RystadEnergy

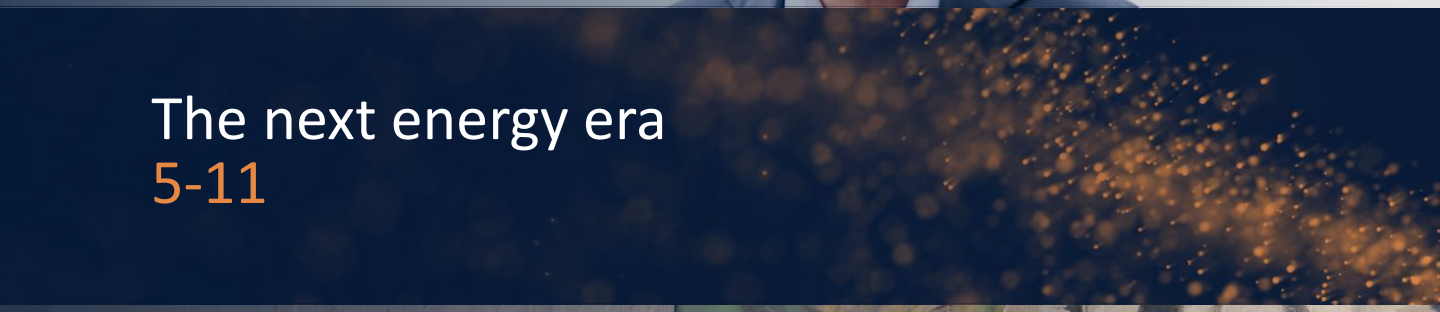
Executive Summary

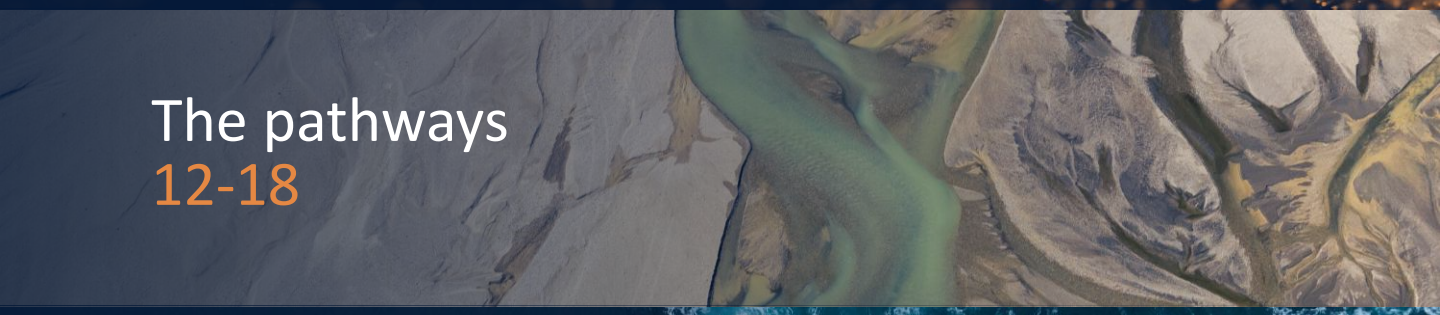
Global Energy Scenarios 2025

The next energy era

Energy Macro Analytics
October 2025

Table of Contents





The next era of the global energy system

Welcome to the fourth edition of our annual flagship report, Global Energy Scenarios 2025. In this edition, we explore the realities of today's energy system, how the energy transition is unfolding, and the pathways it may take.

Already today, we're seeing the energy system take on a hybrid state between renewable and fossil energy. As half the installed global power generation capacity comes from renewable sources, and one in four new cars sold are electric, the energy system is changing fast.

Despite political headwinds, the energy transition continues to accelerate, and solar power – the main workhorse of the transition – continues to overdeliver compared to expectations. This year alone, the world is expected to add over half a terawatt of solar power capacity, more than the total power capacity installed in France, Spain and Australia combined. As a result, every third electron generated will have come from renewable sources.

Yet we see new fossil fuel additions emerging amid this transition, but whether we are witnessing transition or addition depends on a temporal perspective. Transitions are not new, but they are sticky and take time to unfold. Although we have not seen this happen during our current generational lifetime, it has occurred twice before since the 1800s, moving from traditional biomass to coal, and then to oil and gas as the main energy sources powering the world's development. Looking towards the end of this decade, we see net additions across both renewable and fossil sources. But there are already clear signs of change across investments, new capacity additions, and technological adoption curves that indicate we will see a genuine transition over the next two to four decades.

The energy transition is not dead. It remains alive and well. On the other hand, what we now see as "dead" are dystopian climate scenarios. Our analysis this year deems it unlikely that we will reach a world that nears 2.5 or 3.0 degrees of global warming by 2100. Developments unfolding from fundamental economic forces and core national policies do not look likely to reverse, despite some recent directional shifts in politics attempting to stall momentum.

The flipside is that we also see a higher degree of difficulty associated with the lower-end scenarios of 1.5 and 1.6 degrees. Our "house view", representing our consensus energy system view, is centered closely around a 1.9-degree trajectory towards 2040, as we already see a hybrid energy system having arrived.

That is not to say that the move into the next energy era comes without its own set of problems, both for existing socioeconomic structures and for the energy system itself. As with all disruptive technology transitions, there are growing pains and a lot of heavy lifting required. As the system matures, we see solar plant owners struggling with cannibalization of revenues through negative prices and supply-demand mismatches. System operators are paying higher premiums for flexibility and balancing services from battery storage systems and flexible generation.

We also see growing pains in infrastructure as the system turns over, though grids in many areas have been ready for upgrades after three decades of underinvestment. The emerging global energy system will help improve robustness and reduce costs in many regions through mass availability of cheap energy solutions like solar plus batteries, smarter solutions such as more distributed generation, AI-guided grid optimization, and more.

But this will not happen overnight on a global scale. Progress is uneven. Larger economies like the US take more time as existing systems are entrenched, both in consumer interest regarding EVs and in policy. But we see some extraordinary trends in emerging economies, leveraging solutions that have become highly competitive to leapfrog to sustainable energy systems.

One example is solar in Pakistan, which has gone from only 1% to 30% of installed power capacity in just six years. EV sales in Thailand are surpassing 20% only four years after reaching 1% of total car sales. This is enabled by China, which has taken on the role as scaler of these key solutions, using them to grow a stronger hedge against energy imports for the future. In doing so, China has established a firm grip on emerging key value chains, like solar and batteries, and a clear edge in automotive manufacturing.

This means we forecast oil and gas to remain resilient in the near-term. Our house view sets the precedent that we now expect peak oil to emerge in the 2030s. This transition will have significant implications for the cost picture and investments by the energy sector and its consumers. Investments are already pivoting, with the global split between fossil fuels and renewables showing slower growth in fossil fuels while renewables outpace them. Our 1.9-degree scenario shows cheaper costs to end consumers over time.

Policies are pushing forward a faster pathway. Our newest scenario centers on globally announced commitments to the Paris Agreement. The NDCs (Nationally Determined Contributions) scenario, meaning what happens if we see nations stick to their commitments, shows that the world – at least towards 2035 – is on a trajectory compliant with 1.7 degrees of warming by 2100. Not quite 1.5, but well below 2.0, which is the standing minimum requirement of the Paris Agreement.

Our country-by-country assessments across the key three tasks of the energy transition show a clear picture through the Rystad Energy Decarbonization Index. These tasks are: one, decarbonize the power sector; two, electrify everything possible; and three, address the residual emissions. Progress is not even. Some countries are further ahead, while others are just getting started.

The countries that have made the most progress are typically developed countries that already had a history of extracting and using renewable natural resources like hydro power early on. These have a head start and, somewhat unintentionally, have a better vantage point compared to others when it comes to meeting their targets. The Nordics, for instance, are strongly positioned, while other countries have a longer road to travel as the global energy system moves toward the next energy era.

It is important to underscore that not all tasks are equal. The last mile of the transition is the longest, and task three depends heavily on technologies that have yet to break out at scale and become self-sustaining in a free-market situation. As of today, we see some emerging solutions for electrifying hard-to-abate task-three sectors, like steel and heavy-duty transport, but these are not at a point yet where we see them sufficiently mature. Hydrogen, carbon capture and biofuels are the solutions that will need to rise to the occasion.

While we are seeing hydrogen and carbon capture, utilization and storage (CCUS) surrounded by increasingly legitimate actors with large-scale project experience, policy support, such as carbon pricing and direct incentives, is still necessary a factor. Bioenergy is the leading compatible and ready solution that is plug-and-play in many cases, for instance, in shipping.

But task three represents only 20% of the topline emissions reduction. The remaining 80% is set to come from electrification, renewables and non-fossil power, and it is now only a matter of time until we see a turnover of the dominant energy system pillars.

While the short-term defining narratives of the next energy era are being shaped today, the long-term outcome has been under development for decades, starting early as pathfinding nations set out to explore and develop what has now become the most competitive form of energy in most markets globally: solar and batteries combined, often complemented with wind.

Jarand Rystad
CEO

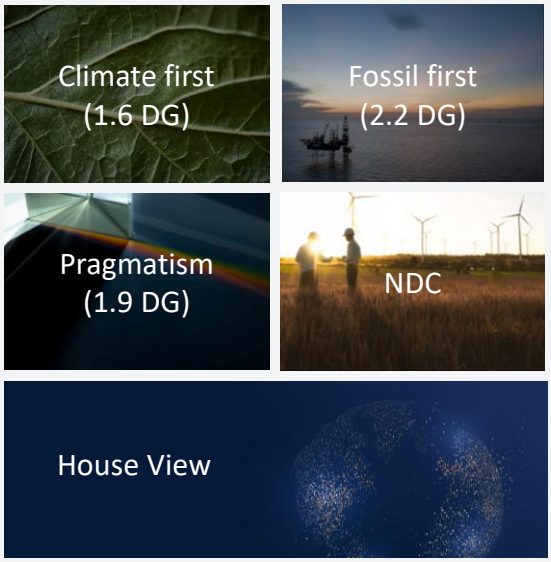
The next energy era

The pathways of the energy system

In this report, we combine insights from resources across the entire Rystad Energy organization, including our cross-vertical House View towards 2040, our energy scenarios research, which provides in-depth degree scenarios towards 2100, and a newly developed nationally determined contribution (NDC) scenario to 2035.

These are complementary perspectives. The focus of our House View is near-term, zeroing in on what we think is most likely to happen based on bottom-up fundamentals. Our degree scenarios are long-term views to 2100, coloured by current sentiment and policies but constrained by carbon budgets aligning with 1.5-to-2.5-degree warming.

We focus on three key cases, which represent different worlds, ranging from "Climate first" in the 1.6-degree scenario, to a more pragmatic middle-road in the 1.9-degree scenario, and Fossil-first in the 2.2-degree scenario. Lastly, our new NDC scenario takes on a lens of what the world may look like if country pledges are implemented.



All scenarios are built from the bottom up, drawing on Rystad Energy's proprietary databases that map the global energy system at asset, company, and country levels. The degree-scenario framework spans 11 scenarios covering the period from 1965 to 2100, covering 217 countries and special territories, nearly 70 sub-sectors, and 70 energy carriers, including oil, gas, coal, electricity, bioenergy, and hydrogen.

Each element of the system – from supply and demand to trade and emissions – is modeled with high temporal and spatial resolution to ensure consistency between physical volumes, costs, and efficiencies across sectors. Power generation, manufacturing capacity and end-use consumption are linked through our multiple vertical-specific products.

This level of granularity provides a transparent and data-rich understanding of how changes in policy, cost and behavior influence the global energy system over time.

>60

sectors

217

countries and special territories

+70

energy carriers

Source: Rystad Energy research and analysis

Prevailing narratives of the next era

Non-linear transition
The transition is not linear. It is marked by sudden accelerations, setbacks, feedback loops, regional disparities, and threshold effects that influence the pace and pattern of change.

Acceleration continues
Emerging cleantech initiatives continue to accelerate decarbonization, following S-curve growth as costs fall and scale rises, with emerging markets leapfrogging and advanced economies progressing more gradually.

Extended runway for oil & gas
High inflation rates, geopolitical volatility, and energy-security concerns are extending the role of oil and gas, concentrating investment in short-cycle, low-cost regions as frontier exploration fades.

Transition amidst addition
Transitions depend on time. Near-term, rising demand drives growth across all technologies. Long-term, a transition unfolds from fossil molecule dominance to renewable electrons as demand shifts, driven by economics and policies.

Useful energy trumps primary energy
Focus is moving from replacing primary energy to delivering useful energy more efficiently. Technologies like EVs and heat pumps cut the primary energy needed for the same services.

Transition creates a new geopolitical landscape
The transition is reshaping geopolitics, shifting power from fuel exporters to technology and mineral producers, with competitiveness and sovereignty driven by innovation and supply chain control.

Convergence of perspectives
A middle ground is emerging between fossil permanence and climate absolutism, as a more pragmatic sub-2.0-degree world gains acceptance as compatible with security and sustainability.

Hard to reach climate goals
Ambition and capacity diverge, with updated Nationally Determined Contributions (NDCs) aligning around a 1.7-degree path, while our House View tracks closer to 1.9 degrees.

The last mile is the longest
About 80% of decarbonization can come from clean power and electrification, while the final 20% hinges on slower progress in CCUS, hydrogen, and biofuels.

Source: Rystad Energy research and analysis

Transitions are not unprecedented – but they are sticky and take time

The next energy era is already emerging, built on clean electricity and electrification, and history suggests its advance will be just as irreversible as those that came before. Over the past decade, the energy sources of the next era have expanded their share of global primary energy from around 9% in 2015 to more than 14% this year. This corresponds to an average growth of almost five percentage points per year, marking one of the fastest structural gains in modern energy history.

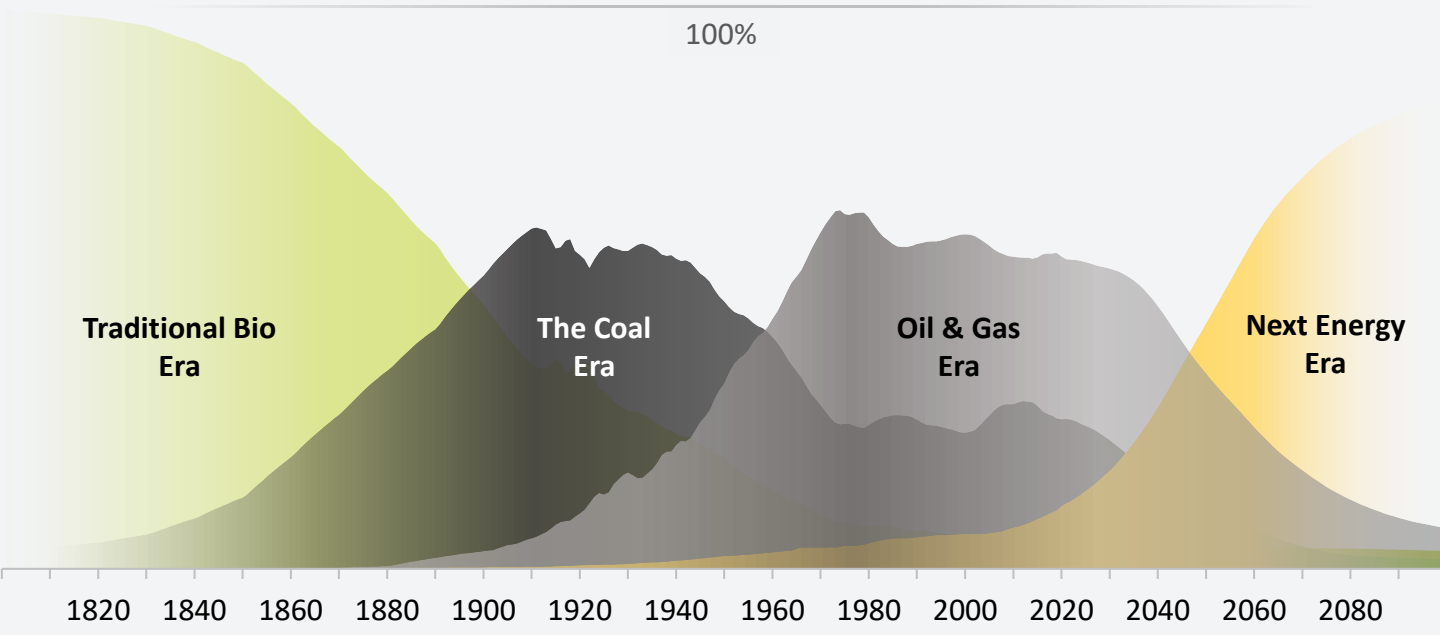
Energy transitions have always been part of economic and technological progress. The shift from traditional biomass to coal in the 19th century reduced biomass' share of global primary energy from 96% in 1800 to less than 60% by 1900. A century later, oil and gas rose from under 2% in 1860 to over 55% by 1970, reshaping economies and societies worldwide.

Each shift was disruptive but unfolded gradually and unevenly across regions. The current transformation toward a low-carbon system follows a similar pattern; while we expect to see addition across energy sources for the next decade, we anticipate a transition unfolding over the next two to four decades.

Technological innovation, investment cycles, and policy coordination across sectors and boarders are reinforcing one another, accelerating cost declines and adoption rates.

Transitions rarely happen overnight. They are constrained by existing infrastructure, capital stock and social inertia, but once tipping points are crossed, new technologies tend to displace incumbents rapidly. Just as coal outperformed wood in terms of energy density, and as oil increasingly outcompeted coal in terms of flexibility, clean electricity is now outcompeting fossil fuels on both cost and efficiency. This sets the stage for another structural reordering of the global energy system.

Relative share of total primary energy consumption by source, RE 1.9 DG
Percent



Source: Rystad Energy research and analysis, EnergyDemandCube

Peak emissions near as transition broadens and priorities rebalance

Global CO_2 emissions are expected to peak around 2026 before starting a gradual decline, driven by rapid renewable deployment in power and EV adoption in transport. This marks a turning point, showing that the world is moving from growth to decline in emissions. However, current NDCs remain far from sufficient to limit warming to 1.5 degrees. Even if fully implemented, they would not achieve the substantial reductions necessary for achieving the lower range of the Paris Agreement.

Rystad Energy's House View, our consensus view on future energy markets, tracks close to a 1.9-degree pathway towards 2035, placing it below the upper range of the Paris Agreement but still short of full alignment. Stronger policy signals and faster deployment are needed to close the gap.

Over the past year, the global energy conversation has shifted more from climate ambition toward cost, security and control. Energy affordability, supply resilience, and industrial competitiveness now dominate the debate.

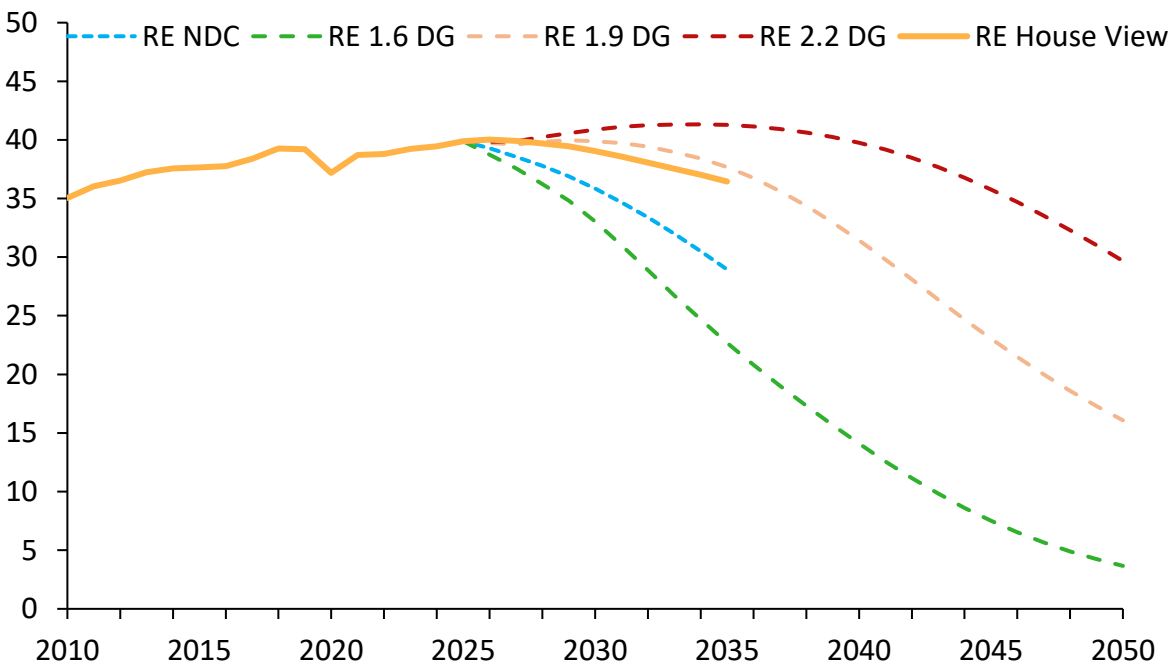
While climate targets remain a priority, the conversation is shifting toward a middle ground that balances fossil fuel resilience with an accelerated energy transition.

The return of protectionism and trade barriers has unsettled global markets. In response, some leaders are re-framing the transition around strategic independence, as captured in European Commission President Ursula von der Leyen's call for Europe's "independence moment". "New" energy technologies are supplementing existing ones, and the road to energy independence for many countries is getting clearer.

At the same time, fossil fuel prices are softening amid oversupply and weaker demand, even as service and project costs rise.

The past 12 months have underlined a simple truth: the energy transition is not a linear race to net zero, but a strategic contest shaped by evolving business, political and globalization cycles.

Annual CO_2 emissions from fossil fuels, 2010–2050
Gigatonnes



Source: Rystad Energy research and analysis

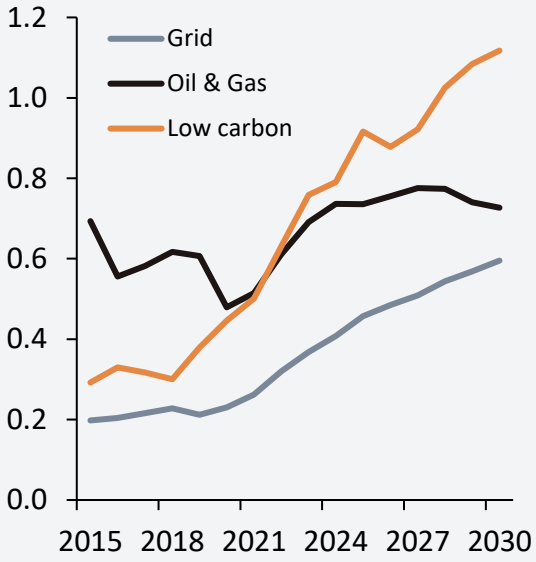
Investments signal shifting dynamics

As a result of the ongoing transition, low-carbon investments are accelerating towards 2030. In contrast, in 2025, oil and gas investments are set to have their first year of contraction since 2020.

Currently, low-carbon technologies attract over $900 billion annually, compared to $735 billion for oil and gas. This $181 billion delta widens to an estimated $391 billion by 2030. This reflects a complete shift in growth dynamics. From 2015 to 2025, low-carbon investment tripled from $292 billion to $916 billion, while fossil fuel spending remained essentially flat at $735 billion despite recovering from its 2020 Covid-19 collapse. Grid infrastructure investment has doubled to $457 billion since 2015, underscoring the system-wide transformation required to integrate variable renewables.

The installed base changes slowly, but investment is a leading indicator: today's capital flows determine the 2040 energy system. By 2030, low-carbon sources are set to capture 46% of all energy investment, compared to 30% for fossil fuels, with grids accounting for 24%.

Global energy investments
USD trillion

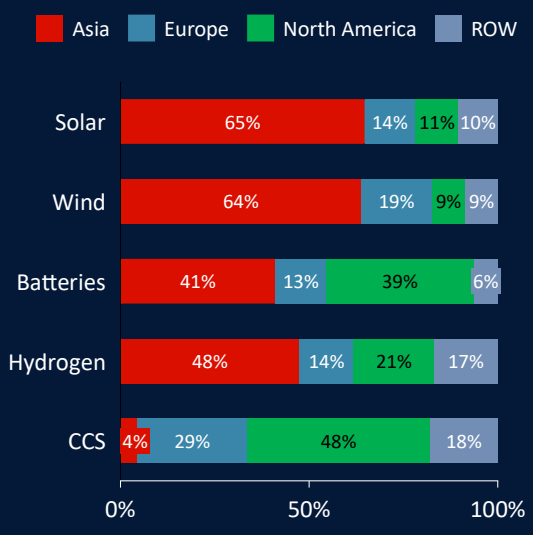


Geographic concentration shapes this investment surge. Asia dominates low-carbon energy deployment across all major technologies, accounting for 65% of solar, 64% of wind, 48% of hydrogen, and 41% of battery investment in 2025.

This largely reflects China's drive for energy independence from oil and gas imports, transiting vulnerable maritime chokepoints, and increasingly contentious supplier nations. Going all-in on cleantech cuts down dependence on energy imports while building manufacturing dominance in 21st-century strategic industries.

The Chinese concentration has driven dramatic cost reductions globally, creating new strategic dependencies. Like EU's shift away from Russian gas, energy importing nations are now transitioning from continuous fuel dependence to equipment purchases. This shifts the reliance from constant supply of molecules to upfront capital access unlocking the home-shored capture of electrons.

Low-carbon investments by technology, 2025
Percent



Note: Low carbon: solar, wind, geothermal, nuclear, hydropower, battery storage. Oil and gas: upstream, midstream and downstream
Source: Rystad Energy research and analysis

Fossil fuels remain resilient

Global fossil fuel demand currently stands at 516 EJ, comprised of oil at 200 EJ (39%), coal at 165 EJ (32%), and natural gas at 151 EJ (29%). Of these, only natural gas is projected to be higher in 2035 than it is today. Oil is expected to plateau before beginning a modest decline, while coal faces the steepest structural reduction.

The global energy mix is thus entering a structural transition. It is fast enough to alter the growth profile of fossil fuels, but not fast enough to deeply disrupt their dominance by 2040. Oil and gas remain the backbone of the system, tied to transport, petrochemicals and energy services, where alternatives are not yet cost-competitive or scalable.

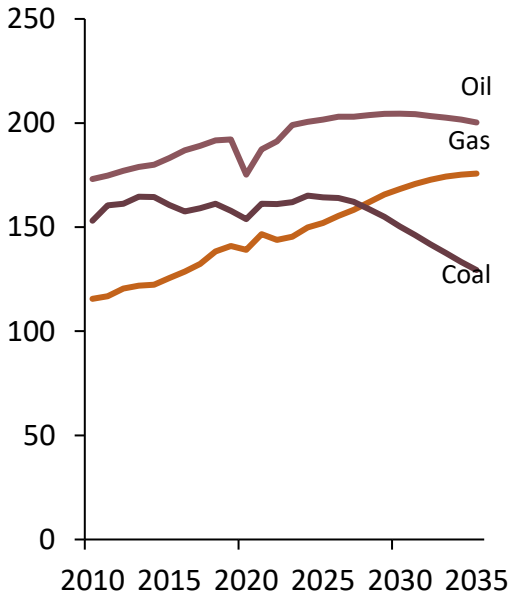
While oil demand is expected to peak in the early 2030s and gas growth slows toward the end of this decade, neither fuel experiences a sharp contraction. Their combined dominance endures, underscoring the inertia of sectors where alternatives remain costly, technologically immature, or slow to scale.

Coal represents the most visible pivot. Global demand is currently at a plateau, persisting through the late 2020s as power and steel demand in China and India offset OECD phaseouts, before entering a sustained decline in the 2030s as solar and wind additions accelerate. This downward trend reflects both tightening policies and shifting market economics, though near-term upside remains from heat-driven power demand and industrial growth in emerging Asia.

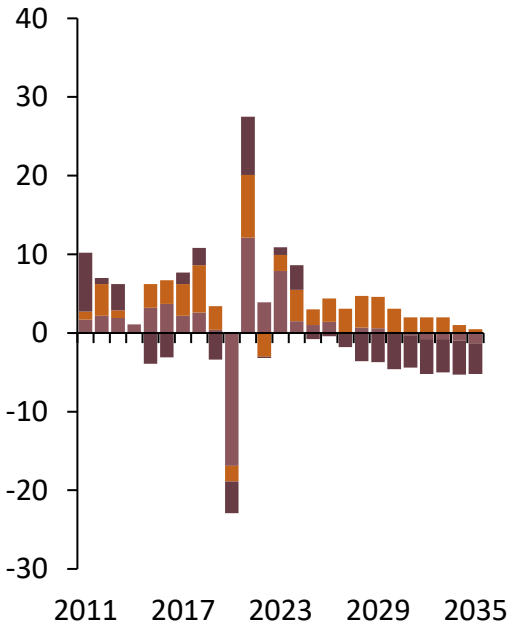
The last decade highlights these dynamics. Natural gas was the primary source of fossil fuel growth, expanding steadily year on year. Oil recorded modest annual increases of 1 million to 1.5 million barrels per day (bpd) in the mid-2010s, before demand fell sharply by nearly 8.5 million bpd during the Covid-19 pandemic, a decline that has not yet been fully recovered. Coal, by contrast, experienced several years of net decline and is expected to continue trending downward as renewable deployment accelerates.

Taken together, these developments signal a structural rebalancing of the fossil fuel system. Coal is in sustained retreat, oil is approaching its peak, and gas is holding ground longer.

Global fossil fuel demand by energy carrier, RE House View
Exajoules



Change in global fossil fuel demand by energy carrier, RE House View
Exajoules



Source: Rystad Energy research and analysis

The pathways

A wide range of possible pathways for the future energy system

The future pathways of the energy system are diverse but not boundless. As the world transitions toward the next energy era, multiple trajectories remain possible depending on choices around technology, policy and economics.

In our updated Global Energy Scenarios 2025 pathways, we consider a broad range of potential outcomes, from 1.5 to 2.5 degrees of global warming compared to pre-industrial times. These can be grouped into three main categories.

Climate First scenarios (1.5–1.7 DG) require rapid deployment of renewables, with solar, wind and batteries expanding to supply 30–50% of primary energy by 2050.

Pragmatism scenarios (1.8–2.1 DG) represent the most likely pathway. Here, oil and gas retain an important role through the 2030s, as electric vehicles advance steadily and coal use declines sharply. Most emission reductions stem from continued substitution of coal in power generation as renewables scale.

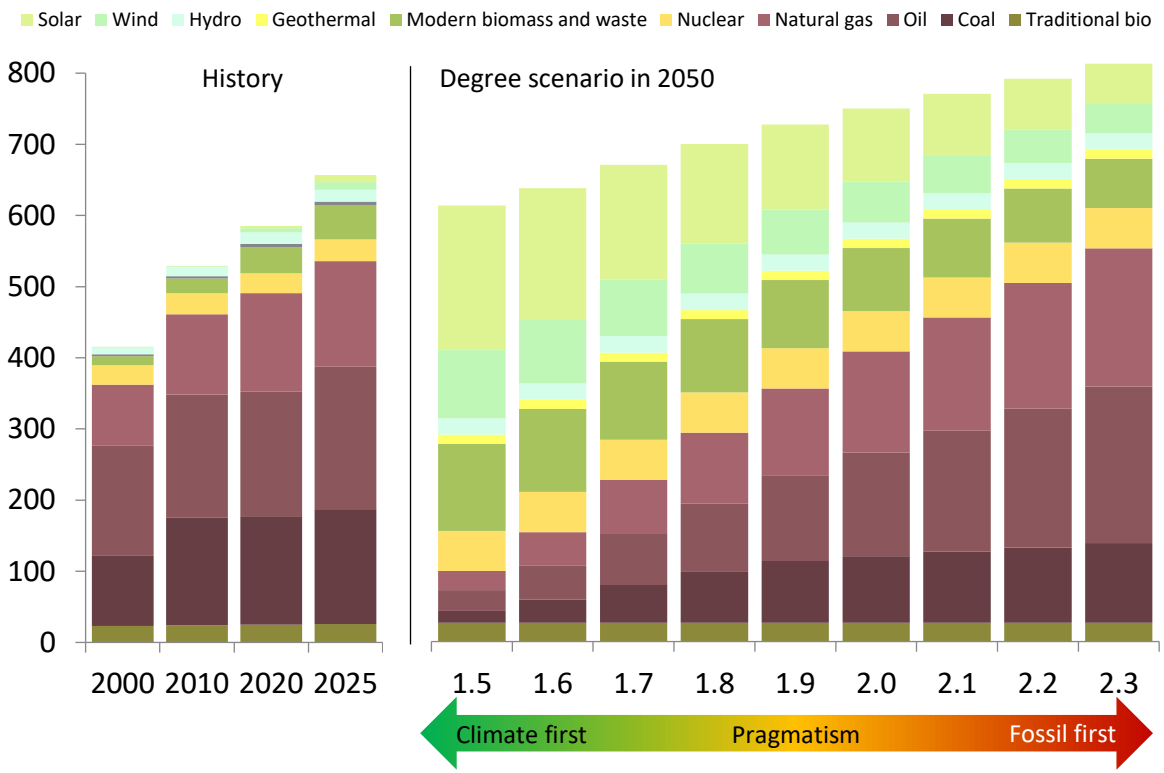
Fossil First scenarios (> 2.2 DG) assume prolonged fossil fuel dominance and slower clean-energy diffusion, limiting renewables to less than 15% of primary energy by 2050. While theoretically possible, these outcomes are increasingly unrealistic.

The global economy lacks both the financial and physical resources to sustain the fossil demand levels implied by warming of 2.5 DG or higher. Similarly, the very low-end pathways below 1.5 DG would require an implausibly rapid transformation.

In practice, the mid-range between 1.8 and 2.1 DG represents the most credible balance between technological feasibility, economic constraints, and current policy trajectories.

Global primary energy demand by scenario and primary energy source

Exajoules



Source: Rystad Energy EnergyDemandCube

While primary energy peaks, useful energy grows through 2050

Today's global energy system is highly inefficient; more than half of all primary energy is lost before it provides any real services. This inefficiency creates the transition challenge we face. To deliver the energy services necessary to support economic development and wellbeing, we do not need to replace all primary energy, only the useful share that actually powers economic activity.

Across our scenarios, useful energy demonstrates remarkably lower variation than primary or final energy. This stability reflects the intrinsic dynamics of energy service demand. While different pathways show divergent trajectories for primary energy supply (varying by fuel mix, efficiency gains, and electrification rates), the underlying useful energy demand remains relatively stable and continues to grow through 2050. This reflects the fundamental energy services that societies need: mobility, thermal comfort, industrial processes, and lighting.

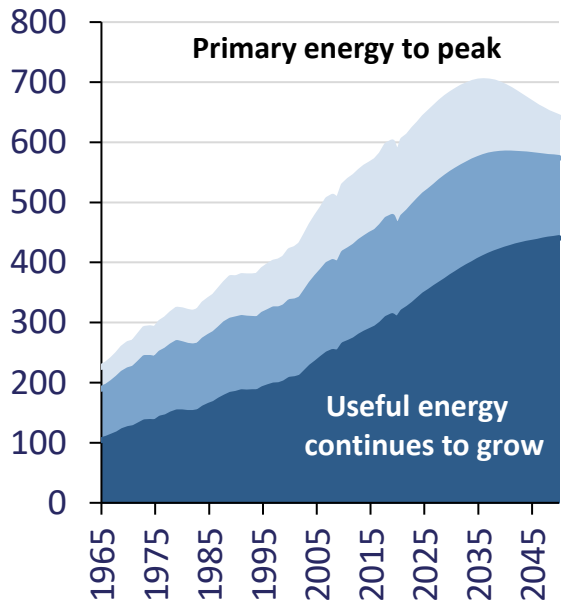
Primary energy can peak and decline while useful energy continues to grow. This apparent paradox is resolved through efficiency improvements.

As renewables and electrification accelerate, losses fall dramatically. Electric motors are three to four times more efficient than combustion engines, and new heat pumps deliver three to four units of heat per unit of electricity. These technological shifts fundamentally change the conversion efficiency of the global energy system.

The data reveals this dynamic clearly. In the 1.9-degree scenario, primary energy peaks around 700 exajoules (EJ) in the late 2030s before declining to approximately 615 EJ by 2090. Meanwhile, useful energy increases from roughly 340 EJ in 2024 to over 440 EJ by mid-century, and then stabilizes.

System-wide efficiency improves significantly, as the future energy system will deliver more useful services from less primary input, with substantially lower losses despite delivering greater useful energy output through clean, efficient electrons.

Global energy demand in the RE 1.9 DG scenario, by primary, final, and useful energy
Exajoules



Collect
Primary energy

Over 20% of harvested energy is **lost** through fuel-based power generation and refining

Consume
Final energy

Another **30%** of final energy is **lost** in combustion by engines, boilers, furnace etc.

Service
Useful energy

Useful energy society is the energy used for desired service after conversion losses.

Source: Rystad Energy EnergyDemandCube

Renewables and electrification are high-confidence in central pathways

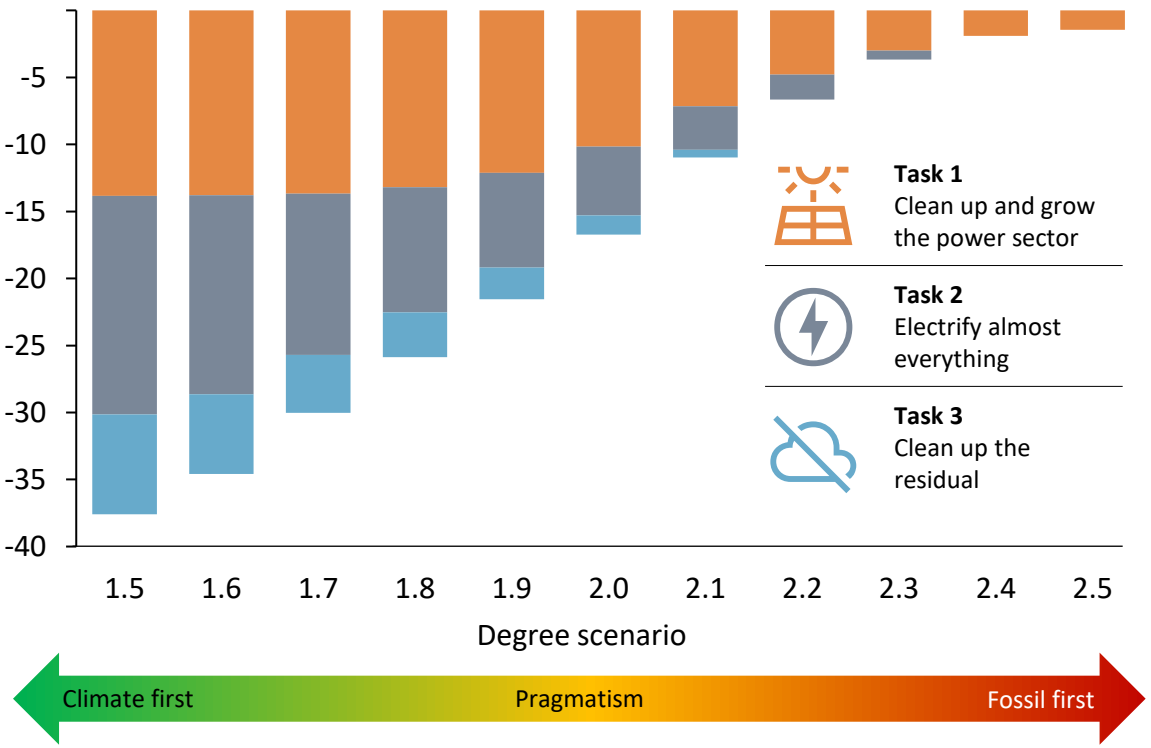
Overall, there is a significant degree of uncertainty about what will happen as the world moves toward the next energy era. Rystad Energy's three tasks of the energy transition are a good framework for analyzing the role of various technologies under different scenarios.

Task 1, which involves cleaning up and growing the power sector, plays a dominant role in driving down emissions through 2050. Our analysis suggests that achieving a global warming scenario more ambitious than 1.9 degrees will require at least 90% of the emission reductions covered under Task 1 to be capitalized. This means that even in a climate-pragmatic market, the power sector will continue to deliver the largest emission reductions and the fastest transition. This underscores the strength of the underlying technology and market forces, particularly in solar, wind and batteries.

Task 2, electrification, becomes particularly impactful, especially in pathways that limit warming to or below 1.6 degrees. The most significant impact comes from the deployment of electric vehicles, as well as a broad range of energy efficiency improvements across buildings, industry and transportation.

Task 3, addressing residual fossil fuel usage through either capturing CO_2 or substituting emissions with low-carbon fuels, contributes little to net reductions before mid-century in pathways that exceed the 2.2-degree scenario. This reflects its later-stage deployment and higher costs. However, addressing residual emissions is necessary to achieve some of the most ambitious climate scenarios. This also includes direct air capture and other removal technologies.

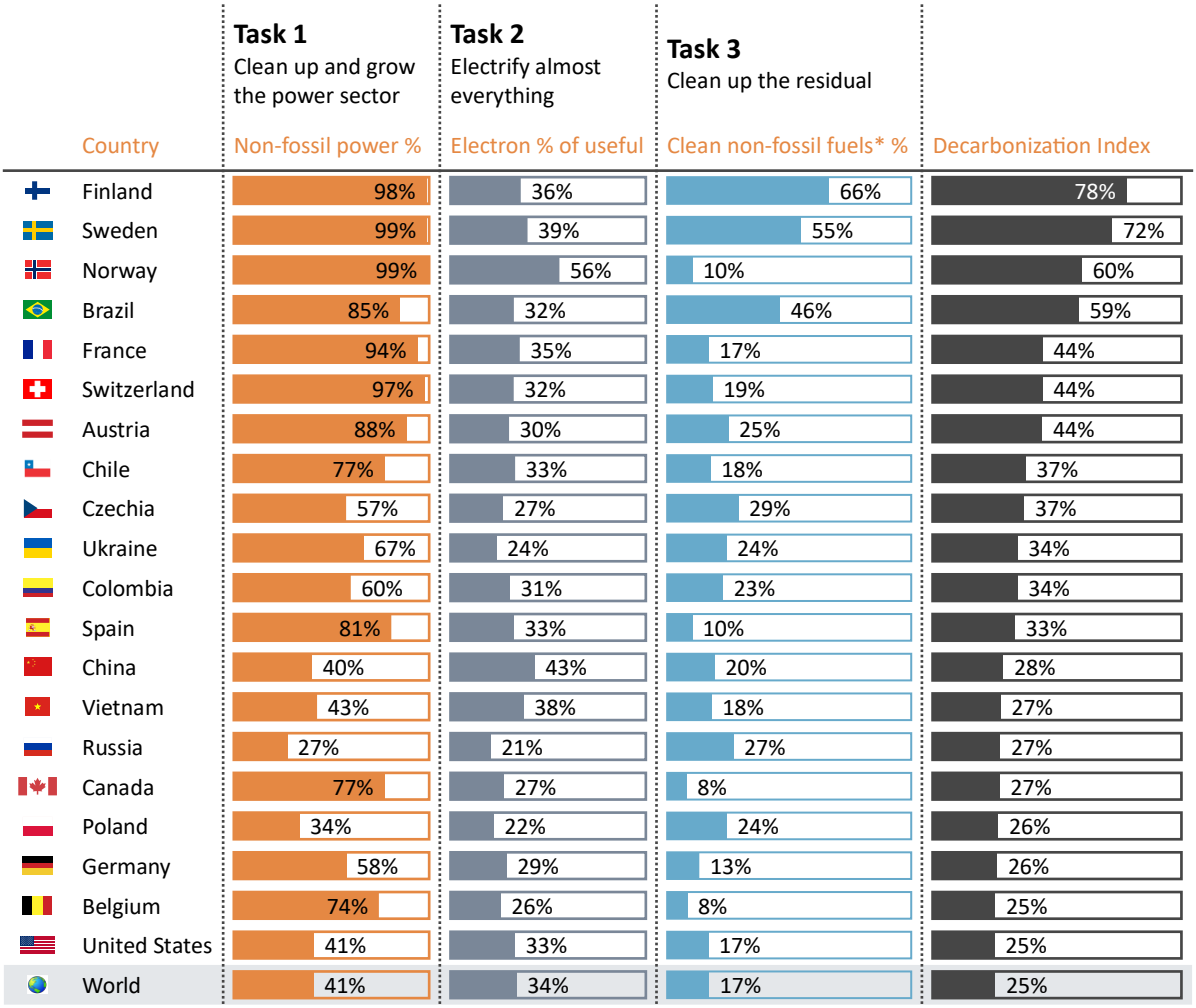
Emission reductions from today to 2050 by task and scenario
Million tonnes of CO_2



Source: Rystad Energy EnergyDemandCube

Finland, Sweden and Norway top the Rystad Energy Decarbonization Index

Rystad Energy Decarbonization Index 2025 – top 20 countries



* Traditional biomass in buildings and feedstock to industry is not included

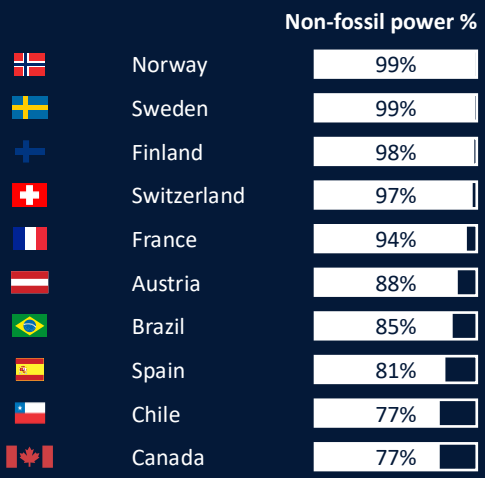
Rystad Energy's Decarbonization Index looks across the three tasks of the energy transition to assess progress towards decarbonization. The index measures the share of non-fossil power (Task 1), electricity in useful energy demand excluding feedstock (Task 2), and clean fuels excluding traditional biomass in buildings (Task 3). A 100% score indicates complete decarbonization, while 0% means that all energy comes from fossil fuels, except for traditional biomass.

On top of the list this year are Finland, Sweden and Norway, all of which have a near fossil-free power sector. Norway is leading the pack in electrification, while Finland and Sweden have the highest shares globally when it comes to use of clean fuel, driven by biomass use in pulp and paper.

China has been steadily climbing the list in recent years, overtaking countries such as the US and Germany. The change is driven by a growing share of non-fossil electricity production and an unprecedented growth in electrification. Currently, 43% of useful energy net feedstock is supplied by electricity in China.

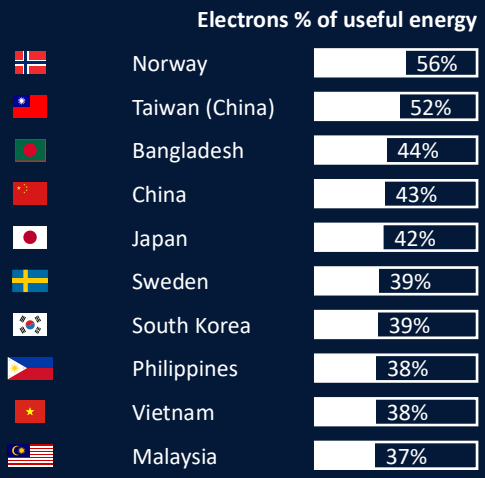
Note: The top 20 index is based on the 50 highest energy consuming nations
Source: Rystad Energy EnergyDemandCube

Europe leads on clean power, while Asia sets the pace on electrification



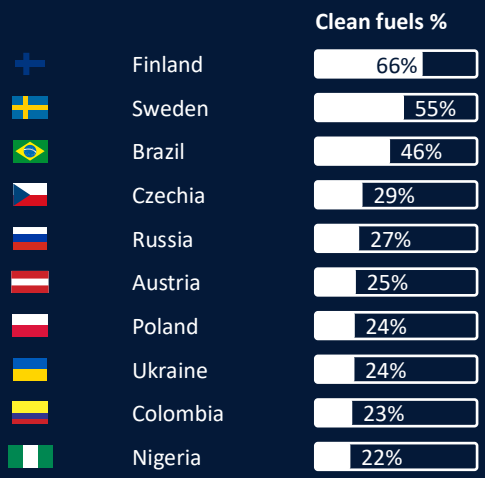
Task 1 | Clean up the power sector

Seven of the world's top 10 countries with the highest share of non-fossil power generation are in Europe, reflecting natural resources and the region's strong commitment to renewable and clean energy. Norway leads with nearly 100% non-fossil generation, followed closely by Sweden and Finland. Brazil stands out as the first non-European country on the list, driven by hydropower. France, Austria, and Spain also achieve high shares, well above the global average of 42%. Chile and Spain are the two countries on the list with most progress over the last 10 years, as many of the countries have older power systems based on hydro and nuclear.



Task 2 | Electrify almost everything

Asia is taking the lead in global electrification, with eight of the top 10 countries showing the highest share of electricity in their useful energy mix located in the region. Norway tops the list, supplying 56% of its useful energy through electricity, far above the global average of 34%. Across Asia, nations such as Bangladesh, Vietnam, the Philippines, and Malaysia have rapidly advanced electrification, effectively leapfrogging traditional energy systems. Meanwhile, Japan and South Korea have maintained steady progress, keeping their electricity share at about 40% over the past decade, demonstrating a sustained commitment to modernization.



Task 3 | Clean up the residual

Despite significant advances in power decarbonization and electrification, progress in cleaning up residual energy use has been much slower, with no region clearly taking the lead. Finland and Sweden top the list of countries with the highest share of clean fuels at 66% and 55%, respectively, followed by Brazil at 46%. The global average remains much lower at around 17%. Notably, Sweden, Finland and Brazil all have substantial pulp and paper industries, which consume large amounts of biogenic fuels. To date, modern bioenergy dominates clean non-fossil fuels, as traditional biomass in buildings is excluded, reducing useful energy by only 5%.

Source: Rystad Energy EnergyDemandCube

Current NDCs track a RE 1.7 DG path to 2035, cutting emissions by 25%

NDCs, the national climate targets underpinning the Paris Agreement, define each country's pathway toward emission reductions and long-term decarbonization.

Collectively, the latest round of submissions charts a trajectory distinct from baseline pathways, aligning with a 1.7-degree scenario by 2035. If fully implemented, these targets would lower global emissions by roughly 3% per year, bringing 2035 levels about 10 gigatonnes (25%) below current emissions. However, two critical gaps remain: an implementation gap between the house view trajectory and the delivery of NDC pledges, and an ambition gap between NDC outcomes and the 1.5-degree pathway required to meet the lower bound of the Paris Agreement goals.

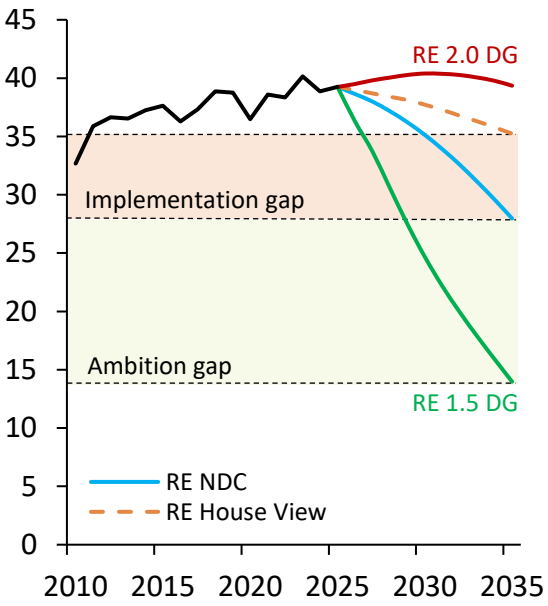
Progress toward these goals is uneven. The UK has already peaked and remains broadly on track, while China appears to be plateauing and would need a sharp downturn this decade to stay aligned with its NDC commitments. India and Indonesia, in contrast, remain off their stated trajectories as emissions continue to rise in key sectors.

Most near-term mitigation under the NDC scenario is concentrated in Asia and Europe, driven by power sector decarbonization and efficiency improvements in transport and buildings. South America delivers smaller absolute reductions but strong relative progress, while Africa's trajectory remains on a higher pathway without stronger measures. Given the recurring policy reversals and Paris Agreement withdrawals, the US is included as a very high risk NDC.

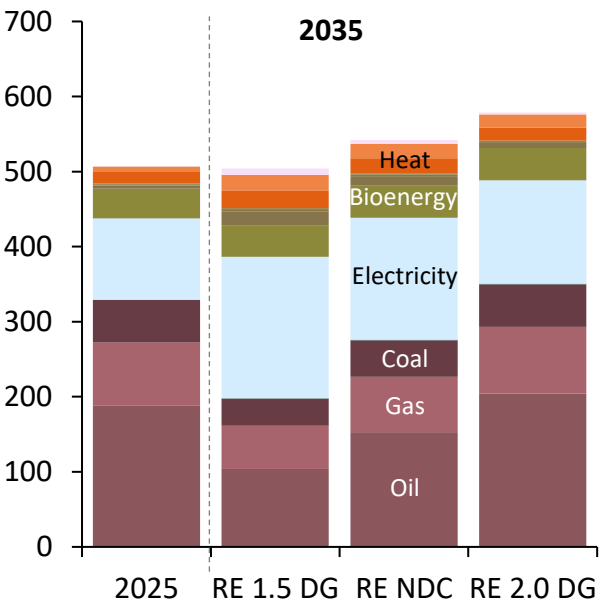
The NDC scenario sits between a Pragmatism pathway and a Climate First scenario. If achieved, NDCs would bend the global emissions curve more quickly than baseline scenarios but still fall short of a 1.5-degree target.

By 2035, oil use remains about 50% higher and electrification 13% lower than in a 1.5 degree-consistent system, highlighting the challenge of translating ambition into full decarbonization. Reaching 1.5 DG would require far deeper structural changes than current NDCs envision, particularly in the power and transport sectors, where progress is most decisive.

Global fossil CO_2 emissions by scenario
Gigatonnes



Global final energy demand by scenario
Exajoules



Source: Rystad Energy EnergyDemandCube

Power sector and electrification cover 90% of emissions reduction by 2035

Our analysis frames the NDCs around the three interdependent tasks of decarbonization, a lens that helps assess both progress and policy focus across regions. Roughly 52% of pledged reductions come from cleaning up the power sector. Many NDCs highlight rapid solar and wind expansion, alongside storage and grid upgrades.

In 2023, nearly 200 countries committed to tripling global renewables by 2030 at COP28 in Dubai, and targets – particularly in the EU and parts of Asia – reflect this push. Progress is strong, with record annual additions, but deployment is still slowed by bottlenecks in permitting, transmission and market saturation risks.

Around 43% of reductions rely on electrifying end-use sectors, transport, buildings, and industry. EV sales have surged from 2% to 25% of new cars in just five years, although scaling still hinges on the development of charging networks and policy support. Heat pump uptake is growing, but high-power prices have dampened sales in some fossil powered regions.

Industrial electrification is advancing through early pilots in steel and aluminum, although most NDCs view this as a mid-term rather than a near-term driver.

The final 5% is achieved by tackling residual emissions in hard-to-abate sectors through CCUS, hydrogen and bioenergy. These are referenced in a rising number of NDCs, and projects are underway, but deployment remains modest compared to renewables and electrification. Long-term success depends on scaling these technologies far beyond their current footprint.

Together, the three tasks – cleaning the power mix, electrifying end uses, and addressing residual emissions – provide a universal framework. Developed economies emphasize decarbonizing power and scaling residual solutions. In contrast, developing countries prioritize electrification as both a growth engine and a pathway to decarbonization. Progress is evident, but momentum must accelerate across all tasks to align NDCs with the goals of the Paris Agreement.

Contribution to emissions reductions by tasks in RE NDC, 2025-2035 (excl. LULUCF)

Task		Key net-zero technology
52%	TASK 1 Decarbonize and grow the power sector	**37%** Solar
		28% Wind
		31% Battery
		2% Nuclear
		2% Hydro
43%	TASK 2 Electrify almost everything	**39%** Electric vehicles
		26% Energy efficiency
		24% Electrification
		1% Heat pumps and buildings energy efficiency
5%	TASK 3 Clean up the residual	**59%** CCUS
		22% Bio energy
		13% Hydrogen
		4% Change process emissions

Source: Rystad Energy EnergyDemandCube

The state of play

Renewables to deliver nearly 50% of power generation by 2030

The balance of global electricity is shifting at historic speed. The power sector is the first to structurally decarbonize.

Renewables are expected to cross the halfway mark in installed capacity by the end of 2025, a milestone once thought to be decades away.

Fossil fuels still provide the majority of electricity generation, but their share is eroding rapidly.

By 2030, renewables will overtake fossil fuels as the largest source of electricity, and by 2035 they secure an enduring lead of more than 20 percentage points.

This shift is driven by scale, economics and policy momentum. Renewables are now being built on a large scale, consolidating their role as the engine of growth in global electricity.

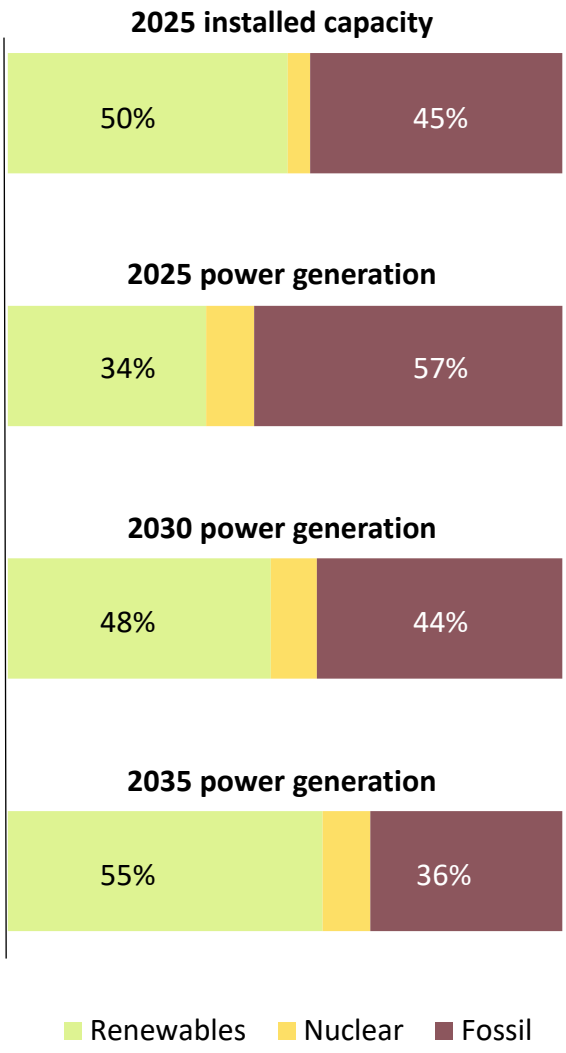
Installed capacity and generation by power source, RE House View
Percent

>50% renewables – first time clean power crosses half of global capacity

Renewables supply **one third of global electricity**

Renewables rise to **48%**, overtaking fossil fuels as the largest source

Renewables reach **55% versus 36% fossil**, locking in a significant structural lead



Source: Rystad Energy research and analysis; Rystad Energy PowerCube

Renewables set for another record year, hitting all-time highs

Global renewable installations continue to surge, with total wind and solar capacity additions for 2024–2025 set to exceed 700 GW.

Solar leads this expansion, forecast to rise from 1,868 GW in 2024 to 2,412 TW in 2025, a 544 GW increase that cements its position as the backbone of new global power generation. Record manufacturing output, sustained cost declines, and accelerating deployment in China, India and the US drive the expansion.

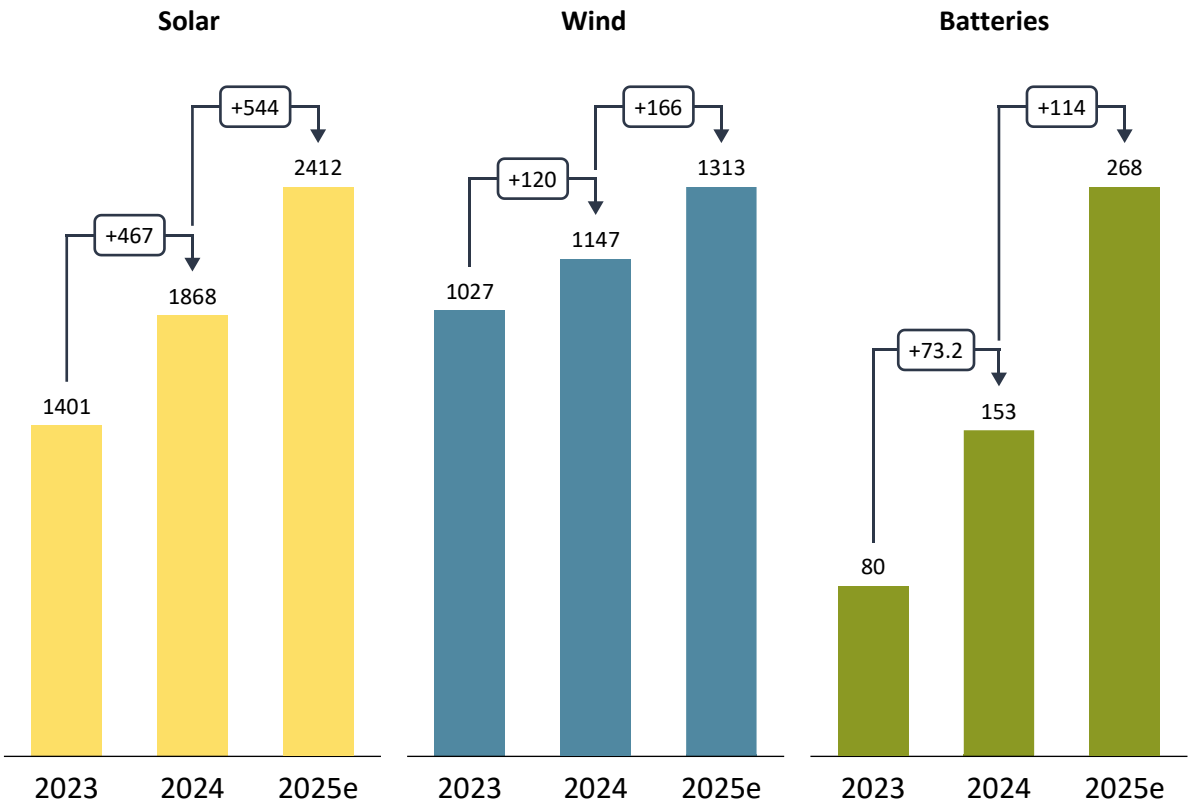
Wind capacity climbs from 1,147 GW in 2024 to 1,313 GW in 2025, adding 166 GW after a temporary slowdown. Offshore wind is regaining momentum as permitting and cost pressures ease, particularly in China and Europe. However, the sector still faces higher capital intensity and financing hurdles than solar.

Battery storage continues to expand at the fastest rate, increasing from 153 GW in 2024 to 268 GW in 2025, a 114 GW rise and more than a threefold gain since 2023. Unlike generation assets, batteries act as the balancing mechanism that enables higher renewable penetration, offering short-term flexibility and grid stability as variable generation rises.

Together, these developments mark another record year for renewables, driven primarily by solar and reinforced by storage expansion. The trend highlights a maturing energy system where generation growth and flexibility investments are advancing in tandem, setting the foundation for more stable and dispatchable clean power over the next decade.

Installed solar, wind and battery capacity

GW_{AC}



Source: Rystad Energy research and analysis, PowerCube

Solar grows fastest in Global South, built on lessons from Europe and Chinese scaling

The diffusion of solar PV has not followed a single trajectory but unfolded in distinct waves, each building on the lessons and scale of the previous one. “Pathfinders”, such as Germany, Spain and Italy, experienced gradual growth, taking 17 to 20 years to reach approximately 35% of their capacity, with an average growth rate of 21%.

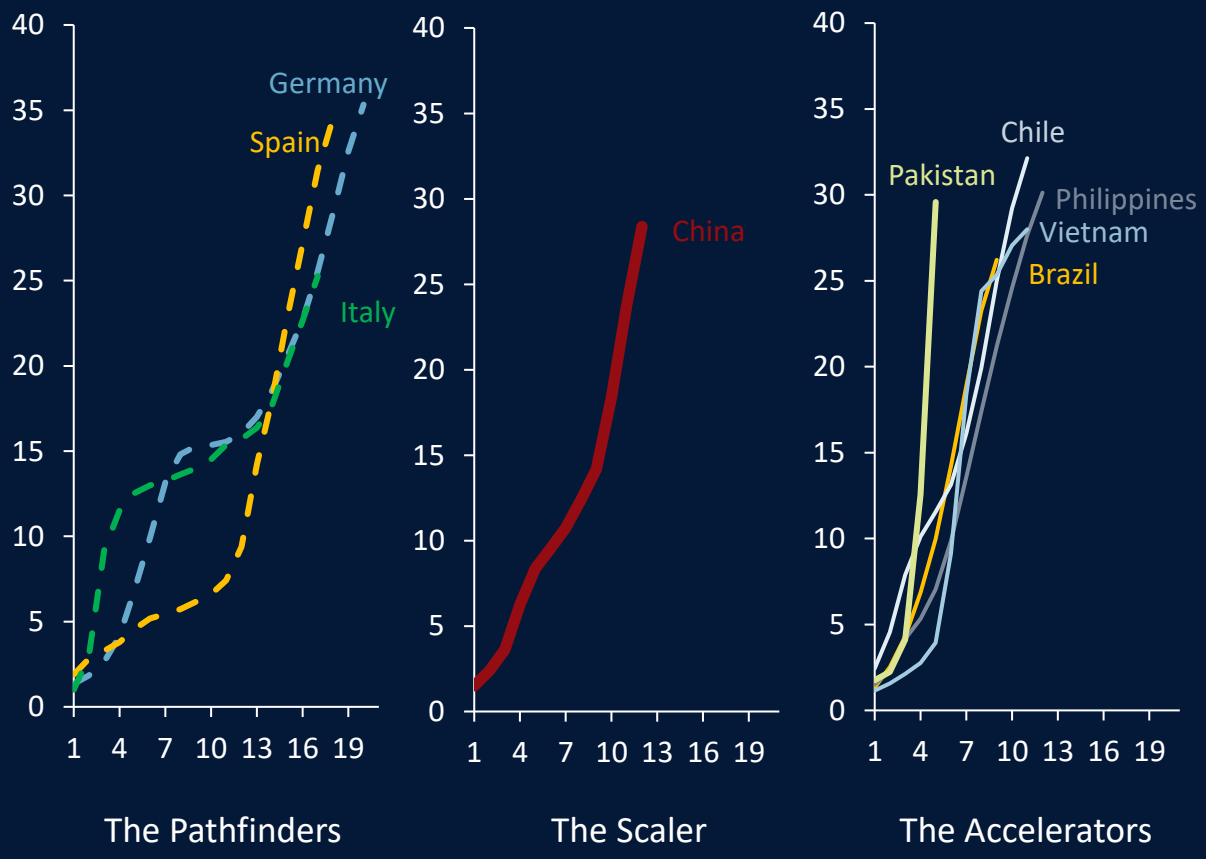
China then emerged as the “Scaler”, lifting its share of installed solar to 50% of global capacity and around 30% of its total power capacity in just 12 years. This occurred with a 32% average annual growth rate, reshaping the sector's economics and supply chain through learning and scaling.

Building on this foundation, “Accelerators” – including Brazil, Chile, the Philippines, and Vietnam – are now surging ahead, reaching a 25% share in only eight to 10 years, at a 38% average growth rate. Pakistan has set a new precedent, reaching 30% in just six years, starting in 2021.

This dynamic shows how technology pioneers bear the cost and risk of early adoption, China leverages scale to industrialize it, and some emerging economies are seizing the opportunity to leapfrog to the next energy era.

Share of solar PV in total installed power capacity

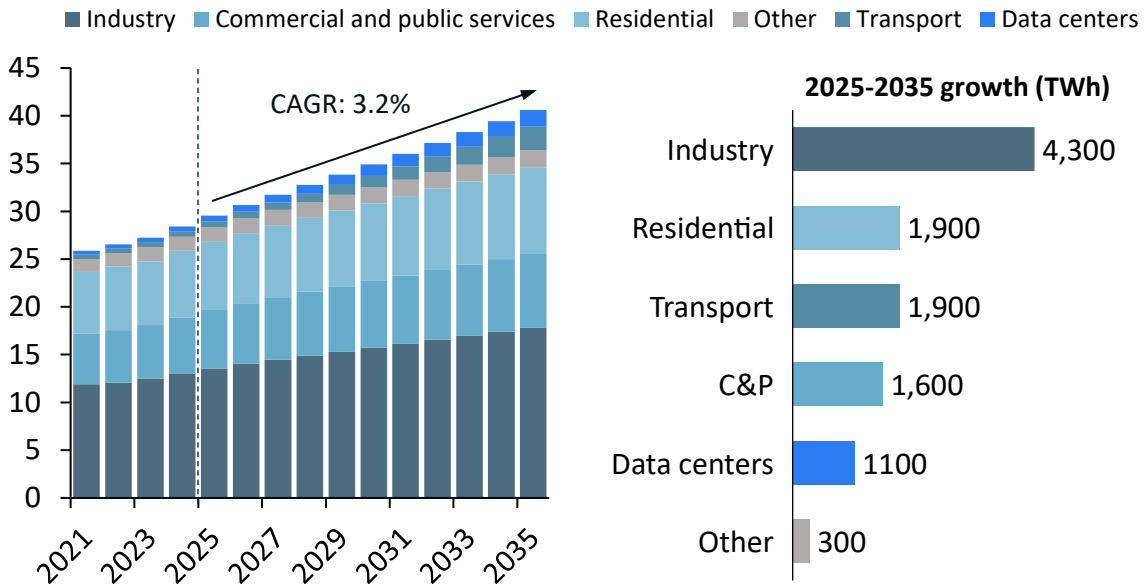
Years since passing 1%



Source: Rystad Energy research and analysis

Global power demand to grow by 37% over the next decade

Global net power demand by sector and 2021-2035 growth, RE House View
Petawatt-hours per year



While expanding output in legacy industrial sectors will continue to drive global electricity consumption, the emerging demand drivers through 2035 will be heating and cooling in buildings, the rise of EVs and the growth of data centers. These changes are reshaping both demand profiles and the system's requirements. Data centers have been an increasingly common talking point and are emerging as a notable source of demand growth, at about 11% annually through 2035. However, in the larger picture it remains quite marginal, accounting for roughly 1.5% of global electricity use today and 4% in 2035.

Global electricity demand has doubled over the past two decades, rising from 14,400 TWh in 2000 to about 29,500 TWh today, now accounting for 21% of global final energy use. Over that period, demand grew at a compound annual rate of 3%. Over the next decade, growth is expected to accelerate slightly to 3.2% per year, reaching 40,600 TWh by 2035.

Consumption is highly concentrated, with two-thirds of electricity used in just seven countries. China and the US are collectively responsible for nearly half. Looking ahead, China is expected to experience the largest absolute growth, adding approximately 2,400 TWh of demand by 2035 as electrification deepens. India is projected to record the fastest relative growth, more than doubling its demand as urbanization and rising incomes reshape lifestyles.

Buildings are the largest source of demand, consuming around 13,300 TWh today. Heating and cooling drive about 40% of this total, with air conditioning closely linked to GDP growth. Cooling is already electric, while heating is still largely supplied by natural gas and biomass, creating a strong case for electrification on both emissions-reduction and public health grounds.

In the industrial sectors, iron and steel dominate demand due to scale, but aluminum stands out for its intensity per unit of output.

Road transport, once negligible, is on the cusp of transformation. EVs currently account for about 4% of transport electricity, but by 2040, they could reach 40%, making road transport a major new driver of demand.

Source: Rystad Energy House View Dashboard

Electrification lets consumers use less energy for the same service

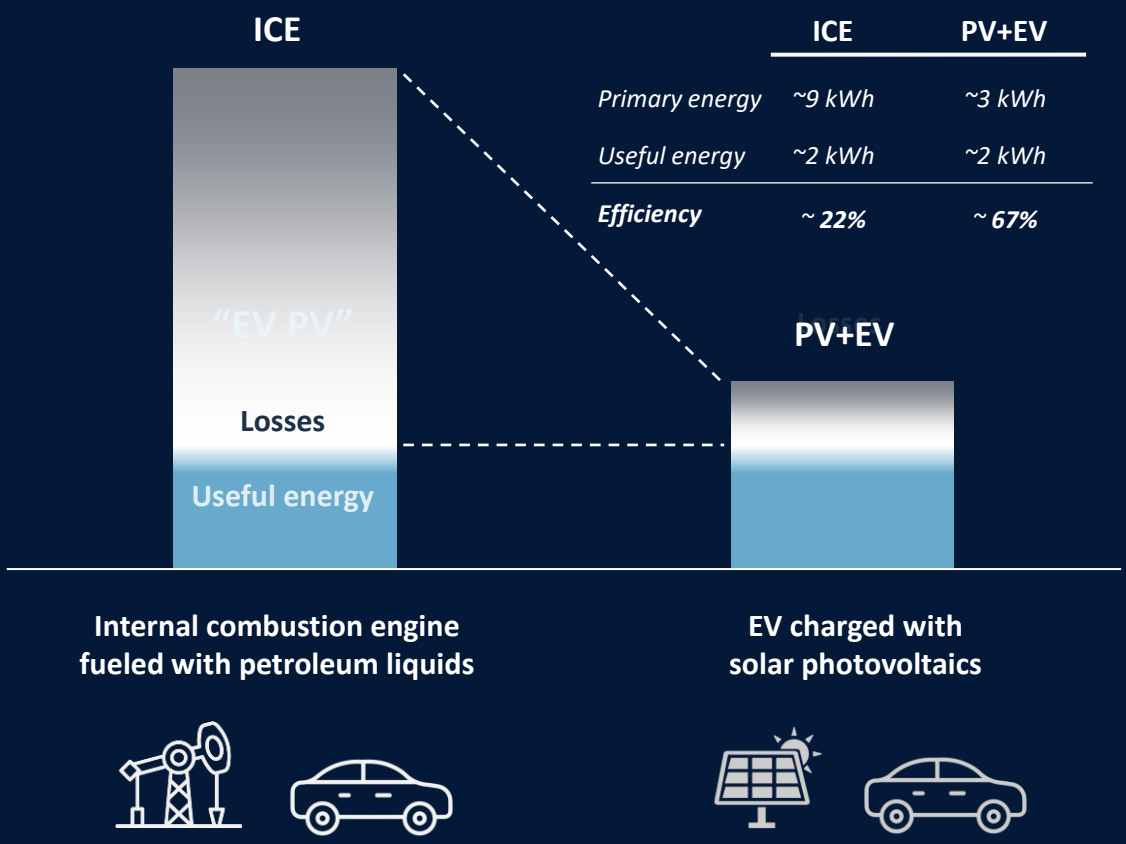
EVs demonstrate why the transition should be understood in terms of useful energy rather than primary energy. Delivering the same mobility service, an EV powered by renewables requires only one-third of the primary energy of an internal combustion engine.

The transition challenge is therefore smaller than primary energy statistics suggest. Useful energy is what societies depend on, yet it is rarely visible in official statistics. By focusing on primary inputs, the scale of the challenge is often overstated.

What appears as reliance on 9 kilowatt-hours (kWh) of fossil input per 10 km trip in an SUV is reliance on only about 2 kWh of useful output, which EVs can provide with far lower losses.

Electrification reduces emissions, improves efficiency, and compresses the energy system into a leaner form. Fossil dependence at the useful energy stage is starting to fall, and the pace of this change is accelerating, even as oil and gas remain resilient in the near term.

Comparative energy flows highlighting useful output for EVs and ICEs



Note: Distance driven approx. 10 km, assumes full-size SUV, losses include steps from sun-to-wheel and well-to-wheel
Source: Rystad Energy research and analysis

Emerging economies are accelerating electrification as technologies scale

The electrification of road transport is becoming the most visible lever of Task 2 in the energy transition. Once electric vehicles pass the 1% share threshold, adoption rarely moves linearly. Instead, growth steepens as cost, infrastructure and consumer confidence align.

Pathfinders like Norway demonstrate what full market penetration looks like, with EVs rising from a niche to more than 90% of sales in just 15 years. The early years delivered compound annual growth above 35%, demonstrating how quickly electrification can displace combustion once tipping points are reached.

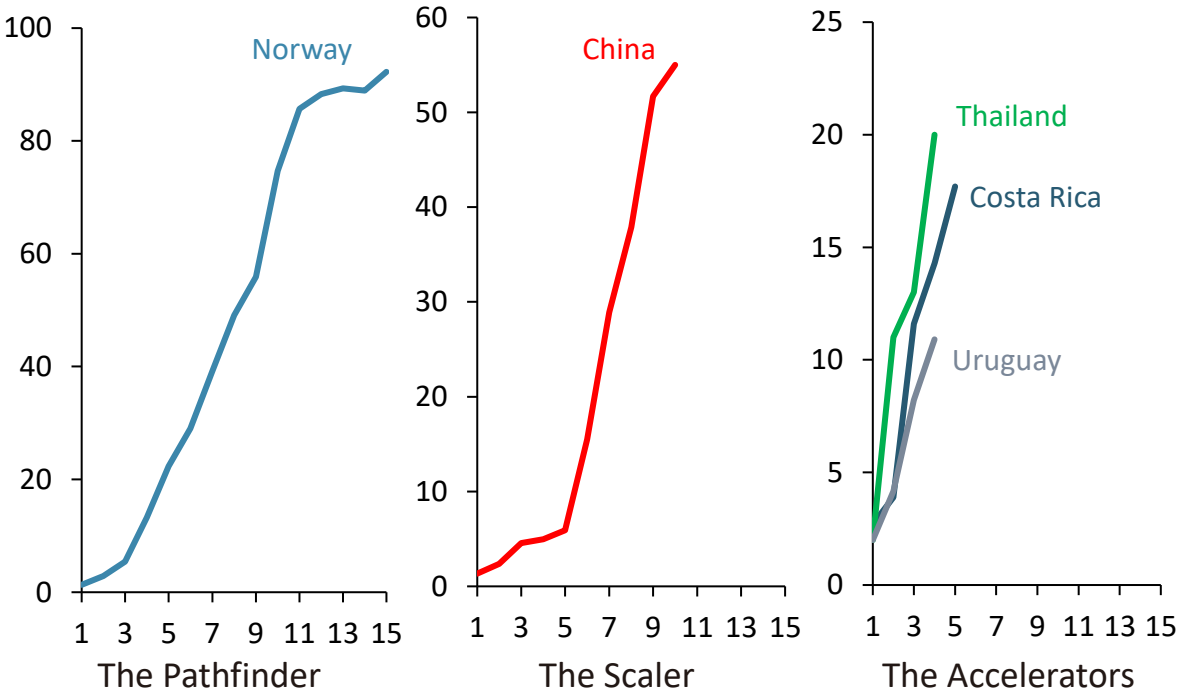
China has since become the Scaler, moving EVs from 1% to more than 55% of all new vehicle sales in under a decade at a 51% annual growth rate. By mobilizing its industrial base and building nationwide infrastructure, China proved that electrification can be achieved at scale, reshaping both the automotive sector and battery supply chain.

While China currently accounts for over half of global EV sales, this lead is set to diminish as other countries scale up sales and the market diversifies.

Accelerators are emerging across developing economies. Thailand surged from 2% to 20% in three years, Costa Rica is approaching 18% in five years, and Uruguay has quadrupled its share in the same timeframe. Annual growth rates of 60 to 115% show that, once economics and access improve, adoption races ahead even in lower-income contexts.

In sum, EVs are the fastest-growing form of electrification, shifting oil demand into electricity and amplifying the impact of clean power growth. As more emerging economies follow this trajectory, transport becomes the channel where electrification delivers the largest structural reduction in fossil fuel use.

EV adoption since passing 1% of total vehicle sales
EV adoption rate (%)



Note: EVs include plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) and refer only to passenger vehicles.
Source: Rystad Energy research and analysis

The last mile is the longest

The decarbonization debate often gets stuck on the final stretch, the so-called last mile of decarbonization. These are the hard-to-abate sectors that make up the remaining 10–20% of emissions: heavy industry, aviation, shipping, high-temperature heat, and residual fossil use in power. They are expensive to decarbonize and attract disproportionate attention compared to their relative share of total emissions, which can distort the bigger picture.

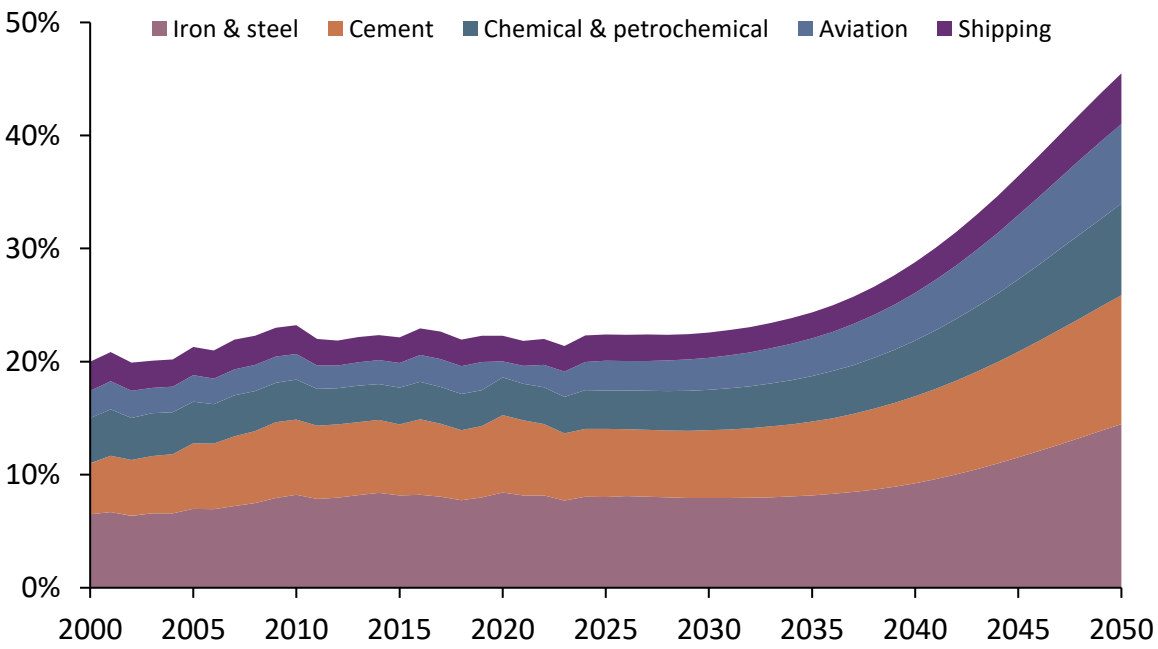
As the system shifts, fossil fuel demand falls in both power and transport, as well as in the global logistics chains that move fuels around the world. As the energy system becomes clean, its infrastructure becomes leaner.

That shift automatically erodes large parts of associated emissions. This means the categories that look marginal today will loom larger against a smaller baseline after 2050, drawing more attention, innovation, policy focus, and capital than they do now.

The economics reinforce this pattern. Early gains yield significant reductions at low or even negative costs. The final fractions demand higher spending, face tougher politics, and yield diminishing returns. This is why the last mile is both the slowest and the most contested part of the journey. However, it is important to emphasize that the focus remains consistent on developing new and innovative solutions, such as exploring where electrons can play new roles that were previously thought to be unviable.

In summary, the next energy era is unlikely to risk missing what is good enough in pursuit of perfection. While what we see as the final 10-20% today may seem large, feedback cycles – such as lower shipping activity resulting from reduced fossil fuel use due to electrified road transport – will mean that the last mile becomes shorter. As overall emissions decline, the remaining sources will appear proportionally larger and attract greater scrutiny.

Hard to abate sectors as share of emissions, RE 1.9 DG
Percent



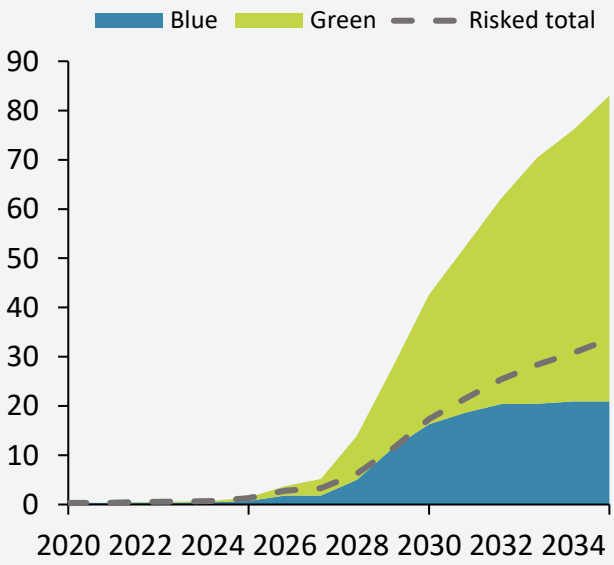
Source: Rystad Energy research and analysis; Rystad Energy EnergyDemandCube

Hydrogen and carbon capture shift focus towards execution

Clean hydrogen and carbon capture – key tools to address the last mile of decarbonization – have moved from announcement booms to a focus on delivery. In hydrogen, project announcements have declined sharply from their 2022 peak as developers concentrate on projects with bankable offtake. The risked supply outlook now points to around 34 million tonnes by 2035, shaped by financial viability rather than ambition.

The current demand of roughly 105 million tonnes remains dominated by grey hydrogen in refining and ammonia, and early clean hydrogen volumes are largely directed towards these legacy sectors. Offtake visibility and regulatory pressure make them the most stable markets, while new uses, such as green steel and shipping, remain smaller. The sector is consolidating around projects that can reach final investment decisions, as electrolyzer supply chains, subsidies, and permitting mature.

Clean hydrogen supply
Million tonnes per annum

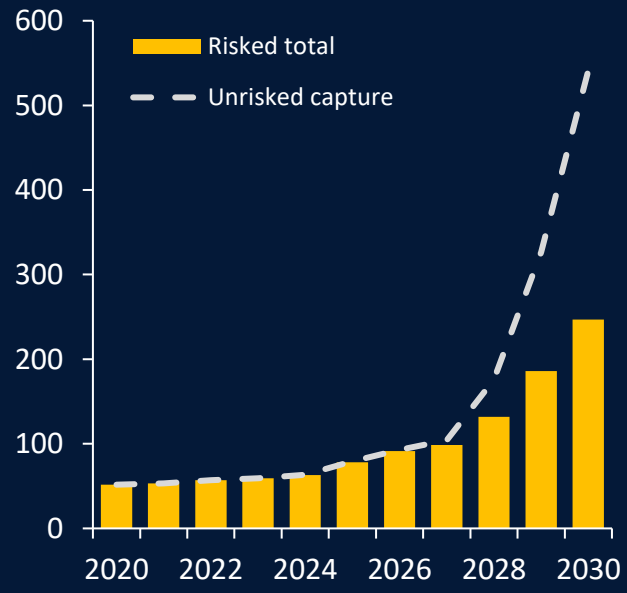


In carbon capture, the pattern is similar. Announcements have dropped by over 80% since 2023 as capital rotates from concepts to construction. The risked pipeline is on track to reach above 200 million tonnes per annum (Mtpa) by 2030, around four times the 2024 level, but just 40% of total announced volumes. Developers are prioritizing projects with secured storage, transport access, and regulatory clarity.

A handful of large-scale projects, such as Northern Lights in Norway and Porthos in the Netherlands, are setting the commercial and technical benchmarks for the next wave of CCUS hubs.

Overall, the market for clean hydrogen and CCUS is shifting from counting announcements to focusing on delivering capacity, marking a more sustainable phase of growth defined by execution quality and credible delivery.

Carbon capture supply
Million tonnes per annum



Source: Rystad Energy research and analysis

Maritime and aviation's biofuel use diverges as policy alignment stalls

Transport remains a major energy-consuming sector, and decarbonization is diverging sharply across modes. Road transport is rapidly electrifying, with battery-electric vehicles displacing demand for liquid fuels. Aviation and maritime face higher barriers, requiring energy-dense fuels and long-lived assets with limited zero-carbon alternatives.

As hydrogen and electrofuels (e-fuels) remain costly, supply constrained and infrastructure-heavy, biofuels offer a pragmatic first step, providing mostly drop-in compatibility and immediate carbon reductions.

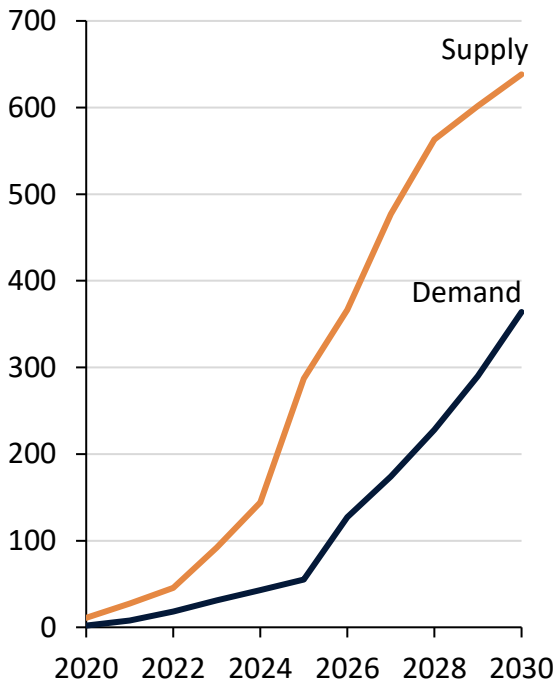
Risked total announced production capacity of sustainable aviation fuel (SAF) scales from about 290,000 barrels per day (bpd) in 2025 to over 630,000 bpd by 2030. Actual output will be lower, as capacity factors are today are at around 60%, expected to rise only to around 70% by 2030. This brings effective supply closer to expected demand, which reaches 365,000 bpd.

Maritime presents a tighter balance. Renewable diesel and biodiesel supply climbs to roughly 250,000 bpd by 2030, while demand could surge from 2028 if the International Maritime Organization (IMO) tightens carbon intensity rules via its Net Zero Framework (NZF).

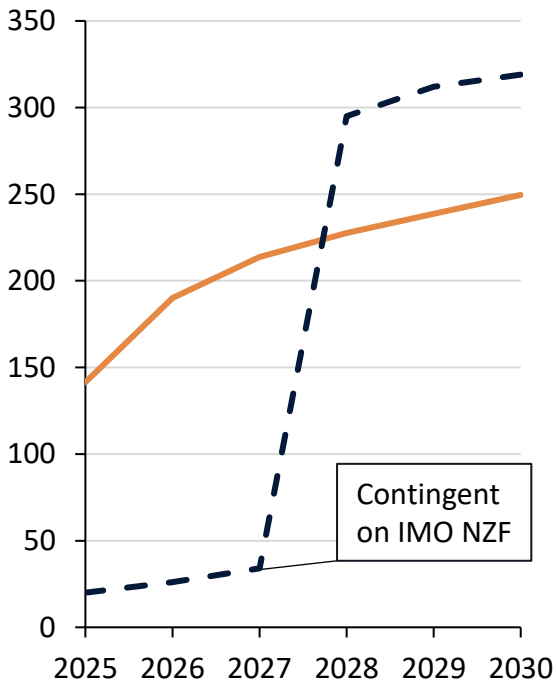
Following joint US-Saudi pressure to retain oil as central fuel, and US pressure to include first-generation biofuels to support soybean markets constrained by weaker exports to China, the final NZF vote was postponed to 2026, pushing back implementation.

In the meantime, a two-speed dynamic is emerging. EU-exposed operators under FuelEU Maritime and the EU ETS continue driving demand for advanced biofuels, such as bio-LNG and renewable diesel, benefiting from lower offtake prices. Should IMO rules take effect, others will face higher costs and tighter access, giving these operators a structural advantage.

Risked announced sustainable aviation fuel supply* versus aviation demand
Thousand barrels per day



Growth in risked renewable and bio diesel supply versus maritime demand
Thousand barrels per day



*SAF supply is risked against our multi-criteria framework, but assumes 100% capacity factor for nameplate capacity
Source: Rystad Energy research and analysis; Biofuel Market Analysis dashboard

Unlock the full insights

This executive summary captures key highlights from our *Global Energy Scenarios 2025* report.

The full report is available exclusively to clients of our **Energy Macro Solution**.

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