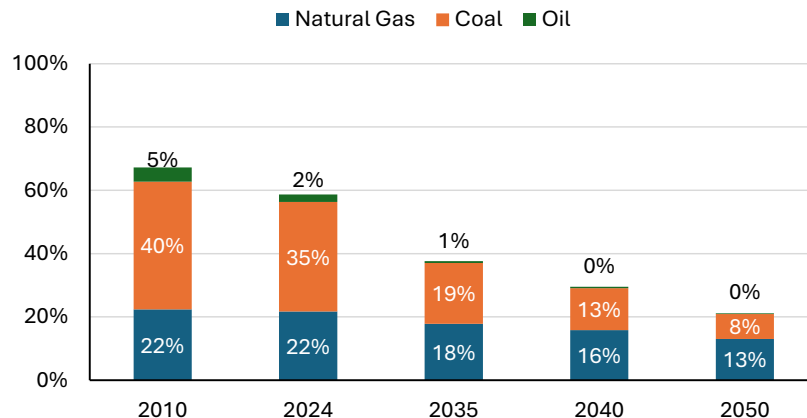
Source: Ember “Monthly Electricity Data”, Value Track Analysis

While global coal demand is expected to peak before 2030, it remains a critical source of **programmable capacity** that can be called upon when the system is under extreme stress from peak demand or low renewable output. This was evidenced in the United States in 2025, where coal generation temporarily rose by 17% to fill gaps left by a shortfall in clean power growth and higher natural gas prices. However, as carbon pricing and emission mandates intensify, **unabated coal plants are identified as primary “losers”**, with their share of global generation projected to collapse to just 20% by 2050.

Oil’s role in the power sector is becoming even more **marginalized**, increasingly serving as a fuel of last resort or a “peaker” for specific regional needs. Global oil-fired generation is set to decline rapidly, with the sharpest reductions occurring in the Middle East as countries like Saudi Arabia pursue their energy transition goals. Like coal, oil is transitioning from a bulk commodity to a source of **instant temporal flexibility** to manage sudden supply shocks that batteries cannot yet satisfy. In ambitious decarbonization scenarios, such as in the Mediterranean Basin, the demand for both coal and oil in the power sector is projected to fall to **near-zero levels by 2040** (at least in the most ambitious scenarios).

Ultimately, the entire fossil fuel complex is undergoing a fundamental shift in its revenue model: **value is moving from the production of the energy commodity to the provision of a "firmness" service**; capacity remuneration mechanisms are increasingly employed to complement short-term markets by rewarding availability and responsiveness.

Global Fossil Fuels Share in Electricity Generation According to the STEPS



Source: IEA "World Energy Outlook 2025", Value Track Analysis

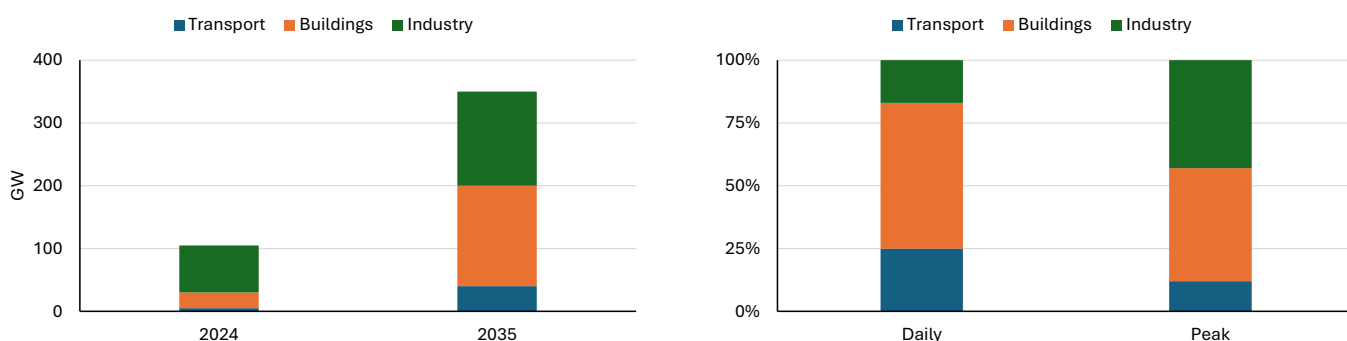
A Push in Digitalization for Energy Flexibility

Digitalization and demand-side response ("DSR") have become essential to **mitigate rising curtailment and frequent negative prices** caused by the simultaneous high output of intermittent wind and solar PV. As the generation mix becomes more weather-dependent, power markets are seeing extreme volatility and a surge in negative wholesale price events, where producers must pay to keep their plants online because the system cannot absorb the surplus. These negative prices serve as a clear economic signal of a **"flexibility scarcity"**.

Digitalization acts as the grid's **"neural network"**, transforming a historically passive system into an intelligent, real-time platform. Technologies such as smart meters, IoT sensors, and digital twins provide the observability needed to manage bidirectional energy flows from millions of decentralized prosumers. AI further enhances this capability through predictive algorithms that optimize weather-dependent supply, automate maintenance, and orchestrate virtual power plants ("VPPs")

Parallel to technical upgrades, the role of the consumer is being redefined through **DSR**, that is the capacity to reduce electricity during peak periods (enabled by assets such as EVs and smart air conditioners and heat pumps). By 2035, the activation of flexible demand is projected to grow **more than threefold**, allowing sectors like transport and buildings to shift consumption away from peak hours to periods of renewable abundance.

Demand Response Activation Increases More Than Threefold by 2035, with Sectors Share in Activation by Timeframe



Source: IEA "World Energy Outlook", Value Track Analysis

Battery and Other Storage Technologies

Serving as a versatile "multi-tool" for the grid, storage technologies provide **instant stability** through fast-acting technical services and ensure **reliability** by shifting renewable energy across various timeframes. The primary driver of this sector is the transition from an "energy-only" market to one that values "flexibility and services". Storage operators profit through "**value stacking**": combining wholesale price arbitrage (buying low, selling high) with high-margin grid stability contracts, such as frequency regulation and voltage support. The storage landscape is bifurcating to meet two distinct system needs:

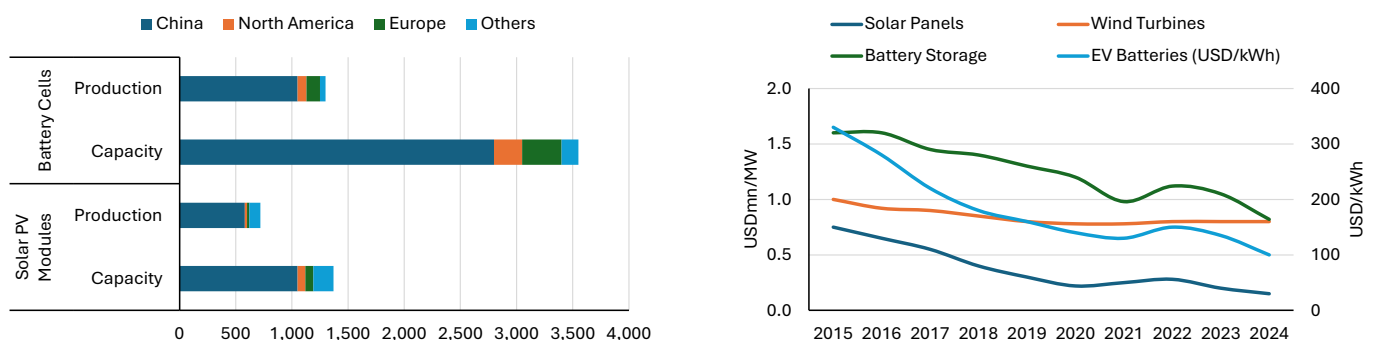
- **Short-Duration Storage:** focused on hourly volatility, providing the "split-second responsiveness" needed to manage daily solar peaks and evening ramps.
- **Long-Duration and Seasonal Storage:** focused on system resilience during multi-day or seasonal gaps where batteries alone are currently insufficient.

Battery Storage

Battery storage is the **fastest-growing power technology**, with global additions up by 40% in 2025 to 108 GW, a critical acceleration to support variable renewable integration. To ensure global grid reliability and absorb surplus renewable output, the installed capacity of stationary batteries must increase significantly: global installed capacity is projected to reach nearly **1,700 GW by 2035** under the STEPS and nearly 2,900 GW in the NZE Scenario to handle short-term flexibility. While total installed capacity is expected to reach 3,380 GW by 2050, regional pipelines vary; in Europe, the current project pipeline (aiming for approximately 160 GWh by 2030, corresponding to ca. 40 GW, or ca. 5x the levels of 2025E) currently lags behind the storage volumes needed to balance aggressive renewable growth.

This expansion is underpinned by a dramatic **70% decline in lithium-ion prices** since 2014, which has made stationary storage cost-competitive with fossil fuel alternatives in many major markets. However, the battery industry is currently characterized by a **massive manufacturing surplus**, with 2024 cell capacity reaching three **times the level of actual demand**; this oversupply drives fierce price competition but also exposes manufacturers to falling profit margins and trade tensions.

Excess Manufacturing Capacity and Falling Critical Minerals Prices Driving Major Price Reductions in Batteries and PV



Source: IEA "World Energy Outlook", Value Track Analysis

Furthermore, as the sector has shifted toward **lithium iron phosphate** ("LFP") chemistries for stationary use, new supply chain vulnerabilities are emerging. Processed materials like **purified phosphoric acid** ("PPA") remain highly concentrated in a single market, with China currently producing **100% of the global supply** of PPA and LFP cathodes. By 2035, the BESS market is likely to segment by use-case: LFP will remain the workhorse for systems up to 6 hours due to its cost and safety features, but once supply chains mature, **sodium-ion batteries** may offer a low-cost, lithium-free alternative for stationary storage, while **flow** and other long-duration chemistries will remain niche.

Other Technologies

While lithium-ion batteries dominate short-term flexibility, **pumped storage hydropower** (“PSH”) and **low-emissions hydrogen** are essential for the **multi-day and seasonal balancing** required in high-renewable grids.

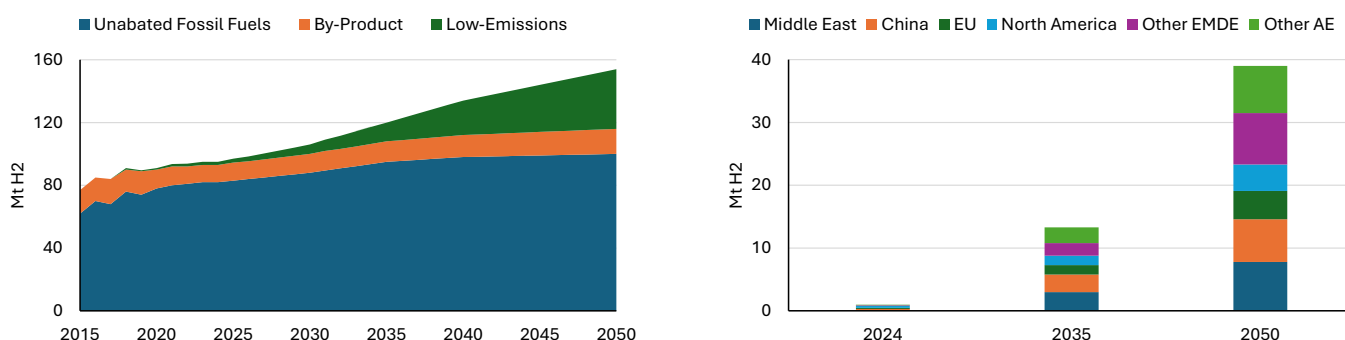
- **PSH** remains the world’s most mature large-scale storage technology, accounting for over **90% of global long-duration energy storage capacity**. It offers round-trip efficiencies exceeding 80% and possesses an operational lifespan, often surpassing 50 years.

Despite these advantages, the expansion of PSH is geographically constrained and faces significant authorization delays, making it a “historical battery” that requires immediate policy support to maintain its role in system adequacy.

- **Low-emission hydrogen storage** is a strategic pillar for seasonal storage and the decarbonization of “**hard-to-abate**” industries (steel, chemicals, maritime shipping) enabling the use of green hydrogen produced via **electrolysis** powered by renewables, nuclear, or natural gas with carbon capture.

The sector currently faces a significant deployment gap: while global production was nearly 100 Mt in 2024, **less than 1%** was derived from low-emissions sources. To meet STEPS goals, low-emissions hydrogen production must scale to **13 Mt by 2035**, requiring the global installed capacity of electrolyzers to surge from 1.5 GW in 2024 to almost 100 GW by 2035.

Low-Emissions Hydrogen is Less Than 1% of Total Production Today But Should Scale to 13-39 Mt by 2035-50 in STEPS



Source: IEA “World Energy Outlook”, Value Track Analysis

In addition to infrastructure gaps, hydrogen faces steep efficiency hurdles, with conversion and storage losses estimated to be between **45% and 70%**. To overcome these economic and technical barriers, the industry is prioritizing three primary storage pathways: **physical high-pressure storage**, **underground salt caverns** for large-scale seasonal balancing, and **ammonia** as a chemical carrier. Ammonia is particularly favored for long-distance maritime transport because it is significantly easier to liquefy and store than pure hydrogen, providing the dense energy molecule required for global trade in a decarbonized economy. Together, these technologies form the essential “buffer” required to transform variable renewable flows into a stable, 24/7 energy supply.

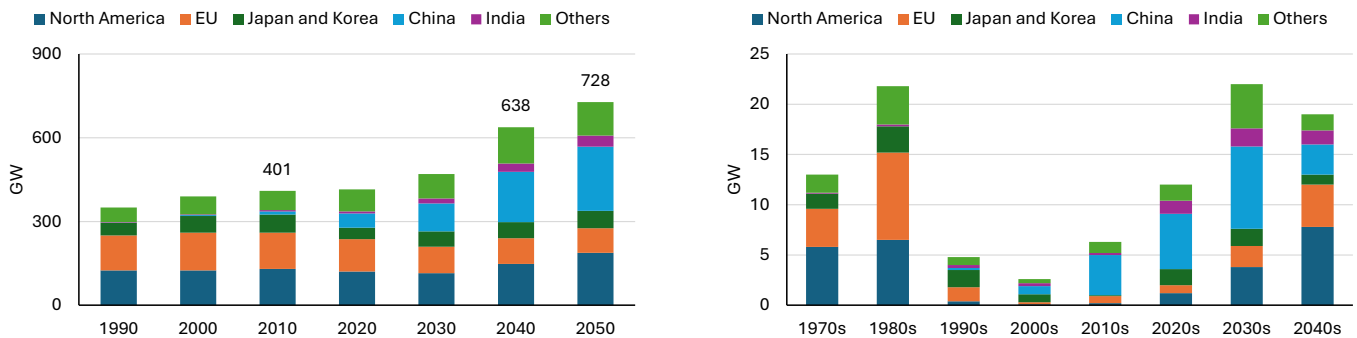
Nuclear Renaissance

Nuclear power is witnessing a definitive global comeback, repositioned as a **clean, stable**, and uniquely **scalable** energy source for heavy-demand profiles.

In 2025, global nuclear capacity reached **420 GW**, accounting for **9%** of the world’s **electricity generation** (a share that rises to **24%** within the European Union). Momentum is building with over **70 GW** of new capacity currently under construction, marking one of the highest activity levels in three decades. Driven by

this pipeline, global nuclear capacity is set to **increase by at least one-third by 2035** across all major scenarios.

Global Nuclear Capacity Set to Increase 34% by 2035 and 73% by 2050 (CPS) After a Resurgence in Average Annual Additions



Source: IEA "World Energy Outlook", Value Track Analysis

This expansion is primarily driven by five key nations: **China, France, India, Russia, and the United States**. China is on track to become the world's largest nuclear operator around 2030, while the U.S. is revitalizing its domestic industry through policy support, aiming to add 300 GW of new capacity by 2050.

Nuclear energy remains the most land-efficient technology available, occupying an area 100 times smaller than a hydroelectric plant and 10 times smaller than a rooftop PV system for the same yearly energy output.

The "AI boom" is a primary catalyst for this resurgence, as **hyperscale data centers** require constant, reliable (and possibly clean) electricity that weather-dependent renewables struggle to provide alone. Consequently, technology giants have become **nuclear "anchor customers"**, signing expressions of interest for 30 GW of **small modular reactors** ("SMRs") to provide "captive" baseload power.

SMRs, defined as advanced, factory-built units no larger than 300 MW, represent a paradigm shift designed to reduce construction risk, lower upfront capital costs, and enable the repurpose of decommissioned coal-fired power plants.

However, the sector faces critical **fuel supply chain vulnerabilities**: natural uranium production is controlled by just seven countries, and the Russian state-owned company TVEL alone holds 40% of the world's uranium enrichment capacity.

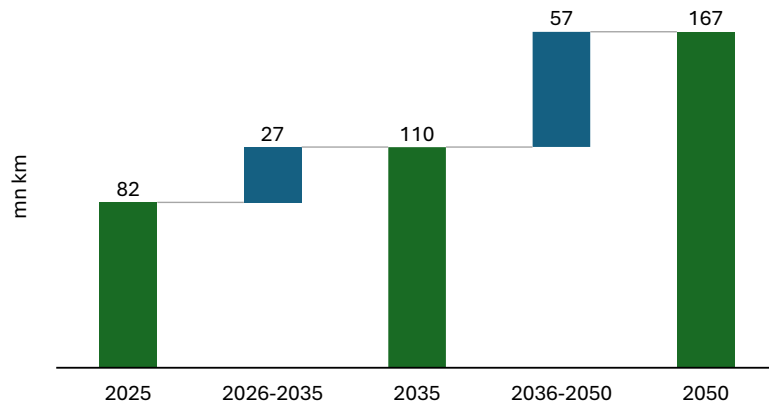
Despite these bottlenecks and the high capital costs of large-scale reactors, **lifetime extensions of existing plants** remain one of the most cost-effective low-carbon solutions at approximately 4 cents/kWh. Currently, over **40 countries** have integrated nuclear energy into their national strategies to ensure energy security and provide the carbon-free "firmness" required to balance a high-renewables grid.

The Infrastructure Supercycle to Meet Current Gaps and Stabilize Supply

Global electricity grids are entering an unprecedented "infrastructure supercycle", requiring an **expansion of over 25 million kilometers by 2035** to connect decentralized generation and modernize a backbone that has faced decades of under-investment.

While annual investment in power generation has surged by **70%** since 2015 to reach **\$1 trillion** in 2025, grid spending has lagged behind (+**25%** over the same period, reaching **\$413bn**), creating a widening investment mismatch where only 0.40 is spent on networks for every \$1 spent on generation, down from \$0.60 a decade ago.

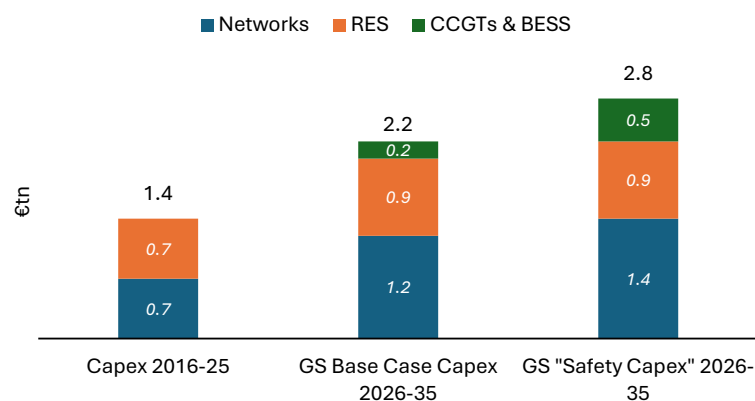
Global Electricity Grids Expanding by Over 25mn km by 2035 (Announced Pledges Scenario)



Source: IEA, Value Track Analysis

In **EU** alone, the power system requires between **€2-3tn** investment over the next decade to overhaul its **40-to-50-year-old** infrastructure (the oldest in the world) and prevent a looming power crisis as reserve margins fall toward zero. This represents a **60-100%** acceleration from the €1.4tn invested over 2016-2025.

European Power System Requiring €2tn-€3tn Investments Over the Next Decade



Source: Goldman Sachs "European Utilities & Clean Energy: Powering Up Europe", Value Track Analysis

In **Italy**, the grid acts as the ultimate "enabler" or "executioner" of the energy transition, prompting Terna to raise its 2024-28 Industrial Plan to **€16.6bn** in regulated investments, the highest in the Group's history.

This capital expenditure is focused on the "Twin Transition" (Energy and Digital), deploying a high-voltage "Hypergrid" layer and subsea links like the Tyrrhenian Link to solve the **structural bottleneck** between high renewable production in the South and heavy demand in the North.

The urgency of these investments is underscored by the rising systemic risk from **extreme weather**, with about 85% of global incidents causing operational disruptions to power lines.

However, the speed of this overhaul is threatened by severe **supply chain bottlenecks: lead times and prices** for essential components (e.g. power cables, large transformers) and key materials (copper, silver, aluminum), have nearly doubled since 2021, with procurement for transformers now extending to >4 years.

Amidst this global scramble for components, Italy has emerged as a strategic hub, currently ranking as the **world's fourth-largest exporter of power transformers**, following China, Korea, and Turkey, as global trade in these critical grid "organs" surged by 85% between 2018 and 2023.

From an equity perspective, **transmission system operators** ("TSOs") like Terna and Snam emerge as the "certain winners" of this cycle. For instance, Terna's regulatory asset base ("RAB") is projected to grow at a 9% CAGR through 2028, with returns guaranteed and remunerated by ARERA, providing highly visible, quality earnings growth in an increasingly volatile market.

Supply Diversification

Supply diversification is undergoing a **structural redefinition**, moving beyond the focus of securing fuel (oil and gas) pipeline routes to the imperative of breaking the extreme market concentration in **clean technology manufacturing** and **strategic mineral supply chains**. Indeed, the modern energy transition has elevated critical minerals (vital for power grids, batteries, and AI data centers) to the frontline of economic and national security.

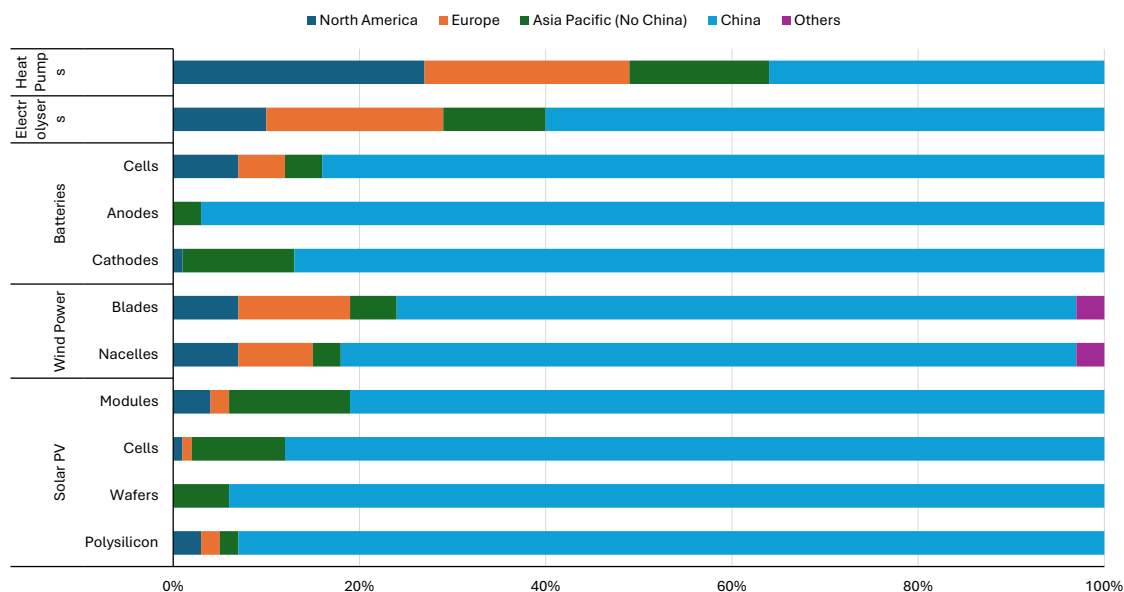
This transformation requires a simultaneous focus on **multi-fuel security** and **capital-heavy affordability**, shifting the geopolitical lens from the delivery of energy molecules to the mastery of energy technologies. Consequently, the most successful actors in this new paradigm are those capable of fostering domestic “gigafactories” and establishing resilient, diversified trade links that protect against single-source dependencies and sudden supply shocks.

The World Energy Map: Powers, Strengths and Weaknesses

The global energy map is being redrawn by a decisive shift in the center of gravity toward **India** and **Southeast Asia**, which are projected to drive **nearly all global demand growth through 2035** (>+30%).

China remains the “green giant” of this new era, effectively leveraging its massive manufacturing surplus to control over **80% and 85% of the world's solar PV and battery storage manufacturing** at every stage of the supply chains, respectively, at prices no competitor can match.

China Holds 80%-85% of Global Manufacturing Solar PV and Battery Storage Capacity

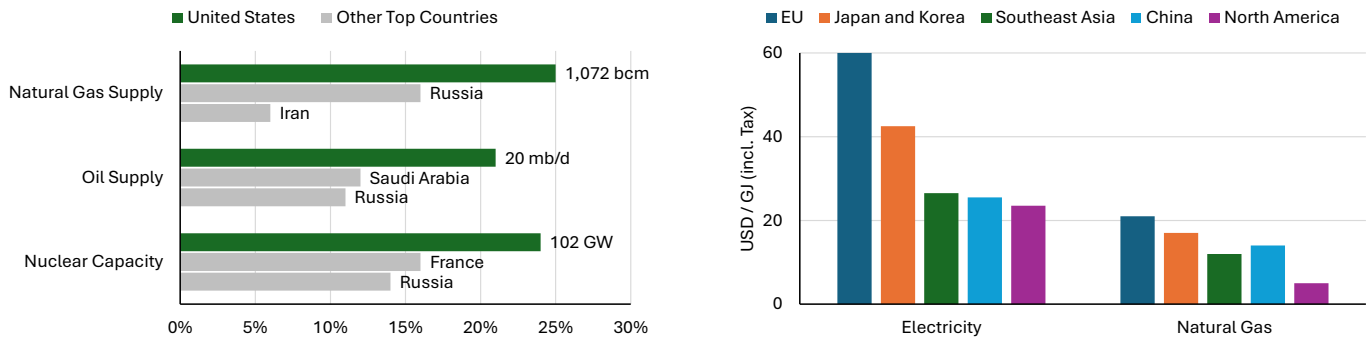


Source: IEA “World Energy Outlook”, Value Track Analysis

While the Americas, led by the **United States**, have cemented their role as the world's leading producers and exporters of both oil and natural gas, the **EU** faces a deepening **competitiveness gap**. High energy prices (with Italian industrial rates significantly exceeding the Euro area average) threaten to trigger a phase of structural de-industrialization unless the region can rapidly localize its clean-tech supply chains.

This geographic imbalance is further exacerbated by China’s “virtuous circle” of low-cost renewable technologies (surging production, falling priced, increasing demand), a sector which now accounts for **10% of its total economy**, leaving European and other Western manufacturers exposed to falling profit margins and intense price competition.

US Leader in Global Oil and Natural Gas Production and in Nuclear Capacity while EU Has the Highest Energy Prices (*)

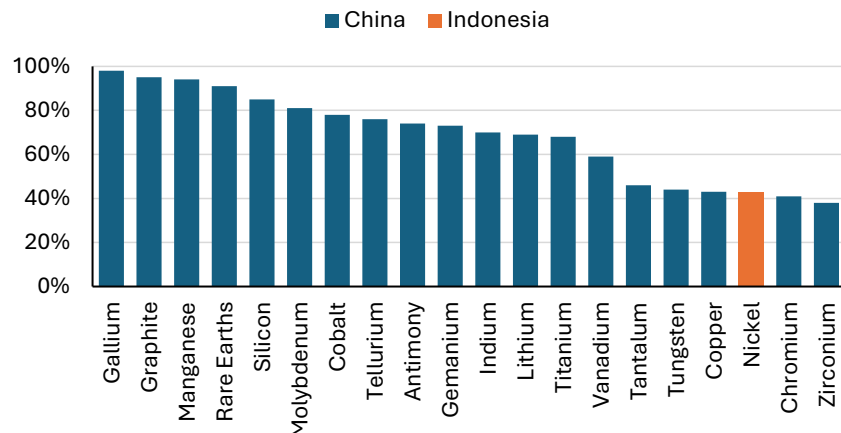


Source: IEA "World Energy Outlook", (*) End-Users Prices in Non-Energy Intensive Industries in 2024, Value Track Analysis

A New Dimension of Energy Security: From Pipelines to Critical Minerals and Technologies

Energy security has expanded into a multi-dimensional challenge, evolving from the physical protection of pipelines to the strategic securing of supply chains for strategic minerals where **market concentration creates extreme systemic vulnerabilities**. The IEA notes a critical "bottleneck" in the refining sector, where a single country (China) currently maintains an **average market share of 70% in 19 out of 20 strategic energy-related minerals**. This concentration risk became a "hard reality" in 2025 with the proliferation of export controls on rare earth magnets threatened the construction of over 650 hyperscale data centers, or 6.2 mn conventional cars, or ca.1 mn industrial motors, or 230k civilian aircraft.

China is the Leading Producer of 19 Out of All the 20 Energy-Related Strategic Minerals



Source: IEA "World Energy Outlook", Value Track Analysis

To mitigate these risks of economic coercion, major economies are shifting toward "friend-shoring" and circularity mandates to ensure **technological sovereignty**. Indeed, the EU's 2024 **Critical Raw Materials Act** has established non-binding but definitive benchmarks, targeting at least 40% of its mineral demand to be processed domestically and mandating that no single supplier provide more than 65% of any strategic material. Simultaneously, the United States is utilizing its **Defense Production Act** and the **One Big Beautiful Bill Act** to finance domestic processing facilities and restrict the influence of foreign entities on critical infrastructure. These strategies are pushing the "mineral frontier" into Africa and South America, where resource-rich nations like the DRC and the "lithium triangle" (Argentina, Bolivia, and Chile) are being courted as strategic alternatives to current dominant refiners.

Ultimately, in the "Age of Electricity," **energy security is no longer determined by who owns the fuel, but by who controls the material and manufacturing basis** of the transition.

#2 Energy Sustainability

Affordability, supply security, and decarbonization are all priorities in the energy sector. However, the observed slowdown in progress toward net zero suggests that some stakeholders are currently prioritizing affordability and supply security over decarbonization. Yet, this may be seen as a cyclical swing of priorities along the global energy transition process and should not distract from the primary long term objectives. The imperative for this transition is underscored by the fact that **2024 was the hottest year on record**, followed by 2023 and 2025, marking the first time global temperatures exceeded 1.5 °C above pre-industrial levels for an entire calendar year.

To navigate this crisis, long-term sustainability hinges on **achieving net zero emissions by mid-century** and the Net Zero Emissions (“NZE”) Scenario outlines a global pathway centered on four essential pillars: (i) **clean electrification**, (ii) doubling the annual rate of **energy efficiency improvements to 4%**, (iii) scaling **low-emissions fuels**, and (iv) achieving an **80% reduction in methane emissions** by 2035.

While **renewables are the primary engine** of this shift (as deeply analyzed in the previous chapter), achieving absolute sustainability requires:

- A complex portfolio of **innovative technological solutions** to address the inevitable temperature overshoot;
- Sustainability transitioning from a purely environmental goal to a structural economic requirement, where **material efficiency and circularity** are as critical as the energy source itself;
- Maximizing the existing infrastructure “value” (i.e. power), via **repowering and revamping** policies, with no further land usage.

Innovative Clean Technologies Beyond Renewables

Technology innovations, both incremental and breakthrough, are also shaping the future energy mix. Since 2015, several technologies have exceeded expectations, including batteries, electric vehicles (EVs), liquefied natural gas, shale oil, and solar photovoltaics. Conversely, some technologies are taking longer to mature despite initial enthusiasm, such as carbon capture and storage and clean hydrogen.

Scaling **“hard-to-abate” decarbonization** requires the rapid commercialization of innovative technologies that move beyond simple electrification to address **high-temperature heat** and **chemical feedstock** requirements.

While solar and wind now dominate the power sector, industries like **steel, cement, chemicals, and long-haul shipping** remain difficult to decarbonize through “electrons” alone due to technical inefficiencies or process-inherent emissions.

Consequently, the most likely decarbonization pathway for these sectors is the one that proves most **cost-effective** within specific regional constraints, shifting the focus from simple power generation to a complex portfolio of **low-emissions molecules and “clean firm” power**.

This transition marks a new phase of the energy system where the goal is no longer just producing clean energy, but mastering the technologies required to manage **residual emissions** and provide stable, carbon-free energy for the most energy-hungry segments of the global economy.

Hydrogen

Hydrogen is a **versatile energy vector** that is transitioning from a niche industrial application to a structural pillar of the global energy system. Unlike electricity, which is difficult to store in large quantities over long periods, hydrogen is a **storable** and **transportable** molecule.

Its primary “business case” is twofold: first, the decarbonization of **“hard to abate”** sectors (e.g., steel, cement, chemicals, and heavy maritime or aviation transport) where direct electrification is technically inefficient due to the extreme process temperatures required (e.g., above 400°C) or the need for chemical feedstocks. Second, it serves as the only viable large-scale “energy battery” for seasonal balancing, capable

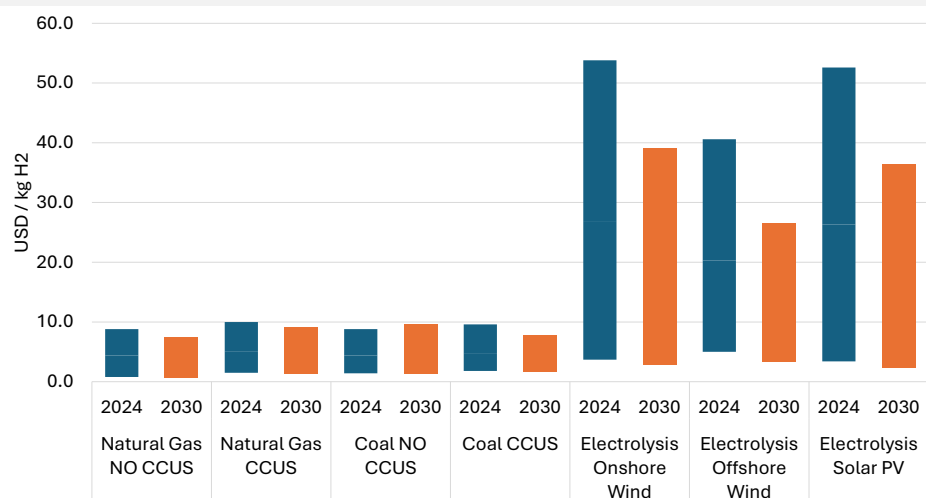
of shifting curtailed renewable energy across weeks or even months to fill the winter “dunkelflaute” (dark, windless periods), a requirement that current lithium-ion batteries, which typically manage only 4-to-8-hour shifts, cannot technically or economically meet.

In the most ambitious scenario (**NZE**), low-emissions **hydrogen production** is projected to scale from less than 1 Mt today to **125 Mt by 2035**, eventually meeting roughly **10% of total final energy consumption by 2050**.

Despite this strategic potential, the pace of adoption has not yet met initial expectations, with a significant **deployment gap**. Indeed, while total hydrogen production reached nearly 100 Mt in 2024, **less than 1% was derived from low-emissions sources**. This was due to a couple of factors:

- **Cost Challenge:** green hydrogen (produced via electrolysis powered by renewables) currently costs **at least three times more** than traditional grey hydrogen produced from fossil fuels. To bridge this affordability gap, “blue” hydrogen (natural gas equipped with carbon capture, utilization, and storage, or “CCUS”) is recognized as an essential near-term lever to enable industrial value chains to scale at lower costs until renewable electricity surpluses are sufficient to drive mass electrolysis.
- **Efficiency Losses:** hydrogen suffers from inherent conversion losses, with current storage and energy conversion performance estimated at just **30% efficiency** (representing a 70% energy loss);
- **Infrastructure Need:** the immediate scaling of the hydrogen economy depends on massive infrastructure development, requiring global electrolysis capacity to surge from 1.5 GW in 2024 to almost 100 GW by 2035. A critical component of this expansion is the deployment of dedicated pipelines to connect production hubs with industrial consumers and seasonal storage sites, such as underground salt caverns.

Levelized Cost of Hydrogen Production (Ranges) in 2024 and in 2030 (STEPS)



Source: IEA, Value Track Analysis

In the **European Union**, the strategy focuses on ensuring energy sovereignty by building a cross-border European Hydrogen Backbone (“EHB”). Under the REPowerEU plan, the EU aims for **20 million tonnes of renewable hydrogen by 2030** (10 Mt domestic production and 10 Mt imports). To finance this, the European Hydrogen Bank was established to provide fixed-premium auctions to de-risk projects. A critical infrastructure project is the 3,300 km “**SouthH2 Corridor**” which will connect North Africa and Southern Italy to German and Austrian industrial hubs, potentially satisfying **40% of the EU’s hydrogen import targets**.

Locally, Italy is positioning itself as a Mediterranean hydrogen hub, supported by €3.64bn in PNRR funding and the development of strategic “gigafactories”. This local momentum is visible across two main fronts:

- **Hydrogen Valleys:** Italy is investing **€500mn** to transform disused industrial areas into “hydrogen valleys”, multifunctional platforms to test integrated production and transport. Notable projects include the Energy & Hydrogen Valley in Mantua, which received the highest national PNRR grant to

produce **1,500 tonnes of green hydrogen annually**, and the Puglia Green Hydrogen Valley, which will utilize a **100 km dedicated pipeline** to decarbonize the Taranto industrial pole;

- **Manufacturing Sovereignty:** To ensure technological independence, Italy is developing domestic manufacturing capacity for electrolyzers. A primary example is the first Italian Gigafactory in Cernusco sul Naviglio, a joint venture between **Industrie De Nora** and **Snam**, which aims to produce up to **2 GW of electrolysis capacity per year** by 2026.

By integrating these large-scale production sites, specialized transport corridors, and chemical carriers like **ammonia** (favored for long-distance shipping due to easier liquefaction), hydrogen provides the essential molecular “buffer” required to stabilize an energy system increasingly led by variable renewables.

Other Emerging Technologies

Breakthroughs in other clean technologies are indispensable for removing residual emissions and accelerating the pace of energy innovation required to meet a 1.5 °C pathway.

While clean electrification and renewables drive the bulk of near-term reductions, closing the circle of net-zero requires a **suite of technologies capable of managing “unavoidable” emissions** and providing carbon-free stability that standard solar and wind cannot deliver alone.

This technological frontier represents a shift from energy abundance to **technology sovereignty**, where the focus moves beyond simple energy generation to mastering the complex systems required to stabilize a decentralized, weather-dependent grid.

Among the most promising or already available, we flag the following.

Carbon Management and Negative Emissions

Managing the carbon cycle requires a two-pronged approach: capturing emissions at the industrial source and removing legacy CO₂ directly from the atmosphere:

- **Carbon Capture, Utilization, and Storage (“CCUS”):** primary lever for decarbonizing sectors like cement and chemicals where CO₂ is an inherent process byproduct. To reach NZE climate goals, global capture capacity must scale 50-fold by 2035, reaching over 2,200 Mt annually;
- **Direct Air Capture (“DAC”) and Bioenergy with CCS (“BECCS”):** these “negative” emissions technologies are essential for addressing the inevitable temperature overshoot above 1.5 °C. While currently expensive and energy-intensive, they are considered a structural necessity for the second half of the century to return warming to safe levels. In Italy, the industrialization of these pathways is centered on the Ravenna CCS project, which aims to store 4 Mt of CO₂ annually by 2030 by utilizing exhausted offshore gas fields;

Firm Low-Carbon Power: The Return of Nuclear and Geothermal

High-reliability sectors, particularly the booming AI data center industry, are driving a resurgence in dispatchable, 24/7 emission-free power sources, such as:

- **Small Modular Reactors (“SMRs”):** these units, typically under 300 MW, represent a paradigm shift designed to reduce the high upfront costs and 15-year lead times of conventional nuclear through factory-based mass production. These units are uniquely attractive for AI data centers, which require massive, constant electricity and are increasingly signing long-term agreements for captive nuclear power;
- **Next-Generation Geothermal:** advanced drilling and stimulation techniques are transforming geothermal from a niche resource into a dispatchable baseload source. Italy possesses vast untapped potential, with an extractable capacity estimated at up to 116,000 TW, far exceeding the nation's annual demand (~300 TW);

Molecular Decarbonization: Bioenergy and E-Fuels

Complementing the hydrogen economy discussed in the previous section, sustainable molecular carriers are essential for sectors where batteries are technically insufficient:

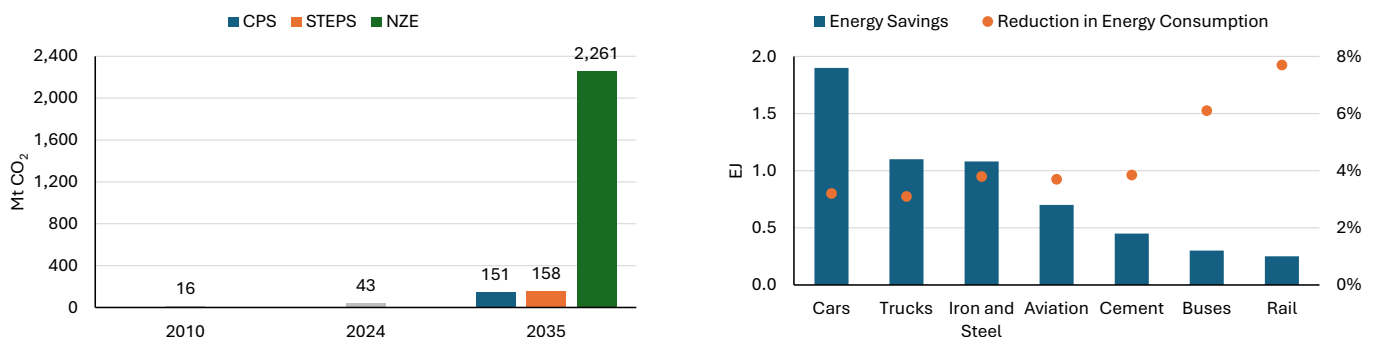
- **Modern Bioenergy:** sustainable biogas and biomethane offer a “drop-in” replacement for natural gas in existing infrastructure. Expanding their use in the EU could save over \$2 billion in annual fuel import costs by 2035 while utilizing existing organic waste streams;
- **Hydrogen-Based Fuels:** beyond pure hydrogen, derived molecules like green ammonia and synthetic methanol are necessary to provide the energy density required for long-haul maritime shipping and aviation.

The Storage Spectrum and Digital Intelligence

Ensuring grid stability in the “Age of Electricity” requires expanding storage beyond the 4-hour limit of lithium-ion and deploying AI to manage system complexity:

- **Hydroelectric Pumping (“PSH”):** as the world’s most mature long-duration energy storage (“LDES”) technology, pumped hydro remains the backbone for multi-day and seasonal balancing, especially in mountainous regions like Italy;
- **Innovative LDES Pathways:** Italian innovators are scaling three primary alternatives: Energy Dome’s liquid CO₂ batteries (75% efficiency at half the cost of lithium), Sinergy Flow’s sulfur-based redox flow batteries (offering 20-hour storage), and Magaldi’s sand-based thermal storage (storing heat at >600°C for industrial use);
- **AI-Driven Efficiency:** AI serves as the “digital brain” of the transition, with the potential to boost energy efficiency by 3%-8% by 2035 through real-time load optimization, predictive maintenance, and the synchronization of millions of decentralized prosumers.

Global Capture Capacity to Reach 2,260 Mt (NZE) and AI Potentially Boosting Efficiency in Transport and Industry by 3%-10%



Source: IEA “World Energy Outlook”, Value Track Analysis

Circular Economy

A circular approach to energy management is the critical link between environmental sustainability and energy security, serving as a structural imperative to ensure technology sovereignty in a resource-constrained world.

While the previous sections focused on the transition to clean energy sources, the circular economy addresses the material reality of that transition: the **global economy is currently only 7.2% circular**, a decline from 9.1% in 2018, even as total material consumption (now around 100bn tons of materials per year) is projected to double by 2050.

Accelerating the transition to circularity is no longer just an environmental goal but a geopolitical necessity: it could **reduce virgin material extraction by over one-third** (~34%) and significantly lower greenhouse gas emissions while enhancing energy independence.

By maximizing technical efficiency and resource recovery, the circular model transforms waste from a liability into a domestic “strategic mine” mitigating the risks of supply chain concentration and ensuring that the “Age of Electricity” remains both affordable and resilient.

Waste-To-Energy: Decarbonizing Through Molecular Circularity

Biogas and **biomethane** represent the **circularity of energy molecules**, utilizing organic waste to provide a domestic, “drop-in” and fully green substitute for natural gas while simultaneously solving waste management challenges.

Biomethane is a strategic pillar because it can be injected directly into existing gas networks, allowing for the decarbonization of “hard-to-abate” industrial processes and residential heating without requiring immediate, expensive hardware overhauls.

Globally, the potential for sustainable biogases production is estimated at nearly **1tn cubic meters** of natural gas equivalent, yet only **5%** of this potential is currently being used. However, the European Union makes use of around **40%** of its biogas potential (more than any other region), with domestic biomethane production projected to save over **\$2bn** in annual fossil fuel import costs by 2035.

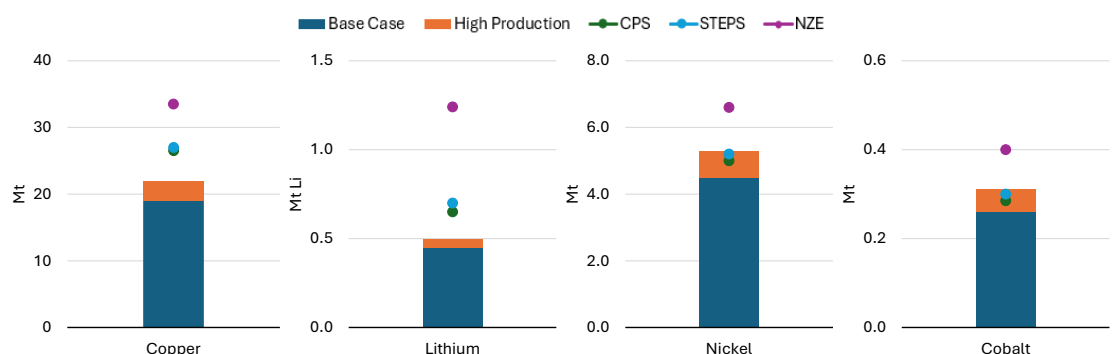
In Italy, the biomethane sector is a central pillar of the National Integrated Energy and Climate Plan (“PNIEC”), supported by **€1.92bn** in PNRR funding. The nation’s potential is calculated at **6.5bn cubic meters**, which could satisfy a significant portion of current gas demand. The Italian strategy focuses on two primary feedstock streams: organic portion of solid urban waste (“FORSU”), which turned **7.4 Mt of waste into energy** in 2021 (up from 2.7 Mt in 2006), and the agricultural sector, which aims to direct at least **65% of livestock effluents** to biogas production by 2030.

These projects provide more than just energy; they offer a “triple win” by **reducing methane emissions** from landfills, **producing nutrient-rich compost** as a natural fertilizer, and **strengthening the economic resilience** of rural communities.

Enhanced Recycling: Bridging the Critical Mineral Gap

Enhanced recycling of materials like copper and lithium is essential to **mitigate the significant supply shortfalls** projected for the next decade as the global scramble for transition technologies intensifies. For instance, current project pipelines for **copper** suggest a potential **30% supply gap by 2035** under stated policies, a figure that rises to **over 40%** in more ambitious net-zero scenarios.

Primary Supply Requirements and Expected Supply by Scenario in 2035



Source: IEA “World Energy Outlook”, Value Track Analysis

The IEA warns of a widening gap between the rapid demand for clean technologies and the long lead times (often exceeding ten years) for new primary mining projects. In this context, recycling serves as a critical “domestic mine,” offering a supply source that is less vulnerable to the high geographic concentration of primary refining, where a single country often controls **70%** of the market.

For instance, by meeting EU recycling targets, Italy could recover approximately **17,000 tons** of critical raw materials, equivalent to **25%** of its current imports from China (2021 data).

Hence, the burgeoning volume of end-of-life clean energy hardware represents a massive future opportunity for “urban mining”. Estimates indicate that the world will face **78 Mt** of photovoltaic waste by 2050, containing precious amounts of silver, silicon, and copper. Innovative Italian companies like 9-Tech and Feragame are already developing automated, thermal-mechanical processes capable of recovering nearly **100%** of a solar panel’s weight.

Beyond solar, the recycling of exhausted EV batteries could meet over half of the European electrical mobility demand for lithium (**52%**) and cobalt (**58%**) by 2040, drastically reducing environmental degradation from new mining operations.

To secure these benefits, the **Critical Raw Materials Act** has mandated that at least **25%** of the EU’s annual consumption of strategic materials must come from domestic recycling by 2030, transforming waste management into a core component of national energy security.

Maximizing Existing Infrastructure: The Repowering Lever

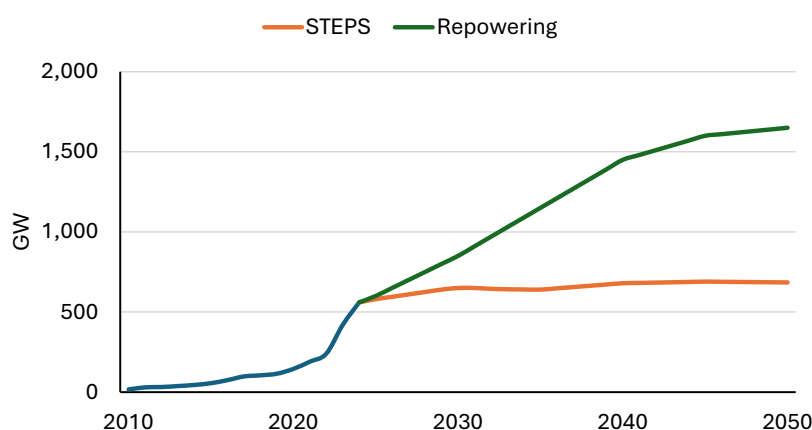
Repowering and revamping existing solar PV and wind sites with modern technology serves as another significant lever of the circular economy, **boosting energy output without increasing the land footprint**.

This strategy involves replacing 10-to-15-year-old modules with state-of-the-art high-efficiency panels, effectively rejuvenating the energy system’s backbone. Because modern solar cells are roughly **40% more efficient** than those installed in 2010, this technological refresh can boost electricity output by **~15%** from solar PV globally while utilizing existing land and grid connections., reducing the Levelized Cost of Energy (“LCOE”) by up to **20%**.

In addition, **repowering allows developers to bypass the bureaucratic wall of new permitting**, which currently averages seven years for Italian projects, making it one of the fastest routes to meeting 2030 decarbonization targets.

Accelerated repowering also serves as a critical strategy to maintain system adequacy and reach 2030 targets without controversial new transmission corridors. In the solar sector, shortening replacement schedules could expand the global PV market by up to **60%** by 2035, even without adding new operational capacity.

Accelerated Repowering Could Increase the Global PV Panel Market Size by Up to 60% in 2035 vs STEPS



Source: IEA “World Energy Outlook”, Value Track Analysis

This approach aligns with the Italian PNIEC’s focus on “system adequacy” ensuring that existing infrastructure remains young and efficient.

Ultimately, by maximizing the utility of existing assets, the circular economy ensures that the transition to the Age of Electricity is not just clean, but also land-efficient and economically optimized.

#3 Energy Affordability

The world is falling short of meeting the Paris Agreement’s targets for emission reduction and without affordability—and bankability—widespread adoption of new low-carbon technologies will not happen.

Affordable energy is fundamental to social and economic well-being, underpinning everything from household comfort and mobility to industrial productivity and national competitiveness.

For many nations, high energy prices can crash an economy and cause social tension, making the predictability of costs as vital as the clean nature of the energy itself. Ultimately, achieving equity means ensuring that the benefits of the transition (such as lower marginal costs) are shared across all social strata while providing investors with the regulatory certainty needed to fund a €3 trillion infrastructure super-cycle.

The transition to the "Age of Electricity" is fundamentally altering the economic landscape of energy provision by shifting the system's risk profile from operational-expense (fuel-based) to capital-intensive (infrastructure-based) models. This structural "flip" creates a causal chain where the high upfront costs of clean technologies dictate the affordability of energy for those who supply it, those who consume it, and those who finance its expansion.

Suppliers Affordability

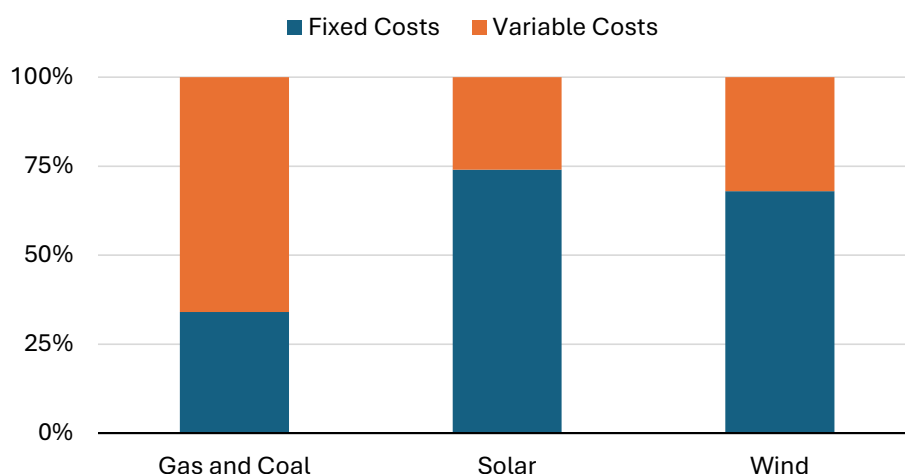
The "affordability" of the energy system for suppliers is defined by their ability to recover massive upfront investments through stable, long-term revenue streams.

Operating today’s global energy system costs approximately USD 7 trillion annually, a figure that includes the maintenance of existing assets and the financing of new grids, power plants, and LNG terminals.

Energy suppliers are currently navigating a profound transformation in their business models, as the traditional risk of fuel price volatility is replaced by the logistical and financial challenges of an infrastructure-heavy grid.

In the legacy fossil-fuel model, fuel and carbon costs accounted for roughly 75% of a project’s lifetime expenses, meaning revenues largely tracked variable operating costs. By contrast, **in the renewables-led system, upfront capital represents over 67% of total costs**, forcing suppliers to operate in a market where the “marginal cost” of energy (the price to produce one additional kilowatt-hour) frequently drops to zero.

Cost Composition of Power Generation Technologies in Europe and the United States in 2025



Source: IEA “World Energy Market Design”, Value Track Analysis

The Capital Recovery Mechanism

Suppliers' investments in energy infrastructure are not paid for instantly but are recovered gradually over the economic lifetime of the assets through consumer energy bills. This process is built into the average cost of energy, which comprises four critical components:

- **Capital Recovery** (Annuities): payments made over decades to recoup the initial multi-billion-dollar investments in generation and storage;
- **Fuel and O&M Costs**: the ongoing variable expenses for commodity procurement and the maintenance of physical hardware;
- **Emissions-Related Costs**: carbon taxes or allowance prices (European emissions trading system, or "ETS"), though these revenues are often recycled back to consumers through government policy;
- **Grid Tariffs**: a specific component of end-user prices that reflects the capital recovery for the expansion and replacement of transmission and distribution networks.

As the system electrifies, grid costs are becoming an increasingly explicit and significant component of the price paid by end-users. Because grid expansion has not kept pace with generation, suppliers face rising costs for system adequacy and congestion management.

Suppliers must ensure that the rate-setting process for these regulatory asset bases ("RAB") provides a fair return (typically around 10% ROE) to maintain their own financial health while avoiding price shocks that could trigger political and social tension.

Integrated Energy Services: from Volume to Management

To manage the risks of high upfront investments and volatile spot prices, suppliers are transitioning from simple "kWh retailers" to integrated service providers.

Indeed, the evolution towards renewables has introduced the "**cannibalization effect**", where simultaneous high output from wind and solar during peak hours pushes market prices into negative territory, a phenomenon that occurred for an average of 308 hours across the EU in 2024.

Consequently, **suppliers are pivoting from selling "naked" energy (kWh) to providing integrated energy services such as grid stability, flexibility, and ancillary solutions.** This pivot is supported by the rise of FlexGen (gas plants and batteries) and capacity remuneration mechanisms, which address the "missing money" problem by paying generators for their availability to the grid rather than solely for the electricity they produce.

Consumers Affordability

While electricity prices vary significantly between consumer groups and countries because of differing resources, technologies, regulations, taxes and subsidies (with households often facing higher prices than industrial consumers) their development over time typically reflects the average cost of supplying a unit of electricity.

Today, oil and electricity dominate household energy bills, accounting for ~50% and ~30% respectively of the total. However, the structural shift toward electric mobility and heating is **increasing consumer sensitivity to electricity price fluctuations.**

The Financing Barrier: Transitioning from Opex to Capex

While household energy bills in advanced economies are projected to fall by 2035 due to the superior efficiency of electric technologies, a new "**financing barrier**" has emerged.

Affordability for the modern consumer depends not only on the price per kilowatt-hour (the operating cost of buying fuel) but on the **ability to finance the high upfront capital costs** to buy efficient equipment (such as heat pumps and EVs) required to access lower long-term operating costs.

Vulnerable segments in the lowest income decile can spend over 30% of their disposable income on residential energy services.

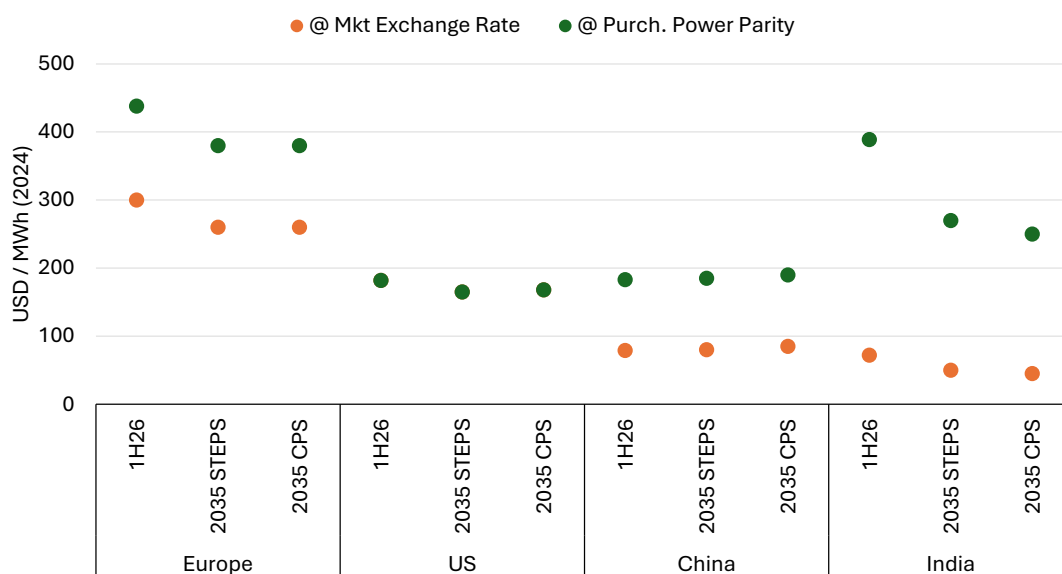
In ambitious net-zero scenarios, targeted support and subsidies for clean technologies could reduce this energy burden to less than 20% of income by 2035.

Market Design and the European and Italian Price Disparity

Household energy bills typically reflect commodity prices and energy delivery costs, but they are also affected by policy and market design: taxes, subsidies and environmental surcharges can substantially influence the final price paid by consumers. Residential electricity prices vary significantly across countries and regions:

- **Europe** has some of the world’s highest prices, which are projected to decline slightly by 2035 in both scenarios as the share and the fuel price of natural gas-fired generation declines;
- **United States’** prices remain significantly lower than in Europe due to many factors, including significantly lower costs for natural gas-fired generation;
- **China and India** boast significantly lower prices than in most advanced economies, although the differences are smaller after adjusting for purchasing power parity. These prices, however, are more tightly regulated and do not always fully reflect actual costs.

Residential Electricity Prices Vary Significantly Across Countries and Regions



Source: IEA “World Energy Outlook”, Value Track Analysis

A fundamental hurdle to reducing these costs is the current market design, which “couples” the price of clean energy to volatile fossil fuel markets through marginal pricing. Under the European “pay-as-cleared” mechanism, the hourly market price is set by the last and most expensive unit needed to meet demand, which is typically a natural gas plant. For instance, in 2022, natural gas set the EU day-ahead wholesale electricity price around 60% of the time, despite generating only 20% of electricity, meaning that even when renewable production is high, gas price spikes directly inflate consumer bills,

In 1H26, Italian domestic electricity prices were ca. €0.35/kWh i.e. 13% higher than the Euro area average. This gap is driven by a high energy component and an escalating fiscal burden. Indeed, pure energy supply costs account for only 50%-60% of total HH bill, with the remaining being System Charges, Transport and Meter Management, Taxes and VAT.

In addition, the rising share of intermittent renewables is driving higher **intraday price volatility**, as seen in Germany where scarcity events caused spikes to **€1,000/MWh**, underscoring once again the need for flexible backup to protect consumer stability.

Well-designed power markets must evolve to leverage the near-zero marginal costs of renewables to effectively insulate end-users from this commodity volatility.

Decentralized Resilience: Prosumers, CERs, and Digital Optimization

Distributed energy solutions and **digital tools** are emerging as the primary levers to bypass market friction and directly enhance consumer affordability. Unlike the traditional “one-way” grid model, these solutions transform consumers into active **prosumers** who manage their own energy flows to minimize costs.

An important mechanism introduced in Italy are **Renewable Energy Communities** (“CERs”).

A CER is not a simple plant, but a sophisticated legal and operative ecosystem (association or cooperative) that shares energy locally. Many models allow private citizens to join as “consumers” with zero upfront investment, receiving bill discounts of 10% to 25% through shared GSE incentives (up to €0.12/kWh), guaranteed for 20 years. This premium acts as a “virtual battery,” rewarding the community for consuming energy at the exact same time it is produced locally, thereby reducing grid congestion. For an average household consuming 3,000 kWh/year, this can translate to a passive saving of €80-€100 annually.

The success of decentralized models depends on active asset and community management. The primary risk is not technical failure, but “inept management”. If the manager fails to synchronize consumption with local production, the economic incentive vanishes. Therefore, communities rely on behavioral demand response, that is using software platforms and apps to notify members to shift heavy loads, such as laundry or EV charging, to peak sun hours.

Furthermore, the rollout of second-generation smart meters and AI-driven platforms allows households to reduce overall energy consumption by 2%–10%, achieving average annual cost savings of €270.

Investors Affordability

The energy transition is fundamentally a structural shift from an “Opex-driven” system to a “Capex-driven” one, making the WACC the single most decisive factor for project viability.

As global energy investment reached \$3.2tn in 2024 (with low-emissions power and grids now exceeding 60% of the total) the affordability for an investor is defined by the ability to secure predictable, long-term returns in a capital-intensive environment.

The Cost of Capital and the “Tenor Gap”

Because clean energy assets require massive upfront spending, even minor variations in interest rates or risk premiums can render high-quality renewable resources economically unviable. Hence, it is important to consider that the cost of capital for power generation projects in emerging and developing economies is over twice as high as in advanced markets.

More, investor affordability relies on standardized market instruments to bridge the structural mismatch between the long-term needs of infrastructure developers and the short-term preferences of energy buyers. Indeed, while project developers require 10-to-20-year revenue certainty to secure bankable debt, most commercial buyers and retail suppliers prefer commitments of under 3 years due to uncertain future demand and competitive switching risks.

To solve this, **the industry utilizes Power Purchase Agreements (PPAs) and Contracts for Difference (CfDs), which make projects “bankable” by providing fixed revenue streams.** In Germany, such long-term contracts have been shown to reduce the overall LCOE by more than 20%.

Winning Business Models

In such a challenging scenario, the players / business models / verticals that in our view are structural beneficiaries of the transition, are the following ones:

1. **Transmission System Operators (TSOs) & Regulated Utilities:** these regulated monopolies are the primary beneficiaries of an **investment super-cycle**.

With Europe requiring ~€3 trillion in investments over the next decade to modernize grids that are 40 to 50 years old, and because these investments are integrated into utilities' RAB, they generate regulated and contracted earnings (estimated at 85% of total sector investment for major utilities), granting investors superior visibility compared to volatile commodity markets.

Indeed, they win through the expansion of their Regulatory Asset Base (RAB), which guarantees a "fair return" (**often ~10% ROE**) on the massive infrastructure needed to modernize grids;

2. **Equipment and Infrastructure Manufacturers:** companies producing high-voltage cables, transformers, switchgear, power electronics and **transformers** hold immense pricing power, for example.

These and other products are the "peak and shovels" of electrification and energy transition. Lead times for critical components have nearly doubled due to a massive global backlog as grids expand by 25 million kilometers;

3. **Smart Grid and AI Software Providers:** these firms act as the "**neural network**" of the transition. They win by providing the digital tools needed to predict weather-dependent supply and manage Virtual Power Plants (VPPs), which monetize decentralized flexibility that was previously invisible to the market;

4. **Flexible Generation and Storage Operators:** in a system led by intermittent renewables, these players win by providing "split-second responsiveness".

They profit from "value stacking": combining wholesale price arbitrage (i.e. buying low, selling high) with **high-margin grid stability contracts**;

5. **Renewables Operators (not always):** EPCs are due to build the massive additional wind and solar capacity (mostly expected by 2030-2035) and IPPs to operate it, provided the former operate in attractive margin segments and the latter adopt flexible models, supported by storage and/or PPAs or fixed-price contracts (CfDs/PPAs), and/or in a stable regulatory framework;

6. **Circular Economy Specialists:** with a projected 30-40% supply shortfall in minerals like copper and lithium by 2035, firms that recover minerals from electronic waste win by creating a strategic domestic supply, reducing dependency on concentrated imports.

7. **Nuclear Technology Vendors and SMR Developers:** Nuclear is experiencing a renaissance as the **only carbon-free source capable of providing 24/7 stable baseload for AI data centers**.

Small Modular Reactors (SMRs) win by offering serialized, factory-built units that reduce construction risk and upfront costs.

Weaker Business Models

Among the business models that in our view might be negatively impacted by the sector changes, there are:

1. **Unabated Coal & Inflexible Baseload Generators:** the biggest losers face structural decline due to carbon pricing ("ETS"). They loose because they cannot ramp output fast enough to handle the "Duck Curve" or negative price events caused by zero-marginal-cost renewables.
2. **Unhedged Pure Commodity Retailers:** facing "extinction-level" risks. Relying on selling "naked" kWh without sophisticated hedging or energy services leaves them exposed to spot market price spikes that can trigger immediate financial distress.
3. **Single-Source Dependent Manufacturers:** industries (particularly automotive and hardware) that rely on a single country for 70-90% of refined minerals face extreme risks from export controls and geopolitical trade barriers.
4. **Standalone/Uncontracted Renewable Operators:** pure play solar or wind without storage or fixed-price contracts (CfDs/PPAs) suffer from "price cannibalization". Their high production crashes market prices during the very hours they are most active, eroding their revenue.
5. **Energy-Intensive Industries with Slow Electrification Pathways:** failing to adopt industrial heat pumps or other electric processes face a "competitiveness gap" due to reliance increasingly penalized fossil fuels
6. **Traditional Residential Gas Utilities and Boiler Manufacturers:** facing terminal demand decline as electric heat pumps and residential technologies physically displace natural gas in buildings.

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