GETTING THE ENERGY TRANSFORMATION DONE

A ROADMAP TOWARDS INDEPENDENCE (IN PROGRESS)

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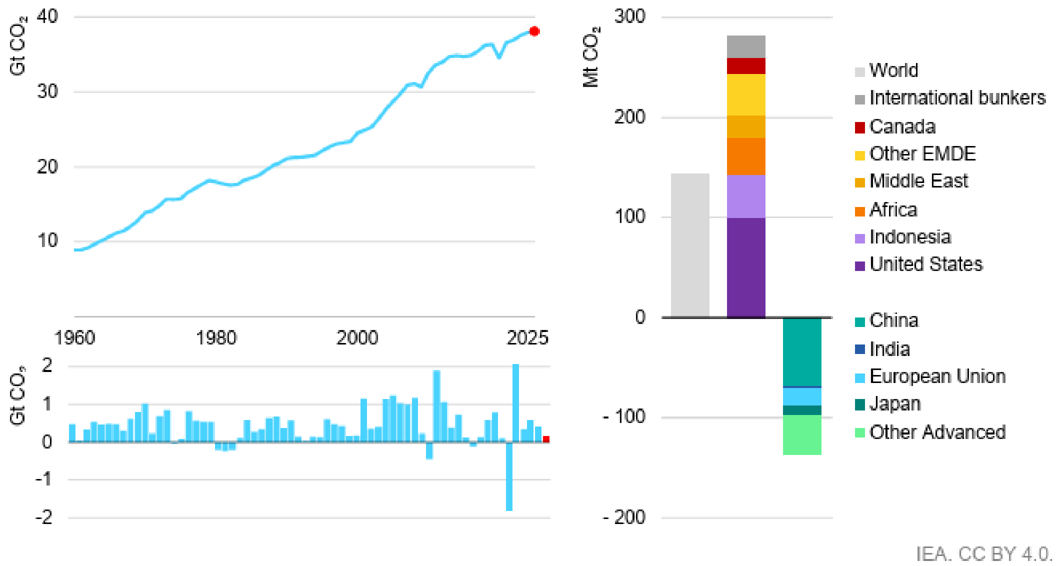
What is a realistic plan to complete an energy transition, which is essential for making European firms to compete and European families to be less exposed to crises? For years we have been "selling" the energy transition as something we need to decarbonize our economy in a *green narrative*, driven by the fight against climate change

The global energy transition is delivering tangible results. The rapid deployment of renewable energy, electrification technologies and other low carbon solutions is reducing reliance on fossil fuels and slowing the growth of emissions. Since 2019, the expansion of solar, wind, nuclear power, electric vehicles and heat pumps have avoided fossil fuel consumption equivalent to around 7% of global demand in 2025, roughly matching the total energy consumption of Latin America.
However, the overall picture remains mixed. Global energy related CO_2 emissions continued to increase in 2025, rising by around 0.4%. While this represents the slowest growth rate in recent years, it confirms that emissions are still moving in the wrong direction despite unprecedented investment in clean energy technologies.

At the same time, the global economy expanded by more than 3%, significantly faster than emissions. This confirms a continued decoupling between economic growth and carbon emissions, demonstrating that economic development no longer requires a proportional increase in emissions. While this trend is encouraging, the pace of emissions reduction remains insufficient to align with climate objectives.
The experience of China highlights both the opportunities and the challenges of the transition. In 2025, the country recorded a slight decline in emissions, driven by the rapid growth of low carbon electricity generation and more moderate growth in power demand. This demonstrates that a steady clean energy deployment can reverse the emissions trends even in large and rapidly evolving energy systems, pairing on a larger scale what already happened in Europe.
These developments point to an important conclusion. The energy transition is working, but not yet at the required scale.
Clean technologies are increasingly displacing fossil fuels and weakening the link between economic growth and emissions. Yet global fossil fuel consumption remains at historically high levels, and total emissions continue to rise. Accelerating the transition will therefore require not only continued investment in clean supply, but also stronger growth in electrified demand and a broader transformation of energy consumption patterns.

In 2023, fossil fuels still accounted for 81.5% of world primary energy consumption, confirming that the global energy system continues to rely overwhelmingly on coal, oil and gas, despite the political commitments and technological progress associated with the energy transformation.

Global energy related CO_2 emissions and their annual change, 1960-2025, and change by region, 2025



Note: EMDE = emerging market and developing economies.

Source: IEA 2026 Global Energy review

Certainly, the global picture discounts different regional patterns.

The EU peaked its emissions in 1981 and yet even the EU has decreased emissions of just 10% since the Paris agreement and should, in theory, triple the speed of its reduction rate to respect the agreement by 2030 (leaving alone a decline of 55% as for the EU “green deal”).

Yet we believe that this “narrative” must be complemented to another most immediate urgency, equally or even more relevant in times of geopolitical crisis. One of the greatest weaknesses of Europe is in fact that we import 58% of the consumed energy on average (this value rises to 80% for Italy and 70% for Germany). We experienced the consequences of this dependency twice in less than 5 years.
This translated into higher energy bills for firms and families and soaring inflation (again differently high in different countries) as the Draghi reports made clear; higher vulnerability to countries that tend to weaponize our fragility (it happened with Russia ad now with Middle East).

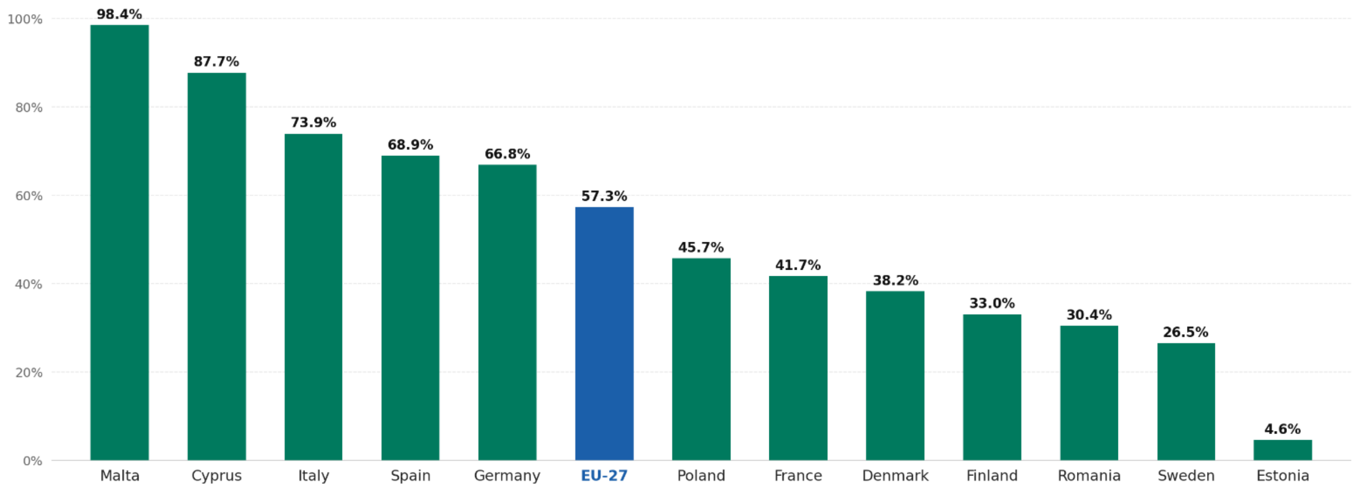
We are permanently on the verge of energy crises caused by geopolitical issues, and it is telling that the reaction to those crises is about minimizing the consequences (by trying to reduce costs of fossil energy that we do not control). Not about developing the plan to solve the structural problem we continue to have. We must have a clear plan to complete the energy transition in the most effective way because this is vital to our short- and medium-term interests. Europe's energy transition is about climate but it's a strategic necessity for the EU's competitiveness, resilience, security and, most of all, autonomy.

The graph below indicates energy import dependency rates across European countries in 2024. The Eurostat indicator measures the share of net imports (imports minus exports) in gross available energy. In 2024, the EU dependency rate remained around 57.3%, meaning that nearly 60% of the energy consumed in the Union was still covered by net imports.

The figures confirm that energy dependency remains a structural constraint rather than a residual issue. Several countries continue to rely very heavily on external supply: Italy, Spain and Germany all sit well above the EU average. These large industrial economies have high energy demand and limited domestic resources, making them significant actors in European energy policy debates. On the one end, other economies show greater self-sufficiency. Sweden), Denmark, France and Finland have lower dependency rates, largely thanks to nuclear power, hydropower, and domestic fossil fuel production.

Overall, the evidence suggests that the European energy transformation has not yet translated into energy autonomy. Despite the growth of renewables and improvements in efficiency, Europe remains significantly exposed to external energy sources, with direct implications for strategic resilience, price volatility and geopolitical vulnerability.

CHART 1.4.2 – Energy imports dependency rate in Europe in 2024 (Total energy - net imports divided by gross available energy, based on terajoules)



SOURCE: Eurostat

The achievement of the net-zero emissions by 2050 requires an immense transformation (it was probably a mistake to call it “transition”). McKinsey recently estimated that it would imply an increase in annual average spending on physical assets of $3.5 trillion[1]. This is an increase in the total current global investments in fixed assets of 61% and it would be necessary to increase tax revenue by a quarter to find this money.

In 2025, the EU imported around EUR 340 billion worth of fossil fuels and in the first 52 days since the beginning of the conflict in the Middle East in March 2026 and the closure of the Strait of Hormuz, Europe has spent an additional EUR 24 billion on fossil fuels imports[2].

[1] McKinsey, The net-zero transition: What it would cost, what it could bring. https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring

[2] AccelerateEU – COM(2026) 370 - https://energy.ec.europa.eu/document/download/7fac9eea-5717-4182-a368-bd68c427ff4c_en?filename=Communication.pdf

However, McKinsey's estimation is not clear in terms of how the figure was calculated; they probably did not consider that the prices themselves of energy transition technologies are declining rapidly; and it may be a mistake to shoot such an unfeasible feat. In general, the hype of some calculations can be part of the problem, and the energy transition is still surrounded by some ambiguity.

Generally, a major policy issue is that, despite decades of integration efforts, Europe still has structurally higher energy prices compared to its competitors. Moreover, the EU continues to exhibit substantial cross-country disparities in electricity costs for non-household consumers[3]. This has implications for industrial competitiveness, inflation and energy security. Electricity prices for non-household consumers in the second half of 2025 vary dramatically across different EU countries. In the second half of 2025, the EU average stood at €0.1837 per kWh, with, however, significant variation: Ireland (€0.2552/kWh) and Cyprus (€0.2429/kWh) sit at the top, followed by Germany (€0.2264/kWh), while Finland (€0.0748/kWh) and Sweden (€0.0970/kWh) remain at the bottom, largely thanks to their hydro and nuclear-heavy generation mix, which insulates them from gas price volatility. Italy also appears among the countries with relatively high electricity costs, at around €0.22/kWh, well above the EU average of €0.1837/kWh. This confirms that the Italian energy system remains particularly exposed to high input costs, with relevant implications for industrial competitiveness and for the ability of firms to absorb the costs of the energy transformation[4].

MEASURING ENERGY TRANSFORMATION

Vision proposes to break the overall question of measuring the energy transformation in **four indicators** that break down the answer into more operational indicators.

The first pillar is **energy efficiency**, measuring the capacity of an economy to generate wealth with lower energy consumption. The second is **electrification**, namely the growing role of electricity within total energy use, which is essential for decarbonizing transport, industry and households. The third pillar is the **clean share of electricity generation**, capturing the extent to which electricity is produced from renewable and nuclear sources rather than fossil fuels. Finally, the fourth pillar concerns the **diffusion of distributed energy production**, measuring the role played by small and domestic systems in generating renewable electricity. Together, these four dimensions provide a broader picture of the energy transformation. These pillars will be analyzed for 10 countries (7 European countries and 3 global leaders, namely the US, China and India), comparing developments between 2000 and 2024.

However, these indicators should not be interpreted according to "the higher, the better" logic. Every country has a different economic structure, geography, industrial specialization, demographic density and resource endowment. Consequently, **each pillar has an optimal level, concerning, both in terms of security and economic sustainability, that may vary significantly across territories and regions**. For example, a highly industrialized economy may require different electrification patterns compared to a service-oriented economy. The objective, therefore, is not uniformity but understanding whether each country is moving coherently toward a more low-carbon and technologically sustainable energy system.

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[3] Eurostat, Non-household electricity prices in 2nd half of 2025: -3.5%. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20260508-2?utm_source=chatgpt.com

[4] Eurostat, Electricity prices for non-household consumers, second half 2025. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Electricity_price_statistics#Electricity_prices_for_non-household_consumers

The four pillars proposed should therefore be considered as macro-indicators aimed at simplifying a highly complex transformation. In future research, each pillar will need to be decomposed into a broader set of more granular indicators to capture all the dimensions of energy transformation.

1st PILLAR OF THE ENERGY TRANSITION

TABLE 1.1 – Energy efficiency: GDP/ energy consumption for 10 countries, 2000 vs 2024

	Italy	France	Spain	Germany	Poland	Denmark	Netherlands	China	India	USA
2024	1.4031	1.2540	1.0651	1.4677	0.8154	2.1631	1.3060	0.3825	0.3449	1.0837
Δ 2000	+156.2%	+187.5%	+171.6%	+197.1%	+379.7%	+211.9%	+214.8%	+270.0%	+174.3%	+180.7%

SOURCE: Vision on World Bank Group (GDP) and Our World in Data (Energy Consumption)

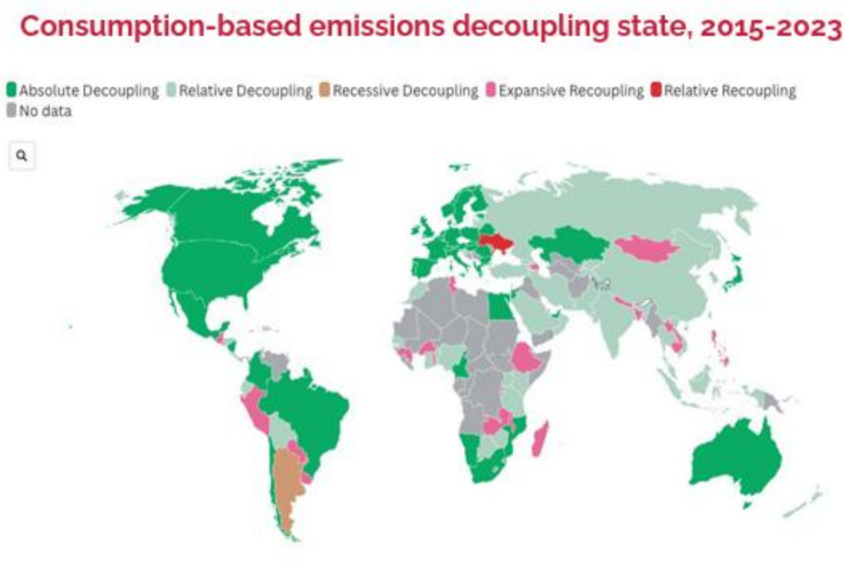


Figure 3 Global distribution of consumption-based emissions decoupling states, 2015–2023

Source: Energy & Climate intelligence Unit, 2025.
https://mcusercontent.com/8ed7ad7972fae058e8f4fb7e8/files/1ca4d953-94f3-4ec8-0dc8-348b67c45306/10YPP_How_emissions_decoupling_has_progressed.pdf

The analysis of energy efficiency trends between 2000 and 2024 reveals a substantial structural transformation across all examined economies. Energy efficiency, measured as the ratio of Gross Domestic Product (GDP) to primary energy consumption (US$/kWh), increased in every country included in the sample, although with significant differences in magnitude and trajectory.

Among the analyzed countries, Denmark emerges as the most energy-efficient economy in 2024, reaching a value of 2.16 US$/kWh. This performance indicates the ability of the Danish economy to generate high economic output with relatively limited energy input. The result is consistent with Denmark's long-term transition toward a service-oriented and technologically advanced economy, combined with extensive investments in renewable energy, electrification and energy optimization policies.

All European countries experienced a marked improvement in energy efficiency over the observed period. Germany (+197.1%), Netherlands (+214.8%), and Poland (+379.7%) recorded the largest relative increases within Europe. Poland represents a particularly relevant case: despite starting from the lowest efficiency level among European countries in 2000, it achieved the highest relative growth. This suggests a rapid economic modernization process in which GDP growth significantly outpaced the increase in energy consumption. The findings indicate that structural economic transformation can contribute to efficiency gains even in economies historically dependent on carbon-intensive industries.

A particularly important pattern emerging from the data is the phenomenon of relative decoupling between economic growth and energy consumption. Both United States and France reduced or stabilized their total energy consumption while simultaneously increasing GDP. The United States presents the clearest example of this trend: primary energy consumption remained almost unchanged between 2000 and 2024, whereas GDP nearly tripled. This indicates substantial improvements in technological efficiency, industrial productivity and the growing weight of less energy-intensive economic sectors.

In contrast, China and India, although demonstrating strong improvements in efficiency (+270% and +174.3%, respectively), remain significantly below the efficiency levels observed in advanced European economies. Both countries experienced dramatic increases in absolute energy consumption, reflecting ongoing industrialization and rapid economic expansion. China quadrupled its energy consumption during the period, while India approximately tripled it. Their efficiency values remain below 0.40 US$/kWh, highlighting the persistence of energy-intensive production structures typical of emerging economies.

Overall, the data indicates that economic growth does not necessarily require proportional increases in energy consumption, demonstrating significant improvements in energy waste reduction.

2nd PILLAR OF THE ENERGY TRANSITION

TABLE 1.2 – Electrification: Share of electricity in total final energy consumption for 10 countries, 2000 vs 2024

	Italy	France	Spain	Germany	Poland	Denmark	Netherlands	China	India	USA
2024	15.8%	22.2%	17.3%	15.5%	15.3%	17.9%	13.2%	20.6%	18.0%	16.6%
Δ 2000	+22.7%	+30.1%	+19.4%	+8.8%	+8.9%	+18.3%	+51.1%	+79.2%	+17.1%	+15.6%

SOURCE: Vision on Our World in Data

The chart maps electrification rates, meaning electricity consumed relative to total primary energy, across ten countries from 2000 to 2024. The headline finding is simple: where rates rose fastest, it was because governments made deliberate choices, not because markets led the way.

Electrification is one of the most effective pathways to reduce emissions, strengthen energy security and improve overall energy efficiency. While it is often presented as a natural consequence of economic development, evidence suggests that the level of electrification achieved by different countries is primarily the result of policy choices rather than wealth, climate conditions or geography.

This is illustrated by the significant differences observed across advanced economies. Electricity accounts for approximately 17.9% of final energy consumption in Denmark and 22.2% in France. China has also increased its electrification rate to 20.6%, demonstrating that rapid progress can be achieved under very different economic and institutional conditions.

Higher electrification is closely linked to energy resilience and strategic autonomy. By replacing imported fossil fuels with domestically generated electricity, electrification reduces exposure to external shocks, improves industrial competitiveness and enhances long-term energy security. Electrification is not an end in itself. Its strategic value lies in the superior efficiency of electric technologies. Heat pumps, electric motors and electric industrial processes typically require substantially less primary energy than fossil-fuel alternatives, reducing both costs and emissions.

Not all sectors can be electrified at the same pace: some of them may continue to require alternative solutions. Nevertheless, a large share of current energy consumption is already technically and economically electrifiable through commercially available technologies. Accelerating their deployment should therefore be considered a central pillar of any long-term energy transition strategy.

3rd PILLAR OF ENERGY TRANSFORMATION

TABLE 1.3 – Clean share of electricity generation: Electricity from Renewables and Nuclear/ Electricity for 10 countries, 2000 vs 2024

	Italy	France	Spain	Germany	Poland	Denmark	Netherlands	China	India	USA
2024	50.2%	94.9%	64.2%	58.6%	31.1%	89.2%	53.1%	38.2%	22.5%	43.1%
Δ 2000	+31.4%	+67.5%	+35.8%	+47.1%	+29.5%	+73.7%	+47.8%	+21.5%	+8.0%	+33.4%

SOURCE: Vision on Our World in Data

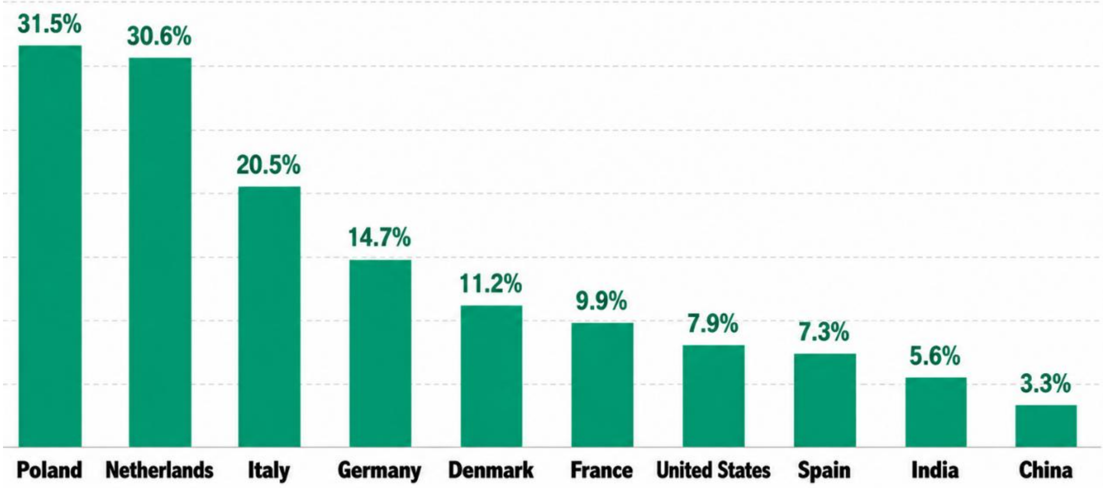
The graph clearly shows that the share of energy generation coming from clean resources rose in all ten countries taken as samples. Denmark, however, stand out as the transformation's leader, drastically increasing its renewables share from 15.5% to 89.2%. Germany and the Netherlands also rose dramatically in their clean share, even though Germany completely abandoned its nuclear fleet (from 5.2% to 0%). Spain and Italy also made strong gains, driven by wind and solar. Several countries that relied on nuclear in 2000 have reduced or eliminated it. Germany is the starkest case. France remains the most nuclear-dependent country in the sample (12% in 2024, down from 14.6% in 2000) but has meaningfully grown its renewables share too (from 12.7% to 27.2%). The US relies on nuclear for only a marginal share (around 0.4%).

Poland is a particularly interesting case. Starting from almost nothing (1.6% clean share in 2000), it reached 31% in 2024. While having made significant progress, it remains, however, heavily coal-reliant and lags behind the other European countries in the sample. The US, the world's second-largest generator, also shows very weak improvements in its clean share, improving from 9.8% to only 24.5%.

For most European countries, the transition is increasingly within reach of the 80–100% clean electricity threshold needed for full decarbonization of the power sector. For large emerging economies, the challenge is different: clean capacity is being added rapidly, but demand is growing even faster.

4th PILLAR OF THE ENERGY TRANSITION

CHART 1.4.3 – Ratio: Electricity being produced by small/domestic systems (< 30 kWp) (%) / Electricity produced by renewables for 10 countries, 2000 vs 2024



SOURCE: Small PV (<30 kWp) shares are estimated from IEA, EIA, Bundesnetzagentur, SolarPower Europe, Mercom and Global Energy Monitor sources (2024–2025). Year-2000 small PV is effectively ~0% for all countries - utility-scale hydro, wind, and biomass dominated renewables and residential solar was negligible. Renewable share of electricity from Our World in Data. The "pillar 4 ratio" = small PV share of total electricity ÷ renewable share of total electricity × 100.

Finally, we consider how concretely is the "transformation" really leading to a paradigm where consumers produce part of the energy they need. On this we are so behind that we even miss specific definitions and measurements. The indicator measures how much of a country's renewable electricity comes from small-scale distributed systems rather than centralized utility-scale plants

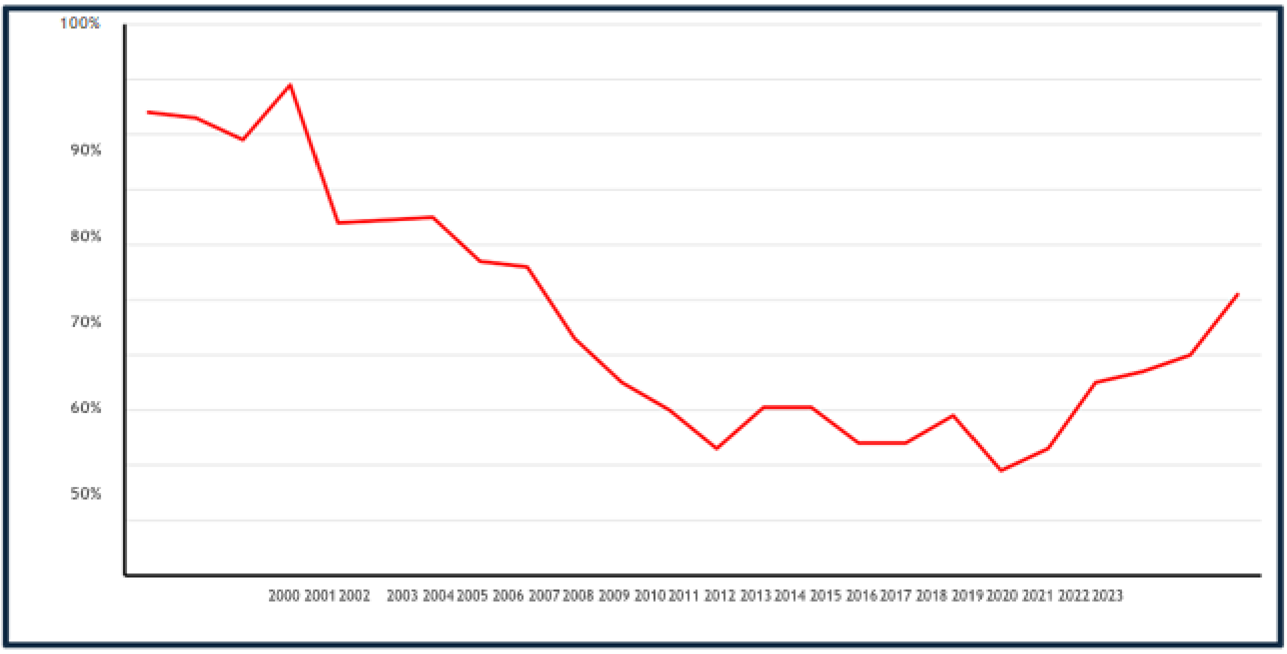
In 2000, solar PV at any scale was negligible across all ten countries. The entire renewable base was hydro, wind, and biomass, inherently centralized or rural. Therefore, the distributed energy paradigm was purely theoretical.

By 2024, the picture is mixed, and the gap between European leaders and the rest is striking. The Netherlands and Poland top the pillar-4 ratio, with roughly 30% of their renewable electricity now coming from small distributed systems. This reflects a genuine structural pattern: both countries have very high residential solar penetration relative to their total renewable base (which still contains modest wind and biomass). Distributed solar already represents around 68% of all operating solar in Germany and 86% in

Italy, yet Italy and Germany sit in the middle range on the ratio because their overall renewable share is also very high (the denominator is larger).

Countries with very high renewable shares (Denmark at 89%, Germany at 58%, Spain at 57%) show modest or medium pillar-4 ratios, because most of their renewable electricity comes from large-scale wind and solar farms. Distributed small solar is growing but is not keeping pace with utility-scale deployment. The graph below considers one of the countries that has been keener on a distributed model of energy production. Germany.

CHART 1.4.4 – Evolution of the share of solar energy being produced by small/domestic systems in Germany (< 30 kWp) (%)



SOURCE: Vision on Fraunhofer ISE data

The larger economies, China, India and the United States, score lowest on the ratio, and this is by design: China's distributed solar fell to 38% of total solar additions in 2024, down from 58% in 2022, as utility-scale deployment surged. In the US, distributed solar contributes just under 2% of total electricity generation, with utility-scale solar growing far faster. India is accelerating residential adoption, but rooftop solar capacity at end of 2024 was 13.7 GW against a total solar base of over 80 GW, still a minor fraction.

In conclusion, the distributed energy paradigm is not winning. Across all geographies and regardless of how much renewable energy is being added, the dominant model remains centralized. The few countries where small distributed solar is most significant (Netherlands, Germany, Italy) got there through generous feed-in tariffs and prosumer policies that are now being phased out, and residential solar share across the EU fell from 28% to 20% of new installations in 2024. The trend, if anything, is reversing. The question is to try to better understand whether the barrier is about technologies, economies of scale or the interests of the incumbents so to provide some realistic recommendations.

ACCELERATING ENERGY TRANSFORMATION

Policy and technological leverages

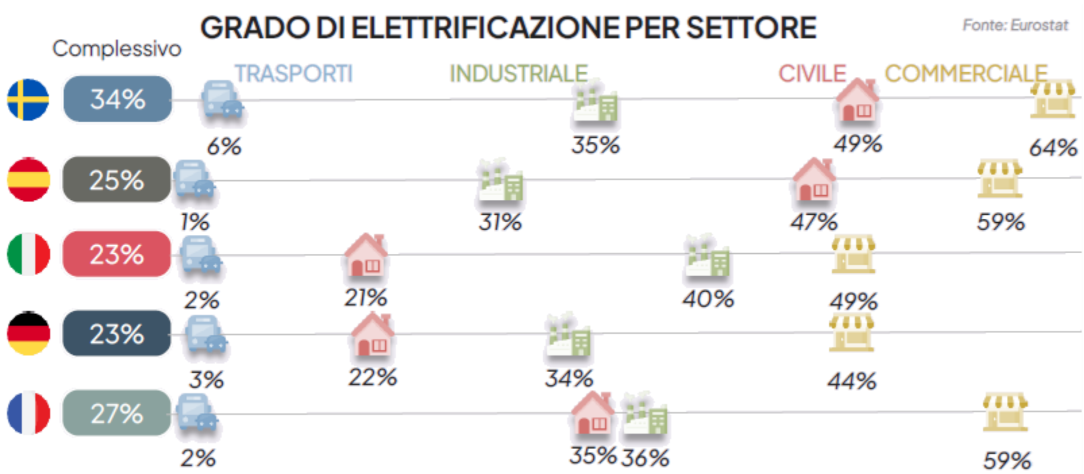
Stimulating Electrification Across the Economy

An effective European energy strategy should place electrification at the core of industrial, energy, and climate policy. The objective is not only to reduce greenhouse gas emissions, but also to strengthen energy sovereignty, reduce exposure to volatile fossil fuel imports, and enhance the competitiveness of European industry.

Europe remains structurally vulnerable in this respect: energy imports still account for nearly 57% of total EU energy consumption, a level significantly higher than that of key global competitors such as the United States, which has substantially reduced its external energy dependence and, in several segments, has become a net energy exporter. Electrification, by enabling a shift from imported fossil fuels to domestically produced clean electricity, therefore represents a strategic lever to reduce dependency and stabilise long-term energy costs.

To fulfil this role, electrification must accelerate across all major end-use sectors, including electric mobility, heating and cooling, and industrial heat. Today, transport and buildings remain largely fossil-based, while industrial electrification progresses unevenly across Member States, often constrained by regulatory uncertainty and distorted price signals. This is particularly relevant given that fossil fuels remain the largest source of EU greenhouse gas emissions, concentrated precisely in these sectors.

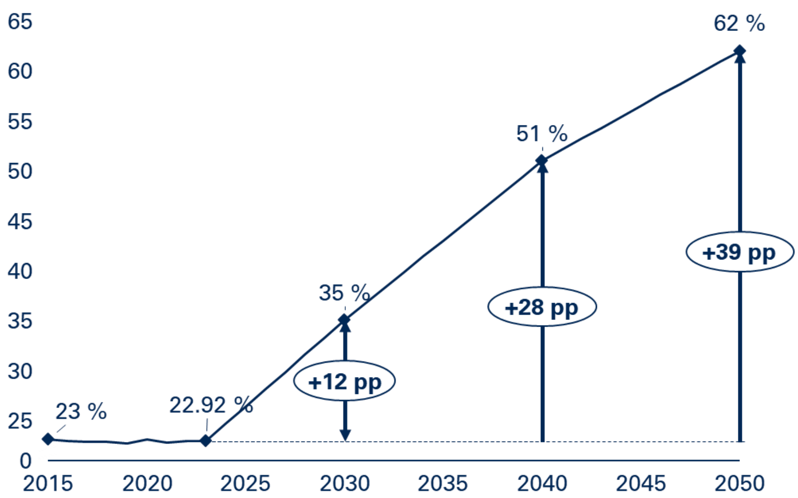
Large differences in electrification rates can be observed not only across countries, but also within individual sectors. Residential heating, industrial processes and transport display markedly different levels of electrification across European economies, despite often relying on similar technologies and facing comparable technical constraints. This variation suggests that electrification is not primarily a question of feasibility. Rather, it reflects differences in policy frameworks, market incentives, infrastructure development and long-term strategic priorities.



By more closely aligning energy and industrial policy, Europe can transform clean electricity from a pure decarbonisation tool into a structural competitive advantage, while addressing the energy trilemma of sustainability, security and affordability. Such alignment is also essential to meet the Clean Industrial Deal objective of reaching at least 32% economy-wide electrification by 2030, a level that implies a substantial acceleration compared to historical trends.

Achieving this objective will require a more proactive approach to electrification than has been observed to date. Recognising this challenge, the European Commission has announced the development of an Electrification Action Plan aimed at accelerating the uptake of electricity across industry, transport, buildings and other end use sectors. The initiative reflects a growing awareness that expanding clean electricity supply alone is not sufficient. Demand side transformation must progress at a similar pace if Europe is to fully capture the benefits of its investments in renewable energy, grids and low carbon generation.

Growing electricity demand from data centres, artificial intelligence applications and industrial electrification should not be viewed solely as a challenge. If properly managed, it can become a catalyst for renewable deployment, grid investment and industrial competitiveness. Demand growth is increasingly a prerequisite for maximising the value of clean electricity investments and reducing dependence on imported fossil fuels.

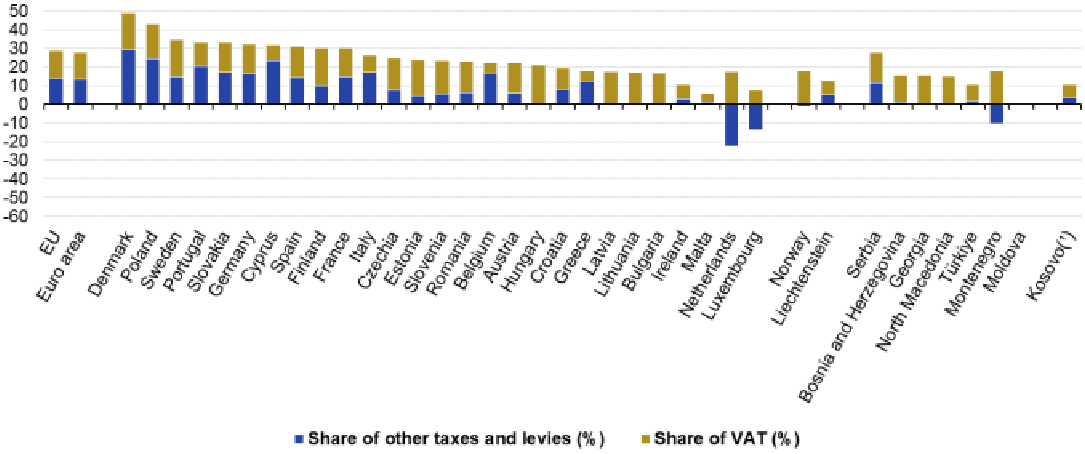


Policy Instruments to Make Electricity Competitive

Achieving this objective requires a coherent policy framework that consistently supports the transition from fossil fuels to electricity.

First, energy taxation and levies should be rebalanced to remove distortions that continue to penalise electricity relative to natural gas and other fossil fuels. In several Member States, taxes and system charges on electricity remain multiple times higher than those applied to gas on an energy-equivalent basis, offsetting much of the efficiency advantage of electric technologies and discouraging fuel switching.

Share of taxes and levies paid by household consumers for electricity, second half 2025
(%)



Second, the EU Emissions Trading System (ETS) should remain the cornerstone of the transition from fossil fuels to electricity, providing a stable and credible carbon price capable of driving decarbonisation while preserving industrial competitiveness. A predictable ETS price signal is essential to unlock clean-tech investment and avoid locking Europe into long-term fossil dependency. Frequent regulatory interventions or fragmented national approaches may weaken the long-term investment signal provided by the ETS.

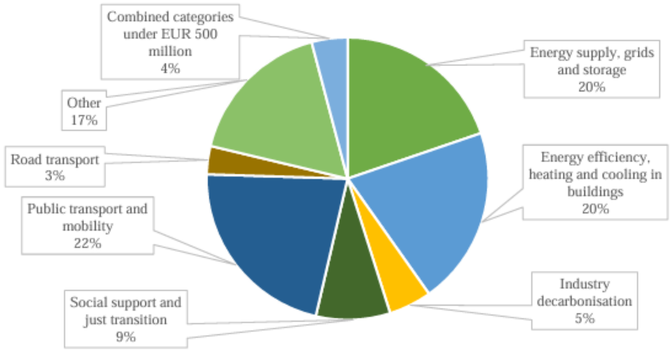
Third, ETS revenues should, as required by EU regulation, be strategically reinvested in electrification, industrial transformation, and clean energy infrastructure, rather than dispersed through short-term compensatory measures. Targeted use of ETS revenues can significantly improve the cost-effectiveness and social acceptability of the transition. From 2013 to the end of 2025, EU ETS auctions have raised over €258 billion in revenue. In 2025 alone, ETS revenues totalled more than €43 billion, with some €24 billion directly benefiting EU Member States.

Too often ETS revenues have been used to support general public budgets or short-term compensatory measures. Redirecting a larger share of these resources towards electrification, grids, storage and industrial transformation would accelerate the energy transition while increasing its economic effectiveness and public acceptance.

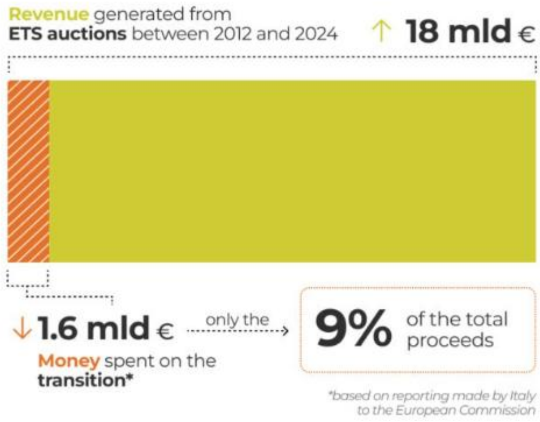
Under Article 10(3) of the ETS Directive[5], Member States are obliged to use 100% of the revenue collected (or an equivalent financial value) to support climate action and energy transformation.

[5] Up to 4 June 2023, Member States were encouraged to use at least 50% of the revenue collected to support decarbonisation and energy transformation investments. For the revenue collected from 5 June 2023 onwards, the obligation to use 100% (or equivalent financial value) to support decarbonisation and energy transformation in ETS sectors applies.

Member States’ use of 2024 ETS revenues in the different categories



Italy’s case in the last 12 years



Additionally, greater pass-through to final consumers of the lower wholesale electricity prices increasingly enabled by renewables, through tariff structures and network charges better aligned with wholesale market dynamics, would further accelerate electrification. Together, these instruments can create the economic conditions necessary to stimulate demand, mobilise investment, and accelerate the structural transition toward a more resilient and competitive European economy.

Bankable Long-Term Contracts for Renewables

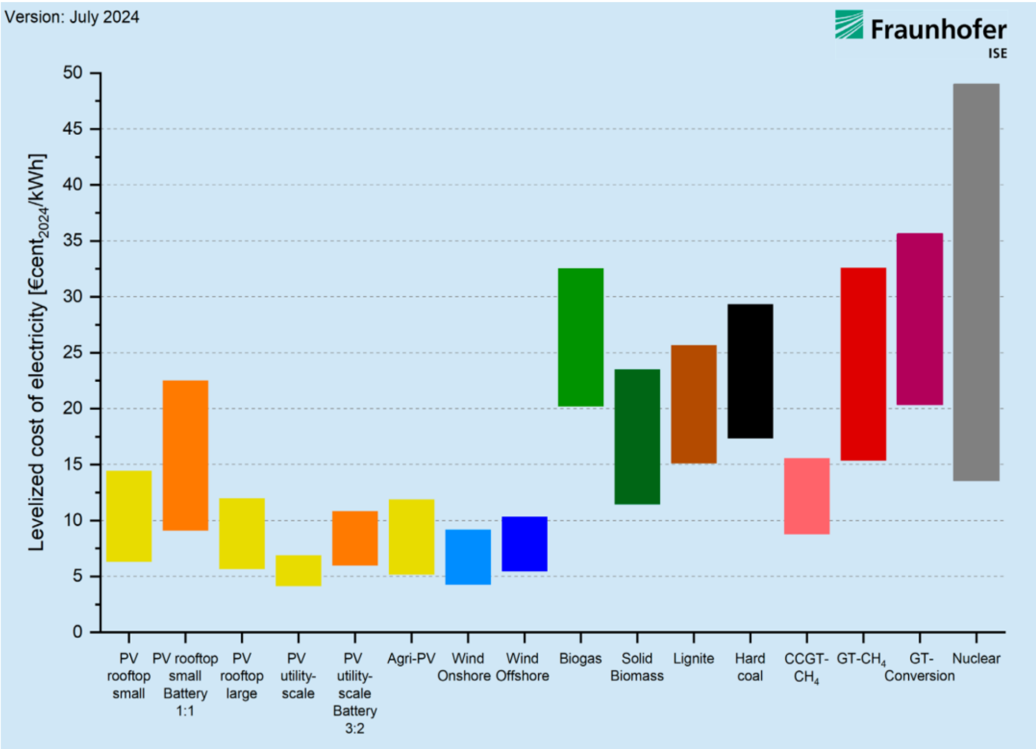
Long-term contracts are essential to reducing market volatility and providing the certainty required to finance large-scale renewable deployment in a system increasingly exposed to price variability and negative-price hours. The growing frequency of negative-price hours should be interpreted not only as a flexibility challenge, but also as evidence of insufficient electrified demand capable of absorbing abundant renewable generation.

Renewables are cost competitive on a levelized cost of electricity basis, outperforming conventional generation technologies in many European markets. However, their cost structure remains heavily capital intensive, with most costs incurred upfront while revenues are spread over long operational lifetimes and exposed to market volatility. As a result, the main barrier is not economic competitiveness, but bankability. This makes long term revenue stabilization mechanisms essential to reduce risk and unlock financing at scale.

Government-backed Contracts for Difference (CfDs) should be planned on a multiannual basis through transparent auction calendars that enable developers and the supply chain to plan investments effectively. Contract durations should be aligned with the economic life of assets, typically 20 years or longer, in order to reduce the cost of capital and ultimately deliver lower prices to consumers.

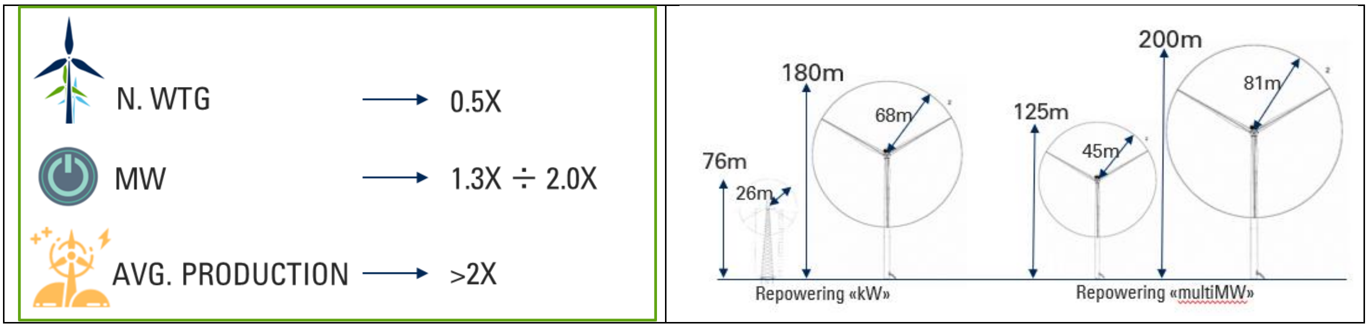
Power Purchase Agreements (PPAs) represent a complementary market-based solution capable of stimulating renewable investment without imposing additional burdens on public budgets. However, smaller and non-investment-grade companies often face significant barriers to market access, compounded by limited hedging capabilities. This constrains the expansion of corporate PPA demand despite strong industrial interest.

Public guarantees of last resort, state-backed hedging mechanisms, and initiatives aimed at strengthening corporate risk-management capabilities could unlock a broader and more diversified PPA market. At the same time, additionality requirements should be designed in a pragmatic and proportionate manner, avoiding unnecessary constraints on demand growth and corporate procurement.



Repowering: More Output from Existing Assets

Wind repowering represents one of the most effective and least disruptive pathways to accelerate renewable deployment. By replacing older turbines with newer and more efficient ones, existing sites can significantly increase installed capacity and electricity generation without requiring additional land use. In many cases, repowering can double output while relying on the existing grid connection.



Repowering projects also benefit from greater local acceptance, as operators have already established relationships with local communities. They build upon infrastructure already integrated into the territory and maximise the use of high-quality resource locations. Nevertheless, current regulatory frameworks do not adequately recognise the additional capital expenditure and opportunity costs associated with repowering, while the implementation of EU rules remains uneven across Member States.

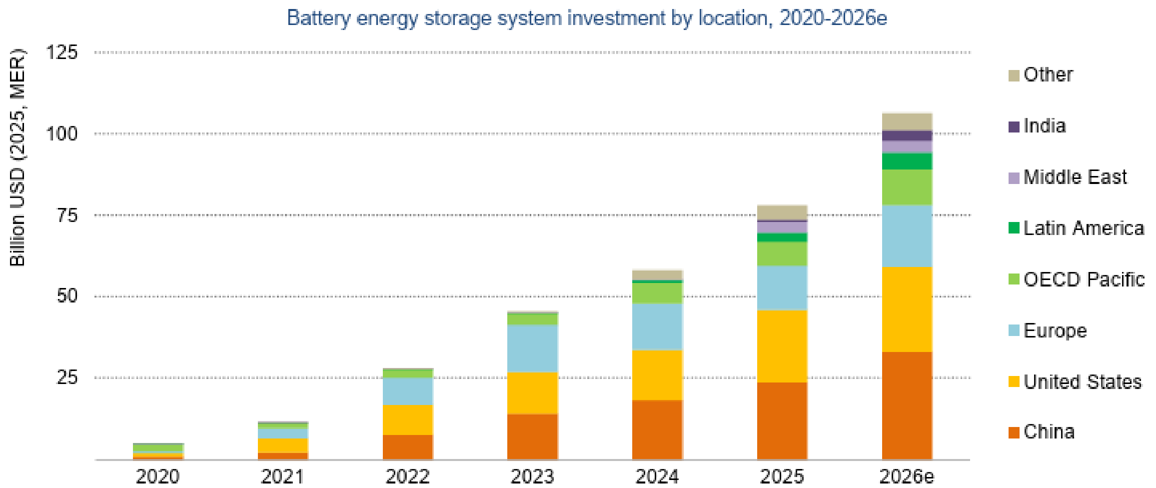
Dedicated auction mechanisms or targeted incentives for repowering, clear targets within National Energy and Climate Plans (NECPs), and streamlined permitting and grid-connection procedures are all necessary to unlock this strategic opportunity.

Flexibility, Storage, and Hybridisation

As renewable penetration increases, flexibility becomes indispensable to maintaining system efficiency and managing the growing frequency of negative-price periods, especially in markets characterised by significant inflexible baseload generation. Recent market data show a rapid increase in negative-price hours as RES shares exceed 50% of generation.

Storage, hybridisation, and digitalisation are critical tools for integrating higher shares of variable renewable generation while optimising the use of network infrastructure. Multiple routes to market are needed, including dedicated support schemes, well-designed capacity markets with coherent derating factors, and regulatory frameworks that facilitate the co-location of storage with renewable assets.

Battery storage is becoming a central pillar of the energy transition, driven by rapidly falling costs and accelerating deployment across power systems. Over the past decade, lithium-ion battery prices have declined significantly, enabling a shift from niche applications to large scale integration in grid balancing, electric mobility and renewable firming. Installed capacity is growing quickly in Europe, the United States and China, reflecting both policy support and improved business case economics, particularly in systems with high shares of solar and wind generation.



Despite this progress, the sector remains highly concentrated. Battery storage today is essentially synonymous with lithium-based technologies, which creates a strong dependency on a limited set of raw materials, including lithium, nickel and cobalt. At the same time, global supply chains for both processing and manufacturing are heavily dominated by China, which controls a large share of refining capacity and battery production. This concentration introduces strategic vulnerabilities, making supply diversification and domestic industrial capacity increasingly important alongside cost and deployment growth.

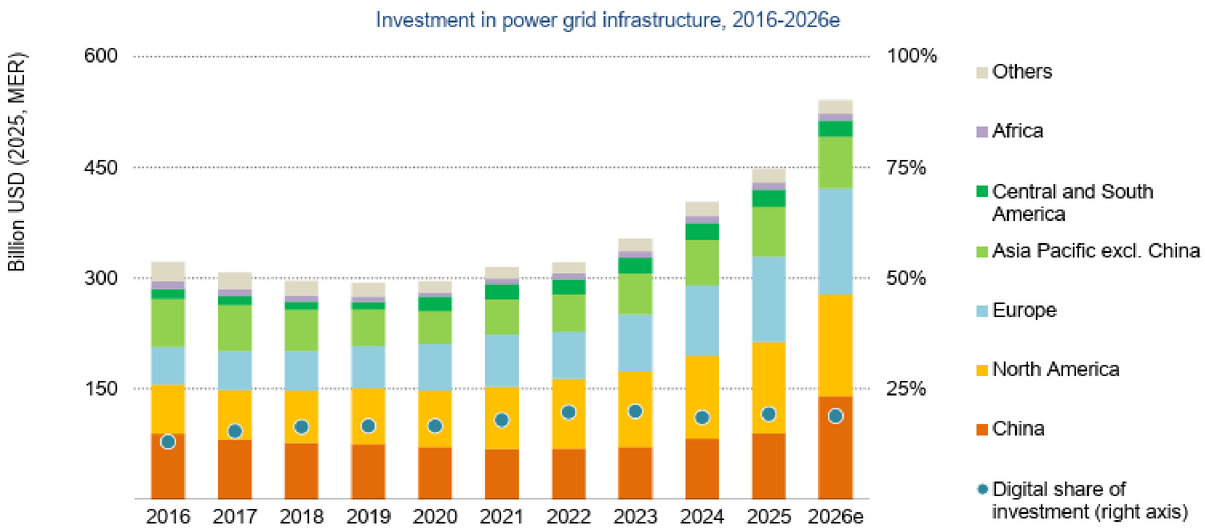
Existing renewable plants should be allowed to integrate storage and other flexibility solutions without losing access to existing support mechanisms, as hybrid plants simply enable output to be shifted to periods when it has greater value for the system. Baseload-oriented CfDs and revised capacity-market rules can further encourage hybridisation and strengthen the contribution of renewables to system adequacy.

Consumers should be able to capture the value they provide to the power system through flexible consumption. This applies both to industrial users willing to participate in demand response schemes and to households adapting consumption patterns to market conditions. Retail tariffs should increasingly reflect actual system costs. Traditional time of use structures, such as those still used in Italy where midday electricity is often priced as a peak period, are becoming less representative of a system increasingly shaped by abundant and low-cost solar generation.

Grids as the Backbone of the Transition

Electricity networks are the essential infrastructure connecting renewable generation, new demand, and flexibility resources.

Insufficient grid capacity increases congestion, curtailment, and overall system costs, ultimately undermining both competitiveness and energy security. Stronger and more modern networks reduce bottlenecks, enable more efficient dispatch, and support the broader electrification of the economy. Grid constraints are already emerging as a key limiting factor in several high-RES regions. After a prolonged period of stagnation, global investment in electricity grids has picked up significantly in recent years. Total spending increased by around USD 45 billion in 2025, reaching close to USD 450 billion, marking the largest rise across the power sector. It is expected to grow by a further 17% in 2026. However, part of this increase is driven by higher costs for grid equipment, including transformers, cables and overhead lines, meaning that the rise in expenditure does not fully translate into a proportional expansion of physical infrastructure.



However, grid expansion and modernization are not progressing at the pace required by renewable deployment and electrification ambitions. To close this gap, Europe must accelerate permitting procedures, strengthen investment incentives, and increase accountability for transmission and distribution system operators to ensure the timely delivery of strategic infrastructure.

The challenge is no longer whether Europe should invest in grids, but whether grid development can keep pace with renewable deployment, electrification and industrial demand growth. Without a substantial acceleration of network expansion and modernization, grids risk becoming the principal bottleneck of the energy transition.

Overriding Public Interest as an enabler of decarbonisation

Delivering a demand-led energy transition requires not only appropriate market signals but also regulatory frameworks capable of removing structural barriers to implementation. In this context, the recognition of energy-transition infrastructure as serving an Overriding Public Interest (OPI) is a critical enabler.

OPI, as increasingly embedded in EU energy and climate legislation (RED III), reflects the strategic relevance of decarbonisation, security of supply, and affordability. When applied consistently, it enables faster permitting, reduces litigation risk, and improves coherence between policy objectives and administrative decision-making.

From the perspective of demand activation, OPI is essential not only for renewable generation but also for grids, repowering, storage, and flexibility assets that enable electrification across transport, buildings, and industry. Without prioritised approval of these enabling infrastructures, electricity demand growth risks remaining structurally constrained, regardless of policy ambition.

Conclusions

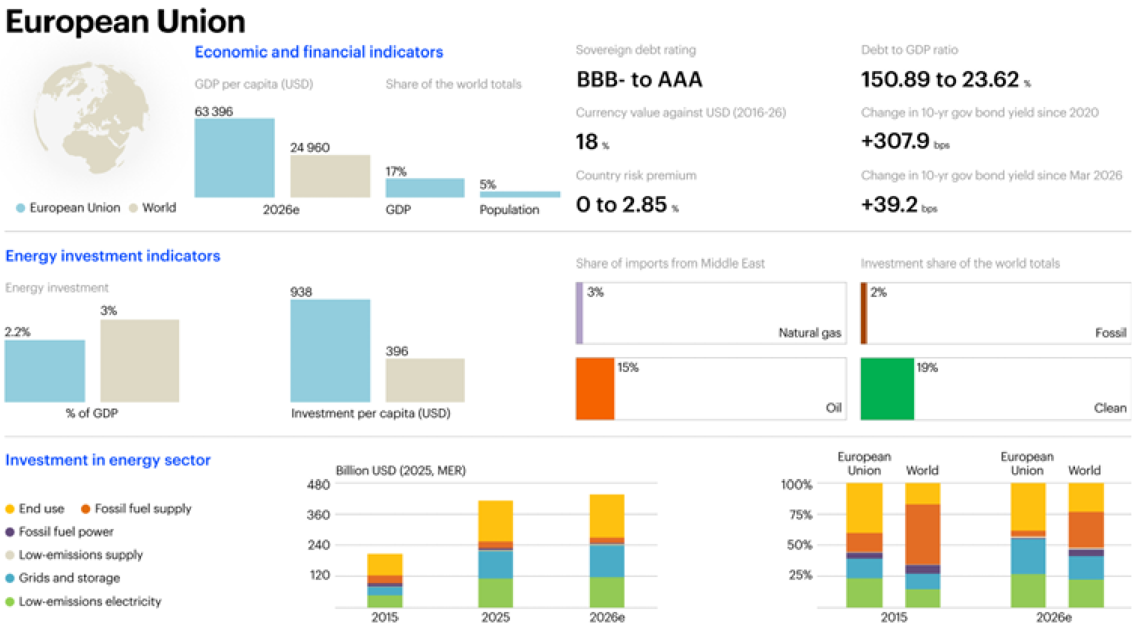
A European Roadmap for Demand-Led Decarbonisation

Europe possesses a large share of the technologies, capital, and industrial capabilities required to lead the global clean-energy transition. The key challenge is to establish a coherent, stable, and predictable policy framework capable of stimulating electricity demand while enabling infrastructure and investment to scale accordingly.

Europe has made decisive progress on clean electricity supply. Renewable deployment has accelerated, costs have declined, and low-carbon generation now represents a structural pillar of the European power system. Yet this supply-side success has not translated into equivalent progress on the demand side. Electricity demand remains structurally weak, electrification advances slowly across key end-use sectors, and the benefits of renewables are only partially reflected in final energy consumption and competitiveness outcomes.

At the same time, new sources of electricity demand are emerging rapidly, including data centres, artificial intelligence applications and industrial electrification. If properly managed, these trends can become a powerful catalyst for renewable deployment, grid investment and European industrial competitiveness rather than a constraint on the energy system.

The analysis presented in this paper shows that the next phase of the energy transition must be demand-led. Without a decisive acceleration of electrification, increasing volumes of renewable generation risk resulting in volatility, curtailment, and weaker investment signals, rather than lower energy costs, greater security of supply, and stronger industrial competitiveness.



Across Europe, the message is consistent: supply-side ambition must be matched by demand activation and system integration. Electrification, long-term contracting, flexibility, grids, and permitting reform are not standalone measures, but mutually reinforcing elements of a single transition architecture. Fragmented or sequential approaches will not deliver the scale or speed required.

Electrification, long-term contracting, repowering, flexibility, and grid development should be understood as mutually reinforcing pillars of a demand-led decarbonisation strategy. By acting decisively across these areas, Europe can build an energy system that is cleaner, more secure, and more competitive, while simultaneously reducing dependence on imported fossil fuels and strengthening its industrial base.

The challenge is no longer whether Europe can produce clean electricity, but whether it can create the conditions to consume it competitively at scale. Europe does not suffer from a lack of climate ambition. It suffers from an implementation gap. The technologies are available, costs continue to decline, and investment capital is increasingly mobilised. The priority now is to accelerate deployment through electrification, grids, storage, repowering and long-term investment frameworks.

Key policy priorities for a demand-led transition

A credible and effective demand-led decarbonisation strategy should therefore focus on the following priorities:

- **Placing electrification at the centre of EU energy and industrial policy**, with clear objectives and binding national trajectories aligned with the Clean Industrial Deal.

- **Rebalancing energy taxation and levies** to remove persistent distortions that penalise electricity relative to fossil fuels and undermine the economic case for electrification.
- **Preserving a strong and predictable EU Emissions Trading System**, avoiding fragmented national approaches and reinvesting ETS revenues in electrification, clean-tech deployment, and enabling infrastructure.
- **Scaling long-term contracts for renewables** through longer-duration CfDs, predictable auction calendars, and broader access to PPAs in order to stabilise prices and investment conditions for both producers and consumers.
- **Unlocking repowering and flexibility**, recognising their system value and removing regulatory barriers that prevent optimisation of existing assets.
- **Accelerating grid development** at transmission and distribution level as a non-negotiable enabler of electrification, renewable integration, and system efficiency.
- **Applying Overriding Public Interest** consistently to renewable, grid, storage, and flexibility projects, ensuring that permitting frameworks reflect the strategic importance of the energy transition and translate policy ambition into timely delivery.

Delivering these priorities would strengthen not only decarbonisation, but also Europe's competitiveness, resilience and strategic autonomy, reducing exposure to imported fossil fuels while reinforcing the continent's industrial base.

By aligning these levers within a coherent and predictable framework, Europe can move from a transition driven primarily by supply expansion to one anchored in effective demand, system resilience, and industrial competitiveness. Clean electricity can then become not only the backbone of decarbonisation, but also a durable structural advantage for Europe’s economy and society.